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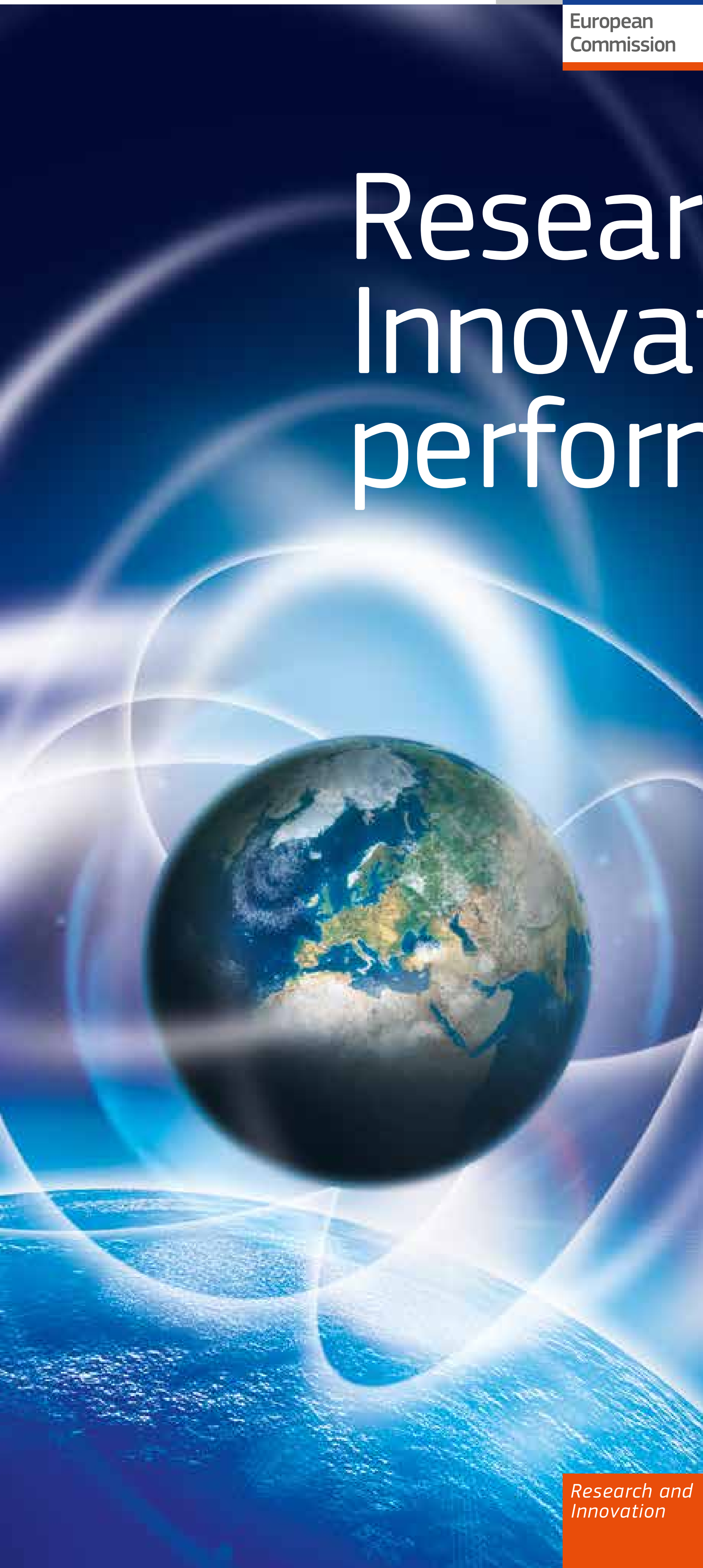

Research and Innovation performance in EU Member States and Associated countries

Innovation Union progress at country level

2013

Research and Innovation

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Foreword

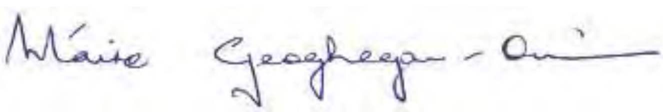
The State of the Innovation Union report, which is published together with the present Research and innovation country profiles, shows that despite the deep economic recession we are currently facing, research and innovation remains alive and well in Europe. This is good, as a competitive European economy with high-quality jobs can only be based on innovative products and services.

The strength of this report is that it looks at the overall picture and individual country performances. With a similar analytical structure for each country, policy makers and stakeholders can compare and reflect in a transparent manner. The research and innovation system in each country is described in a comprehensive form based on the very latest official statistics from Eurostat, OECD and other major data sources. They cover the entire innovation cycle, from input of investment and skilled workforce to the economic impact of innovation on structural change and international competition.

Looking at the facts and figures, the picture is mixed. We can identify 'Innovation Leaders' that are showing the way by boosting investment in research and development. Others are only now taking steps to reform their research and innovation systems, improving efficiency and effectiveness. The report shows the challenges each country is facing, but also their technology strengths and innovation opportunities. Slowly, the European economy is transforming into a knowledge-based Innovation Union.

However, the path from ideas to market is still not a smooth one. We have made progress on some big ticket items like the Unitary Patent and new rules for venture capital. We are on track to fulfil the commitments taken under Innovation Union. Yet there is still much to be done both at the European and at the national level. This is the case for reform of research and innovation systems as well as for funding. The EU still lags behind major players such as the US, Japan and South Korea in terms of R&D investment relative to GDP. There are also large differences between EU Member States in funding and innovation performance. We are not closing the gap between the top performers and those that are less innovative.

It is worth reminding ourselves every now and then exactly what the goal of the EU's Europe 2020 strategy is: a smart, sustainable and inclusive economy. In order to achieve this we need to make the European Union a more knowledge-based, more competitive economy. This requires us to monitor research and innovation performance, not as an end in itself, but in order to design policy and funding that best contribute to creating growth and jobs in Europe.



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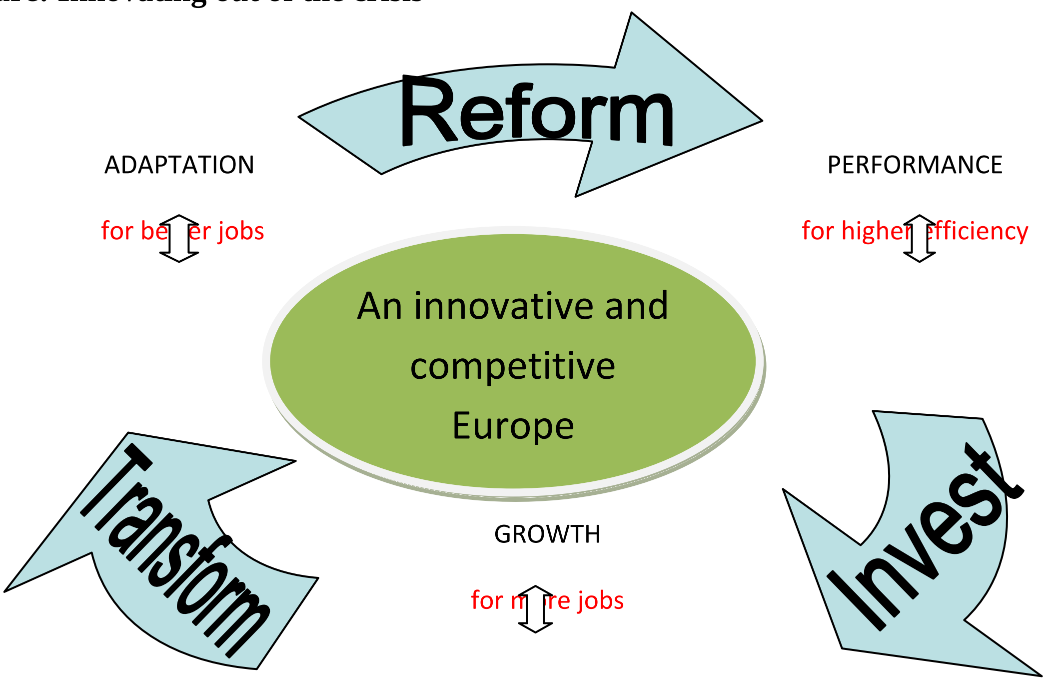
Introduction

The Europe 2020 strategy relies to a large extent on efforts made at country level, to which European instruments can contribute. Progress towards a European Innovation Union[1] is therefore closely linked to the performance of Member States in mobilising reforms of R&I systems, investing in knowledge and making structural changes towards more knowledge-intensive economies.

As highlighted in the Commission's Communication on the State of the Innovation Union 2012, an effective innovation policy requires a combination of three crucial dimensions: **Europe needs to reform, invest and transform**. In the current period of economic crisis, reforms to achieve greater efficiency are urgent and feasible; alongside these reforms, there need to be continuous investment and smart fiscal consolidation to lay the groundwork for the recovery. However, the crisis has also highlighted more structural weaknesses in the European economy. Our future beyond the crisis depends on having the capacity to transform the structure of the economy towards more knowledge-intensive and innovative industries and services.

Figure: Innovating out of the crisis



The Research and Innovation country profiles provided in this publication constitute a key policy tool for stakeholders and policy makers and cover these three dimensions. These country profiles facilitate the framing of policies and the elaboration of national strategies based on factual evidence. They were first published in June 2011 as part of the Innovation Union Competitiveness report,[2] providing policy makers and stakeholders with concise, holistic and comparative overviews of research and innovation (R&I) in individual countries.

[1] State of the Innovation Union 2012, Accelerating change

[2] Link: ec.europa.eu/iuc2011.

This 2013 publication is an updated and extended version of the country profiles published in 2011 with particular emphasis on thematic and sector-based analysis.

The country profiles cover the whole innovation cycle: the main policies concerning investment in R&I, performance and reforms of the R&I system, hot spots and specialisation in science and technology, new R&I policy strategies, dynamics of fast-growing innovative firms, upgrading of manufacturing industries, the contribution of high-tech and medium-tech industries to the trade balance, and the overall link between innovation and progress towards Europe 2020.

As in 2011, the performance of individual countries is benchmarked against the EU average and against a group of other European countries with similar knowledge and industrial structures. The benchmarking employs the same methodology that was used in 2011,[3] thus ensuring comparability over time. The policy analysis draws on the policy assessments already published as part of the Europe 2020 process[4] in the Commission staff working document assessing the National Reform Programmes, and also on the supporting Country-Specific Recommendations.

The statistical data and evidence of policy reforms have been verified with each Member State and associated country. Each country profile, however, does not constitute a policy statement but rather is an objective analysis by the Commission services. In order to ensure cross-country learning and comparability, Eurostat and OECD data have been used, complemented by data from some other sources[3].

[3] See methodological notes at the end of this document.

Key findings

1. The need for reforms for a more efficient research and innovation system

One of the Europe 2020 targets is to reach an R&D investment intensity of 3% in the EU. Governments and firms are investing strongly in research and development. However, the use of these resources will not be effective if they are not invested in a first class research and innovation system that is capable of transforming ideas into innovation and spurring the development and deployment of technologies for industry and society. A more efficient R&I system means generating the best possible output from invested input; a more effective system means attaining more relevant outcomes for the economy and society. The objectives of efficiency and effectiveness should therefore be actively pursued and must cover the whole research and innovation cycle.

There is no ideal or absolute model for an R&I system. Its specific configuration will not be optimal if it is not tailored to the industrial, social and cultural setting at national and regional level. However, many features of a system can be transposed from one setting to another with slight adaptations, notably from other countries with similar patterns.

The country profiles show that some countries excel more than others at science and technology (S&T) for the same level of public investment. In some countries, the challenge for efficiency starts at the reforms needed to achieve scientific and technological excellence. Growing investment has raised levels of excellence in S&T in many countries, but the degree of improvement may still be lower than the EU average. For other countries the main challenge is to trigger fast-growing innovative enterprises and international competitiveness by disseminating knowledge.

The synthesis table below illustrates these findings. The first column shows the latest levels of R&D intensity of each country and its growth over the last decade. This input can be seen alongside two new composite indicators on research excellence and on structural change towards a more knowledge-intensive economy.[4] Finally, an effective innovation system should have an effect on international competitiveness and on the trade balance of more sophisticated products and services. The last column, based on a recognised methodology used by the OECD, provides important insights into the competitiveness of a country. In order to interpret it, parallel information on the trends in absolute values of exports is made available in each country profile.

[4] For an overview of these composite indicators, see the methodological notes at the end of this document.

Table: Overview of R&I performance in Member States and Associated countries

	Country	R&D intensity[1] 2011		Excellence in S&T 2010		Index of economic impact of innovation 2010-2011	Knowledge-intensity of economy 2010		HT&MT contribution to trade balance 2011	
		value	**growth rate[1]** (2000-2011)	**value**	**growth rate** (2005-2010)		**value**	**growth rate** (2000-2010)	**value**	**growth rate[2]** (2000-2011)
EU	**European Union**	2.03	+0.8	47.86	+3.09	0.612	48.75	+0.93	4.2	+4.99%
AT	**Austria**	2.75	+3.25	50.46	+4.51	0.556	42.4	+2.78	3.18	+20.24%
BE	**Belgium**	2.04	+0.35	59.92	+3.5	0.599	58.88	+1.06	2.37	+10.39%
BG	**Bulgaria**	0.57	+1.06	24.65	+3.4	0.234	29.45	+3.65	-4.78	n.a.
HR	**Croatia**	0.75	-2.72	12.25	+2.31	0.353	n.a	n.a.	2.98	+133.23%
CY	**Cyprus**	0.48	+6.24	27.77	+0.17	0.558	44.11	+3.27	1.72	-0.83%
CZ	**Czech Republic**	1.84	+4.23	29.9	+4.58	0.497	39.58	+2.91	3.82	+42.62%
DK	**Denmark**	3.09	+4.64	77.65	+3.41	0.713	54.95	+1.64	-2.77	n.a.
EE	**Estonia**	2.38	+13.31	25.85	+11.7	0.450	46.48	+2.94	-2.7	n.a.
FI	**Finland**	3.78	+1.12	62.91	+2.71	0.698	52.17	+0.49	1.69	+33.50%
FR	**France**	2.25	+1.02	48.24	+3.54	0.628	57.01	+0.63	4.65	+1.66%
DE	**Germany**	2.84	+1.28	62.78	+3.88	0.813	44.94	+1.04	8.54	-0.70%
EL	**Greece**	0.60	+0.56	35.27	+2.53	0.345	32.53	+2.52	-5.69	n.a.
HU	**Hungary**	1.21	+4.64	31.88	+2.03	0.527	50.23	+1.87	5.84	+9.04%
IE	**Ireland**	1.72	+4.07	38.11	+5.39	0.690	65.43	+1.94	2.57	+26.26%
IT	**Italy**	1.25	+1.69	43.12	+3.56	0.556	35.43	+1	4.96	+8.13%
LV	**Latvia**	0.70	+4.15	11.49	-0.15	0.248	34.38	+3.96	-5.42	n.a.
LT	**Lithuania**	0.92	+4.13	13.92	+2.62	0.223	35.28	+5.04	-1.27	n.a.
LU	**Luxembourg**	1.43	-1.34	19.84	+1.29	0.589	64.75	+1.4	-3.35	n.a.
MT	**Malta**	0.73	+4.68	17.53	+4.07	0.350	54.45	+2.67	0.92	-14.37%
NL	**Netherlands**	2.04	-0.45	78.86	+2.72	0.565	56.22	+0.48	1.68	+53.81%
PL	**Poland**	0.77	+1.6	20.47	+4.45	0.313	31.78	+1.65	0.88	+37.56%
PT	**Portugal**	1.50	-0.16	26.45	+4.23	0.387	41.04	+3.18	-1.2	n.a.
RO	**Romania**	0.48	+2.53	17.84	+7.81	0.384	28.35	+5.86	0.38	n.a.
SK	**Slovakia**	0.68	+0.41	17.73	+3.85	0.479	31.64	+0.07	4.35	+32.26%
SI	**Slovenia**	2.47	+12.46	27.47	+3.99	0.521	45.9	+4.25	6.05	+14.72%
ES	**Spain**	1.33	+3.56	36.63	+3.66	0.530	36.76	+2.65	3.05	+23.73%
SE	**Sweden**	3.37	-0.96	77.2	+3.58	0.652	64.6	+1.41	2.02	-1.97%
UK	**United Kingdom**	1.77	-0.23	56.08	+2.27	0.621	59.24	+1.2	3.13	+4.83%
IS	**Iceland**	3.11	+1.7	38.8	+9.22	0.485	n.a	n.a.	-13.57	n.a.
IL	**Israel**	4.40	+0.31	77.13	+2.68	n.a.	n.a	n.a.	5.42	+8.62%
NO	**Norway**	1.70	+0.66	51.77	+11.61	0.433	39.99	+2.22	-17.38	n.a.
CH	**Switzerland**	2.87	+1.9	97.59	+3.42	0.837	70.05	+2.11	8.44	+2.69%
TR	**Turkey**	0.84	+5.82	13.79	+2.52	0.315	18.6	+0.92	-2.22	n.a.

Source: European Commission, DG Research and Innovation, Economic Analysis Unit (2012)

Notes: [1]R&D intensity: EL: 2007; CH: 2008; IS: 2009; IL: 2010. Average annual growth rate is calculated for the period 2000-2011, or between the latest available data (considering the breaks in the series for certain countries): CH:2000-2008; DK:2007-2011; EL:2001-2007; FR:2004-2009; HR:2002-2011; HU, MT:2004-2011; IS:2000-2009; IL, NL, TR:2000-2010; PT:2008-2011; SI:2008-2010; SE:2005-2010; NO:2001-2011.

[2]CZ: 2001-2011; CY,AT: 2004-2011; FI: 2003-2011; NL: 2007-2011; HR, IE, PL, IL: 2008-2010. These countries have positive values only for the periods mentioned above, the rest of the values are negatives. For countries with negative values of the HT&MT products' contribution to the trade balance, in the period 2000-2011, the average annual growth rate cannot be provided. The EU value is the weighted average of the values for the Member States.

At EU level, growing investment in R&D has had a positive impact on S&T, structural change and competitiveness. The most successful Member States have managed to increase the scientific quality and economic impact of their science through innovation, while others still face efficiency problems or problems related to the inadequate impact of public investment.

EU Member States and associated countries have launched ambitious policy reforms with the aim of making their R&I systems **more efficient and more effective** in line with the objectives of the European Research Area.[5] Many of these reforms were initiated before the economic crisis, but have since been extended and deepened.

The economic crisis has shown that there is a need for stronger integration of research and innovation in broader industrial and macro-economic policies. New innovation bills have been launched in several countries and many countries are linking innovation to broader reform packages on entrepreneurship, the business environment and the labour market. Most Member States have designed or implemented legislative changes increasing the autonomy of universities. Others have introduced new employment conditions for public sector researchers that allow them to work with the private sector and commercialise their scientific and technological findings. Efficiency is being promoted through a better balance between institutional and project-based funding and a general move towards competitive funding. Performance-based institutional funding is being linked to scientific excellence, internationalisation, and collaboration with business on science and technology.

However, there is still room for improvement. Only a handful of countries have put in place effective mechanisms for allocating funding that give strong incentives to excellence, while such reforms are clearly having an impact on the efficiency of the public R&I systems of these countries. Institutional block funding for universities and public research organisations is often allocated without reference to any performance criteria, and when criteria are used they do not always cover key features such as cooperation with industry or dissemination of results. Individual research actors may still have limited incentives to engage in Europe-wide networking or competition if financial returns are absorbed by the funding institutions. Institutions have limited incentives to strive for excellence or to cooperate with private sector actors when neither their institutional funding nor the evaluation of their work is linked to the results achieved. Equally worrying is the fact that, despite progress in student mobility, too few universities and public research organisations recruit foreign professors or recognise the international professional experience gained by their staff.

In these times of crisis and reduced funding, **strategic priority setting** and the establishment of technology profiles are gaining increased attention. Most Member States, including the larger ones, are engaged in the strategic priority setting of specific science and technology profiles. They use a combination of criteria for their choices: dialogue with industry on their needs for new knowledge and technologies, dialogue with stakeholders on major societal challenges in the country and beyond, and efforts to streamline the national priorities with thematic priorities at the EU level, in particular the FP7 and the upcoming Horizon 2020. In most Member States, it is the national government that leads the dialogue on strategic priority setting. In some countries the private sector takes the lead while in others regions or public research organisations are responsible for their own priority setting in dialogue with industry.

The approach to priority setting can often be substantially improved. In several Member States there are glaring inconsistencies between scientific specialisation and technological specialisation, indicating both a mismatch and an insufficiency of collaboration between the public and the private sectors. Other Member States are facing the need to diversify and to develop specialised human resources and technology for new industries. Such changes have come about following major changes in global value chains that have affected domestic

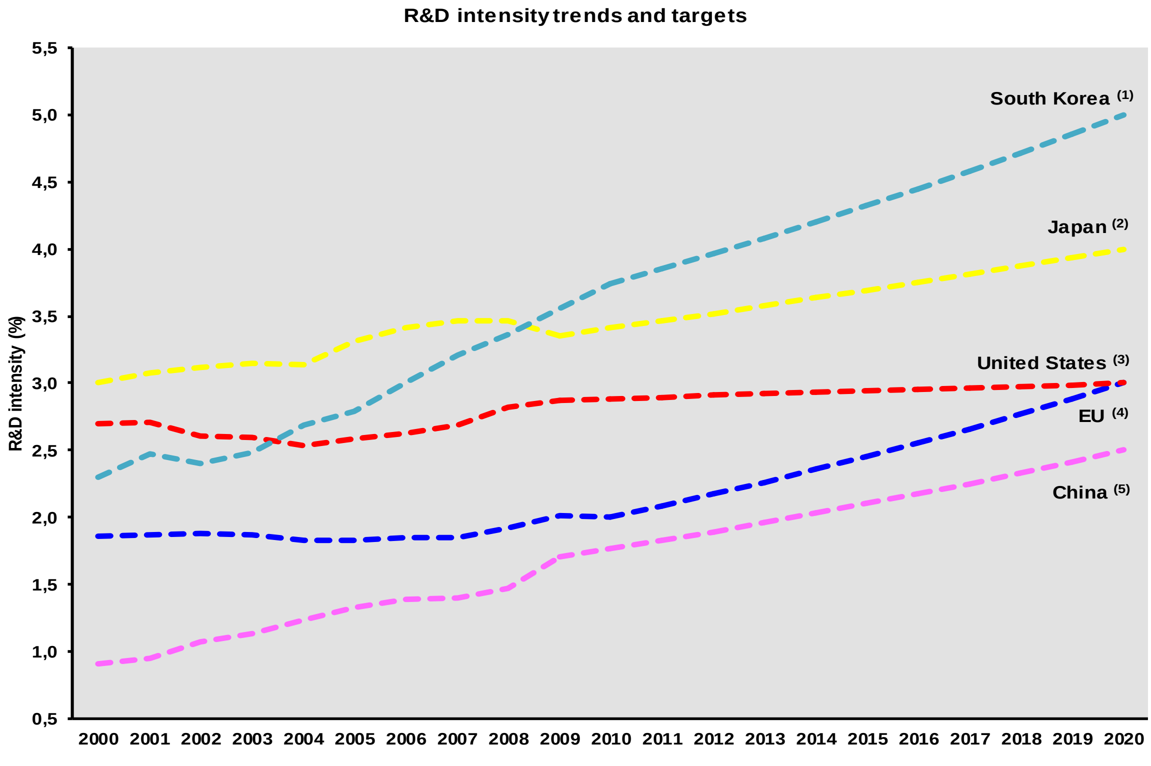
[5] A reinforced European Research Area Partnership for Excellence and Growth, COM(2012) 392final, 17.7.2012.

employment in multinational firms. And while the number of graduates in science and engineering has gone up considerably over the last decade, gaps remain in some knowledge-intensive economies that are faced with the gradual retirement of large numbers of researchers and engineers. Many higher education institutions are revising their courses and curricula to ensure that the qualifications and skills of future professionals are better suited to labour market needs, in particular to the needs of growing industries in areas addressing societal challenges such as health, clean energy and environment.

2. The need for continuous investment in knowledge

The EU still lags behind the United States and Japan in overall **R&D intensity**; China is rapidly catching up. The EU has set an R&D intensity target of 3% for 2020, which is below the Japanese target of 4% but in line with those of the United States and China. The funding allocated to research and innovation in the EU Framework Programme for Research and EU Structural Funds has increased substantially since 2000, and further increases are expected for the period 2014-2020. However, efforts are also needed at Member State level to achieve national R&D intensity objectives, despite the economic crisis.

Figure: R&D Intensity trends and targets



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD
Notes: (1) South Korea: (i) The projection is based on an R&D intensity target of 5,0% for 2020; (ii) There is a break in series between 2007 and the previous years.
(2) Japan: (i) The projection is based on an R&D intensity target of 4,0% for 2020; (ii) There is a break in series between 2008 and the previous years.
(3) United States: (i) The projection is based on an R&D Intensity target of 3.0% for 2020; (ii) R&D expenditure does not include most or all capital expenditure.
(4) EU: The projection is based on an R&D Intensity target of 3.0% for 2020.
(5) China: The projection is based on an R&D Intensity target of 2,5% for 2020.

Since the onset of the current crisis, many Member States and associated countries have been engaged in **smart fiscal consolidation** that prioritises investment in R&I. Public and private investment in R&D increased up to the start of economic crisis. When, in 2008 or 2009, depending on the country, the impact of the crisis started to be felt in public funding, some governments chose to implement a countercyclical strategy, keeping up investment in R&D and incentivising the private sector to follow suit. In fact, most Member States have maintained or increased their investment in R&D despite fiscal constraints. In many Member States this strategy has worked well, in particular in countries where the private sector is knowledge-intensive and internationally competitive. These countries were affected by the crisis for a shorter period of time and have staged a stronger economic rebound.

However, in a few countries the countercyclical strategy did not sufficiently **stimulate private investments** to generate a rebound. This occurred mainly in those countries where the economy suffered persistent liquidity constraints combined with lower demand for knowledge by business. Unfortunately, the latest information collected from the Member States shows that the number of countries maintaining or increasing their efforts in R&D investment is falling. The importance of staying at the forefront and engaging in smart fiscal consolidation must therefore be emphasised now that some countries might be tempted to lower the priority they give to public investment in knowledge creation.

With increasing fiscal constraints and cuts in national research budgets, in particular in the most crisis-affected Member States, the relative importance of EU funding for research and innovation is increasing. Before the crisis, EU funding represented more than 20 % of project-based funding in Europe, and this has increased since then thanks to higher annual budgets in the Seventh Framework Programme for Research and Technological Development (FP7). The increased budgets for research, innovation and entrepreneurship in the Structural Funds for 2014-2020 and in the upcoming Horizon 2020 are likely to boost this innovation-triggering effect further. This impact is enhanced by the fact that in the 2011-2012 period a larger number of Member States revised how they implement their Structural Funds in order to better incentivise R&I investment by the private sector.

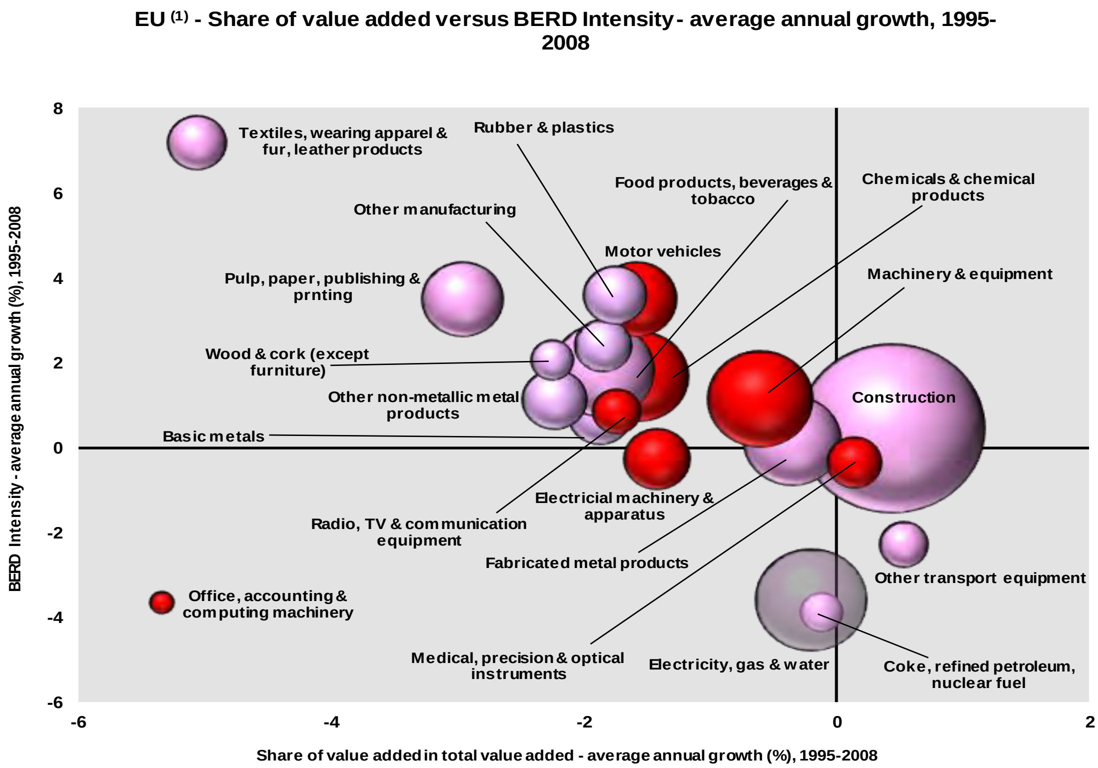
Overall, **European enterprises** have slightly increased their investments in R&D as a share of GDP since 2008. They also expect to increase their investment in R&D globally by an annual average of 4 % over the period 2012 – 2014. However, there are large differences between Member States and between industrial sectors and actors. Some countries are suffering cuts in R&D investment by the private sector, in particular by SMEs. Larger international corporations tend to increase their level of investment but not necessarily in their country of origin, confronting innovation leaders with the challenge of knowledge specialisation and cluster building on a global scale. As regards sectors, many countries have seen an increase in R&D intensity in more traditional medium-tech industries (metals, rubber and plastics, food products) and in growing markets that are influenced by societal challenges such as waste treatment and the need for clean energy and water.

3. The need for structural change towards a more knowledge-intensive economy

Europe needs to restructure its economy to be more flexible and better adapted to the multi-polar economy that is emerging from the crisis. This requires Europe to adapt to broad societal challenges and to position itself vis-à-vis new technological models and new growth markets. In other words, we need to increase our capacity to channel knowledge, creativity and technology into innovative, internationally competitive products and services that respond to societal needs.

Overall, the European economy has a lower level of knowledge intensity than the economy of the United States, although it is catching up slightly. As in the United States, the proportion of manufacturing sectors in the overall economy has decreased (leftward move in the graph), with the exception of the construction sector before the bursting of the property bubble in 2008. In the period 1995-2008, the EU did achieve a slight R&D-driven upgrade in many manufacturing sectors, including the more strategic high-tech and medium-high-tech sectors (in red). However, momentum was lost in important sectors such as electricity and water, electrical machinery, and office, accounting and computing machinery.

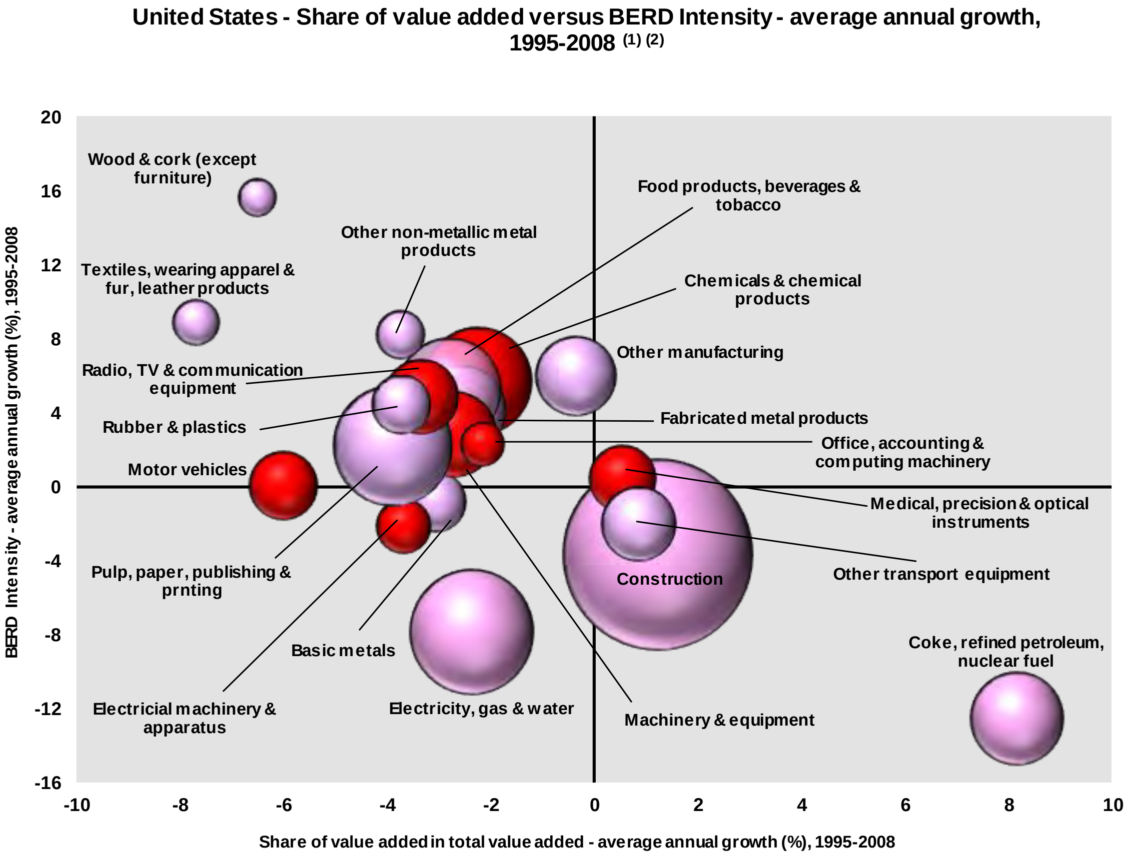
Figure: Structural change in the EU manufacturing



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) (i) EU does not include BG, EE, CY, LV, LT, LU, MT, RO; (ii) Elements of estimation were involved in the compilation of the data.
(2) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.

The United States is encountering similar structural challenges to the EU with relatively modest knowledge-driven structural changes, a reduction in the economic weight of the manufacturing industry and a dominant construction sector. In fact, the way in which the manufacturing sectors in the two blocs evolved over the 13-year period before the economic crisis is surprisingly similar. The trend was different in only a few sectors. In the EU, the motor vehicle, pulp and paper, and rubber and plastics sectors have upgraded more than in the United States, while the United States economy has seen more of an upgrade in ICT and health-related sectors such as office, accounting and computing machinery, medical precision and optical instruments and the larger radio, TV and communication equipment sector.

Figure: Structural change in the US manufacturing



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) Coke, refined petroleum, nuclear fuel, Electricity, gas and water, Medical, precision and optical instruments, Other manufacturing: 1995-2007; Construction: 1996-2007; Pulp, paper, publishing and printing: 1999-2007; Wood and cork (except furniture): 1999-2008.
(2) There is a break in series between 2003 and 2004 which affects BERD for Pharmaceuticals, Office, accounting & computing machinery, and Radio, TV and communication equipment,
(3) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.

Each individual country profile tells a different story as regards industrial upgrading and structural change. However, one striking finding in this country-based report is that Europe's economic landscape is developing much more than commonly perceived. The challenge is to develop strategies and policies to guide this change in a direction that will create good quality and sustainable jobs over time and across Europe.

Some countries have achieved a knowledge upgrade in traditional sectors such as wood, basic metals and textiles. R&D intensity in the high-tech and medium-high-tech sectors has not increased in all countries, although it has done in the most dynamic countries of the last decade. There are also interesting trends of new (or renewed) industries growing in value added and in knowledge intensity. This has been the case primarily in the recycling, electrical machinery and publishing and printing industries. The construction sector has been dominant in most European countries and the level of R&D intensity in that sector went up in many of these countries (albeit from relatively low levels) in the period up to the economic crisis.

Member States with the highest performing research and innovation systems, backed up by considerable and growing investment, have not only high but increasing levels of knowledge intensity in their economies (see also the previous overview table on R&I performance). However, some of these countries are being tested by the speed of economic globalisation and their competitiveness is falling in relation to high-tech and medium-tech goods. This illustrates that there is no guarantee that currently held competitive advantages will last. For this reason, even the best performing Member States may need to pursue an ambitious policy to increase their R&D intensity further and to improve even more the effectiveness of their R&I systems.

The country profiles also illustrate **the catching-up process** that has taken place over the last decade. Countries in eastern and southern Europe have in general a lower knowledge-intensity in their economies, but they have almost all managed to work towards structural change, as is evidenced by rising levels of international competitiveness in high-tech and medium-tech goods. The few exceptions are correlated with very low R&D intensities and mediocre performance in science and technology.

Innovation-driven structural change must be analysed at sector and industry level and linked to strategic technological capacity and to areas where there is growing global demand. Adapting the dynamics of business and innovation to growing markets in the post-crisis period will have an impact on technological development, given the crucial role of technologies in both product and process innovation. Incremental innovation is likely to happen inside each area of technology. However, more radical innovation can be expected when different technologies converge, for example in the area of clean energy technologies, renewables as strategic raw materials, technologies addressing water scarcity, mobility technologies and ICT for sustainable and smart cities. There is thus a strong need to review policies and framework conditions to ensure that they are oriented to these types of technologies and the ways in which they converge.

Historically, Europe has been strong in systemic transition technologies while conceding ground in pervasive technologies to the United States and the rising East Asian economies. However, the economic crisis has had a strong mobilisation effect on the United States and China with regard to several systemic transition technologies, in particular renewable energy, environmental and new material technologies. The EU's share of world PCT patents in green energy and environmental technologies is decreasing while the shares of both the United States and the Asian economies are increasing and are now higher than that of the EU. China is accelerating the wide deployment of several of these technologies. The EU has not adapted its technological specialisation to these growing global markets and remains focused on traditional European industries such as food and agriculture, construction and automobiles. Only a few EU Member States, mainly in western and northern Europe, have large-scale and visible scientific and technological capacity in areas such as health, new materials, energy, environment, ICT and biotechnologies.

European countries and countries outside of Europe have strong international and regional dimensions to their R&I systems and their industries are part of global value chains. EU policies and instruments (for both supply and demand) increasingly influence the national R&I systems of Member States. At the same time, Structural Funds for research, innovation and entrepreneurship reinforce the regional dimension by building regional capacity and boosting diversification. **Smart specialisation** in science and technology opens up new possibilities for intra-European knowledge flows and trade in related areas and industries and would support economic convergence between EU Member States and regions.

Several Member States have set up cluster policies and in many cases promoted the development of science and technology parks or clusters. Clusters are found in the automobile, food, biotechnology, energy, and ICT sectors, among others. However, there have been only very few cases of the emergence of **real innovation-driven clusters** in Europe. And so far, no European cluster has had a transformation impact as effective as that of Silicon Valley. At the European level, more can be done both to agglomerate clusters and to enhance knowledge flows between related clusters located in different European countries, thus enhancing dispersion of knowledge in the single market. As in the United States, the most dynamic clusters in Europe are geographically concentrated, with the main concentrations located in central and northern Europe. However, related clusters do exist in other locations, providing opportunities for structural change through technology flows, absorption and adaptation in new European industry.

The following country profiles provide verified information in a structured way that will help guide countries in pursuing ambitious strategies in R&I, integrating reforms, and making changes to investment policies and structures.

Austria

The challenge of further enhancing the innovation base of a knowledge-intensive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Austria. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 2.75% (EU: 2.03%; US: 2.75%) 2000-2011: +3.25% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 50.46 (EU:47.86; US: 56.68) 2005-2010: +4.51% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.556 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 42.4 (EU:48.75; US: 56.25) 2000-2010: +2.78% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Energy, Environment, Transport technology	*HT + MT contribution to the trade balance* 2011: 3.18% (EU: 4.2%; US: 1.93%) 2000-2011: +20.24% (EU: +4.99%; US:-10.75%)

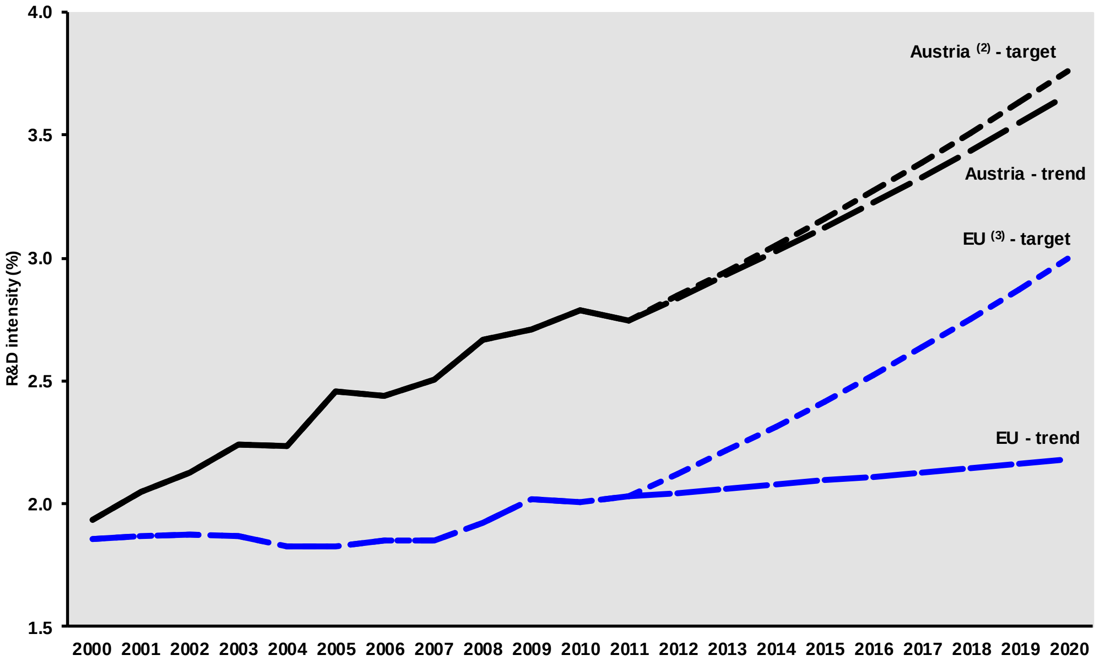
Austria has expanded its research and innovation system over the last decade with investments in research and innovation growing more quickly than the EU average. These efforts have been translated into a high and growing level of excellence in science and technology and clear strengths in key technologies for energy, environment and transport. The Austrian economy is characterised by specialised niche players, which are in constant need of innovation, in particular technological innovation, in order to remain leaders in their market segment. The level of innovation in Austrian firms is hence relatively high. Overall, according to several indicators on trade, firm innovations and patent revenues from abroad, the Austrian economy is, partly for structural reasons, less knowledge-intensive than many other EU Member States. However, the indexes on structural change and on the trade balance both point towards an upgrading of knowledge-intensity and linked to that an increase of competitiveness.

Nevertheless, the efforts to boost research need to be maintained, given the specialisation of the Austrian economy in a limited number of knowledge-intensive sectors where international competition is strong. This includes for example transport technology, biotechnology and the energy sector. The economic crisis has hit Austria less than other Member States and the unemployment rate is currently the lowest in the EU. To maintain its competitiveness and hence its favourable economic position, Austria is depending on an on-going high rate of innovation.

Austria's research and innovation policies are addressing these challenges by means of educational reform, improved governance of the R&D sector, by establishing new research centres of excellence, by setting up a more effective system of public research funding and more generally by promoting a further increase in the already high level of public and private investment in R&D.

Investing in knowledge

Austria - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) AT: This projection is based on a tentative R&D intensity target of 3.76% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.

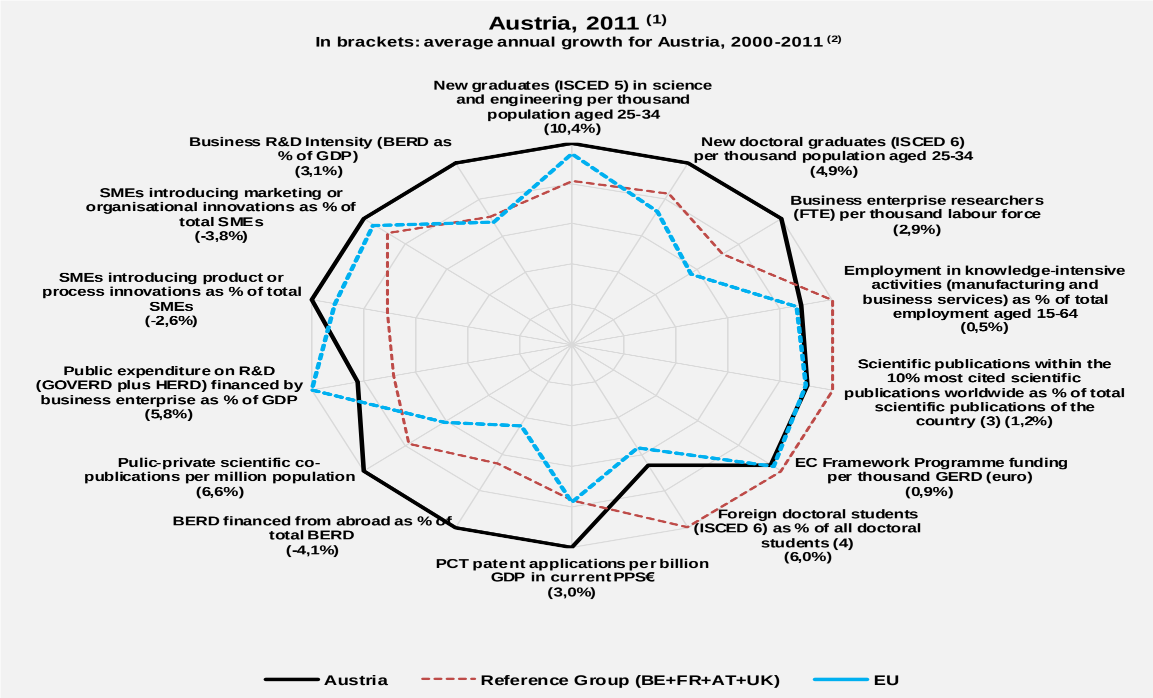
Austria has set a national R&D intensity target of 3.76%, one percentage point above the performance in 2011 and the third highest national target among EU Member States. In the past decade, R&D intensity in Austria has progressed faster than the EU average - reaching 2.75% in 2011. Overall, Austria is almost on track to achieve its national R&D intensity target, if the recent slowdown in R&D investment growth can be overcome.

Public spending on R&D as a % of GDP has shown a clear upward trend in Austria since 2002 and increased also during and after the recession of 2009, despite budgetary constraints. Also business R&D as a % of GDP has expanded strongly in the last decade and is now among the highest in Europe. However, in recent years, progress in private spending has decelerated, with a stagnation in the share of GDP and no increase in absolute spending in real terms during the recession of 2009 and only a moderate increase in 2011.

Austrian research and innovation are also benefitting from support from the EU budget, via co-funding for private and public R&D investment as well as other innovation, training and entrepreneurial activities. Main instruments are the Structural Funds and the 7th Framework Programme for Research. For the ERDF programme period 2007-2013, nearly € 500 million has been allocated from the EU budget to activities related to research, innovation and entrepreneurship in Austrian regions (corresponding to over 70% of the ERDF resources allocated to Austria). Austria still has scope to increase its funding of R&D from the 7th Framework Programme. The success rate of Austrian applicants is 21.7%, slightly lower than the EU average success rate of 22%. Up to mid-2012, over 2000 Austrian participants had been partners in a FP 7 project, with a total EU financial contribution of € 710 million.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Austrian R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The graph shows that the Austrian R&I system is balanced, with a good performance in all areas: human resources, scientific production, technology development and innovation. Progress has in general also been good. However, some warning signals come from falling innovation in SMEs and declining shares of R&D investments by foreign firms.

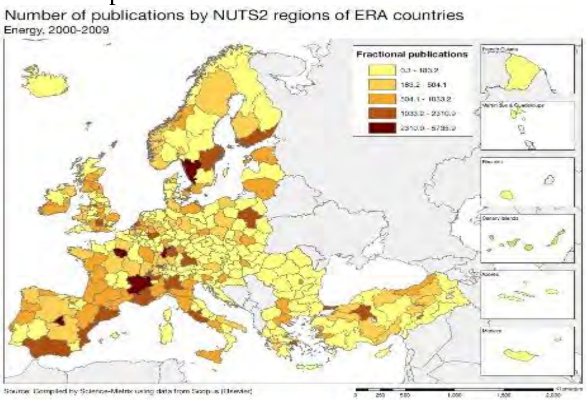
In the field of human resources for research and innovation, Austria performs at or above EU average and progress has been good since 2000. Tertiary attainment has been traditionally low in Austria, with many graduates classified as post-secondary, non-tertiary (ISCED 4), but a relatively high share of Austrian students study science and technology subjects and an above average proportion of them graduate at the doctoral level. Despite a strong inflow of foreign students, notably from Germany, Austria still has a lower share of foreign doctoral students than comparable countries. Highly-skilled graduates are relatively well absorbed into the Austrian economy, as evidenced by the relatively high number of business enterprise researchers and, linked to that, the good performance of Austria in the field of patent applications. Austria does not significantly outperform the EU average in high-quality scientific publications, nor in success in international competitions for EU Framework programme funds to R&D. There is a high share of Austrian universities among the good performers in major international rankings, but Austrian universities are not well represented at the very top of such rankings. Austria has improved public-private cooperation considerably in the past, both in scientific production and in contract research by business enterprises cooperating with public research organisations and now performs above the EU average in this field. Austria also performs well as regards innovation in SMEs.

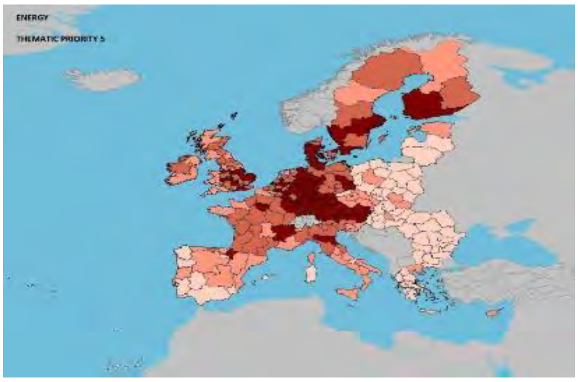
Austria's scientific and technological strengths

The maps below illustrate several key science and technology areas where Austrian regions have real strengths in a European perspective. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

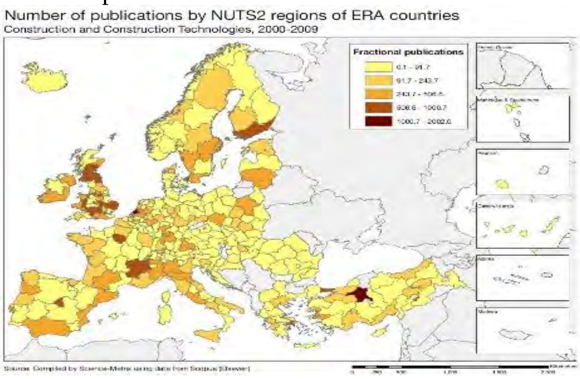
Strengths in science and technology at European level

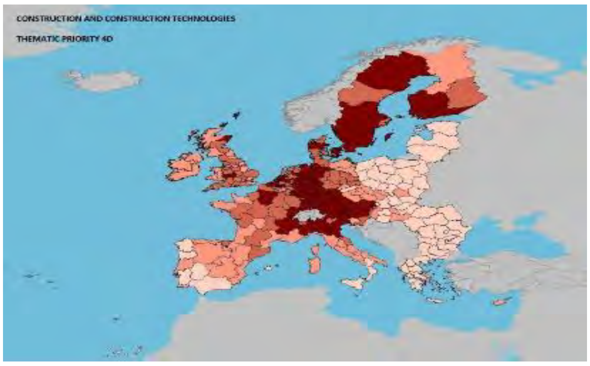
Scientific production **Energy** Technological production



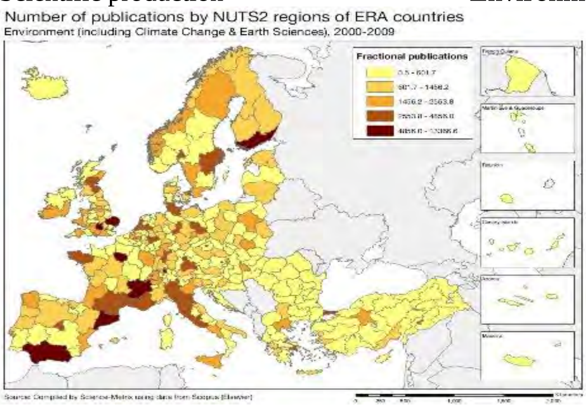


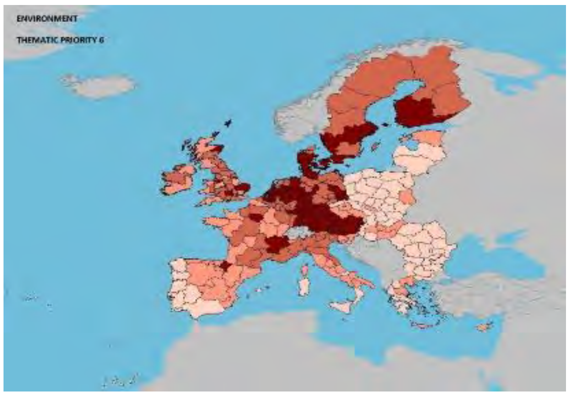
Scientific production **Construction and construction technologies** Technological production





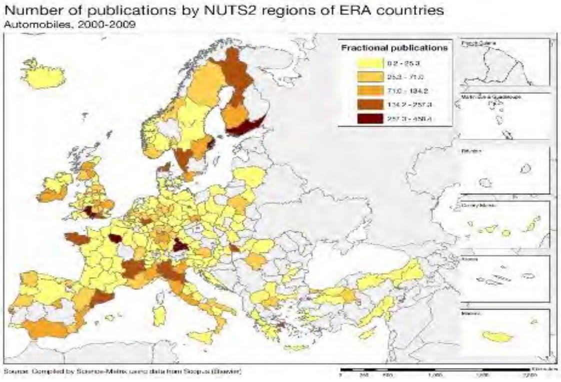
Scientific production **Environment** Technological production

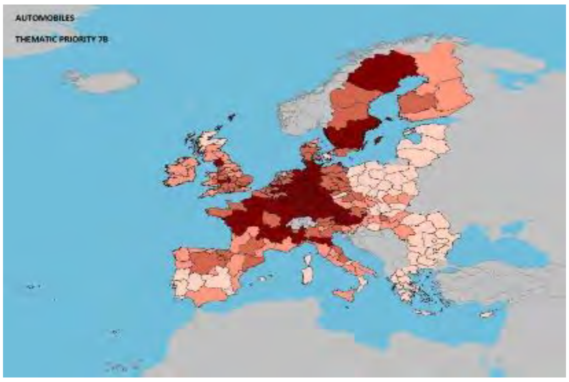




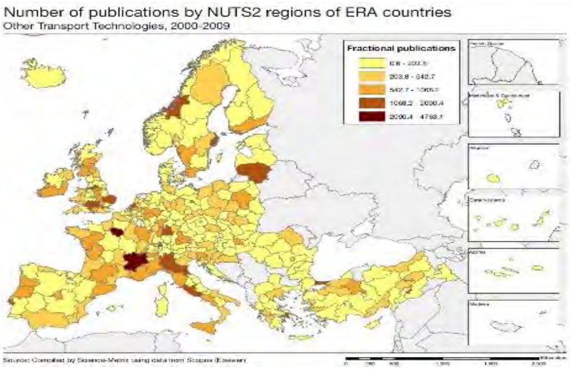
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

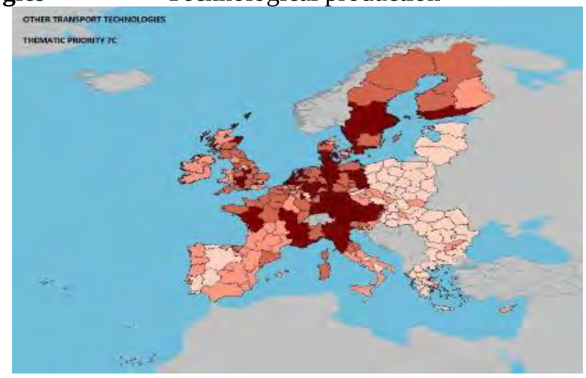
Scientific production **Automobiles** Technological production



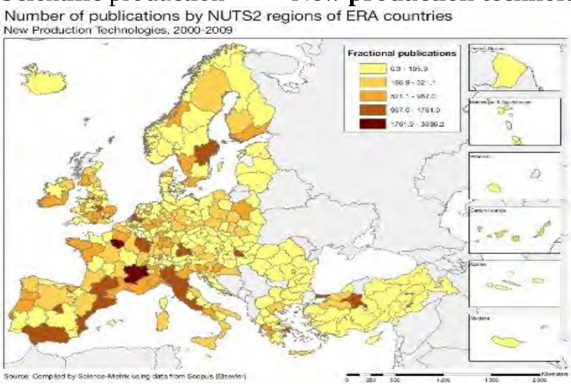


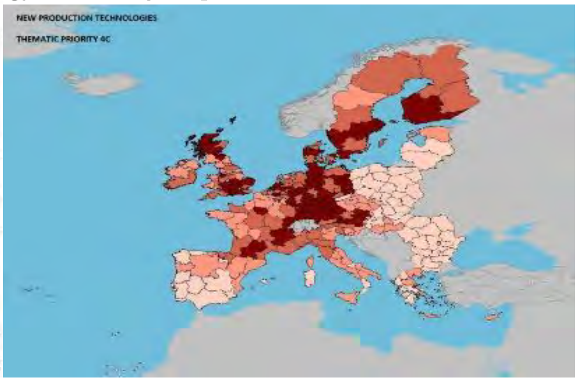
Scientific production **Other transport technologies** Technological production





Scientific production **New production technology** Technological production





As shown by the maps above, in terms of scientific production, only a few Austrian regions perform at high output levels and the number of high performance sectors, specifically environment, food and agriculture and information and communication technologies (the latter two not illustrated on the maps), is limited. This is partly due to the relatively small size of Austrian regions - the average population of an Austrian NUTS 2 region is less than half the EU NUTS 2 average. Leading regions (Länder) in Austria in terms of scientific production in these fields are Steiermark (Styria) and Vienna.

In terms of technology patenting, which is more closely linked to business innovation, the relative position of Austria is much better than in scientific production, with many Austrian regions among the top quarter in Europe, notably in the fields of energy, construction and construction technologies, environment, automobiles and other transport technologies and in new production technology. This reflects economic structures and the areas where Austrian enterprises are innovative and have a strong market position. The comparison between scientific output in terms of publications and patenting thus shows a certain imbalance, since the strong fields for the Austrian science base are not necessarily the same as the sectors where Austrian firms have the strongest technology development. Moreover, Austria's performance in terms of scientific output is relatively low compared to the EU average and is concentrated in specific fields and regions, whereas in relation to patenting there is good performance over many fields and regions. It will be a challenge for the future to bring scientific output in Austria to the same level as patenting, and also to ensure the long term sustainability of innovation.

Policies and reforms for research and innovation

Austria formulates R&D policies from a relatively favourable position in terms of overall R&D intensity. While research is among the priority areas in public spending, the share of private sector expenditure on R&D in total R&D expenditure has fallen from 71 % in 2007 to 68 % in 2011, thus putting at risk the achievement of the ambitious Europe 2020 R&D intensity target of 3.76 %. Among the factors explaining the recent low growth in private spending are the economic crisis and a shortage of venture capital. However, the government has taken steps to stimulate additional private sector spending on R&D. Between August and November 2011 on the initiative of the Austrian Ministry for Transport, Innovation and Technology (bmvit) 22 of the larger Austrian companies, representing more than one fifth of business enterprise research spending in Austria, have committed themselves to increase R&D spending by 20% by 2015.

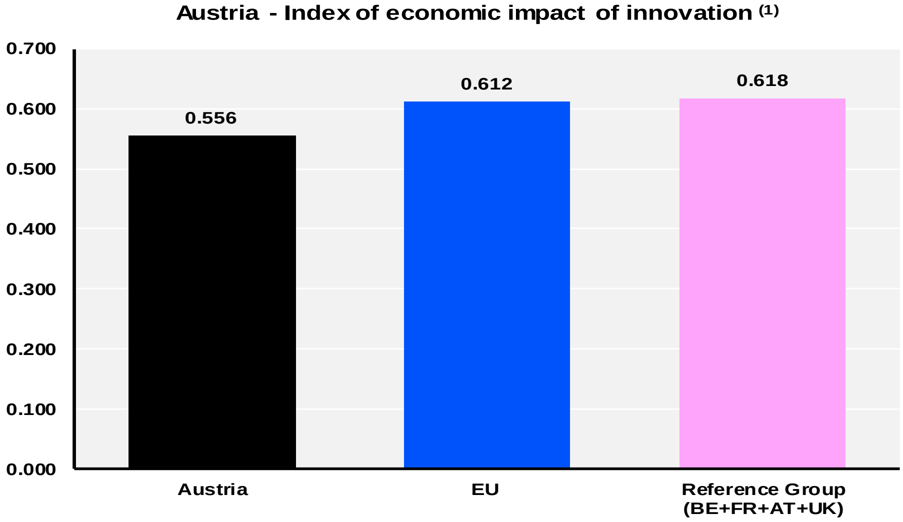
The Austrian RTDI Strategy ‘Becoming an innovation leader’, which was published in 2011, contains many initiatives to improve the performance of the research and innovation system. These include initiatives to strengthen the links to the education system, to increase the share of tertiary graduates, to promote high quality research infrastructure and fundamental research and to use public procurement to promote innovation.

The Austrian government has set up a Task Force for the implementation of the RTDI strategy. The initiatives of the RTDI Strategy are echoed and enhanced in the 2012 National Reform Programme and the Euro Plus Pact commitments. The most prominent measure is the simplification of the tax regime for R&D activities to a single tax credit raised from 8 % to 10 %. In addition, the cap on the amount which could be subcontracted while remaining eligible for tax credit rises from € 0.1 million to € 1 million. These measures are budget neutral and are expected to encourage subcontracting to research centres and universities. On the other hand, this approach favours established activities more than the breakthrough research needed for an economy like Austria's. Moreover, whereas the National Reform Programme of 2012 lists numerous initiatives in the field of research and innovation, it still lacks clear prioritisation and details of players and budgets and implementation timetables and it does not address the need for a closer integration of the Austrian R&I system within the European Research Area.

As regards sustainability of economic activities, which plays an important role in the acceptance of innovation by the public and which in itself can be a source of innovation, the National Energy Strategy from 2010 aims at increasing efficiency, energy security and the share of renewables. Funding is available for the greening of industries and an action plan was set up in October 2010 for Green Public Procurement. In 2011 a strategy paper to promote electrical mobility was prepared and in 2012 a resource efficiency action plan (REAP) was adopted.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[6].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Overall, Austria's employment is slightly more oriented towards knowledge-intensive sectors than the EU average. Austria's scores on the indicators "*PCT patents application per billion GDP*" and "*Contribution of medium and high-tech products exports to trade balance*" is also above EU average, reflecting the very good innovation performance of its manufacturing sector. Austria's low score on the summary index is strongly influenced by a very low score on the indicator "*Knowledge-intensive services export as % of total services exports*", which is explained by the dominance in its services export of the tourist sector, which is classified as non-knowledge-intensive.

The recent economic crisis has been less severe on Austria than on other EU Member States with the result that the conditions for innovation have faced fewer challenges in Austria than in most other EU countries, although the availability of business financing has decreased in 2009. In 2010, according to enterprise surveys[7] Austria was among the middle performers in the EU as regards the ease of access to loans and the availability of venture capital. Austria currently also ranks in the middle group of EU member states in the World Bank's index *Ease of doing business.* However, Austria ranks low regarding the time needed to start a business, since the number of administrative procedures required for setting up a business is still relatively high. There are on-going efforts to reduce the administrative burden on enterprises.

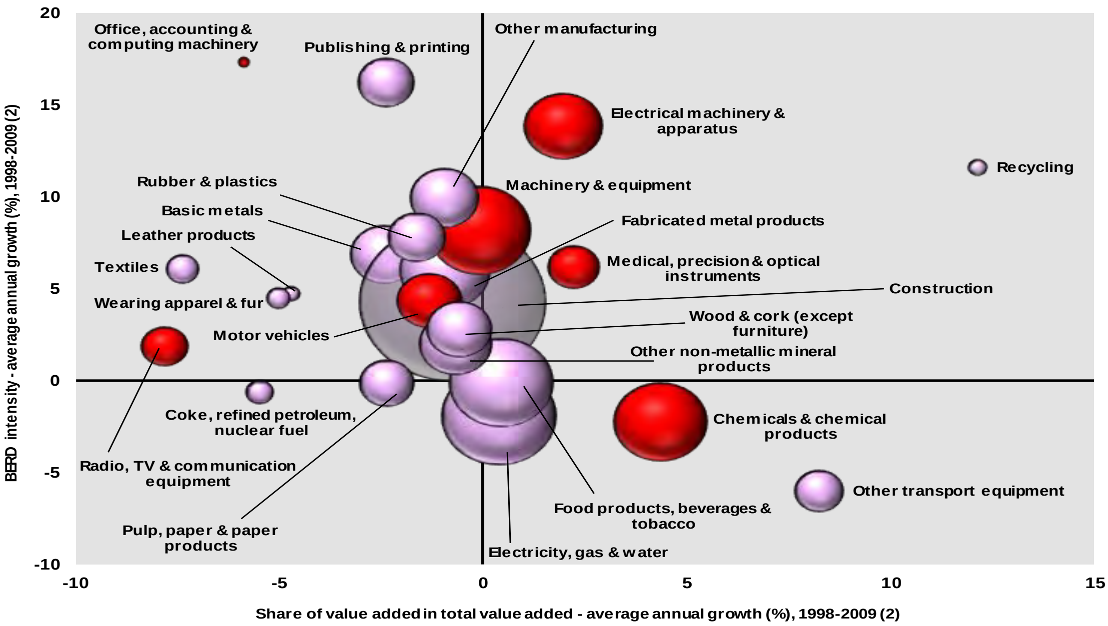
Expenditure on R&D is high by European standards, but Austria may not be sufficiently exploiting and maintaining its innovative potential. One reason for this is an underdeveloped venture capital market (venture capital represented 0.04% of GDP in Austria in 2011 compared to an EU average of 0.35%), which suffers from an unfavourable legal framework and from structural and other problems of the Austrian VC market (e.g. small size and limited differentiation, general reluctance to invest in early stages, uncertainty concerning the treatment of non-incorporated companies as VC funds etc). In addition, the education system faces the challenge of providing the skills required as a basis for innovation and competitiveness, but the low tertiary attainment rate and the general demographic development might lead to a scarcity of skilled people in the long term.

[6] See Methodological note for the composition of this index.
[7] World Economic Forum, The Global Competitiveness Report 2012-2013, pages 97-98 and 482

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Austria - Share of value added versus BERD intensity - average annual growth, 1998-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Leather products', 'Wearing apparel & fur': 1998-2007; 'Recycling': 2003-2009.

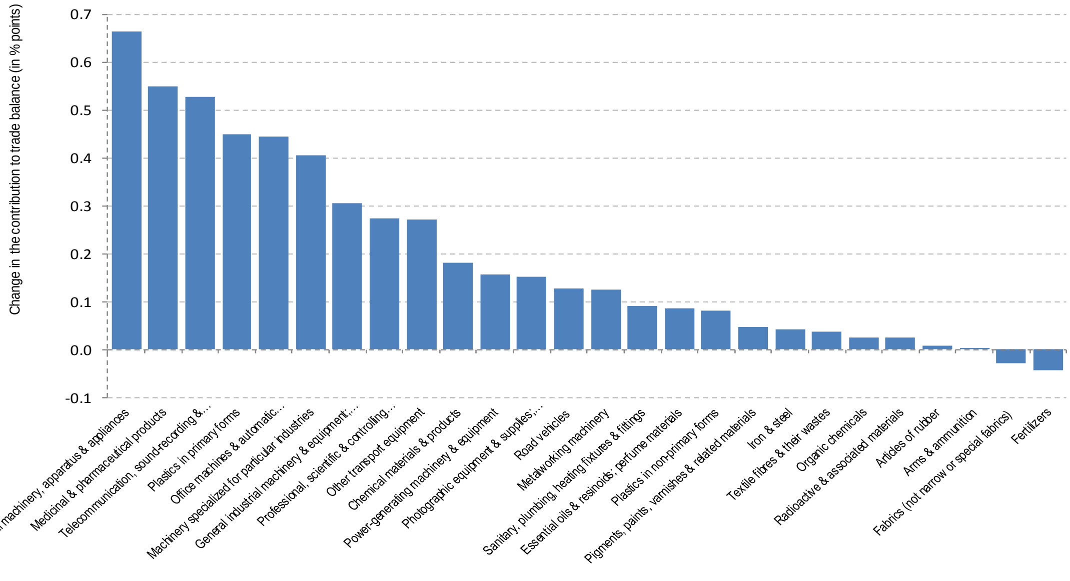
Austria is one of the EU countries having a high contribution of manufacturing industry to total value added (around 19% compared to an EU average of 16%). In parallel, Austrian manufacturing industry has clearly increased its knowledge-intensity in high- and medium-high-tech sectors as well as in the medium-low and low-tech sectors (with the notable exception of chemicals, other transport equipment and the electricity, gas and water sector).

As in many other European countries, one of the largest sectors in the economy is the construction sector, but unlike other EU countries, the construction sector did not increase its share of the economy in the years leading up to the economic crisis, while its research intensity improved slightly. Research intensity has mostly increased in high-tech and medium-high-tech sectors, with in most cases positive results when it comes to value added. However, despite an increase in research intensity, the manufacturing of radio, TV and communication equipment has declined in importance, partly as a result of a reclassification of the activities of a large Austrian manufacturing firm, which was until 2006 attributed to this sector and probably also due to a shift of production to low wage countries. The chemicals and chemical products sector, on the other hand, has increased in economic importance despite a decline in research intensity. As regards electrical machinery and medical, precision and optical instruments an increase in research intensity has been accompanied in Austria by a growth in value added.

Competitiveness in reaping income of global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Austria between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The Austrian economy is characterised by a relatively small contribution of agriculture to GDP and a comparatively high share of manufacturing industry in total value added. The service sector, including a relatively large tourism sector, also has an above EU average share of the economy. The strongest growth in value added over time tends to occur in the service sector.

As shown by the graph above, Austria succeeded in improving its trade balance for most of its high-tech and medium-tech products over the period 2000-2011. A limited number of medium-tech products showed a stagnation or slight decline in their contribution to the trade balance. On the other hand, the trade balance improved significantly in the electrical machinery, apparatus and appliances sector – the high-tech sector, where R&D intensity has increased most over the last decade .

Overall Austria has improved its total factor productivity faster than the EU average over the last decade, a sign of innovation in line with the balanced and expanding R&I system and the upgrading of its manufacturing sector. Progress has also been made in technologies addressing societal challenges such as health and the environment and on all of the Europe 2020 targets. However, compared to other EU Member States, Austria shows a relatively low tertiary education attainment rate. Furthermore, this rate is progressing only slowly. The picture improves if post-secondary, non-tertiary education (ISCED 4), which Austria considers equivalent to tertiary education, is included. Furthermore, the high employment rate and the low rate of early leavers from education and training show that Austria makes good use of its human capital.

Table on key indicators

AUSTRIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	1.42	1.53	1.79	1.90	2.18	2.02	1.97	1.92	2.03	2.10	2.30	:	:	4.9	*1.69*	6
Business enterprise expenditure on R&D (BERD) as % of GDP	:	:	1.42	:	1.52	*1.72*	1.72	1.77	*1.85*	1.84	*1.90*	*1.87*	:	*3.1*	*1.26*	5
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	:	0.69	:	0.71	*0.74*	0.72	0.73	*0.81*	0.85	*0.88*	*0.86*	:	*2.4*	*0.74*	7
Venture Capital [3] as % of GDP	0.07	0.06	0.06	0.04	0.05	0.05	0.04	0.13	0.08	0.05	0.04	0.04	:	*-5.1*	0,35 [4]	16 [4]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	40.5	:	:	:	:	50.5	:	:	4.5	47.9	8
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	9.9	9.6	9.5	10.4	10.4	10.5	10.7	11.4	10.9	:	:	:	:	1.2	10.9	9
International scientific co-publications per million population	401	386	402	590	688	759	784	896	967	1014	1096	1180	:	10.3	300	7
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	67	70	77	84	86	:	6.6	53	6
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	3.8	3.6	4.1	4.4	4.8	5.0	5.3	5.2	4.6	5.0	:	:	:	3.0	3.9	6
License and patent revenues from abroad as % of GDP	:	:	:	:	0.13	0.13	0.16	0.20	0.22	0.19	0.18	0.19	:	5.7	0.58	13
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	10.6	:	13.6	:	11.2	:	11.9	:	:	2.0	14.4	16
Knowledge-intensive services exports as % total service exports	:	:	:	:	19.3	21.8	22.7	24.0	22.8	23.1	22.2	:	:	2.4	45.1	21
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-1.83	-1.46	-0.91	-0.09	0.87	1.59	2.41	2.20	2.69	2.29	2.59	3.18	:	-	4,20 [5]	8
Growth of total factor productivity (total economy) - 2000 = 100	100	100	101	101	102	103	106	108	108	104	105	106	106	6 [6]	103	12
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	32.2	:	:	:	:	37.8	:	:	:	:	42.4	:	:	2.8	48.7	16
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	13.8	14.2	14.4	14.0	:	0.5	13.6	13
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	49.4	:	47.8	:	39.6	:	42.2	:	:	-2.6	38.4	10
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.47	0.46	0.42	0.47	0.50	0.44	0.47	0.59	0.61	:	:	:	:	3.2	0.39	4
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.55	0.73	0.67	0.80	0.62	0.64	0.77	0.76	0.62	:	:	:	:	1.6	0.52	6
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	71.4	71.5	71.8	72.0	70.8	71.7	73.2	74.4	75.1	74.7	74.9	75.2	:	0.9	68.6	5
R&D Intensity (GERD as % of GDP)	*1.93*	*2.05*	2.12	*2.24*	2.24	*2.46*	2.44	2.51	*2.67*	2.71	*2.79*	*2.75*	:	*3.3*	*2.03*	5
Greenhouse gas emissions - 1990 = 100	103	108	110	118	117	119	115	112	111	102	108	:	:	5 [7]	85	21 [8]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	22.9	25.0	26.6	28.9	29.2	31.0	30.1	:	:	4.7	12.5	4
Share of population aged 30-34 who have successfully completed tertiary education (%)	:	:	:	:	21.0	20.5	21.2	21.1	22.2	23.5	23.5	23.8	:	1.8	34.6	23
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	17.5	16.8	17.8	16.7	18.6	17.0	16.6	16.9	:	-0.5	*24.2*	5 [8]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Values in italics are estimated or provisional.

Belgium

The challenge of fostering innovation-based competitiveness through the business economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Belgium. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	**Performance/economic output**
Research	*R&D intensity* 2011: 2.04% (EU: 2.03%; US: 2.75%) 2000-2011: +0.35% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:59.92 (EU:47.86; US: 56.68) 2005-2010: +3.5% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.599 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:58.88 (EU:48.75; US: 56.25) 2000-2010: +1.06% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food and agriculture, ICT, nanotechnologies, new materials, biotechnology, environment	*HT + MT contribution to the trade balance* 2011: 2.37% (EU: 4.2%; US: 1.93%) 2000-2011: +10.39% (EU: +4.99%; US:-10.75%)

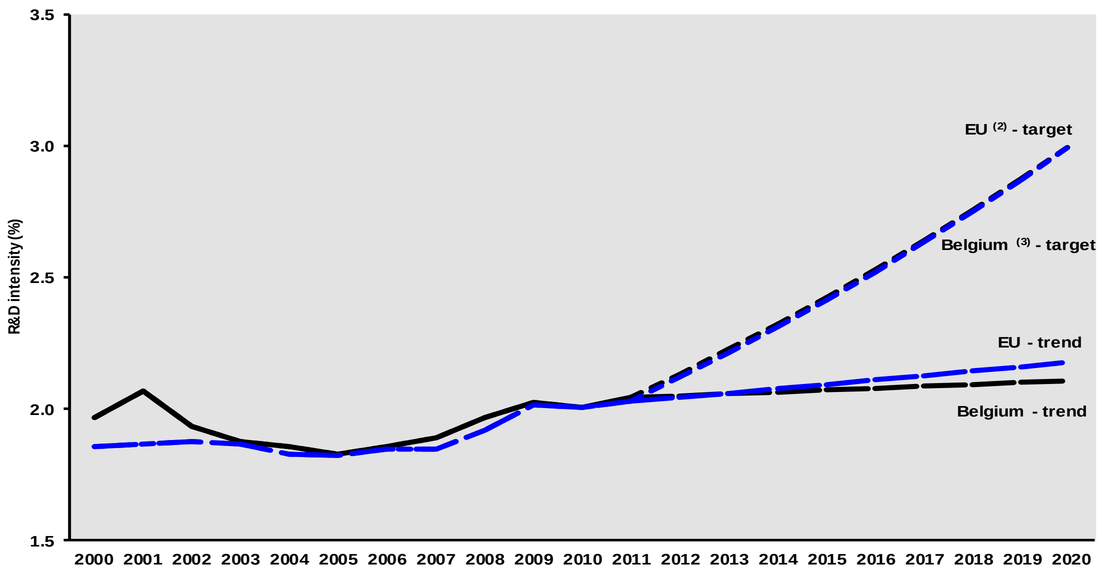
Belgium has a very high quality research system, as reflected by its third highest score among all EU Member States on the S&T Excellence index. Belgium has been able to exploit this strength to its economic advantage in several sectors. A particularly good performance is visible in the bio-pharmaceutical sector, where high scientific quality, business investment, product innovation and trade performance reinforce each other. Moreover, several service sectors, such as computer-related and other business services, strongly contribute in Belgium to a structural change towards a more knowledge-intensive economy, notably through the growth of innovative firms.

However, despite these very positive sectoral dynamics, Belgian R&D intensity stagnated in the period 2000-2011 and there was even a decline in business expenditure on R&D, especially between 2001 and 2005. This is due to a de-industrialisation trend, which has notably affected several high-tech and medium- high-tech manufacturing sectors. The de-industrialisation trend has been accompanied by a rapid deterioration of the Belgian trade balance since 2002, showing that the strengths of the services and of the bio-pharmaceutical sectors cannot alone support the competitiveness of Belgium.

There is a consensus in Belgium about the critical importance of fostering the innovation-based competiveness of Belgian businesses. This has been reflected in the development of sophisticated and comprehensive policy mixes at national and regional levels and in significant budgetary efforts in favour of R&D from all political entities, especially between 2005 and 2009. At federal level, fiscal incentives for R&D are an important tool. In the Walloon Region the focus has been on supporting a limited number of competitiveness poles (a cluster approach). In the Flemish Region, the willingness to address through innovation some specific societal challenges is a main driver of research and innovation policy. In the Brussels Capital Region, an updated innovation strategy including a ‘smart specialisation’ approach has been launched in 2012.

Investing in knowledge

Belgium - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) BE: This projection is based on a tentative R&D intensity target of 3.0% for 2020.

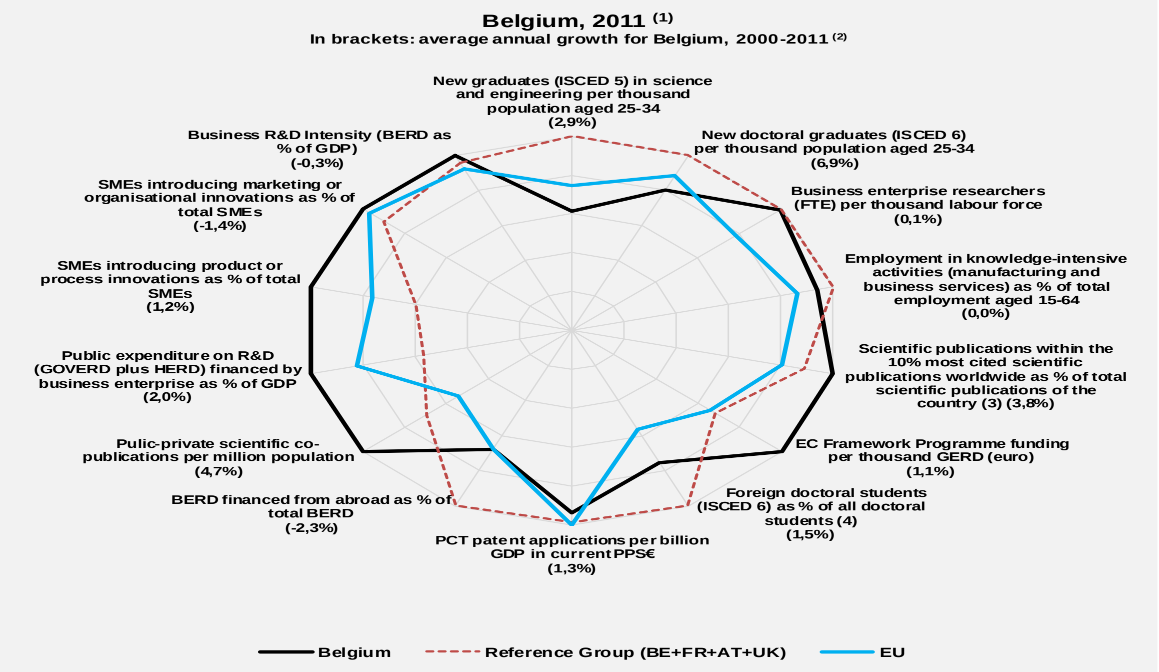
Belgium is not on track to reach its R&D intensity target for 2020 of 3%. After a peak in 2001 at 2.07%, Belgian R&D intensity decreased to 1.83% in 2005. This decrease was due to a fall in business R&D intensity (from 1.51% in 2001 to 1.24% in 2005). Business R&D intensity partially recovered in 2006-2008, up to 1.34%, and in 2011 slightly increased further, up to 1.37%, but this remains still well below its 2001 peak. However, thanks to an increase in public R&D intensity since 2000 (public R&D intensity was 0.52% in 2000, 0.55% in 2007 and 0.65% in 2011), overall R&D intensity in 2008-2011 was again close to its 2001 peak. Since 2010, public investment in R&D has been stable and a 5% increase is expected for 2013. However, the growing role of fiscal incentives must be stressed. If coupled with a reorientation of business investment in Belgium, this may foster R&D business intensity and hence help Belgium to improve its trend to meet the headline target.

The decrease in business R&D intensity during the last decade is linked to a strong reduction of R&D activities in Belgium in two industry sectors: radio, TV and communication equipment, and chemicals and chemical products (excluding pharmaceuticals). In 2000, radio, TV and communication equipment (18%), chemicals and chemical products (excluding pharmaceuticals) (17%) and pharmaceuticals (16%) accounted for slightly more than half of Belgian business R&D expenditure (BERD). Since then, these three sectors have experienced diverging trends. While pharmaceuticals-related R&D expenditure has more than doubled, representing 28% of total Belgian business R&D expenditure in 2009, the R&D expenditure of the two other sectors has declined. R&D expenditure decreased by 8% in the case of chemicals and chemical products (excluding pharmaceuticals) and by 62% in the case of radio, TV and communication equipment, reducing their shares in BERD in 2009 to respectively 11% and 5%. The service sector "Computer and related activities" has on the contrary become increasingly important, accounting for 8% of BERD in 2009, compared to 4% in 2000.

Belgium has been very successful in the EU Framework Programme. Up to early 2012, slightly over 3350 Belgian participants had been partners in an FP7 project (a success rate of 24%), with a total EC financial contribution of € 1.0 billion. Regarding the other main source of EU funding, the FEDER Regional Funds, in the programming period 2007-2013, a total of € 643 million (31.2% of the total FEDER fund to Belgium) was allocated to research, innovation and entrepreneurship in the Belgian regions.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Belgium's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The overall shape of the graph highlights the strong performance of the Belgian research and innovation system. Belgium scores higher than the EU average for the vast majority of the indicators. In particular, Belgium has a high quality public research and higher education system, characterised by a strong international openness. The quality of the Belgian research system is evidenced by the high share of its scientific publications within the top 10% most cited scientific publications worldwide[8], the strong position of Belgium in the context of the EU R&D Framework Programmes, as well as its attractiveness for foreign doctoral students[9]. Its international openness is further evidenced by the highest "Collaboration Index"[10] of all the EU Member States (1.33). Belgium also performs well above the EU average for the two indicators on cooperation between public research institutions and firms (co-publications and business funding of public R&D), confirming the quality of the public scientific and technological base and highlighting its relevance for businesses.

As shown on the graph, a weak point of the Belgian research system is a share of science and engineering graduates in the population aged 25-34 that is lower than the EU average. Combined with the overall ageing demographic in Belgium, this raises the question of how Belgium will be able to assure for the future the pool of highly skilled human resources necessary to keep an innovation-based economy running. However, the share of S&E graduates has rapidly increased in recent years.

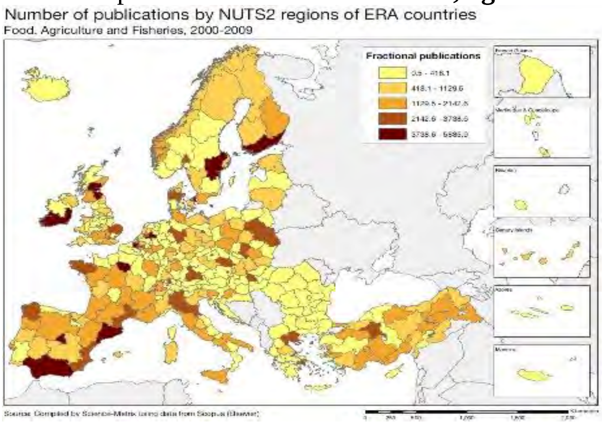
[8] 13. 6%, well above EU average of 10. 9% - this is the third best EU performance.
[9] Belgium has proportionally the third largest inflow of doctoral students from other Member States: 12% of doctoral students come from another Member State.
[10] Index calculated by Science-Metrix, based on the number of co-publications while taking into account the size of national scientific output.

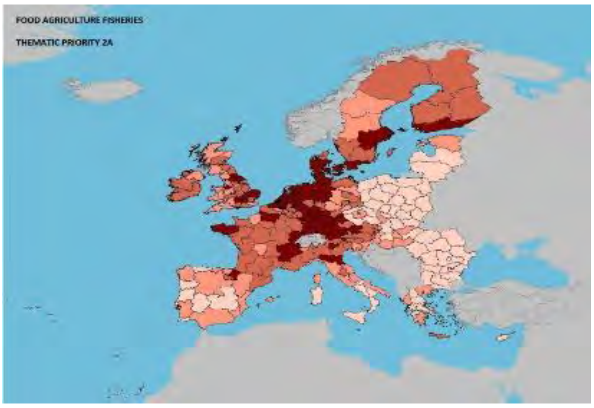
__Belgium's scientific and technological strengths__

The maps below illustrate six key science and technology areas where Belgium has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

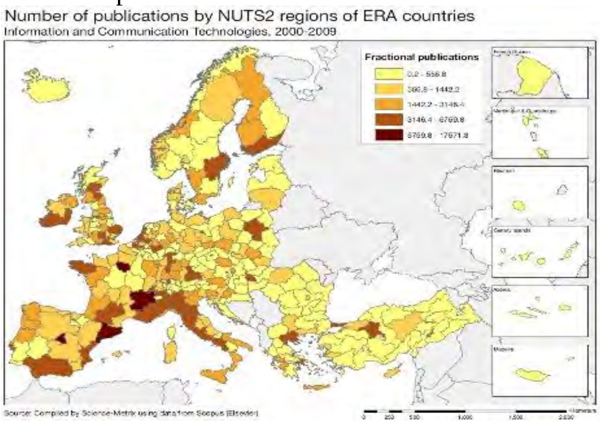
Strengths in science and technology at European level

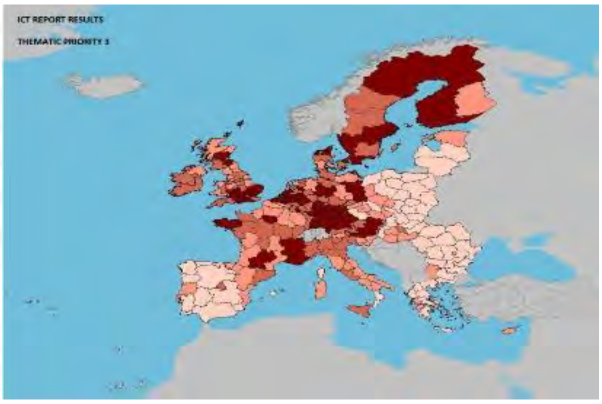
Scientific production **Food, agriculture and fisheries** Technological production



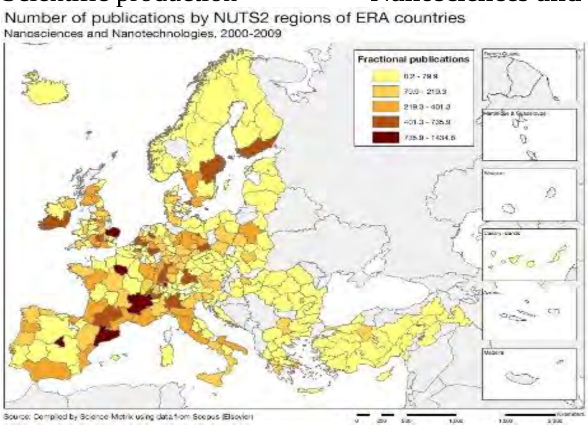


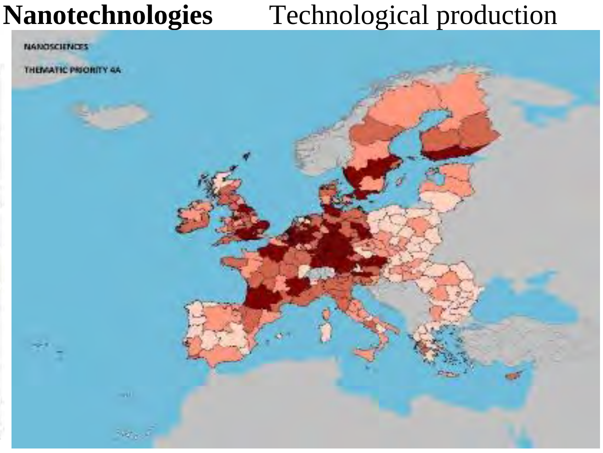
Scientific production **Information and Communication Technologies** Technological production





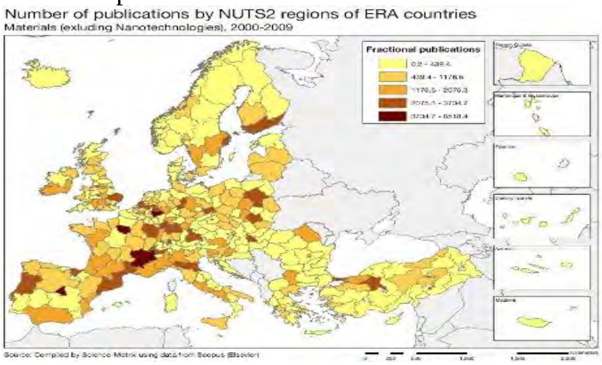
Scientific production **Nanosciences and Nanotechnologies** Technological production

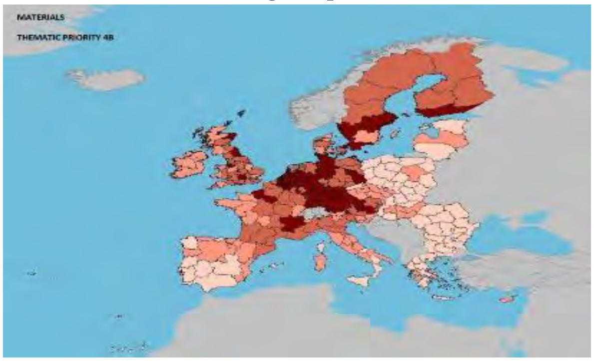




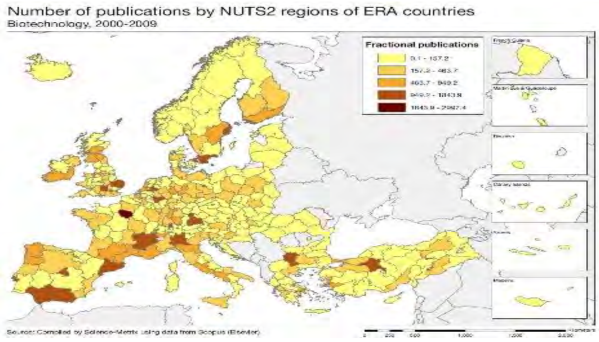
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

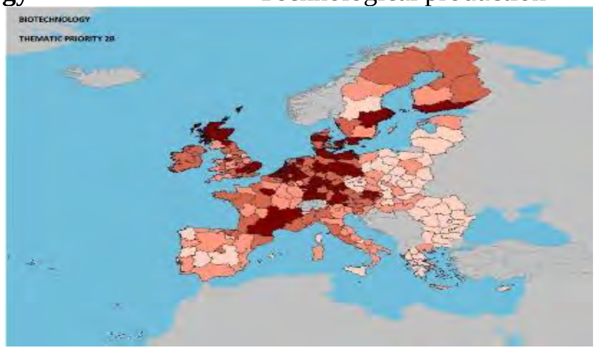
Scientific production **Materials** Technological production



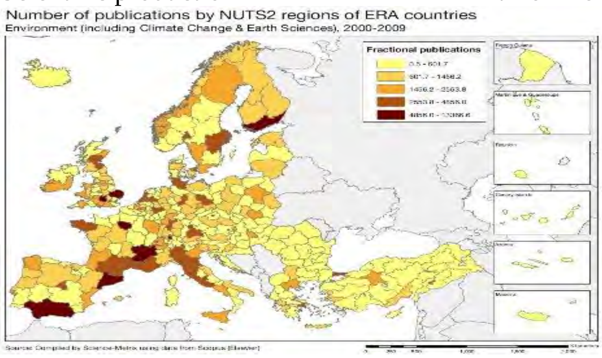


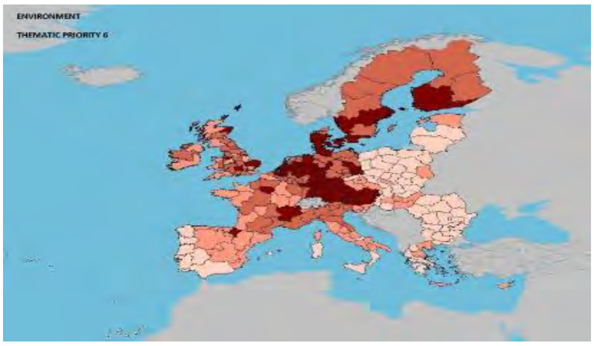
Scientific production **Biotechnology** Technological production





Scientific production **Environment** Technological production





The maps in the left column above show a high volume of scientific production in some Belgian provinces in food, agriculture and fisheries, ICT, nanoscience and nanotechnologies, biotechnology, and environmental science and technologies. It is mainly in the provinces of Flemish Brabant and Eastern Flanders that these high volumes of scientific production are visible on the maps, reflecting the presence in these provinces of the two largest Belgian universities: Leuven and Ghent. In all the fields mentioned above, Belgium also displays high scientific excellence (based on citations, with Average Relative Citations above 1.35 and a share of scientific publications within the 10% most-cited above 13%), with the notable exception of nanoscience and nanotechologies. Other fields where Belgian scientific production is excellent include science related to materials, new production technologies, construction, other transport technologies, and security. The number of scientific publications has been increasing very rapidly in the case of construction technologies.

Maps on the right side show high volumes of patenting in all six fields in the vast majority of Belgian provinces, revealing clear synergies between scientific strengths and technological innovativeness. In most of those fields, both Flemish and Walloon provinces exhibit high volumes of patenting. The maps show that in these key technological fields nearly the whole of Belgium is part of a transnational knowledge-intensive macro-region which includes also parts of the Netherlands and parts of Germany. Based on patenting activities, Belgium is the most specialized EU Member State in materials and the second most specialised (after Denmark) in biotechnology. Construction is also a strong technological specialisation area for Belgium. Biotechnology is the area with the strongest growth of patenting activities since 2000.

Policies and reforms for research and innovation

In Belgium, policies and funding for research and innovation are mainly in the hands of the Regions and the Communities, but the federal authorities still play an important role in some specific areas (e.g. space) as well as through fiscal instruments. The existing consensus in Belgian political circles about the importance of research and innovation as a key source of economic growth, has led to significant budgetary efforts from all political entities. Between 2000 and 2010, government budget appropriations for research and development (GBAORD) increased by 37% in real terms. This growth was notably driven by strong increases since 2000 in the Flemish budget for R&D (which represents about half of GBAORD). The Walloon budget for R&D has also strongly increased since the launch of the Walloon "Marshall Plan" in 2005. The growth of public funding of R&D since 2000 reinforced proportionally all R&D performing sectors: between 2000 and 2009, public funding of R&D performed by higher education increased by 60%, public funding of R&D performed by other public research organisations increased by 42% and public funding of R&D performed by businesses increased by 45%. Moreover, in recent years the federal government has developed powerful R&D tax incentives (in particular a 75%[11] payroll tax exemption for researchers), leading to a situation where foregone revenues due to R&D tax incentives are almost equivalent to the amount of direct public funding of business R&D. Taking into account both forms of support, public support for business R&D represents in Belgium a higher share of GDP (0.17%) than in most other EU Member States.

After slight decreases in 2009/2010, GBAORD has been stable in 2011/2012 and may grow again in 2013, taking into account the decision by the Flemish government to increase its R&I budget by at least € 200 million between 2011 and 2014 and the willingness of the other entities to preserve the allocations for R&D despite difficult budgetary situations.

The way public funding of research is organised contributes both the quality and the openness of the Belgian research system. Firstly, about half of public funding is allocated through project-based competition (this is one of the highest rates in the EU), secondly, 12% of public funding is transnationally coordinated (this is the highest share among the MS for which information is available), in particular through participation in Europe-wide actions such as ESA, Article 185 initiatives, Joint Technology Initiatives with national funding, and ERA-NET's joint calls[12].

All Belgian regions have developed strategic innovation approaches covering all major aspects of a successful innovation strategy. In the Walloon Region the focus has been on supporting a limited number of competitiveness poles (a cluster approach); in 2011, € 125 million was allocated to the R&D projects of competitiveness poles under the "Marshall 2.Green" plan. New approaches have been developed under the so-called 'Creative Wallonia' Plan as in the field of support to market take-up for new products and services (technologically based or not) and the promotion of cultural and creative industries. In the Flemish Region, the willingness to address through innovation major economic and societal challenges is a main driver of research and innovation policy. Flanders also has a policy of developing strategic research centres able to provide high quality service to businesses[13]. In 2011, the competence poles for industrial design, logistics, materials research and mobility have been extended and a new competence pole for sustainable chemistry has been created. A particular investment fund (TINA fund) with € 200 million at its disposal has been set up in order to help reform the Flemish economy through innovation. In the Brussels Capital Region, an updated innovation strategy, including a ‘smart specialisation’ approach, has been launched in 2012. To improve innovation financing, the Region created a fund to support young innovative companies (Brustart).

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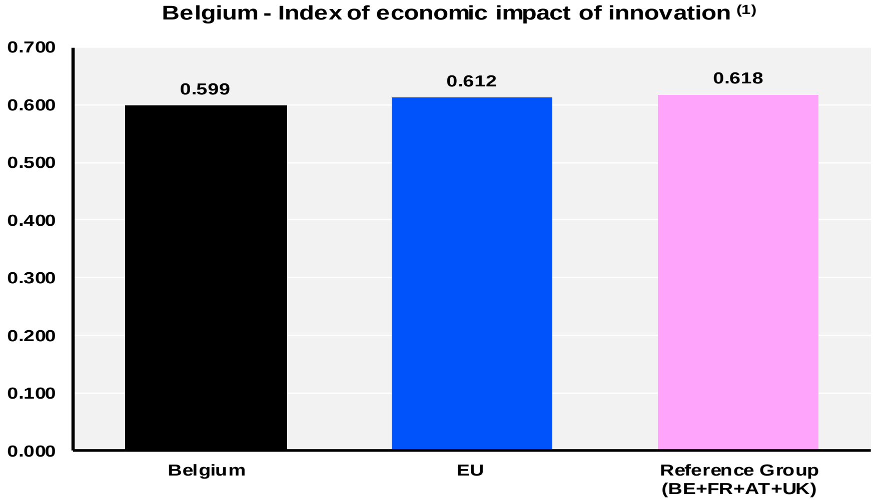
[11] Increased to 80% since 1 January 2013

[12] Belgium also participates in several research infrastructure projects as part of the ESFRI roadmap. Its main contribution to the implementation of the ESFRI roadmap is as lead partner on the MYrrHA European Fast Spectrum Irradiation Facility: Belgium will contribute 40% of the construction costs as part of a broad international consortium.

[13] IMEC for instance is selling its service to industrial players from all over the globe.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[14].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Belgium's score on this index is comparable to the average scores of the EU and of the reference group of countries. However, Belgium's score results from different situation in each indicator composing the index.

On the positive side, knowledge-intensive sectors provide more jobs in Belgium than (on average and proportionally) in other Member States. Moreover, thanks to excellent trade performance in a range of research-intensive products, the contribution of medium and high-tech product exports to the Belgian trade balance has strongly increased in the last decade.

On the negative side, Belgium's score is lower than EU average on the indicators "*Share of knowledge-intensive exports in services exports*" and "*Sales of new to market and new to firm innovations as % of turnover*". However, the low score of Belgium on the indicator "*Share of knowledge-intensive exports in services exports*" is largely explained by high volumes of export in some logistics, transport and trade related services which are linked to the geographical intermediation role of Belgium and which are classified as non-knowledge-intensive. Moreover, the low score of Belgium on the indicator "*Sales of new to market and new to firm innovations as % of turnover*" is explained by the fact that Belgium is strongly specialised in sectors with long innovation cycle as pharmaceuticals or chemicals and strongly under-specialised in sectors with short innovation cycle as IT[15]. As the low scores of Belgium on these two indicators reflect some specificities of the industrial structure of Belgium not related to any underperformance, the situation of Belgium in terms of economic impact of innovation is more positive than the image given by the index.

While the Belgian research and innovation system seems to be effective in generating economic impacts in the sectors in which R&D investments are concentrated, the key issue for Belgium is to broaden its innovation base beyond those sectors. All Belgian regions have developed some efforts in this direction (see last paragraph on previous page). However, Belgium needs more growing innovative firms to fasten the renewal of its economic fabric and speed-up the transition towards a more knowledge-intensive and innovation-driven economy.

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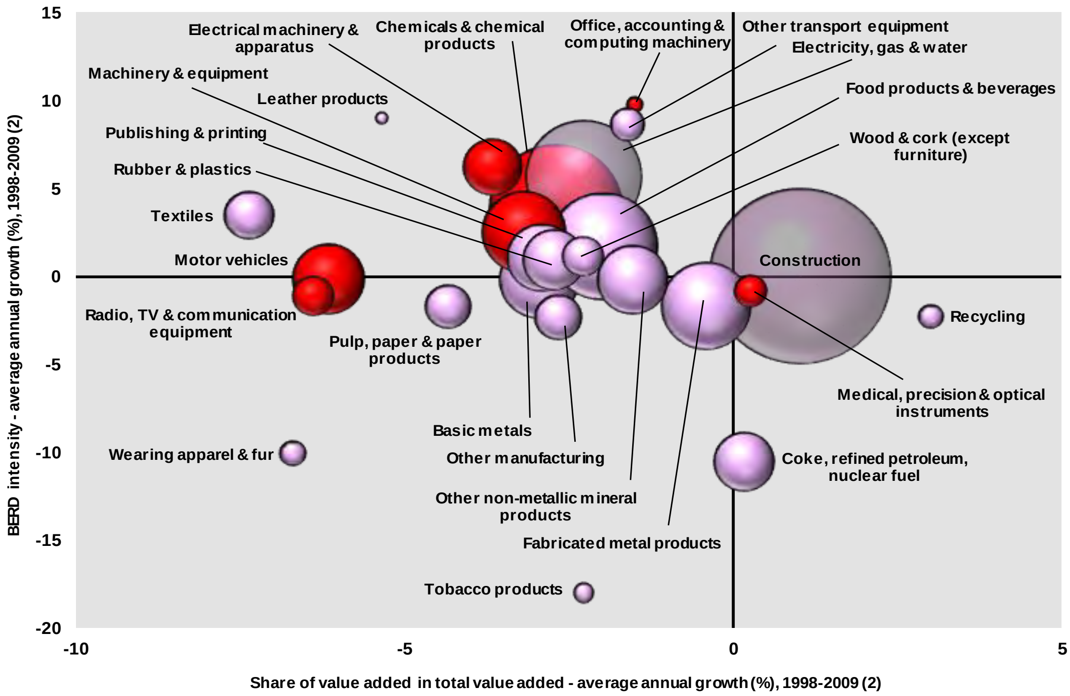
[14] See Methodological note for the composition of this index.

[15] Due to differences in innovation cycle, the share of innovative products introduced the last three years in the turnover is about 10% for global innovation leaders in pharmaceuticals or chemicals vs. more than 60% in IT hardware: see http://iri.jrc.ec.europa.eu/docs/survey/2012/Survey2012.pdf

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Belgium - Share of value added versus BERD intensity - average annual growth, 1998-2009



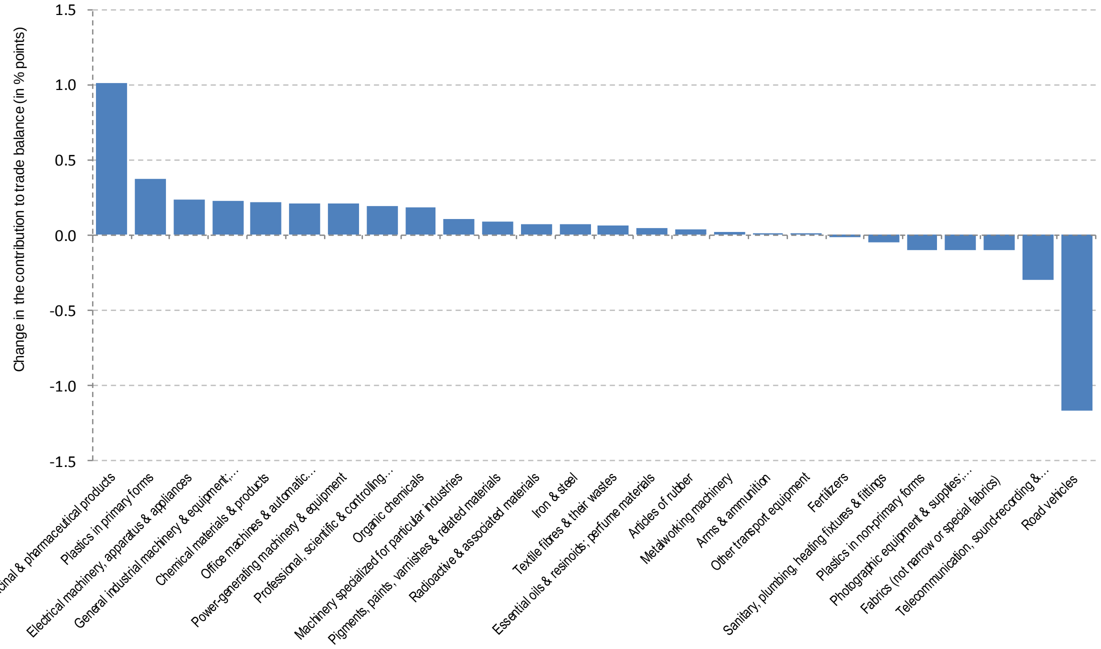
Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Basic metals', 'Electrical machinery and apparatus', 'Fabricated metal products', 'Food products and beverages', 'Motor Vehicles', 'Office, accounting and computing machinery', 'Other manufacturing', 'Other transport equipment', Publishing and printing', 'Pulp, paper and paper products', 'Radio, TV and communication equipment', 'Recycling', 'Textiles', 'Tobacco products', 'Wearing apparel and fur': 1998-2008.

The graph also points at some of the factors behind the evolution of business R&D intensity described in the section "*Investing in knowledge*". The shares in total Belgian value-added of nearly all manufacturing sectors declined between 1998 and 2009. This evolution reflects the trends toward a more service-oriented economy, and is similar to the one observed at the level of the EU as a whole. It has however been more pronounced in Belgium, where manufacturing now accounts for 14% of gross value added compared to 19% in 2000. High-tech and medium-high-tech sectors have not been spared from this trend: in particular, the radio, TV and communication equipment sector, which in 2000 was the sector contributing the most to BERD, has been strongly affected. Thus, although the sectoral R&D intensities of most of the manufacturing sectors have been stable or increasing, the negative impact of the de-industrialisation trend on the evolution of overall Belgian business R&D intensity has been overwhelming. Foreign multinationals, which represent nearly 60% of BERD, played a key role in these dynamics: for instance, decisions to disinvest in Belgium from foreign firms active in the radio, TV and communication equipment sectors explain the above mentioned trends in this sector.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Belgium between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Since 2002, the Belgian trade balance has deteriorated rapidly, mainly due to loss of market shares on global markets, to the extent that it now constitutes an important emerging risk for the Belgian economy. The improving services balance has not been sufficient to offset the decline in the goods balance, from a surplus of 4.3% of GDP in 1995 to a deficit of 2% of GDP in 2011. This negative evolution was especially strong in labour-intensive and mainstream industries, where it is linked to a cost-competiveness issue for Belgium.

At the same time, the contribution of high-tech and medium-tech (HT & MT) products to the trade balance has increased. This increase has been driven by excellent performance in pharmaceuticals exports as well as by positive evolutions across a wide range of HT&MT products, notably plastics and other chemical materials and products. The increase of the overall contribution of HT & MT products to trade balance would have been even more impressive without the strong deteriorations of the trade balances in road vehicles and, to a lesser extent, in telecommunication apparatus. The trade balance deterioration in these sectors is due to the sharp reduction of the volume of activities of these industries in Belgium (visible on the bubble graph in the previous section), including through the closure of some factories.

It is thus clear that the strengths of the Belgian research and innovation system have to some extent played a counter-balancing and mitigating role vis-à-vis the Belgian cost-competiveness issue in the manufacturing sector. Since 2000, total factor productivity has remained rather constant in Belgium. Between 1996 and 2007 it was close to 0 but for goods it increased 10% and for services it decreased by 6.5%. The employment rate has increased slightly. Belgium is making progress on the other Europe 2020 targets, in particular in the field of the environment, although there is room for further progress.

Key indicators for Belgium

BELGIUM	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.79	0.92	1.00	1.03	1.07	1.16	1.25	1.25	1.37	1.38	1.53	:	:	6.9	*1.69*	12
Business enterprise expenditure on R&D (BERD) as % of GDP	1.42	1.51	1.36	1.31	1.28	1.24	1.29	1.32	1.34	1.34	1.33	*1.37*	:	*-0.3*	*1.26*	9
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.52	0.54	0.55	0.54	0.55	0.56	0.55	0.55	0.61	0.66	0.66	*0.65*	:	*2.0*	*0.74*	12
Venture Capital [3] as % of GDP	0.21	0.12	0.09	0.04	0.08	0.04	0.17	0.30	0.19	0.30	0.13	0.16	:	-2.6	0,35 [4]	11 [4]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	50.5	:	:	:	:	59.9	:	:	3.5	47.9	6
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	10.1	11.3	10.8	11.9	11.8	12.8	13.0	13.4	13.6	:	:	:	:	3.8	10.9	3
International scientific co-publications per million population	469	421	489	691	777	874	903	990	1063	1123	1195	1280	:	9.6	300	6
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	81	85	88	90	97	:	4.7	53	5
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	3.3	3.1	3.0	3.1	3.6	3.6	3.7	3.8	3.5	3.7	:	:	:	1.3	3.9	8
License and patent revenues from abroad as % of GDP	:	:	:	:	0.28	0.36	0.39	0.36	0.30	0.53	0.50	0.50	:	8.6	0.58	10
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	12.9	:	13.6	:	9.5	:	12.4	:	:	-0.7	14.4	14
Knowledge-intensive services exports as % total service exports	:	:	:	:	42.0	41.9	42.7	37.8	40.6	41.6	41.3	:	:	-0.3	45.1	8
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	0.80	0.65	0.25	-0.07	0.03	1.06	1.81	1.61	1.69	1.17	1.46	2.37	:	-	4,20 [5]	12
Growth of total factor productivity (total economy) - 2000 = 100	100	99	100	100	102	102	104	105	104	100	102	102	102	2 [6]	103	18
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	53.0	:	:	:	:	56.7	:	:	:	:	58.9	:	:	1.1	48.7	5
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	14.9	14.4	14.6	14.9	:	0.0	13.6	11
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	46.9	:	45.4	:	44.0	:	50.3	:	:	1.2	38.4	2
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.29	0.34	0.22	0.28	0.27	0.22	0.23	0.28	0.33	:	:	:	:	1.7	0.39	9
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.77	0.70	0.83	0.80	0.76	0.86	0.67	0.58	0.51	:	:	:	:	-4.9	0.52	10
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	65.8	65.0	65.0	64.7	65.6	66.5	66.5	67.7	68.0	67.1	67.6	67.3	:	0.2	68.6	15
R&D Intensity (GERD as % of GDP)	1.97	2.07	1.94	1.87	1.86	1.83	1.86	1.89	1.97	2.03	2.00	*2.04*	:	*0.4*	*2.03*	9
Greenhouse gas emissions - 1990 = 100	102	102	101	102	103	100	97	93	95	87	92	:	:	-10 [7]	85	14 [8]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	1.9	2.3	2.6	2.9	3.3	4.5	5.1	:	:	17.9	12.5	22
Share of population aged 30-34 who have successfully completed tertiary education (%)	35.2	35.2	35.2	37.7	39.9	39.1	41.4	41.5	42.9	42.0	44.4	42.6	:	1.7	34.6	9
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	21.6	22.6	21.5	21.6	20.8	20.2	20.8	21.0	:	-0.4	*24.2*	12 [8]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Values in italics are estimated or provisional.

Bulgaria

Seizing the economic growth potential of innovation – policy coordination and strategic planning

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Bulgaria. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.57% (EU: 2.03%; US: 2.75%) 2000-2011: +1.06% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:24.65 (EU:47.86; US: 56.68) 2005-2010: +3.4% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.234 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:29.45 (EU:48.75; US: 56.25) 2000-2010: +3.65% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Agriculture, Nano- and Biotechnology, ICT and Energy	*HT + MT contribution to the trade balance* 2011: -4.78% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

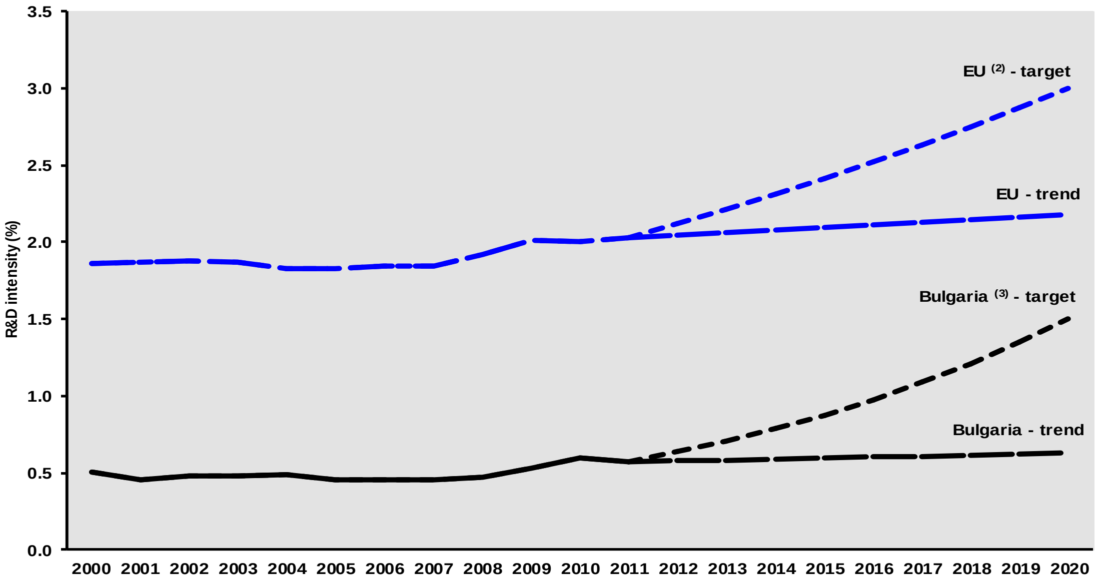
Bulgaria has in the past decade increased its R&D expenditure in nominal terms in line with the strong growth of its GDP, with only slight setbacks during the current crisis. After slowly increasing from 0.09% of GDP in 2002 to 0.16% of the GDP in 2009, business expenditure on R&D has surged to 0.3% of GDP in 2011, matched by sustained catching up in levels of excellence in science and technology, but also innovation. The economy is also steadily catching up to EU-level averages in terms of high-technology and medium-technology sectors, albeit from low levels. There have also been some recent positive policy developments with the adoption of national strategies for research and innovation, as well as the recent establishment of a ranking of universities, which will better inform resource allocation.

However, multiple challenges remain if Bulgaria is to be able to fully benefit from the knowledge economy. Bulgaria has low levels of knowledge-intensive economic activity, and its overall structure has not changed substantially over the last decade. Bulgaria's participation rate in FP7 is much below potential and working conditions are not attractive for highly productive researchers. Consequently, both public and private R&D investments are hampered by a lack of skilled human resources. A substantial increase in R&D spending, both in absolute and relative terms, is a prerequisite if Bulgaria is to raise its economic competitiveness and secure high-quality jobs.

Tackling these challenges is crucial to achieving sustainable economic growth in the future. A new mechanism for effective collaboration and coordination between the structures and institutions that support the executive in conducting scientific and innovation policy in Bulgaria is under development. Recent progress made in securing private investment in ICT and pharmaceuticals should be capitalized upon. Bulgaria has a strategic focus to move up the value chain and away from a sectoral specialisation in low technologies. This will require increased public investment in researchers and infrastructures as well as fostering an environment that is conducive to collaborations between universities and business (implementing what is already in the National Development Programme "Bulgaria 2020"). Moreover, more focus should be placed on incentives for excellence and internationalisation, in particular through an increase in the part of public funding which is allocated competitively, transparently and based on merit. Further support should also be given to research and innovation collaboration platforms such as technology parks and clusters; the drive to create Sofia Tech is a valuable reference point in this regard. At regional level, more support from the Structural Funds should be channelled towards research and innovation infrastructures.

Investing in knowledge

Bulgaria - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) BG: This projection is based on a tentative R&D intensity target of 1.5% for 2020.

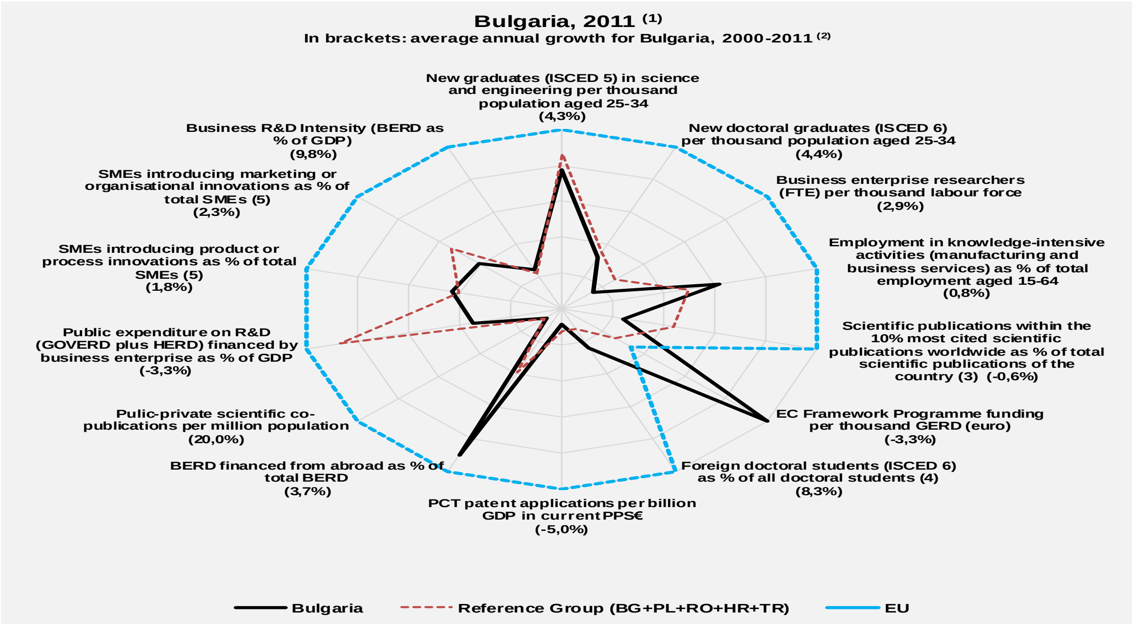
In June 2010, the Bulgarian government adopted a national R&D investment target of 1.5 % of GDP by 2020. R&D intensity has not changed significantly over time: it was 0.51% in 2000 and was 0.57% in 2011. Moreover, the 2011 public budget for science remained at 0.3% of GDP, despite a planned increase in absolute terms. Therefore, although R&D expenditure in Bulgaria has been increasing, a further dramatic increase would be required if Bulgaria is to reach its 2020 R&D intensity target. The public sector has historically been the main research funder and performer: in 2011 it provided 38.8% of total R&D funding, a substantial crisis-related drop from pre-2010 levels. For example, the Academy of Sciences saw a ~40% cut in its initially approved budget.

After slowly increasing from 0.09% of GDP in 2002 to 0.16% of GDP in 2009, business R&D intensity surged to reach 0.3% of GDP in 2011. Business expenditure on R&D more than doubled from € 55 million in 2009 to € 117 million in 2011 surpassing total public expenditure on R&D. In 2011 business enterprise expenditure on R&D accounted for 53 % of total R&D expenditure in Bulgaria compared to an EU average of 62%. This encouraging sudden increase is attributable to investments by ICT and pharmaceutical companies, but there are doubts as to whether this extremely positive trend can be sustained. The low level of R&D intensity is due to the economic crisis and the lack of demand for development of innovation on the domestic market

Some general trans-national funding initiatives partially complement national R&I funding. The allocated Regional Development and Cohesion Funds support for the 2007-2013 period amount to € 310.6 million for Research and Innovation and related activities and € 292 million for support of innovation in SMEs. The level of Bulgarian participation in the Framework Programmes is low. As of February 2012 Bulgaria ranks 20th among EU Member States both in terms of number of applicants (0.91 % of the EU total) and requested EC contribution (0.55 % of the EU total). The applicant success rate of 17,2 % is lower than the EU average (21.2 %) as is the EC financial contribution success rate of 10,8 % (EU average 20,4 %). Bulgaria received € 64.5 million of FP7 funding, of which € 16.3 million went to SMEs. Adjusted for population, this comes to eight euro per capita, a value comparable to those of Poland and Slovakia.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Bulgaria's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) TR is not included in the reference group.

Even if its overall position in the Innovation Union Scoreboard is rather low, Bulgaria being among the modest innovators, there are some encouraging signs in the disaggregated dimensions. Most important is the fact that Bulgaria is the "EU catching-up leader", with a 9% growth in innovation performance in 2011 (and ~6% in 2010), albeit from a low level. Bulgaria also scores relatively high on the quality of its Human Resources and in Firm Investments. As the graph above shows, Bulgaria is significantly lower than the EU average for all dimensions except, as would be expected for a catching up innovator, in terms of EU funding and in terms of foreign business expenditure on R&D. Of particular concern is the low level of public-private scientific co-publications and the very small number of business enterprise researchers, which are in a sense related, as well as the very limited number of PCT applications compared to the EU average.

Moreover, Bulgaria still faces major challenges in key policy dimensions related to European Research. Bulgaria has been experiencing massive outflows of researchers and highly skilled people: for example, in 2010 the number of Bulgarian students at graduate level who went to the United States was higher than the corresponding numbers for Poland and Romania. There is therefore an urgent need to enhance the quality of the higher education system and to address the failure to channel skilled people into domestic employment. In 2010 a new Academic Staff Development Act aimed at supporting the career development of researchers was adopted. Bulgaria is slowly catching up in terms of increasing the excellence and internationalisation of its universities and public research organisations. The overall number of scientific co-publications based on collaborations between Bulgarian and other ERA country researchers is one of the lowest in Europe, suggesting that the country is not sufficiently benefitting from international knowledge flows, despite having several bilateral cooperation agreements with over 12 EU and Third countries which promote joint scientific projects, exchange of research staff and support co-publications. Bulgaria's most significant co-patenting partners are Germany, Switzerland and Belgium.

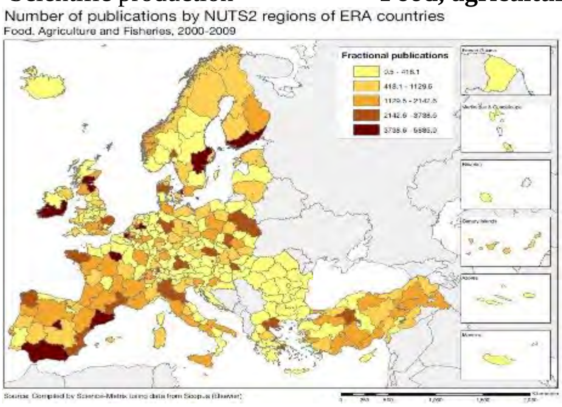
Bulgaria's scientific and technological strengths

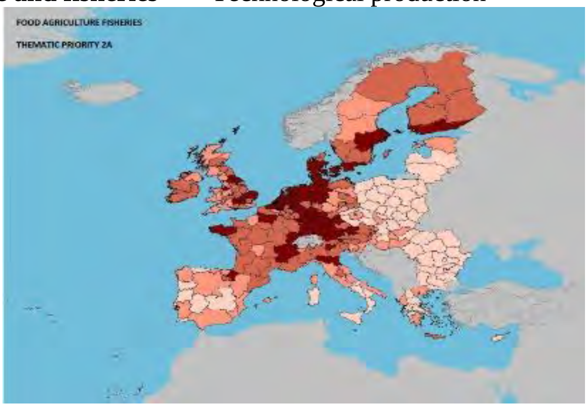
The Bulgarian R&I system is faced with the typical dilemma of a catching up innovator with limited resources. Some efforts have been aimed at defining some key areas of focus on which to build a truly excellent research base upon which to further base a framework of support for innovation. In order to concentrate resources, the National Science Fund has decided, under the 2012 call for proposals, to support predominantly fundamental and applied research projects as well as experimental developments in the priority areas defined in the National Research Strategy. However, not enough is currently being done in Bulgaria to properly direct scarce resources, the result being that they are spread too thinly.

The maps below illustrate five key science and technology areas where Bulgaria has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

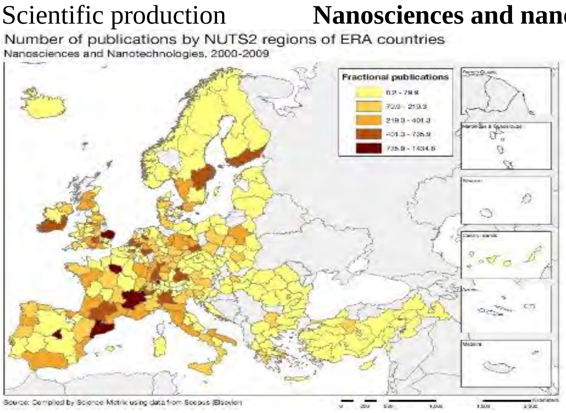
Strengths in science and technology at European level

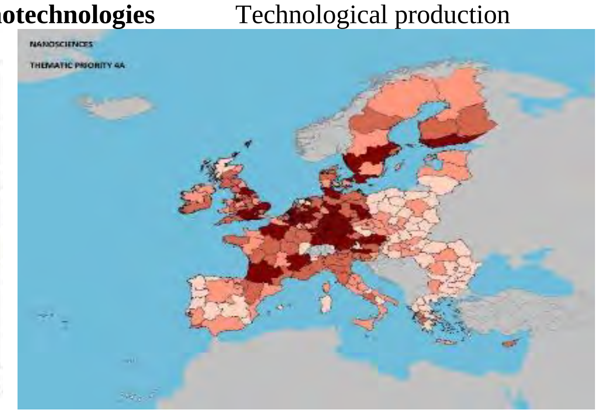
Scientific production **Food, agriculture and fisheries** Technological production



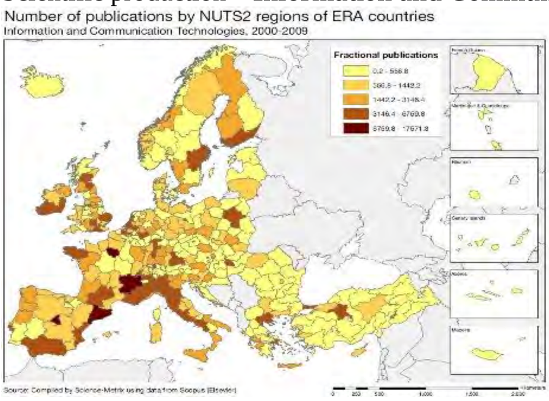


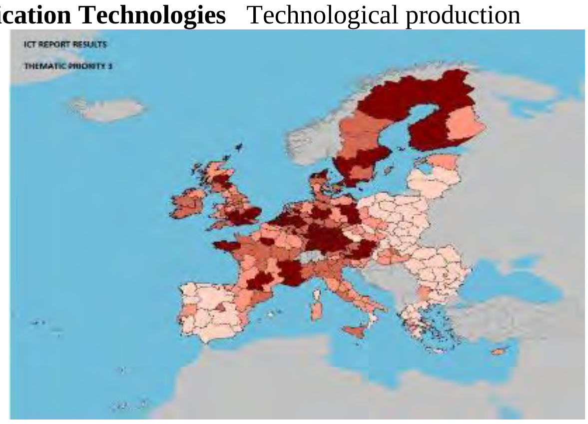
Scientific production **Nanosciences and nanotechnologies** Technological production





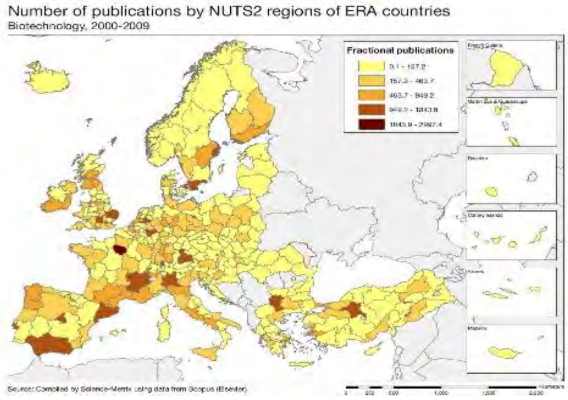
Scientific production **Information and Communication Technologies** Technological production

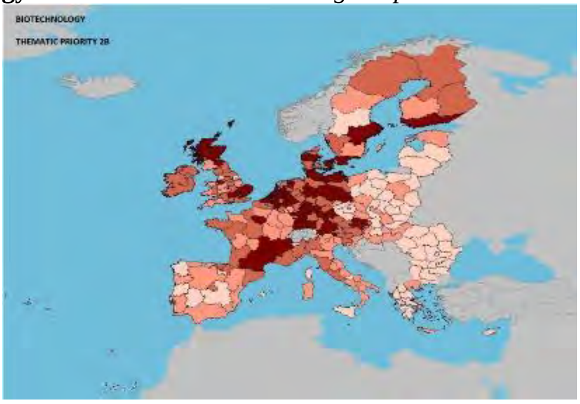




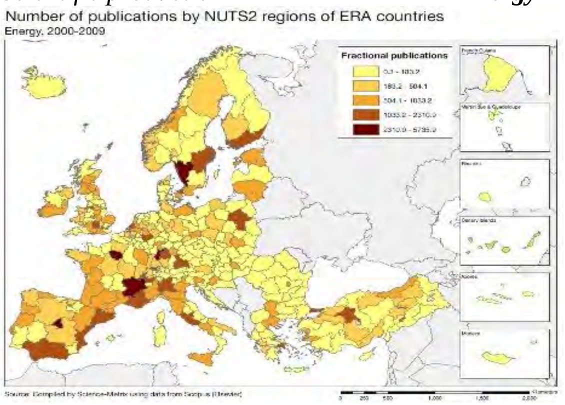
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

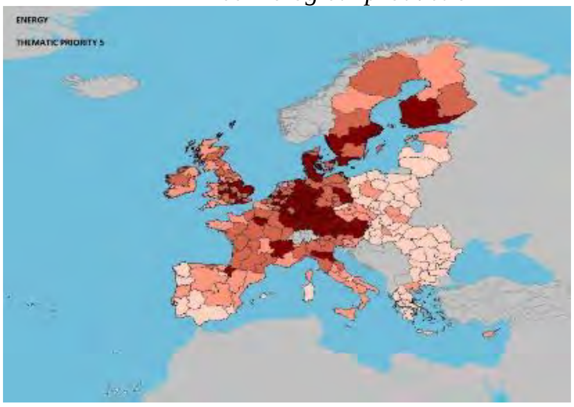
Scientific production **Biotechnology** *Technological production*





Scientific production ***Energy*** *Technological production*





The maps above are selected based on existing or emerging regional clusters in scientific or technological production. These are in the areas of agriculture, nano- and biotechnology, ICT and energy. Furthermore, based on citations and the impact of scientific publications, Bulgaria also shows strength in the area of transport. Nevertheless, current trends indicate a lack of clarity in the country's areas of specialisation that should be addressed with smart specialisation strategies. In order to define the country's areas of Smart Specialization, the Government has signed a service agreement with the Word Bank and set up an inter-institutional working group including representatives of all interested ministries, regional authorities and social partners.

Overall, patenting in Bulgaria is behind most European countries, most probably still affected by the post-communism decline, when activity in its traditional industries (metallurgy, chemicals, heating and medicine) was scaled back. Although these industries are nowadays limited to technological upgrades with foreign capital (rather than in-house development), there are signs of intensification, fuelled by R&D intensive FDI, in other areas, primarily in ICT as seen in the maps above.

Scientific production is increasing but not strongly enough for Bulgaria to improve its global standing. The impact of this research has also increased, and is currently comparable to regional peers such as Romania and Croatia, but is behind Poland. In general, scientific publications are mainly concentrated in the field of pure sciences. Co-authorship with foreign researchers has increased to over half of all publications, the main partners being in Germany, France and Italy, but also in the United States and, more recently, in Poland and Spain.

Policies and reforms for research and innovation

There have not been any notable changes in the innovation policy mix, programmes and measures in Bulgaria between 2009 and 2011. Institutional fragmentation continues to present a challenge to policy implementation: R&I policies remain within the authorities of two different ministries that have different policy-making mechanisms and policy implementation structures. Nevertheless, there has been some collaboration: for example the joint consultation for the elaboration of the National Strategy of Scientific Research to 2020 (NSSR2020). The Strategy, incorporating for the first time important science, technology and innovation policy guidelines into one document, was adopted in 2011. The adoption of a new Law on Innovation, as well as a new Higher Education and Science Law, should be treated as a priority. In order for both the national and Europe 2020 objectives to be achieved, all strategy documents, as well as their implementation measures, should be harmonised and jointly developed by all stakeholders. The measures should include standardisation, public procurement rules, regulations, etc.

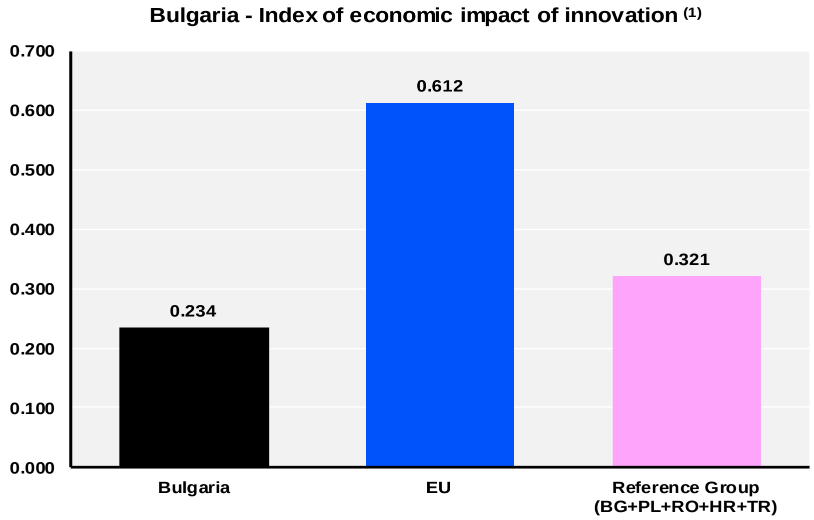
The lack of up to date statistical and qualitative data on the implementation of research and innovation policy and measures is another general weakness that affects policies and reforms. Evaluation is performed ad-hoc and irregularly, and statistical data are produced with a time lag of several years. A positive step is the newly introduced university rating system (launched in 2010), which is intended to serve as a tool for discretionary state funding based on the universities' achievements. Progress has been made in establishing evaluation systems and rules for initiating policy and structural changes in all innovation and research-related institutions based on the recommendations from the evaluations. The NSSR2020 foresees as one of its measures the introduction of scientific activity evaluation of research organisations, which will help the State to design better policy measures. A draft of the "Regulation for the monitoring and evaluation of the research carried out by universities and research organizations" is expected to be adopted soon.

In 2008, for the first time, the ratio between national institutional (direct subsidies for public research organisations) and competitive funding was almost equal. National competitive funding usually does not have strict thematic or sectoral focus, or it tends to focus on the support of 6-7 areas per one open call. It should be noted, however, that several of the sectors listed as priorities in the NSSR2020 currently receive less than 1% of government budget appropriations or outlays on R&D. Notwithstanding the existence of a national roadmap for research, specific R&I cross-border or regional programmes and support schemes have been limited so far, as have been plans for involvement in any ESFRI projects. HEIs provided a minute 0.20% of the total R&D funding in 2011, while total higher education expenditure on R&D (HERD) which amounted to € 22.5 million in 2011 accounted for only 10.2% of total R&D expenditure in Bulgaria. The main change in R&D expenditure trends, in 2011, was the increase in R&D investment from abroad. The share of R&D financed by abroad, which was in the range of 5-8% for the 2000-2009 period, increased to 43.9% in 2011. The main competitive public R&D funding instruments are the National Innovation Fund (NIF) and the National Science Fund (NSF). Due to considerations related to overlapping with EU funding programmes, the NIF has not distributed any funds since 2008, when it reached a budget of € 10.3 million. The NSF's budget peaked in 2009 (€ 51.1 million), but government cuts in 2010 have substantially reduced it to € 13 million.

The level of cooperation between companies and R&D institutions and universities is still low. A number of measures aimed at building a favourable environment and encouraging the interaction between universities and business are foreseen in the National Youth Strategy 2010-2020, the "Bulgaria 2020" Programme, the NSSR 2020, and are supported by a scheme launched under the Operational Programme "Development of Human Resources", which has also been used to fund training for some researchers. There are no specific policy measures aimed at promoting public-private knowledge transfer or spin-offs. Mobility of research staff between the public and private sectors is rare and is in general not supported by specialised programmes for fostering inter-sectoral mobility. The majority of Bulgarian enterprises do not have research units and are not attracting research staff from the public sector. In order to promote private investment in R&I, the state should further develop and implement instruments such as start-up funding schemes, support for clusters, technology centres for the commercialisation of patents, while financial engineering instruments, guarantees and venture capital funds should be further enhanced.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[16].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The graph above shows that raising the economic impact of innovation constitutes a challenge for Bulgaria and currently leaves a lot of room for improvement. There is a need to support future growth in the economy as well as employment by harnessing the power of innovation to create new and sustained high value-added exports. This is of paramount importance because Bulgaria's exports have stagnated in terms of quality and product sophistication. There is agreement among policy makers that exports would play a pivotal role in achieving a robust recovery, but for this to happen, exports must become more diversified and more innovation-based and the share of high-technology goods must increase. The economic crisis seems to have accelerated Bulgaria’s structural change towards more advanced and knowledge-intensive industries and sectors, as demonstrated by the sizeable gains in exports by technology-driven and mainstream manufacturing industries. However, Bulgaria is still catching up with respect to competitiveness. Much of the innovation that businesses are currently engaged in is related to catching-up and the upgrading of technology through acquisitions and FDI in the most research-dynamic sectors. For example, in 2007 one fifth of all inward business investment in R&D in Bulgaria originated from the chemical industry, with the majority of the investment coming from outside the EU.

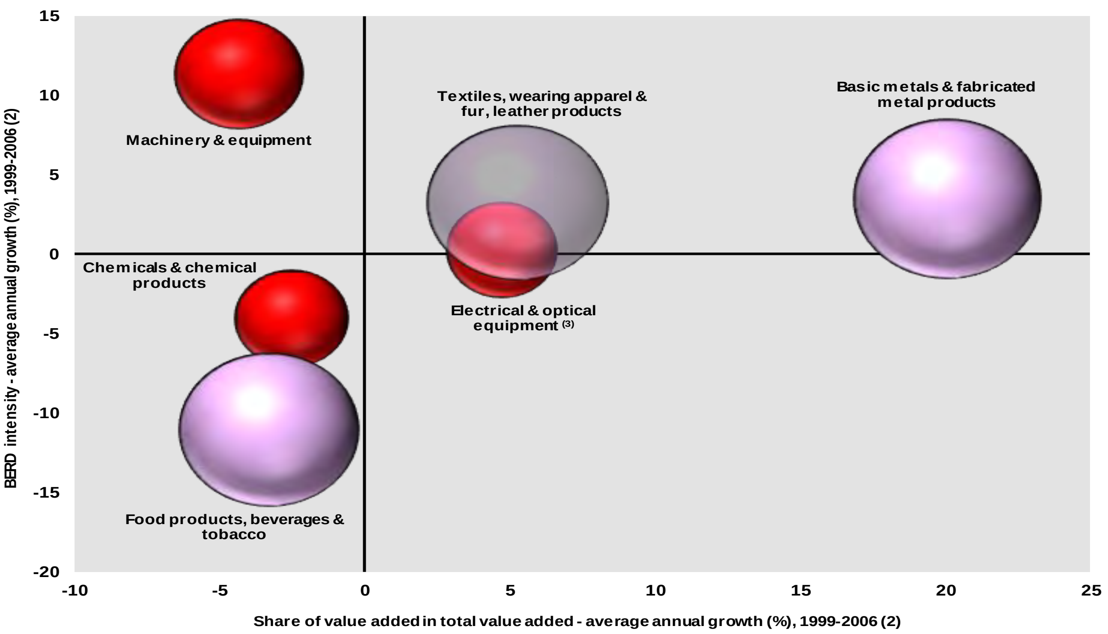
The World Bank (WB) has assessed private innovation based on the World Bank's enterprise survey, and concluded that Bulgarian firms which innovate grow 1.5 times faster and create more jobs than their non-innovating counterparts. But this powerful engine is hampered by insufficient access to the external finance needed for long-term R&I investments. Over the past years, SMEs have encountered difficulties in financing innovative projects due to high interest rates and credit rationing, while start-ups have not been able to find appropriate funding. Bulgaria has also experienced the largest increase in the EU in unsuccessful loan applications - from 3 % in 2007 to 36 % in 2010 (Eurostat). Moreover, the regulatory environment is not stable and predictable for companies as legislative acts change very often. National harmonisation with EU legislation is sometimes complex and contradictory. In the WB Doing Business 2012 survey, Bulgaria's ranking worsened for the second consecutive year (from 57 in 2010 to 59 in 2011), pointing to excessive red tape and inefficiencies, including difficulties with permits, access to electricity, contract enforcement, and the insolvency framework.

16 See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Bulgaria - Share of value added versus BERD intensity - average annual growth, 1999-2006



Source: DG Research and Innovation - Economic Analysis unit
Data: Eurostat
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Basic metals and fabricated metal products': 2004-2006.
(3) Electrical and optical equipment includes: 'Office, accounting and computing machinery', 'Electrical machinery and apparatus', 'Radio, TV and communication equipment' and 'Medical, precision and optical instruments'.

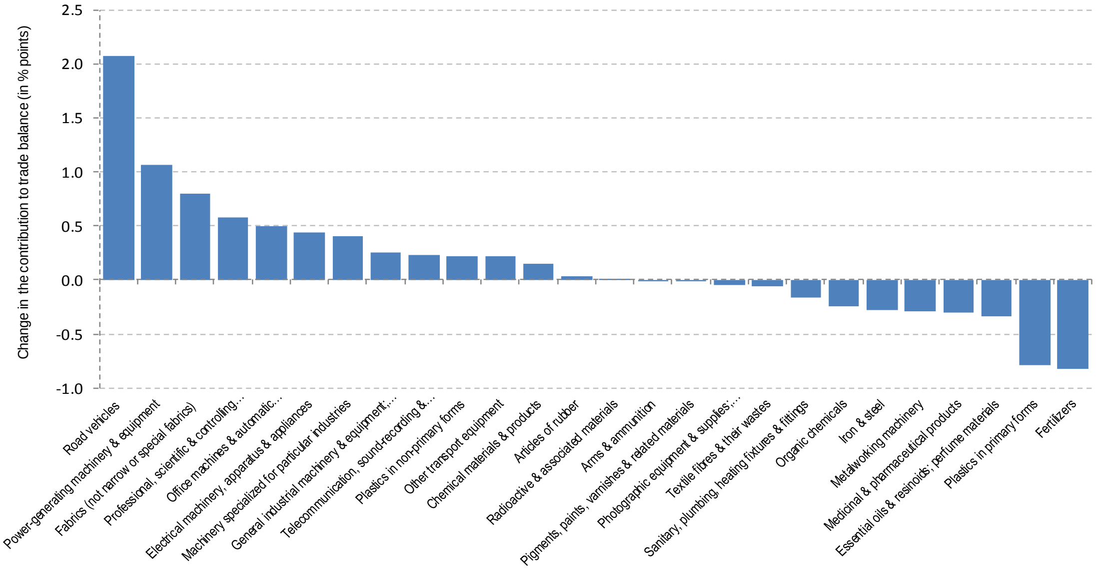
The manufacturing sector plays a slightly bigger role in Bulgaria than in the EU as a whole. This is mainly due to specialisation in labour-intensive industries (e.g. textiles and clothing, leather and footwear), and in capital-intensive industries (e.g. cement, refined petroleum and non-metallic mineral products). The primary sector is larger than the EU average due to the higher share of agriculture and, in general, the economy is dominated by sectors with low and medium-low technology intensity (DG Enterprise, 2012). The graph shows the large relative weight of textiles, metals and agricultural products in the economy, as well as the large share of value-added growth that they still represent. Two of the high-tech sectors have seen their shares of value added decrease over time (i.e. machinery and equipment, and chemicals, although BERD intensity increased in the case of machinery and equipment), whereas the electrical and optical equipment sector has increased its weight.

Overall there is a positive trend in the evolution of Bulgaria's economic structure. The Composite Indicator on structural change (DG Research and Innovation, 2012) also reflects this by showing steady improvement over time, the largest increase being from 2005 to 2009. There appears to be a general consensus that while improvements are evident and the manufacturing and export sectors are gradually shifting towards higher value-added and a more high-tech mix, this change is not happening fast enough to sustain competitiveness levels in the globalized economy.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Bulgaria between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: The data for "Radioactive & associated materials" refers to the period 2000-2004 and those for "Arms & ammunition" refers to the period 2002-2011.
"Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

So far, the Bulgarian economy has been associated with marketing and organisational innovation but not with technological innovation. Its economic specialisation has been based on low costs and a cheap labour force. The latest strategy documents call for measures to strengthen high value added and technology intensive sectors. There are already some encouraging data to show that this is happening, in particular a reduction of employment in low-tech sectors such as processing and apparel manufacturing coupled with employment growth in ICT. Another positive sign is that several medium-tech products (in particular products in machinery and transport-related sectors) are increasing their weight in Bulgaria's trade balance, as illustrated in the graph above. Although Bulgaria has a negative trade balance, both overall and in high-tech and medium-tech products, the export of medium-tech products has grown in absolute numbers since 2008.

Nevertheless, Bulgaria is still in the process of catching up with the EU average for a series of indicators related to competitiveness (see Key indicators for Bulgaria, below). The trends shown by these indicators are reminiscent of the larger shifts in the economy that have been outlined above, and point to the moderate pace of positive change. For example, while total factor productivity has increased by 13% since 2000 compared to 3% for the EU, employment in knowledge intensive activities is still rather low. Bulgaria has also made some strides in patenting in crucial sectors such as health and environment-related technologies. Overall, Bulgaria is making good progress on several of the Europe 2020 targets, although from a lower level than other EU Member States. A worrying sign is the falling employment rate and the growing share of population at risk of poverty following the economic crisis.

Key indicators for Bulgaria

BULGARIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.35	0.32	0.34	0.35	0.34	0.46	0.51	0.54	0.53	0.56	0.53	:	:	4.4	*1.69*	23
Business enterprise expenditure on R&D (BERD) as % of GDP	0.11	0.09	0.09	0.10	0.12	0.10	0.12	0.14	0.15	0.16	0.30	*0.30*	:	*9.8*	*1.26*	20
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.40	0.36	0.39	0.39	0.37	0.35	0.34	0.31	0.32	0.37	0.29	*0.26*	:	*-3.7*	*0.74*	26
Venture Capital [3] as % of GDP	:	:	:	:	:	:	:	0.13	0.04	0.02	0.01	0.03	:	-31.2	0,35 [4]	19 [4]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	20.9	:	:	:	:	24.7	:	:	3.4	47.9	20
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	2.7	2.8	3.3	2.9	3.6	4.1	4.8	3.6	2.6	:	:	:	:	-0.6	10.9	27
International scientific co-publications per million population	91	87	92	135	158	175	180	208	199	218	211	205	:	7.7	300	25
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	2.0	2.7	3.6	3.5	4.1	:	20.0	53	26
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.5	0.6	0.6	0.5	0.4	0.5	0.5	0.4	0.3	0.3	:	:	:	-5.0	3.9	24
License and patent revenues from abroad as % of GDP	:	:	:	:	0.03	0.02	0.03	0.02	0.02	0.02	0.03	0.03	:	3.1	0.58	22
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	12.5	:	10.3	:	14.2	:	7.6	:	:	-8.1	14.4	23
Knowledge-intensive services exports as % total service exports	:	:	:	:	11.7	15.0	16.7	20.5	22.5	21.9	26.8	:	:	14.8	45.1	17
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-8.42	-9.52	-9.50	-9.38	-10.86	-9.89	-9.31	-7.83	-7.43	-5.99	-4.84	-4.78	:	-	4,20 [5]	25
Growth of total factor productivity (total economy) - 2000 = 100	100	103	106	109	113	115	117	118	117	109	110	113	113	13 [6]	103	7
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	20.6	:	:	:	:	24.7	:	:	:	:	29.5	:	:	3.7	48.7	26
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	8.2	8.6	8.6	8.4	:	0.8	13.6	26
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	14.9	:	17.8	:	20.7	:	16.6	:	:	1.8	38.4	24
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.02	0.02	0.02	0.03	0.03	0.05	0.02	0.00	0.03	:	:	:	:	6.5	0.39	21
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.02	0.07	0.05	0.04	0.04	0.06	0.06	0.02	0.04	:	:	:	:	9.2	0.52	22
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	55.3	54.8	55.8	58.0	60.1	61.9	65.1	68.4	70.7	68.8	65.4	63.9	:	1.3	68.6	21
R&D Intensity (GERD as % of GDP)	0.51	0.46	0.48	0.48	0.49	0.46	0.46	0.45	0.47	0.53	0.60	*0.57*	:	*1.1*	*2.03*	25
Greenhouse gas emissions - 1990 = 100	55	57	55	59	58	58	59	62	60	52	54	:	:	-1 [7]	85	5 [8]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	9.6	9.5	9.6	9.3	9.8	11.9	13.8	:	:	6.2	12.5	11
Share of population aged 30-34 who have successfully completed tertiary education (%)	19.5	23,6 [9]	23.2	23.6	25.2	24.9	25.3	26.0	27.1	27.9	27.7	27.3	:	1.5	34.6	20
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	61.3	60.7	38,2 [10]	46.2	41.6	49.1	:	8.7	*24.2*	27 [8]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Break in series between 2001 and the previous years. Average annual growth refers to 2001-2011.

(10) Break in series between 2008 and the previous years. Average annual growth refers to 2008-2011.

(11) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Improve the access to finance for start-ups and SMEs, in particular those involved in innovative activities."

Croatia

The challenge of structural change for a more knowledge-intensive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Croatia. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.75% (EU: 2.03%; US: 2.75%) 2000-2011: -2.72% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:12.25 (EU:47.86; US: 56.68) 2005-2010: +2.31% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.353 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:n.a (EU:48.75; US: 56.25) 2000-2010: n.a. (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Healthcare sector; Food processing and agro-business; Energy technology; Electronics and Advanced materials and Digital techniques	*HT + MT contribution to the trade balance* 2011: 2.98% (EU: 4.2%; US: 1.93%) 2000-2011: +133.23% (EU: +4.99%; US:-10.75%)

Croatia is building up its research and innovation system. Although starting from a low level, its science and technology excellence has clearly improved after 2005. Efforts are still needed to enhance R&D investment and to build up capacities in key technology areas and to improve international competitiveness and trade by producing more technology-intensive goods.

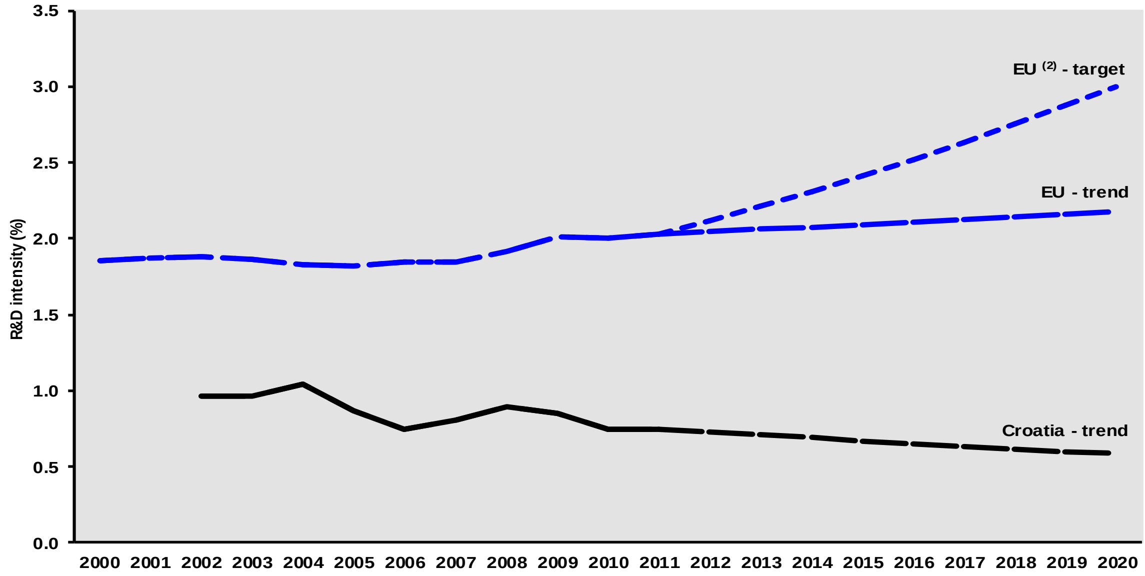
Since 2000, Croatia has restructured its science (and education) system with the objectives of turning the country into a knowledge based society and of strengthening the country's research capacity as a lever for economic development. Driven its determination to join the EU, Croatia has taken steps to strengthen its national research capacity by taking measures and adopting polices that are compatible with EU policy on the European Research Area. Croatia, however, has been slow to implement the envisaged actions and lacks reliable statistics and the administrative capacity to monitor and follow-up the envisaged reforms. Croatia has also suffered from the economic recession.

The new Government elected in December 2011 continued the efforts to reform the science system by proposing amendments to the Act on Scientific Activity and Higher Education aimed at creating an adequate legislative framework for a more programme-based and competitive funding of research institutes (adoption by Parliament foreseen before end of 2012).

A new R&D strategy and a "National Innovation Strategy is under preparation for the period 2013-2020.

Investing in knowledge

Croatia - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.in the the case of the EU and for 2002-2011 in the case of Croatia.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) HR: An R&D intensity target for 2020 is not available.

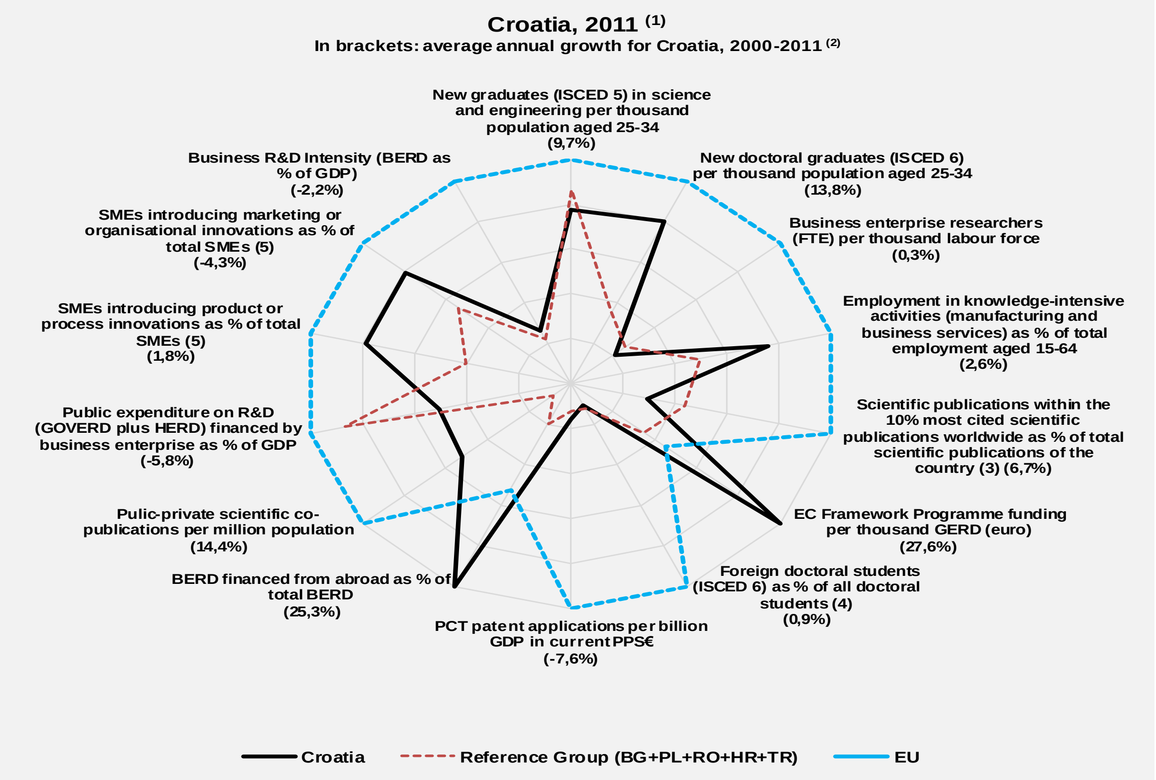
In 2011 Croatia had an R&D intensity of 0.75% and a business R&D intensity of 0.33%. Croatia's R&D intensity decreased from 0.90% in 2008 to 0.75 % in 2011. This was mainly due to an overall slowdown of the national economy during the last four years, which was additionally affected by the global financial and economic crisis. Croatia did not meet its own national target of 1% by 2010. Accordingly, Croatia has opted to first reform the science system before setting new targets. Total R&D expenditure (GERD) which amounted to € 330 million in 2011 decreased by 3.2% between 2004 and 2011. Croatia's R&D intensity of 0.75% in 2011 was well below the EU average of 2.03% and has decreased at an average annual rate of 2.7% over the period 2002-2011.

Regarding EU funding, Croatia participates in FP7 as an associated country. It has a good level of participation (an average success rate close to 18%) which has amounted to about € 50 million of EU funding for Croatian research entities since the beginning of FP7. Croatia is particularly successful under the scientific themes in which it is also strong at national level i.e.: healthcare, ICT, biotechnology and transport. Participation of SMEs is also good: out of 225 applicants 57 (or more than 25%) were selected for funding. Croatia is a full member of the Eurostar initiative. Croatia is also a member of COST and EUREKA.

As a Candidate Country, and since December 2011, an Accession Country, Croatia is eligible for EU support under the Pre-Accession Instrument (IPA) and has used that instrument in support of research and innovation capacity building such as the creation of the Business Innovation Centre of Croatia (BRICO) which is a dedicated institution for the promotion of research and innovation in SMEs. The latter is a good demonstration that Croatia is concentrating its efforts on innovation and creating links between the public and private sectors. Croatia wll become a member State on 1 July 2013 and will then have access to the Structural Funds and notably the European Regional Development Fund (ERDF) and the European Social Fund (ESF) for R&I capacity building purposes. BRICO will be the ggency in charge of the competitiveness axis under the Structural Funds.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Croatia's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) TR is not included in the reference group.

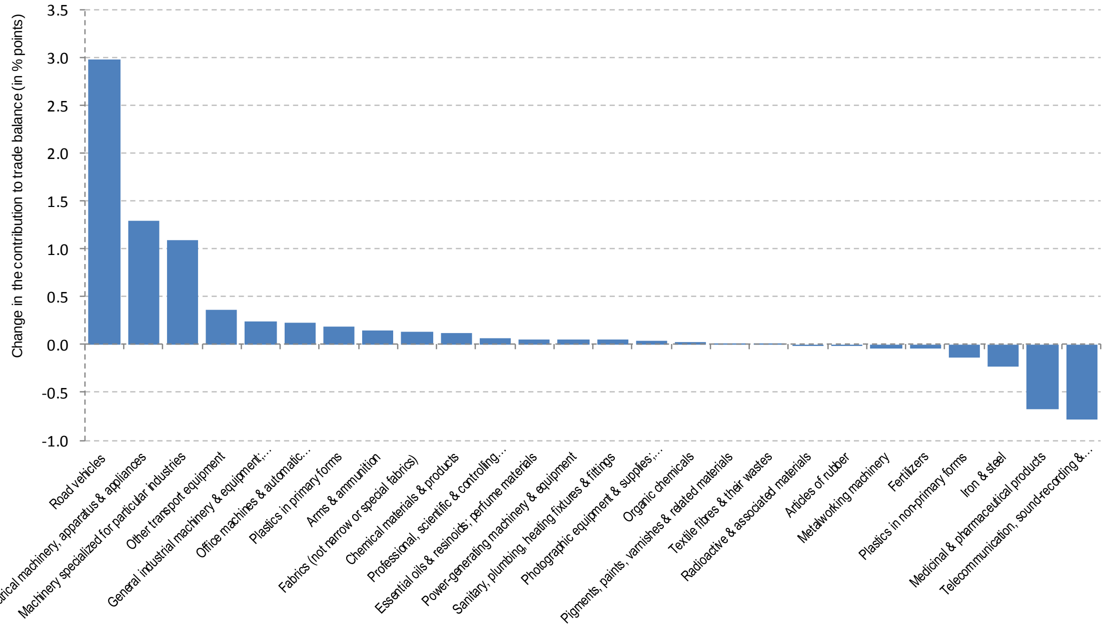
This graph shows that Croatia is lagging behind the EU average on most key research and innovation indicators but it is doing well or better than several other Member States and Associated Countries with a similar knowledge and economic structure. Croatia is performing above the EU average in attracting business R&D from abroad, although this is also linked to the low total business R&D in the country. Croatia faces a particular challenge in improving private-public cooperation and in valorising and commercialising research generated by publicly funded institutes.

Human capital building in S&T is below the EU average. Croatia still has a large scientific diaspora. The lack of attractive research infrastructures and good research management is leading to a further increase in brain drain. The MSES and the Agency for Mobility have, however, stepped up efforts on human capital building by actively supporting the principles of the European Charter for Researchers and the Code of Conduct for Recruitment of Researchers. In total, nine Croatian institutes have been accredited for HR excellence in research. Croatia is participating in the work of the Steering Group on Human Resources and Mobility (SGHRM). The Croatian Researchers Mobility Portal was launched in 2009.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Croatia between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Croatia is a net importer with a trade deficit in the order of € 8 billion in 2010 compared to about € 3.5 billion in 2001. Following the economic crisis, trade volume decreased significantly in 2009, 2010 and 2011 but exports in high-tech and medium-tech products continued to grow. Croatia is, for example, a net exporter of goods and products in which its research capacity is also strong such as fertilizers, plastic products in primary forms, electrical machinery and transport equipment. The graph above shows that important sectors such as road vehicles, electrical and specialised machinery have increased their contribution to the Croatian trade balance.

Croatia's employment rate has fallen since 2008 as a result of the economic crisis. The share of renewable energy in total energy consumption has slightly increased over the last years. However, Croatia's performance on energy efficiency and reducing the level of CO2 by stimulating the use of renewable energy is still at a low level, which is also reflected in the Croatian research capacity under the FP7 environment theme.

Key indicators for Croatia

CROATIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]
ENABLERS															
Investment in knowledge															
New doctoral graduates (ISCED 6) per thousand population aged 25-34	:	:	:	0.55	0.60	0.64	0.72	0.76	0.80	0.92	1.35	:	:	13.8	*1.69*
Business enterprise expenditure on R&D (BERD) as % of GDP	:	:	0.41	0.38	0.44	0.36	0.27	0.33	0.40	0.34	0.33	0.33		-2.2	*1.26*
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	:	0.55	0.59	0.61	0.51	0.47	0.48	0.50	0.51	0.42	0.41	:	-3.1	*0.74*
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation															
Composite indicator of research excellence	:	:	:	:	:	10.9	:	:	:	:	12.2	:	:	2.3	47.9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	1.9	1.9	2.3	2.1	2.4	2.8	3.0	3.1	3.2	:	:	:	:	6.7	10.9
International scientific co-publications per million population	*81*	*84*	97	149	172	194	210	233	247	293	334	388	:	15.3	300
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	16	18	23	27	27	:	14.4	53
FIRM ACTIVITIES AND IMPACT															
Innovation contributing to international competitiveness															
PCT patent applications per billion GDP in current PPS€	1.3	1.2	1.8	1.6	1.4	1.2	1.1	0.9	0.7	0.6	:	:	:	-7.6	3.9
License and patent revenues from abroad as % of GDP	:	:	:	:	0.10	0.16	0.09	0.07	0.06	0.05	0.05	0.04	:	-12.9	0.58
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	:	:	13.0	:	14.4	:	10.5	:	:	-5.2	14.4
Knowledge-intensive services exports as % total service exports	:	:	:	:	13.9	14.8	14.8	16.8	16.0	14.0	15.0	:	:	1.3	45.1
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-3.06	-2.79	-3.25	-4.07	-2.21	-2.46	-2.27	-1.22	0.23	-0.44	2.12	2.98	:	-	4,20 [3]
Growth of total factor productivity (total economy) - 2000 = 100	100	103	106	107	109	110	110	111	109	101	101	102	101	1 [4]	103
Factors for structural change and addressing societal challenges															
Composite indicator of structural change	32.0	:	:	:	:	37.1	:	:	:	:	38.2	:	:	1.8	48.7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	9.5	9.2	9.9	10.3	:	2.6	13.6
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	28.3	:	31.5	:	30.4	:	:	1.8	38.4
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	:	:	:	:	-6.9	0.39
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.12	0.24	0.40	0.48	0.23	0.36	0.25	0.05	0.07	:	:	:	:	-6.1	0.52
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES															
Employment rate of the population aged 20-64 (%)	:	:	58.4	58.3	59.6	60.0	60.6	62.3	62.9	61.7	58.7	57.0	:	-0.3	68.6
R&D Intensity (GERD as % of GDP)	:	:	0.96	0.96	1.05	0.87	0.75	0.80	0.90	0.85	0.75	0.75	:	-2.7	*2.03*
Greenhouse gas emissions - 1990 = 100	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	15.2	14.1	13.8	12.4	12.2	13.2	14.6	:	:	-0.7	12.5
Share of population aged 30-34 who have successfully completed tertiary education (%)	:	:	16.2	16.9	16.8	17.4	16.7	16.7	18.5	20.6	24.3	24.5	:	4.7	34.6
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	:	:	:	:	31.3	32.7	:	4.5	*24.2*

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) EU is the weighted average of the values for the Member States.

(4) The value is the difference between 2012 and 2000.

(5) Values in italics are estimated or provisional.

Cyprus

A new integrated innovation strategy to valorise opportunities of a small service-oriented economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Cyprus. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.48% (EU: 2.03%; US: 2.75%) 2000-2011: +6.24% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 27.77 (EU:47.86; US: 56.68) 2005-2010: +0.17% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.558 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 44.11 (EU:48.75; US: 56.25) 2000-2010: +3.27% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* New production technologies, Construction, ICT	*HT + MT contribution to the trade balance* 2011: 1.72% (EU: 4.2%; US: 1.93%) 2000-2011: -0.83% (EU: +4.99%; US:-10.75%)

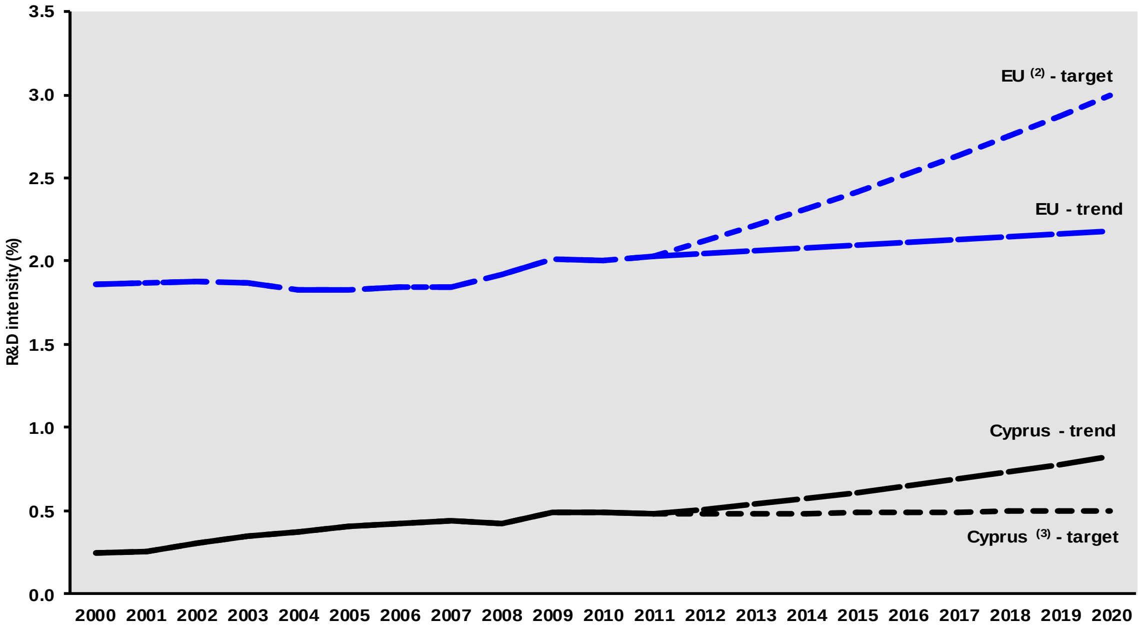
In the last decade, Cyprus has achieved a significant increase in its R&D intensity, which has led to improved excellence in science and technology. Cyprus has also managed to increase the knowledge-intensity of its economy to a level approaching the EU average.

Research and innovation presents some challenges to policy makers. A main bottleneck of the R&I system is the low number of human resources for research activities. This is due to the weak demand from business and industry. There is a sharp contrast between the high number of tertiary education graduates which has grown by 80% between 2000 and 2010 and the very low number of human resources for research. This is partially explained by a still unfavourable environment for research activities which leads to a substantial brain-drain of S&T graduates to other countries, mainly the United Kingdom and the United States. In addition, business involvement in research and innovation is very limited mainly due to the lack of big companies and the absence of high-tech industrial activity. The business sector is focused on services and is dominated by very small enterprises that have not developed an innovation culture.

The government has introduced financial incentives for business R&D and new support schemes for innovation such as innovation vouchers. There is also a strong emphasis on the importance of a stronger cooperation between the higher education system and industry. Currently, there is a too broad research orientation that lacks prioritisation and an integrated R&I policy. The National Research and Innovation Strategy (2011-2015) is under preparation. The Cyprus authorities consider that the absorption capacity of Cyprus in the field of R&D is limited and that it is better to encourage the development of existing products in an innovative way. Non-technological innovation as well as innovation in services could be real options for Cyprus.

Investing in knowledge

Cyprus - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) CY: This projection is based on a tentative R&D intensity target of 0.5% for 2020.

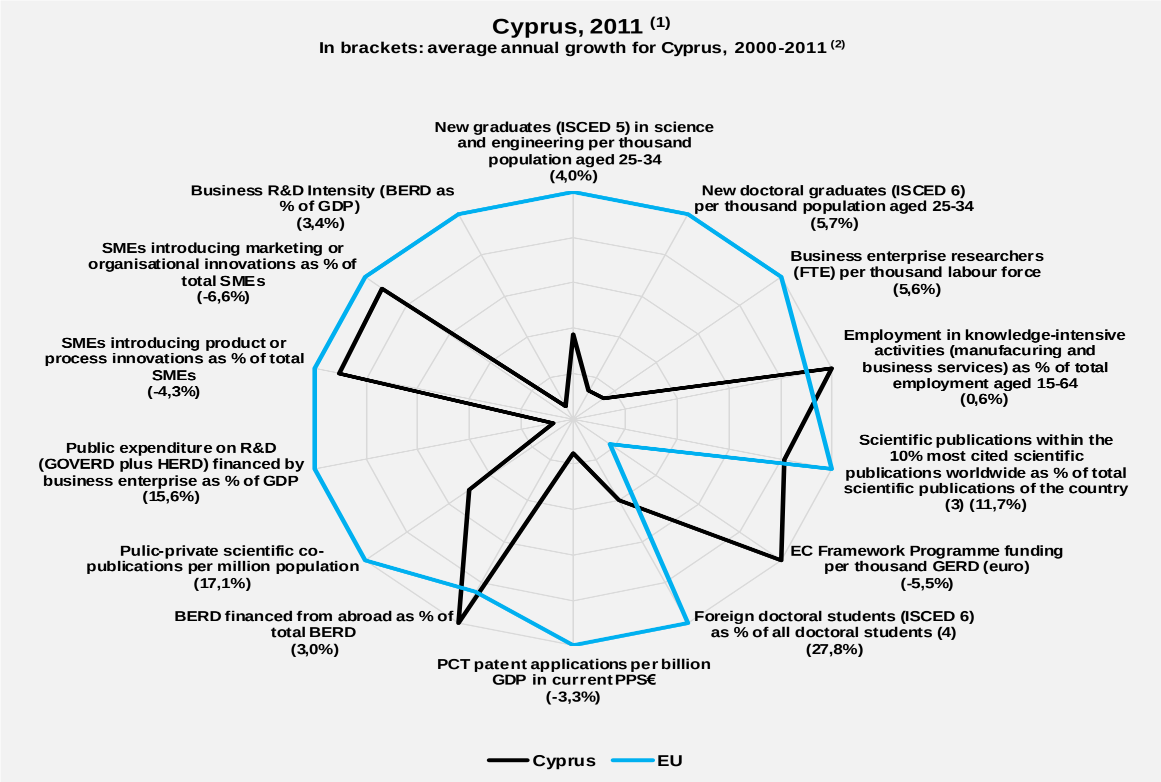
The research and innovation system in Cyprus is relatively new. It has evolved mainly over the last two decades and it relies predominantly on public expenditure. In 2009, 69% of total R&D expenditure (GERD) was financed by government, the highest percentage in the EU and considerably above the EU average of 34.9%. There is indeed a persistent problem of underinvestment in research and innovation by the business sector. Business R&D expenditure (BERD) as a % of GDP was equal to 0.09% in 2010, the lowest level in the EU. In its National Reform Programme Cyprus set a very modest R&D intensity target of 0.5% for 2020, the lowest R&D intensity target in the EU, and in fact this target had been reached in 2010. However, the R&D intensity decreased to 0.48% of GDP in 2011. The economy is not oriented towards high value-added products and services. Cyprus has been affected by the financial crisis with the result that the R&D budget and several measures related to innovation have been put on hold during the process of fiscal consolidation.

In the last decade, a significant increase of public RTDI funding has taken place across various disciplines without focusing on the limited number of scientific fields where the national innovation system could be expected to excel. There is a low involvement of firms in research and innovation activities in terms of participation and expenditure on R&D and innovation. In 2010 only 17.5% of total R&D expenditure (GERD) was performed by business enterprise compared to an EU average of 61.5%. This share has decreased from 22.8% in 2008.

Conversely, research performed by the higher education sector has increased over the same period from 43.7% to 49.6% of GERD, a value which is more than twice the EU average. In 2010 the government budget for R&D amounted to 0.46% of GDP to be compared with the EU average of 0.76%. In 2009, 12.1% of R&D was financed from abroad compared to an EU average of 8.4%. The main source of foreign funding has been the EU Framework Programme for Research and Technological Development (FP7). Cyprus is successful in raising funds from the FP7. Around one third of the EU funds raised by Cypriot participants through the FP7 up to February 2012 were directed to SMEs i.e. € 18.7 million out of € 52.55 million. Cyprus has most FP7 collaborative links with the United Kingdom, Germany and Greece.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Cyprus's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit

Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) The values refer to 2011 or to the latest available year.

(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.

(3) Fractional counting method.

(4) EU does not include DE, IE, EL, LU, NL.

The graph above shows that in the case of Cyprus FP7 funding per GERD is much higher than the EU average. The graph also shows that two other indicators, BERD financed from abroad (as percentage of total BERD) and employment in knowledge-intensive activities (as percentage of total employment aged between 15 and 64 years), have higher values than the EU average. The biggest gaps between Cyprus and the EU average occur for BERD as % of GDP, public expenditure on R&D financed by business enterprise as % of GDP, and PCT patent applications per GDP. These findings underline the conclusion that there is a significant underinvestment in research and innovation activities, affecting mainly the business sector.

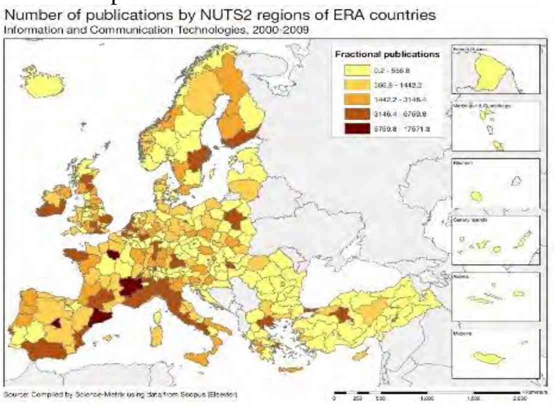
Research policy has a strong international dimension and is well aligned with the ERA pillars. ERA policy is seen as an opportunity to integrate the small national R&I system into the broader European market and in this context internationalisation of the research system is a high priority. The national scientific landscape does not provide space for large research infrastructures. However, due to the strong performance of its ICT and computing base, Cyprus puts particular emphasis on e-infrastructure. Cyprus participates actively in the FP7 and recent results confirm a successful participation in the ICT programme, in particular.

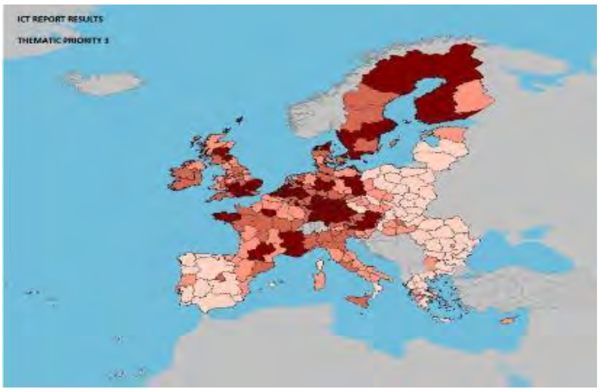
Cyprus' scientific and technological strengths

The maps below illustrate six key science and technology areas where Cyprus has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

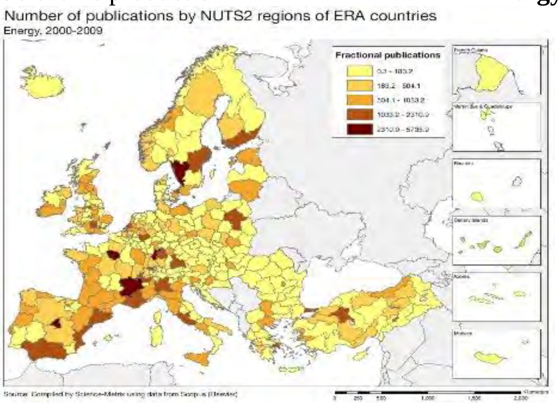
Strengths in science and technology at European level

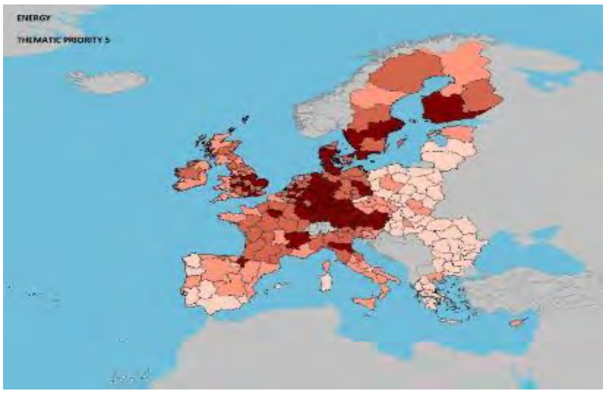
Scientific production **Information and Communication Technologies** Technological production



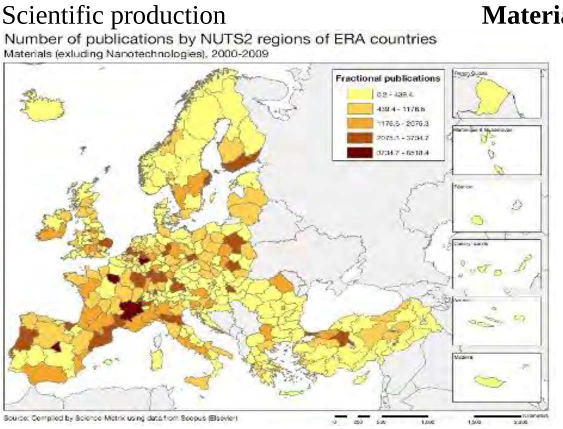


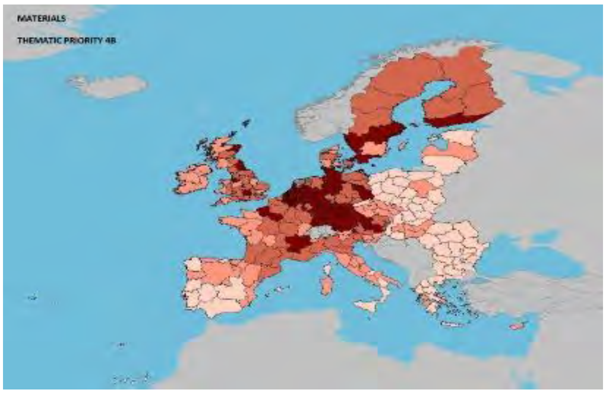
Scientific production **Energy** Technological production





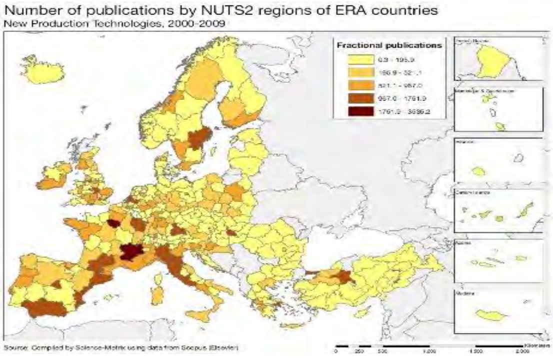
Scientific production **Materials** Technological production

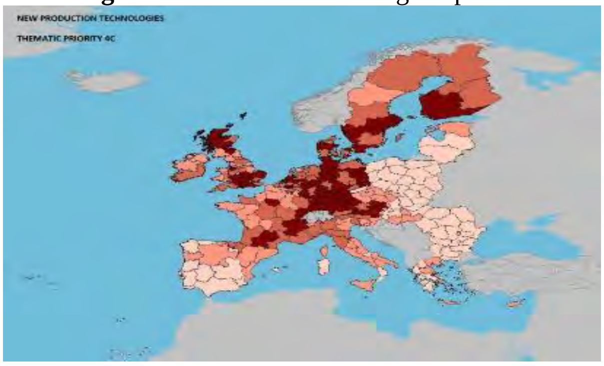




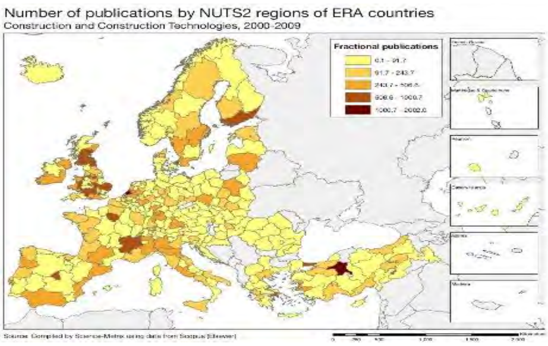
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

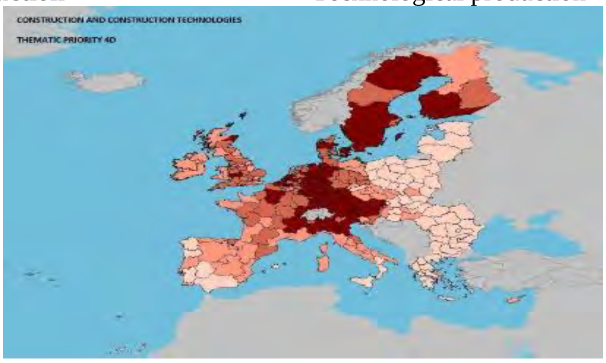
Scientific production **New production technologies** Technological production



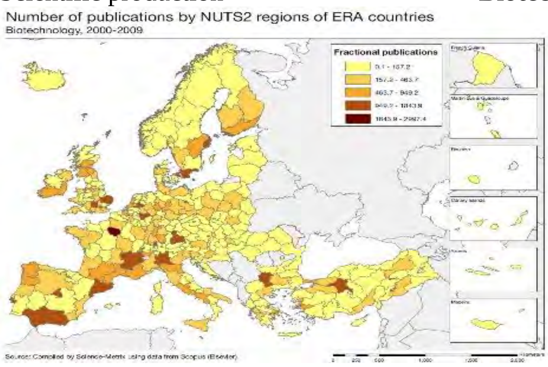


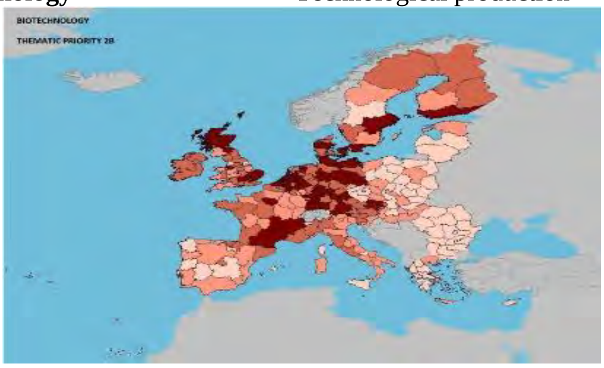
Scientific production **Construction** Technological production





Scientific production **Biotechnology** Technological production





In terms of research output, Cyprus is underperforming. In 2010 Cyprus had the fourth lowest number of scientific publications in the EU ahead of Luxembourg, Latvia, and Malta. However, Cyprus had the second highest average annual growth rate in the EU after Luxembourg in numbers of scientific publications between 2000 and 2010. The level of PCT patent applications is very low with Cyprus well below the EU average. The situation concerning PCT patent applications in societal challenges is even worse.

Bibliometric indicators between 2000 and 2009 on information and communication technologies (ICT), as a FP7 thematic priority, show that Cyprus has one of the highest specialisation index values at 2.59. In addition the collaboration index in information and communication technologies (ICT) for Cyprus at 1.44 is at the highest level in the EU.

The growth index for Cyprus in the field of materials (excluding nanotechnologies) is also very high. Cyprus together with Israel and Denmark has the highest ARIF score (the average of relative impact factors) in this field.

Cyprus produced the most collaborative publications in the EU, relative to its size, in the FP7 research theme of new production technologies (with a Collaborative Index value of 1.82). It has the second highest growth index value (3.84) behind Lithuania for scientific publications in the field of construction and construction technologies. Cyprus together with Lithuania and Turkey is amongst the most specialised countries in this field.

Cyprus has a very high ARC score (the average of relative citations) of 2.29 for scientific publications on energy, meaning that these publications are cited more than twice as often, on average, than the world level in this research area. In addition, 21.2% of Cypriot scientific publications in the field of energy are in the top 10% most cited publications in this field. This is one of the highest levels in the EU.

A quantitative analysis of the numbers of EPO patents (2000-2010) by applicant classified by FP7 thematic priorities shows that Cyprus achieved good results in the fields of information and communication technologies (ICT), new production technologies, construction technologies, materials, and energy and environment. These are areas in which Cyprus also had its best outputs in terms of scientific publications over the last decade.

Policies and reforms for research and innovation

The new R&I strategy currently in preparation should better address the main challenges of the R&I system. These include a more focused employment of the limited financial resources to ensure smart specialisation, better prioritisation, an increased involvement of SMEs in R&I activities and more career opportunities for researchers. In the new research and innovation strategy, research priorities will target a broad spectrum of multi-thematic research projects in the following pre-selected fields: manufacturing technologies, information and communication technologies, sustainable development, health and bio-sciences and social sciences.
The low level of innovation in Cyprus is linked to its particular economic structure which has a limited capacity to increase private research and innovation. The Government is making efforts to support a more active involvement of businesses in innovation activities by introducing new subsidy schemes for enterprises.

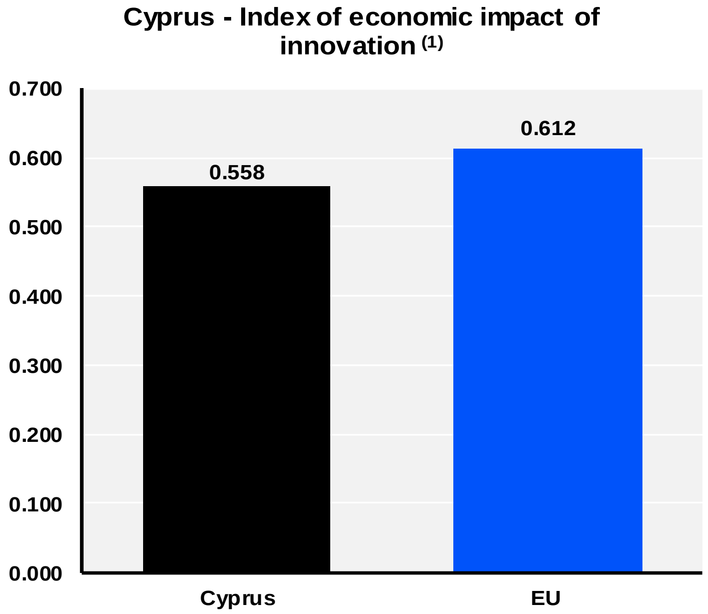
The European Commission recommended in 2012 that the government should take further measures to reinforce occupational mobility towards activities of high growth and high value added and to address youth unemployment, with an emphasis on work placements in companies and promotion of self-employment, as well as appropriate policy measures on the demand side to stimulate business innovation. As the service sector is significantly more developed than industry, measures in favour of non-technological innovation could be a useful option to take into consideration.

The Research Promotion Foundation was established in 1996 to promote the development of scientific research, technology and innovation. The National Framework Programme (2008-2010) is a medium-term development mechanism aiming at the development of research and innovation sector of the Cypriot economy. It covers the main research and innovative activities that have been supported and financed by the Research Promotion Foundation and the Structural Funds of the European Union. The budget for new calls for proposals was around € 14.5 million in February 2011.

To date, Cyprus has allocated only around 18% of available Structural Funds (2007-2013) under the Operational Programme for 'Sustainable development and Competitiveness' to knowledge society and innovation. As a result of a limited institutional capacity to absorb these funds, the Cypriot authorities have indicated their intention to redirect a part of this already limited share to other priorities.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[17].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The performance of Cyprus on four out of the five indicators composing this index is slightly above the EU average: contribution of high- and medium-tech products to the trade balance, knowledge-intensive services exports, employment in knowledge intensive activities, sales of new-to-market and new-to-firm products. The resulting index value is below the EU average due to the very low performance of Cyprus in patents inventions.

Business demand is still low and special efforts would be needed to develop an innovation culture among firms. Policies promoting innovation are recent and have a relatively limited impact. Support for innovation is mainly based on traditional direct funding. Venture capital schemes and other less traditional financial incentives are almost non-existent. The government intends to use public procurement as a demand side policy to drive innovation. The adoption of pre-commercial procurement is expected to act as an important stimulus for innovation. However, commercial exploitation of knowledge is difficult to increase further without a significant increase in demand.

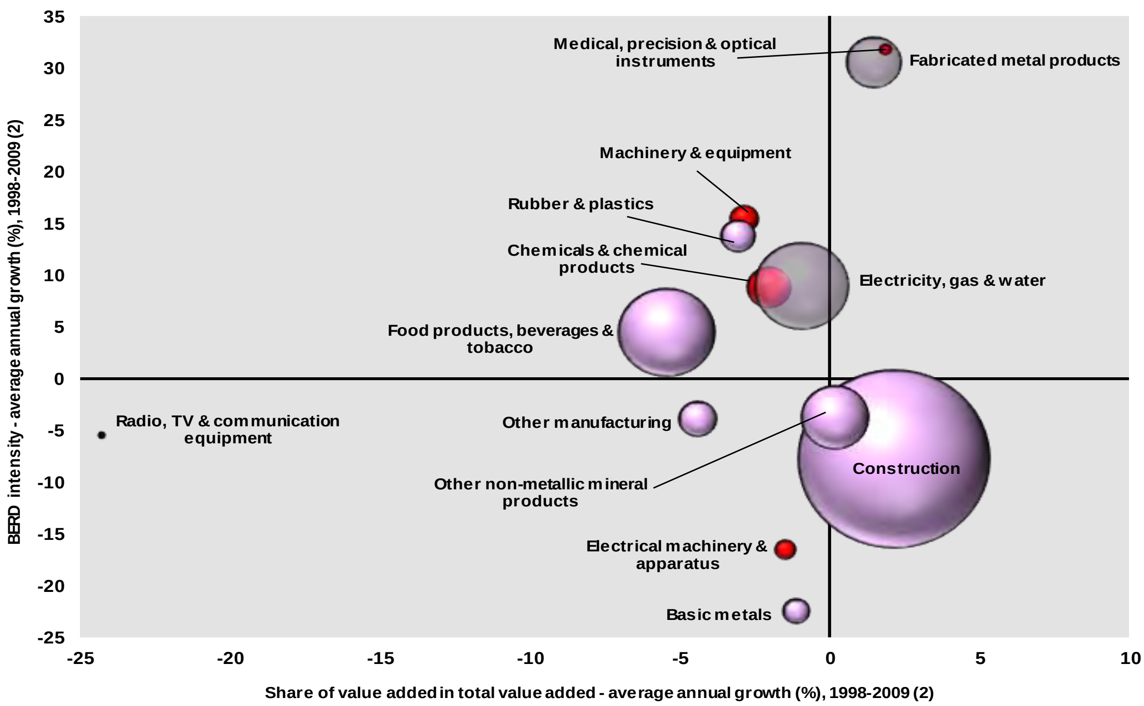
A scheme of innovation vouchers is a relatively new measure which is being used to stimulate a more active involvement of SMEs in innovation activities in collaboration with research organisations. The Research Promotion Foundation (RPF) supports the strengthening of links between the academic and business sectors in coordination with the Business Support Centre of Cyprus which is a member of the Enterprise Europe Network. Recent measures supported by the RPF aim to bridge the gap between the supply and demand of innovation through a mechanism of intermediation between research institutions and SMEs. In 2009-2010, an "innovation clusters" measure targeted the creation of cooperation networks between enterprises, public research organisations and intermediaries.

[17] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Cyprus - Share of value added versus BERD intensity - average annual growth, 1998-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: Eurostat
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red.
(2) 'Construction', 'Fabricated metal products': 2001-2009; 'Electricity, gas and water': 2002-2009; 'Basic metals', 'Other manufacturing': 2005-2009; 'Radio, TV and communication equipment': 2006-2009,

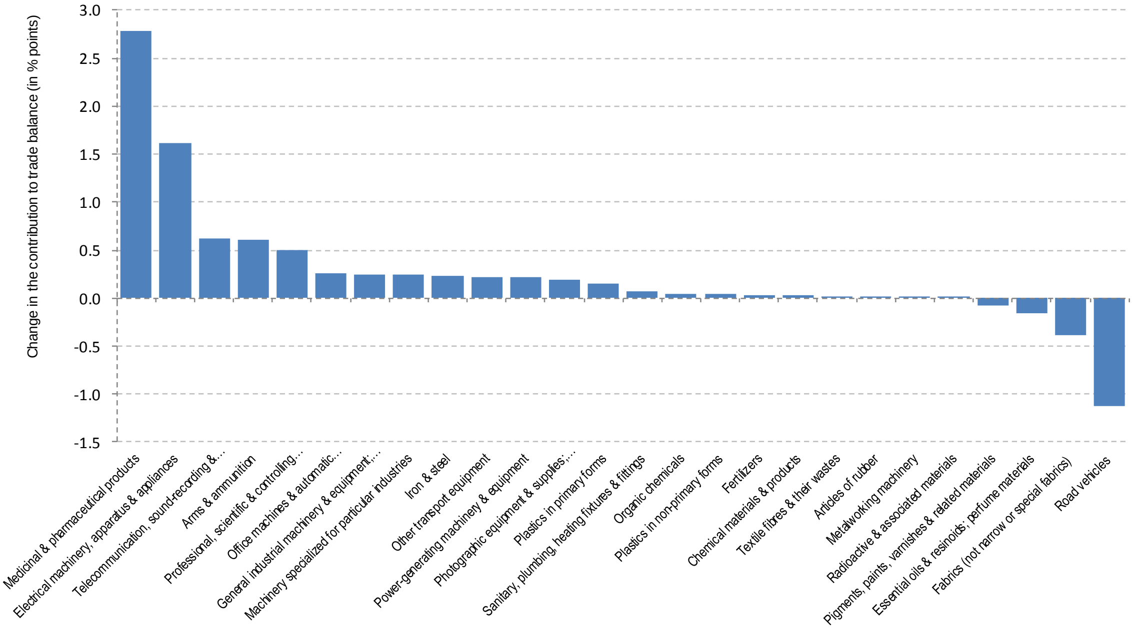
The Cypriot economy is dominated by very small sized family-run enterprises with limited export orientation. This economic structure does not favour R&D. The economy of Cyprus is dominated by the service sector, mainly tourism, transport and finance, with manufacturing representing only around 7%. SMEs which provide mostly low value added support services are unlikely to invest in research and innovation. Most firms tend to concentrate on low value added products and services and do not take risks on new products or export markets.

The graph above shows that manufacturing industry in Cyprus is largely dominated by low and medium-low-tech sectors (which are less research intensive) and mainly by the construction sector followed by the electricity, gas and water sector and the food products, beverages and tobacco sector. Structural changes towards more research-intensive economies are in general driven by high and medium-high-tech manufacturing sectors. In Cyprus, there are three such sectors: machinery and equipment, chemicals and chemical products, and electrical machinery and apparatus. Three manufacturing sectors have an increased their weights in the economy: construction, other non-metallic mineral products, and fabricated metal products which also had the highest growth in research intensity.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Cyprus between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The Cypriot economy is currently facing the challenge of strengthening its external competitiveness and fostering growth. The deteriorating outlook for growth and increasing unemployment are challenges for Cyprus's economy which grew by a modest 0.5 % in 2011. GDP is projected to contract by 0.8% in 2012 due to a fall in domestic demand, traditionally the main driver of growth, and to the weaker external environment, in particular persistent financial market uncertainty. The large exposure of the financial sector to Greece and the banks' need for recapitalisation have increased the cost of financing and have limited the availability of finance to the private sector. Conversely, the external sector has made a positive contribution to growth.

The graph above shows that most high-tech and medium-tech industries have increased their contribution to Cyprus's trade balance over the period 2000-2011. Those industries which significantly improved their contribution are medical and pharmaceutical products, electrical machinery, and telecommunications. In contrast, the contributions of the road vehicles industry, fabrics woven of man-made textile materials and other transport equipment have significantly diminished.

Cyprus is making progress towards most of the Europe 2020 targets, with the exceptions of the targets for greenhouse gas emissions and the share of the population at risk of poverty. Technology development is oriented towards societal challenges such as environment and health, but there is a falling number of environment-related patents. Total factor productivity in the Cypriot economy stagnated between 2000 and 2008, after which it decreased markedly during the economic crisis.

Key indicators for Cyprus

CYPRUS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.13	0.03	0.02	0.01	0.12	0.04	0.25	0.13	0.22	0.23	0.23	:	:	5.7	*1.69*	26
Business enterprise expenditure on R&D (BERD) as % of GDP	0.05	0.05	0.06	0.08	0.08	0.09	0.10	0.10	0.10	0.10	0.09	*0.08*	:	*3.4*	*1.26*	27
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.18	0.18	0.21	0.25	0.26	0.29	0.30	0.31	0.28	0.33	0.34	*0.33*	:	*6.0*	*0.74*	24
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	27.5	:	:	:	:	27.8	:	:	0.2	47.9	16
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	3.7	5.5	9.4	9.6	9.5	7.0	7.9	9.0	8.9	:	:	:	:	11.7	10.9	16
International scientific co-publications per million population	151	142	193	206	366	419	484	578	699	857	985 (3)	1004	:	21.3	300	9
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	14	13	16	27	27	:	17.1	53	17
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.8	1.0	0.4	0.9	0.2	1.0	0.6	0.3	0.5	0.6	:	:	:	-3.3	3.9	20
License and patent revenues from abroad as % of GDP	:	:	:	:	0.11	0.09	0.09	0.10	0.05	0.05	0.04	0.01	:	-28.2	0.58	25
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	5.6	:	12.3	:	16.1	:	14.7	:	:	17.6	14.4	10
Knowledge-intensive services exports as % total service exports	:	:	:	:	34.9	33.2	35.2	41.2	47.1	47.5	48.5	:	:	5.6	45.1	6
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-4.71	-3.91	-1.25	-0.35	1.82	3.79	1.78	0.60	-0.13	1.07	0.66	1.72	:	-	4,20 (4)	14
Growth of total factor productivity (total economy) - 2000 = 100	100	101	101	99	99	99	100	101	101	97	97	96	96	-4 (5)	103	25
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	32.0	:	:	:	:	38.4	:	:	:	:	44.1	:	:	3.3	48.7	15
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	14.8	14.1	14.2	15.1	:	0.6	13.6	8
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	45.2	:	37.9	:	42.2	:	34.8	:	:	-4.3	38.4	14
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.13	0.24	0.10	0.05	0.00	0.17	0.10	0.12	0.10	:	:	:	:	-2.9	0.39	15
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.09	0.26	0.16	0.07	0.00	0.26	0.06	0.11	0.00	:	:	:	:	4.2	0.52	20 (6)
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	72.3	74.1	75.1	75.4	74.9	74.4	75.8	76.8	76.5	75.7	75.4	73.8	:	0.2	68.6	6
R&D Intensity (GERD as % of GDP)	0.25	0.26	0.30	0.35	0.37	0.41	0.43	0.44	0.43	0.49	0.50	*0.48*	:	*6.2*	*2.03*	27
Greenhouse gas emissions - 1990 = 100	156	154	161	167	173	171	178	177	176	172	168	:	:	12 (7)	85	27 (8)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	2.4	2.4	2.5	3.1	4.1	4.6	4.8	:	:	12.2	12.5	23
Share of population aged 30-34 who have successfully completed tertiary education (%)	31.1	32.7	36.0	39.9	41.0	40.8	46.1	46.2	47.1	44.7	45.1	45.8	:	3.6	34.6	5
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	25.3	25.4	25.2	22,4 (9)	22.9	22.9	23.5	:	1.6	*24.2*	16 (8)

Source: DG Research and Innovation - Economic Analysis Unit
Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.
(2) EU average for the latest available year.
(3) Break in series between 2010 and the previous years. Average annual growth refers to 2000-2009.
(4) EU is the weighted average of the values for the Member States.
(5) The value is the difference between 2012 and 2000.
(6) Rank in 2007.
(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.
(8) The values for this indicator were ranked from lowest to highest.
(9) Break in series between 2008 and the previous years. Average annual growth refers to 2008-2011.
(10) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Take appropriate policy measures on the demand side to stimulate business innovation."

The Czech Republic

Improving the output of the science base to foster business R&I investment

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in the Czech Republic. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	**Performance/economic output**
Research	*R&D intensity* 2011: 1.84% (EU: 2.03%; US: 2.75%) 2000-2011: +4.23% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:29.9 (EU:47.86; US: 56.68) 2005-2010: +4.58% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.497 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:39.58 (EU:48.75; US: 56.25) 2000-2010: +2.91% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Automobiles, transport, construction, materials, energy and environment	*HT + MT contribution to the trade balance* 2011: 3.82% (EU[1]: 4.2%; US: 1.93%) 2000-2011: +42.62% (EU[1]: +4.99%; US:-10.75%)

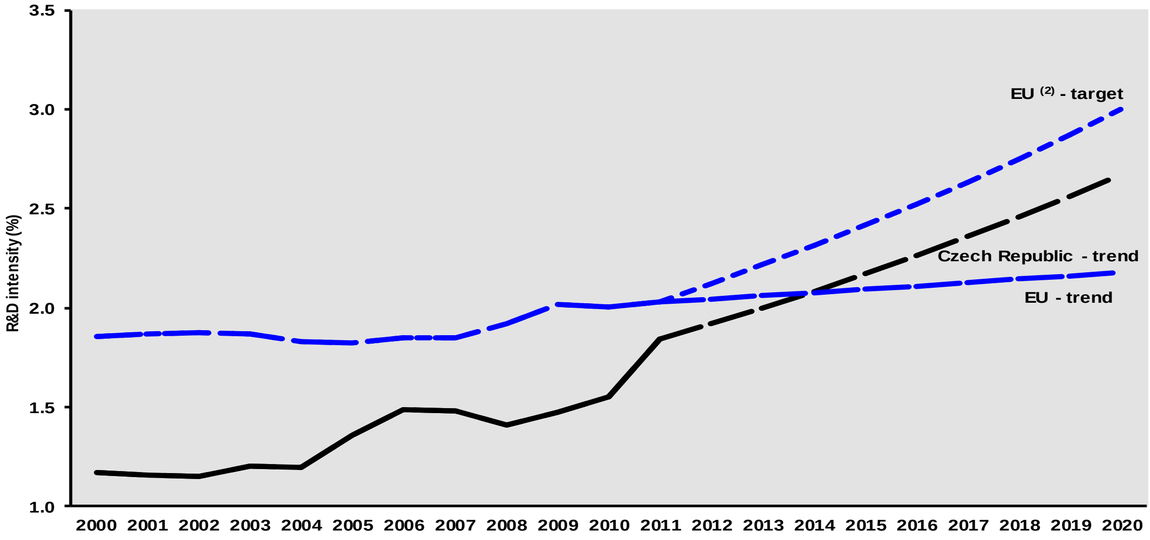
Public funding of R&D and the available pool of S&E graduates are in line with the level of development of the Czech economy although the level of excellence in S&T is markedly lower than the EU average (with the exception of S&T in other transport and energy) and is catching up only very slowly, which impacts negatively on the ability of the Czech innovation base to expand to its full potential. As a result, business investment in R&D is relatively low in relation to the structure of the economy (size of the manufacturing sector in general and of HT and MT sectors in particular) and the innovation performance of the country is sub-optimal. The situation is, however, improving as evidenced by the structural change towards a more knowledge-intensive economy and the fast-rising contribution of HT and MT sectors to the trade balance. The latter has increased much faster than the EU average in spite of a sharp improvement in the total trade balance over the same period.

Despite progress, the main challenge for the Czech research and innovation system remains therefore the insufficient quality of the scientific and technological output of the science base, which is notably linked to an inadequate system for evaluating research and allocating public R&D funding. Despite a public R&D intensity of 0.72%, similar to the EU average, the level of S&T excellence and the amount of intellectual property assets produced remain, in relative terms, well below the EU average.

Another persistent weakness of the Czech research and innovation system is the low extent of cooperation between the science base and the business sector originating from a combination of poor absorptive capacity of domestic firms, a lack of incentives to support collaboration between universities and firms and the shortage of scientific and engineering skills. This is evidenced notably by the extremely low shares of the R&D carried out by universities and by the government sector that are funded by business - 1% and 3.4%, respectively. According to innovation surveys, neither universities nor public research organisations are considered by firms as key partners for their innovation activities. These challenges are linked to the overdue reform of the higher education system and to the persistent weaknesses of the current system for evaluating research performance and allocating public R&D funding to higher education and research institutions. The Czech Republic International Competitiveness strategy for 2012-2020 plans to address several of these issues, as described in the following parts of the present country profile.

Investing in knowledge

Czech Republic - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) CZ: An R&D intensity target for 2020 is not available.

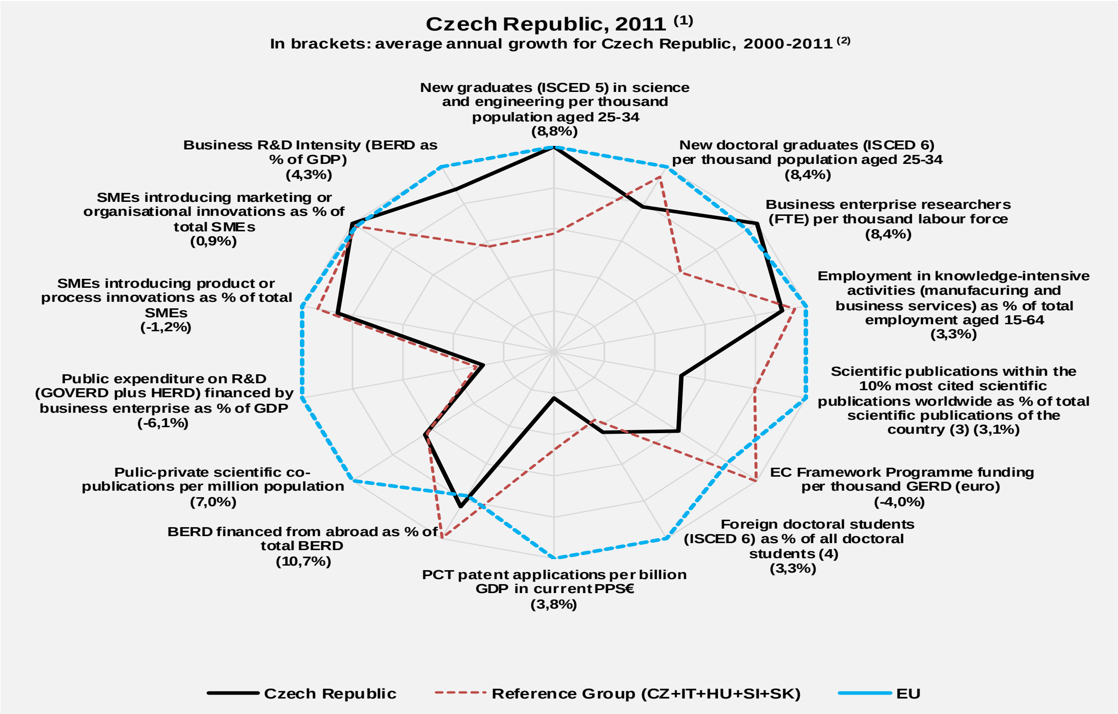
R&D intensity rose steadily from 1.17% in 2000 to 1.49% in 2006 at an average annual growth rate of 4.1%, before falling to 1.41% in 2008 and rising again to 1.84% in 2011. In 2011, the Czech Republic set a target for public funding of R&D of 1% of GDP by 2020. This indicator currently stands at 0.70%, very close to the EU average and significantly higher than in most other EU-12 Member States. The government budget for R&D has so far been protected during the economic crisis (€ 1053 million in 2011) but there is currently no multiannual funding framework to ensure that it will continue to increase.

The relatively good performance of the Czech research and innovation system in terms of business expenditure on R&D (BERD reached 1.11% of GDP in 2011) is largely due to a strong manufacturing sector (24% of total value added in 2009) with a marked industrial specialisation in innovative sectors (such as 'motor vehicles' and 'electrical equipment'), combined with an increasing level of R&D financed from abroad (0.28% of GDP in 2010). However, BERD is highly concentrated in a few multinational corporations that accounted for 55% of total BERD in 2009. Whereas BERD performed by domestic companies almost doubled from € 284 million in 1998 to € 487 million in 2009, inward BERD increased six fold during the same period. This reflects the country’s rising attractiveness for foreign R&D activities and highlights the growing role played by foreign firms in the Czech research and innovation system. Medium-high-tech (MHT) manufacturing and knowledge-intensive services account for the larger share of total inward BERD. The share of inward BERD in high-tech industries almost doubled from 2002 to 2009 (16%) and the share of inward BERD in knowledge-intensive services almost tripled between 2002 and 2009 (22%). During the same period, the share of inward BERD decreased in the MHT sectors, as exemplified by the motor vehicles sector where it went down from 65% in 2002 to 37% in 2009.

About € 5.8 billion of Structural Funds are earmarked for research, innovation and entrepreneurship in the Czech Republic in the current programming period (2007-2013). This represents 22.1% of total ERDF Structural Funds. Structural Funds are therefore one of the largest sources of public funding of R&D in the Czech Republic. Up to 2010, 34.3% of these funds had been absorbed. The success rate of Czech entities in FP7 (20%) is only marginally lower than the EU average (22%) but, if overall progress in quality was significant, their share of the total funding (0.72%) – which corresponds to more than € 164 million - could still be improved when compared to the share of the Czech Republic in total EU investment in R&D (0.95%).

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Czech R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The Czech innovation system displays a complex pattern of relative strengths and weaknesses affecting both its input and output. While it currently scores lower than the EU average on most S&T indicators, it has been catching up with the group of innovation followers[18] and outperforms its reference group in terms of new graduates in science and engineering, business R&D intensity, researchers employed by the business sector and innovation in SMEs. The region of Prague is amongst the EU regions with the highest share of researchers (full-time equivalent) in total employment (superior to 1.8%) and is the EU leader in terms of the share of the labour force employed in a S&T occupation (more than 50%). Other relative strengths include international co-publications, non-R&D business expenditure and HT and MT exports. The number of international scientific co-publications has surged over the last decade, in particular in partnerships with Germany, the United Kingdom, France, Italy and Slovakia, which is evidence of increased scientific networking within the ERA.

The S&T output of the Czech innovation system is critically weak in terms of high impact scientific publications, PCT patents and attractiveness to foreign doctoral students (other than Slovaks). Other marked weaknesses highlighted in the IU scoreboard include public R&D expenditure, access to venture capital and license and patent revenues from abroad. There are also relatively few co-inventions of patents, which may hint at potential weaknesses in the capacity to engage in international technological networks.

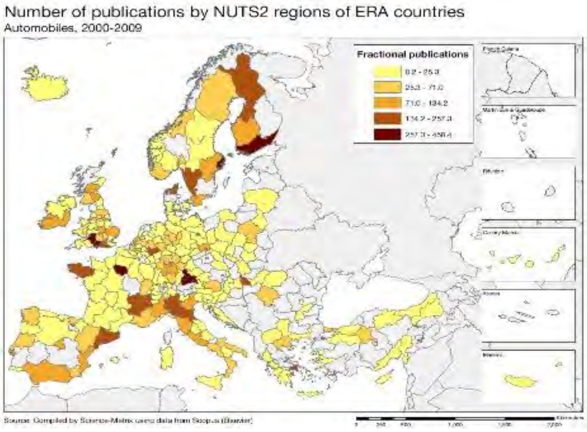
[18] IU scoreboard 2011: http://www.proinno-europe.eu/inno-metrics/page/country-profiles-czech-repucblic

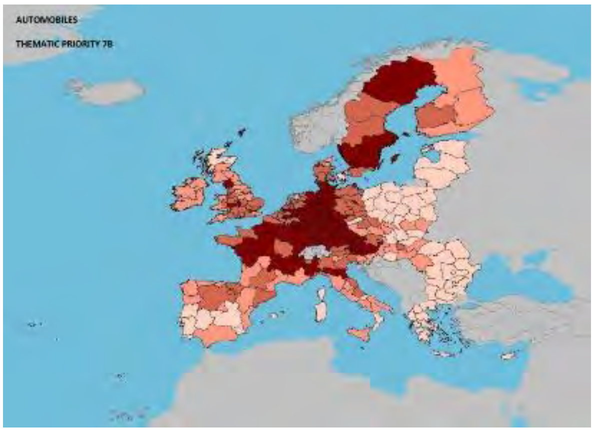
The Czech Republic's scientific and technological strengths

The maps below illustrate six key science and technology areas where the Czech Republic has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

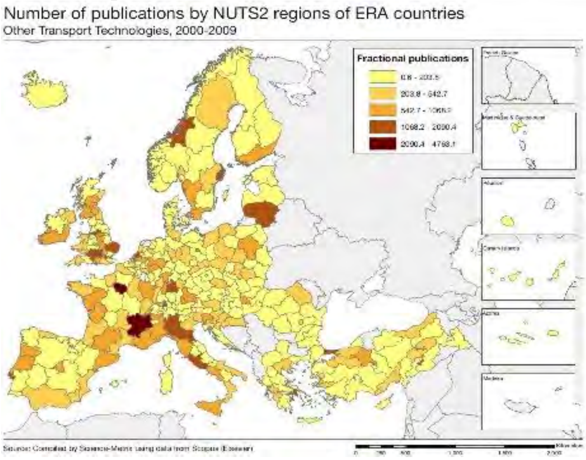
Strengths in science and technology at European level

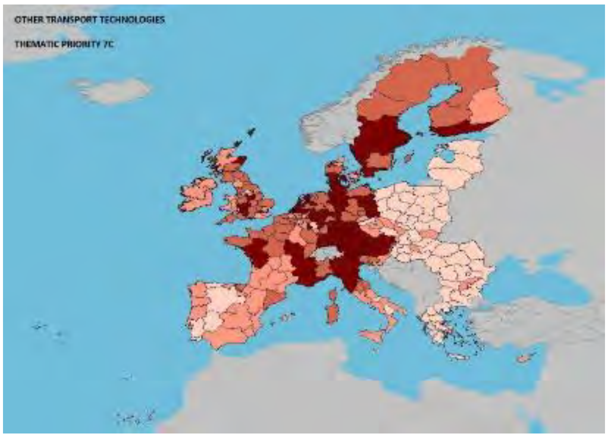
Scientific production **Automobiles** Technological production



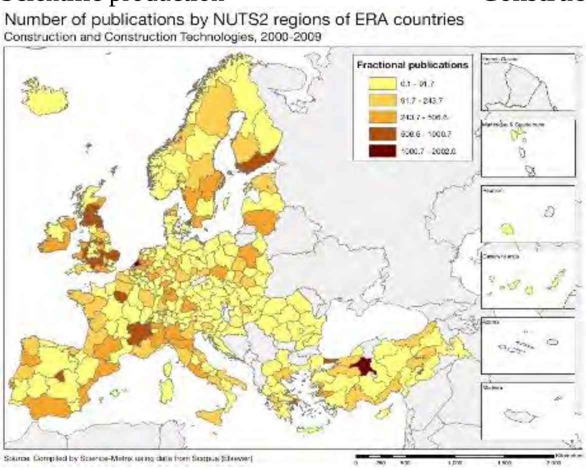


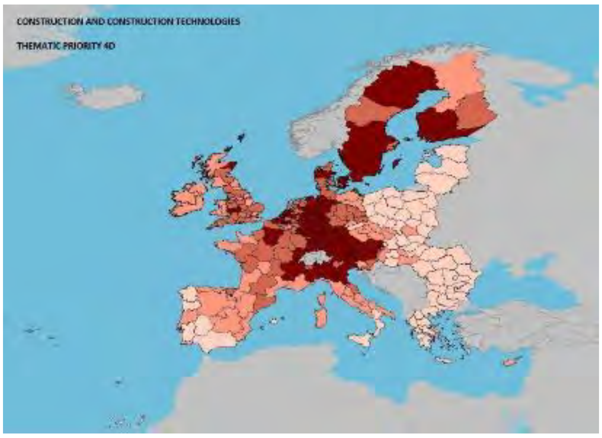
Scientific production **Other transport** Technological production





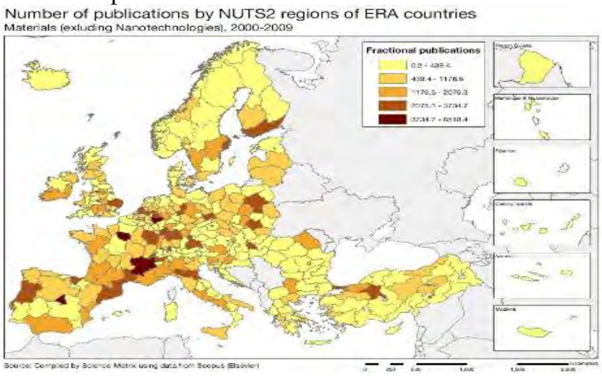
Scientific production **Construction** Technological production

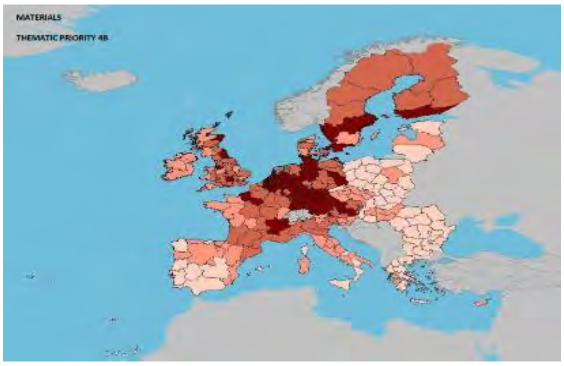




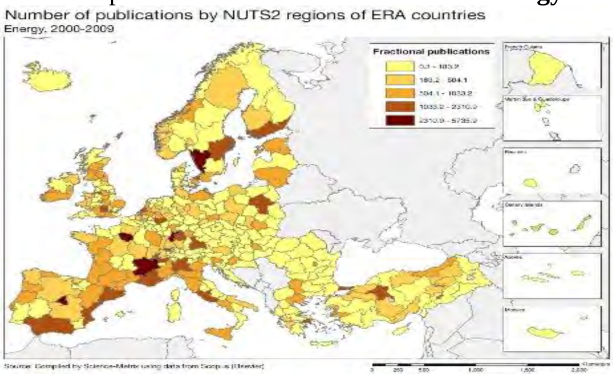
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

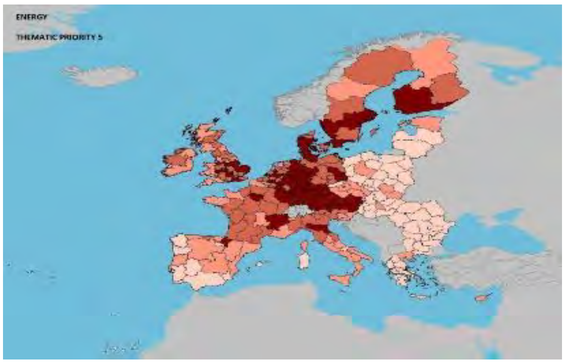
Scientific production **Materials** Technological production



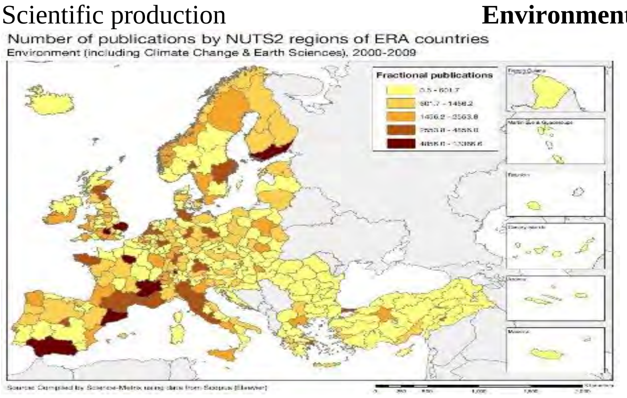


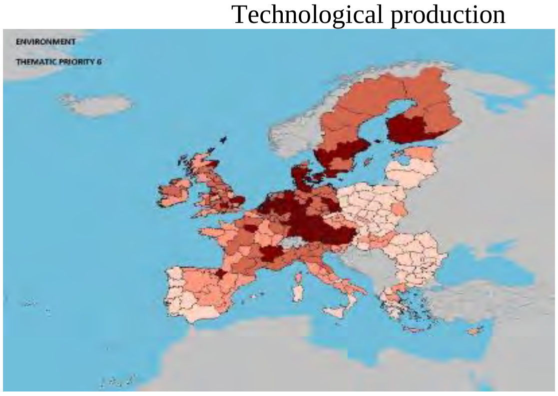
Scientific production **Energy** Technological production





Scientific production **Environment** Technological production





There is a considerable diversity in the Czech Republic amongst regional innovation performances, ranging from low to medium-high[19]. Overall, other transport, construction, materials, energy, and environment are the five areas where the Czech Republic combines a strong scientific output in terms of the number of scientific publications and a strong technological output in terms of the number of patent applications. In the case of other transport and energy this combination is further reinforced by the quality of the scientific output. While the automobiles sector also features a strong technological output, the corresponding scientific field displays weak outputs. Food, agriculture and fisheries stands out as an area of strong scientific specialisation with many publications but has poor scientific impact and little technological output.

In terms of EPO patent applications the Czech Republic and all regions lag significantly behind the European average - in particular in ICT and biotech applications - and on average only 4.9% of Czech scientific publications are amongst the 10% most cited worldwide. Energy, aeronautics and space and transport stand out as scientific fields where the Czech Republic displays a high degree of scientific excellence and of international collaboration. This is also true to a lesser degree for research on biotech, materials and new production technologies. However, with the exception of materials science, these are not areas of high specialisation in the Czech science base.

[19] Corresponding resp. to Severozapad and Prague

Policies and reforms for research and innovation

Recent reforms are intended to put the Czech innovation system on path to converge with the EU innovation followers by 2020. The Czech Republic International Competitiveness Strategy for 2012-2020, which includes the new National Innovation Strategy (NIS), aims to strengthen the importance of innovation as a source of competitiveness for the Czech Republic. It builds on the ambitious reform programme presented in the 2011 and 2012 NRPs to increase the effectiveness of the national research and innovation system, including the quality of its output and the links between the science base and the business sector. This includes amending the Investment Incentives Act to offer investors (as of July 2012) tax incentives for creating or upgrading manufacturing facilities, R&D centres and business support centres; amending the Income Tax Act so that private firms can (as of January 2014) deduct from their taxable income the cost of R&D activities contracted out; launching new programmes to stimulate cooperation between R&D institutions and industry in sectors such as transport, energy and environment through the ALFA Programme of the Technology Agency (which also supports the development of Competence Centres); developing a new evaluation methodology to ensure that long-term R&D financing is based on excellence/quality and that support is focused on the best research teams; creating a fund to improve access to venture capital for financing innovation; reforming the tertiary education system and improving researchers' career prospects, especially for top scientists, in order to prevent brain drain.

The implementation of the International Competitiveness Strategy is coordinated by an intergovernmental Steering Committee which is also responsible for the National Innovation Strategy. However, the governance of the national research and innovation system would benefit from a clarification of the respective roles of this Steering Committee and of the Council for R&D and Innovation which advises the Prime Minister on related matters.

The national R&D target currently only covers public funding of R&D. The lack of commitment to an overall R&D target, encompassing both public and private R&D intensity, could jeopardise the adoption (and/or endanger the rigorous implementation) of important policies and measures to incentivise private R&D investment. There are also important delays in implementing the planned reforms which may lead to a loss of attractiveness for domestic and foreign R&I investors. This is particularly the case for the overdue modernisation of the higher education system which is a prerequisite to a change of attitude of academia towards the business sector with whom it should start developing stronger collaborations[20].

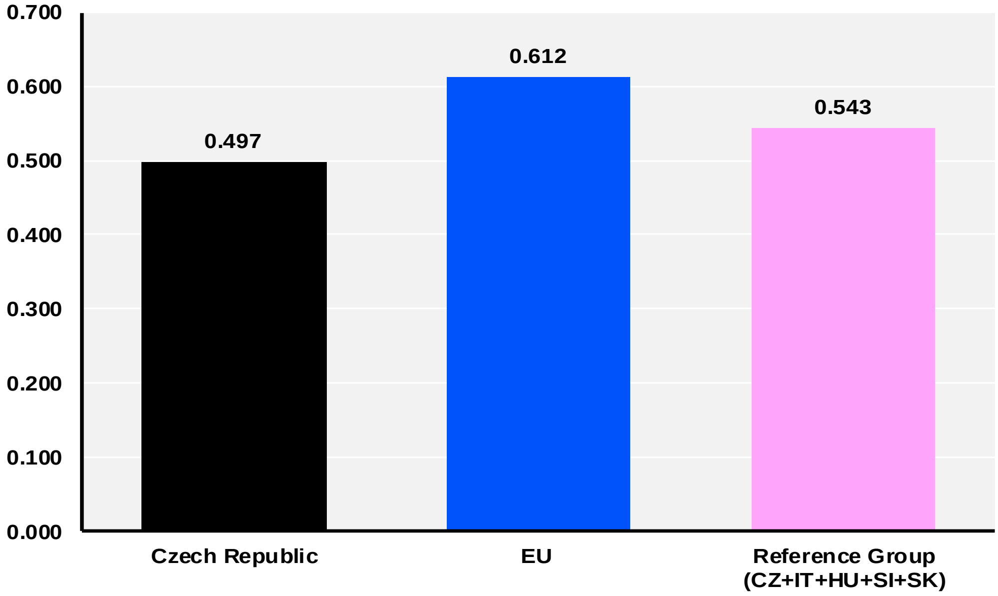
A broad set of priorities for applied research, development and innovation had been defined for the period 2009-2011 by the Council for R&D and innovation, covering in particular biological and ecological aspects of sustainable development; molecular biology and biotechnologies; sources of energy; smart materials; competitive engineering; information society; security and defence. As part of the revision of the National R&D&I policy 2009-2015, the Government adopted in July 2012 a new set of better targeted priorities focusing on six major societal challenges (competitive knowledge economy, sustainable energy and material resources, environment for quality life, social and cultural challenges, healthy people and secure society). The priorities were identified on the basis of the work of expert panels and cover the period up until 2030. A detailed plan of implementation (starting in 2014) will be submitted to the Government by July 2013.

[20] The proposed Higher Education Act was rejected in June 2012

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[21].

Czech Republic - Index of economic impact of innovation (1)



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

According to this index, the Czech Republic underperforms its reference group and is clearly below the EU average. The country ranks 17th due in particular to its poor performance in "patent applications per GDP" and "share of knowledge intensive services in total export of services". These marked weaknesses reflect the still insufficient innovation orientation of the national economy and are only partly compensated by a strong performance in terms of the "contribution of medium and high-tech product exports to the trade balance" and the "sales of new to market and new to firm innovations as % of turnover of firms".

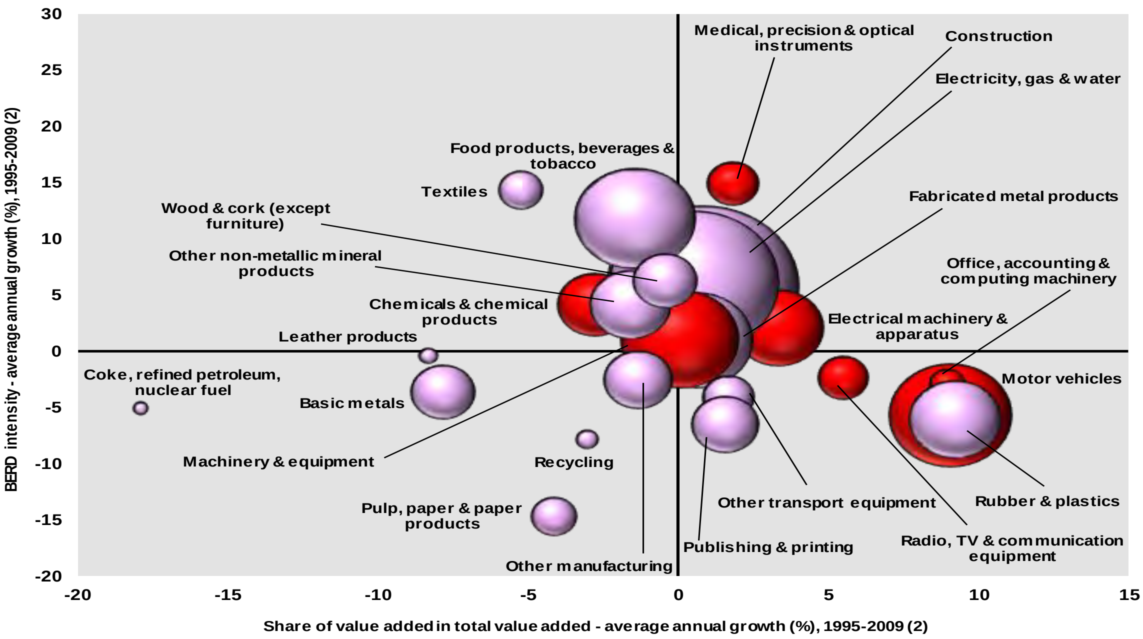
Recent policies and reforms – including the extension of the R&D tax incentives, the setting up of a seed fund and the Government's recent approval of a joint stock company to support the creation of SMEs and the development of innovative and technologically oriented enterprises – can contribute to establishing a more stable and predictable legal framework for developing innovation activities. At present the main instruments available for supporting the growth of innovative SMEs are two loan guarantee schemes (one of them is funded through OP Enterprise and innovation) and the more recent pre-seed fund. The capacity to transform the Czech Republic into a strong innovation-oriented economy by 2020 will ultimately depend on the capacity to implement the recent and planed reforms quickly and effectively.

[21] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Czech Republic - Share of value added versus BERD intensity - average annual growth, 1995-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Publishing and printing': 1996-2009; 'Recycling': 2000-2009.

The graph above shows that the weights in the economy (horizontal axis) and/or the *BERD intensities* (vertical axis) of almost all manufacturing sectors in the Czech Republic have increased substantially since 1995. This trend concerns all the HT and MHT manufacturing sectors (colored in red) - in particular motor vehicles, electrical machinery and apparatus and machinery and equipment - which are all contributing to the overall increase of total BERD in the Czech Republic.

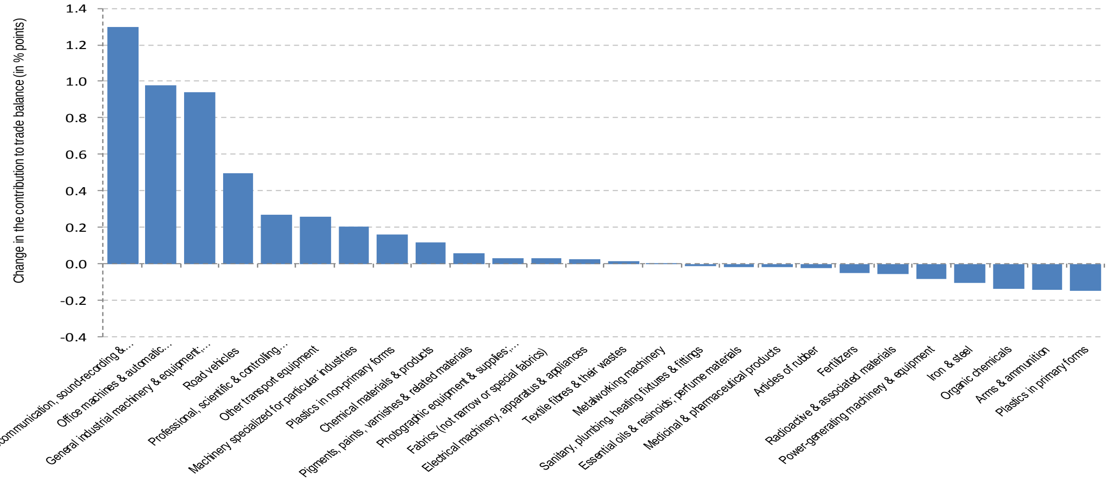
This reflects to a large extent the attractiveness of the country for foreign investors, with 55% of BERD performed by foreign-owned affiliates. The share of inward BERD doubled over the period 1999-2009. Around 80% of this inward BERD comes from EU-owned firms out of which half comes from German-owned firms. With shares of inward BERD in total BERD of more than 85%, pharmaceuticals and motor vehicles are the manufacturing sectors that show the highest degree of internationalisation. The dominance of foreign affiliates in HT and MHT sectors is reflected by the absence of Czech firms amongst the EU top 1000 R&D investing firms[22]. In the manufacturing sector, the share of inward BERD in total BERD (about two thirds) is slightly higher than the share of the value added created by foreign affiliates, indicating that foreign-owned affiliates investing in the Czech Republic also invest in R&D and that their R&D intensity is equal or above that of domestic firms. In other words, inward BERD follows FDI.

[22] EU Industrial R&D Scoreboard

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Czech Republic between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The trade balance in high-tech (HT) and medium-tech (MT) products of the Czech economy improved considerably between 2000 and 2010. At the beginning of the period the country was running a mild trade deficit to which HT/MT products were contributing. Starting in 2004, HT/MT sectors literally pulled the trade balance out of the red, more than offsetting trade losses in other sectors. Since 2007 the HT/MT trade surplus has been maintained at a very high level and helped the country weather out the economic crisis. HT and MT products have therefore played a critical role in redressing the trade balance of the Czech economy and now constitute the backbone of its trade surplus, indicating a relative HT/MT trade specialisation.

The graph above shows the increase of this positive contribution for the majority of HT and MT products. The largest increases are for telecommunications and sound-recording and reproducing apparatus; office machines and automatic data-processing machines; general industrial machinery and equipment; and road vehicles. This shows that the trade balance situation of these products has improved even faster than the overall trade balance of the Czech Republic, indicating an increasing trade specialisation of the country in these products. This is also true to a lesser extent for professional, scientific and controlling instruments; other transport equipment; machinery specialised for particular industries;, plastics in non-primary form; and chemical materials and products.

The industries corresponding to these products have largely upgraded their R&D intensities and, with the exception of chemicals, they have been growing faster than the Czech economy on average (see graph in previous section), highlighting a mutually supporting pattern of trade and value added specialisation. In contrast, the trade balance in electrical machinery, apparatus and appliances has stagnated despite an increasing research intensity effort and share in the economy.

After an initial sharp increase by 20% from 2000 to 2006, total factor productivity has remained stable in the Czech Republic (table below) which is the 4th best performance in the EU. Regarding the Europe 2020 targets, the country's best ranking is attained for the risk of poverty (1st) and the worst for the level of tertiary education among the 30-34 years old. The employment rate is high, greenhouse gas emissions have been decreasing, backed up by clear growth in renewable energy and environmental technologies.

Key indicators for the Czech Republic

CZECH REPUBLIC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.59	0.68	0.84	0.95	1.03	1.12	1.17	1.31	1.37	1.38	1.32	:	:	8.4	*1.69*	16
Business enterprise expenditure on R&D (BERD) as % of GDP	0.70	0.70	0.70	0.73	0.75	0.86	0.97	0.92	0.87	0.88	0.96	1.11	:	4.3	*1.26*	11
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.46	0.46	0.44	0.46	0.45	0.49	0.51	0.56	0.53	0.58	0.58	0.72	:	4.1	*0.74*	9
Venture Capital (3) as % of GDP	0.19	0.04	0.03	0.00	0.01	0.01	0.00	0.05	0.02	0.04	0.03	0.12	:	-3.9	0,35 (4)	13 (4)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	23.9	:	:	:	:	29.9	:	:	4.6	47.9	15
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	4.3	3.9	4.1	4.4	4.7	5.0	5.4	4.8	5.5	:	:	:	:	3.1	10.9	21
International scientific co-publications per million population	190	178	193	273	311	344	390	423	442	466	509	529	:	9.8	300	18
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	26	28	31	33	34	:	7.0	53	13
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.6	0.6	0.6	0.7	0.7	0.7	0.8	1.0	1.0	0.9	:	:	:	3.8	3.9	18
License and patent revenues from abroad as % of GDP	:	:	:	:	0.03	0.03	0.02	0.02	0.03	0.05	0.05	0.05	:	5.9	0.58	20
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	15.5	:	14.6	:	18.7	:	15.3	:	:	-0.3	14.4	6
Knowledge-intensive services exports as % total service exports	:	:	:	:	20.8	31.6	29.7	29.3	30.1	29.3	27.3	:	:	4.6	45.1	15
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-0.26	0.11	3.05	0.71	1.74	3.02	3.74	3.52	3.77	3.53	3.42	3.82	:	-	4,20 (5)	7
Growth of total factor productivity (total economy) - 2000 = 100	100	102	103	106	110	115	120	124	124	119	121	122	120	20 (6)	103	4
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	29.7	:	:	:	:	35.0	:	:	:	:	39.6	:	:	2.9	48.7	18
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	11.2	11.3	11.8	12.3	:	3.3	13.6	17
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	35.5	:	32.0	:	34.9	:	33.0	:	:	-1.2	38.4	15
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.02	0.03	0.02	0.06	0.06	0.06	0.06	0.10	0.09	:	:	:	:	23.1	0.39	17
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.08	0.11	0.10	0.10	0.10	0.11	0.13	0.13	0.11	:	:	:	:	4.3	0.52	17
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	71.0	71.2	71.6	70.7	70.1	70.7	71.2	72.0	72.4	70.9	70.4	70.9	:	0.0	68.6	9
R&D Intensity (GERD as % of GDP)	1.17	1.16	1.15	1.20	1.20	1.35	1.49	1.48	1.41	1.47	1.55	1.84	:	4.2	*2.03*	11
Greenhouse gas emissions - 1990 = 100	74	74	72	74	75	75	76	76	73	69	71	:	:	-3 (7)	85	8 (8)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	6.1	6.1	6.5	7.4	7.6	8.5	9.2	:	:	7.1	12.5	18
Share of population aged 30-34 who have successfully completed tertiary education (%)	13.7	13.3	12.6	12.6	12.7	13.0	13.1	13.3	15.4	17.5	20.4	23.8	:	5.1	34.6	22
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	19.6	18.0	15.8	15.3	14.0	14.4	15.3	:	-4.0	*24.2*	1 (8)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Adopt the necessary legislation to establish a transparent and clearly defined system for quality evaluation of higher education and research institutions. Ensure that the funding is sustainable and linked to the outcome of the quality assessment."

Denmark

Innovation for productivity addressing societal challenges

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Denmark. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 3.09% (EU: 2.03%; US: 2.75%) 2000-2011: +4.64% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:77.65 (EU:47.86; US: 56.68) 2005-2010: +3.41% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.713 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:54.95 (EU:48.75; US: 56.25) 2000-2010: +1.64% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Energy, Environment, Food, Biotechnology, Health	*HT + MT contribution to the trade balance* 2011: -2.77% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

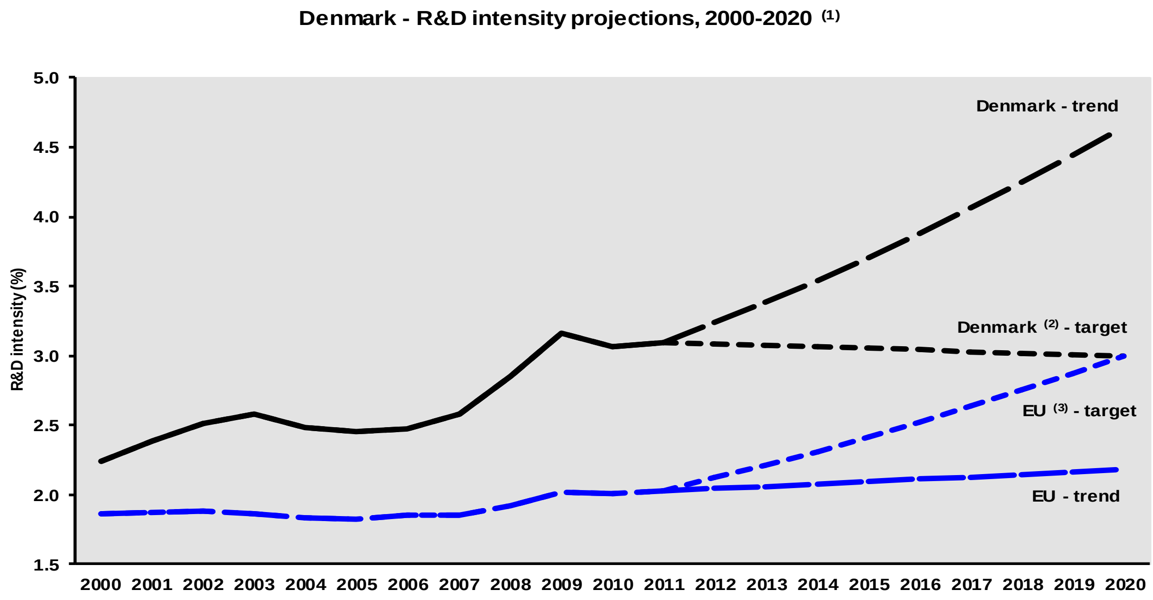
Denmark has considerably expanded its research and innovation system over the last decade and currently has the third highest R&D intensity among EU Member States. Denmark is also one of the most efficient European countries in terms of quality of scientific output per unit of public R&D investment. In Denmark public R&D investment has been at the level of 1% of GDP since 2009 and the Danish scientific production system is of high quality and efficient in terms of quality citations per invested public money. Nevertheless this good research performance has not yet fully translated into increased competitiveness and productivity in the Danish economy.

In the last decade Denmark experienced a lower productivity growth, especially in construction and in services, than other knowledge-intensive countries, and even experienced falling levels of productivity during the economic crisis over the period 2007-2010[23]. Furthermore, value added in high-tech and medium-high-tech manufacturing sectors plus high-tech knowledge-intensive services as a % of total value added has been lower than the EU average since 2000. Other remaining challenges are weak competition in some sectors and relatively poor innovation performance, despite a favourable innovation environment. There is thus a need for a better valorisation of knowledge by enterprises and for boosting innovation to enhance productivity, growth of firms and structural change.

The Danish government has identified the trend of slow productivity growth as a serious economic challenge and in response has developed a new national innovation strategy which focuses on the five Danish regions and their innovation efforts. A Productivity Commission was furthermore established in spring 2013 in order to examine the reasons for the slow growth of productivity in Denmark and for answering specific questions on ways to make the Danish economy more productive and competitive.
The current policy focus is on expanding public-private cooperation, reinforcing cluster dynamics and finding new solutions to link the supply of innovation closer to public demand (through public procurement of innovative products and services) and to private demand (firm-to-firm technology markets). At the level of human resources, there is a determined effort to enhance creativity and entrepreneurship throughout the education system, including adult education.

[23] Measured as change in GDP per person employed

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2007-2011 in the case of Denmark.
(2) DK: This projection is based on a tentative R&D intensity target of 3.0% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(4) DK: There is a break in series between 2007 and the previous years.

In the context of Europe 2020, Denmark set a national R&D intensity target of 3% for 2020. However, this target has already been achieved in 2009. In 2009, Denmark also achieved its objective of reaching a public R&D investment level of 1% of GDP. This target was achieved following an increase in the government budget for R&D of 8.9% over the period 2009-2011. [24] A high share of the EU regional structural funds available to Denmark was allocated to research and innovation (over 34%). However, Denmark was less successful in obtaining funding from the EU research framework programme.[25]

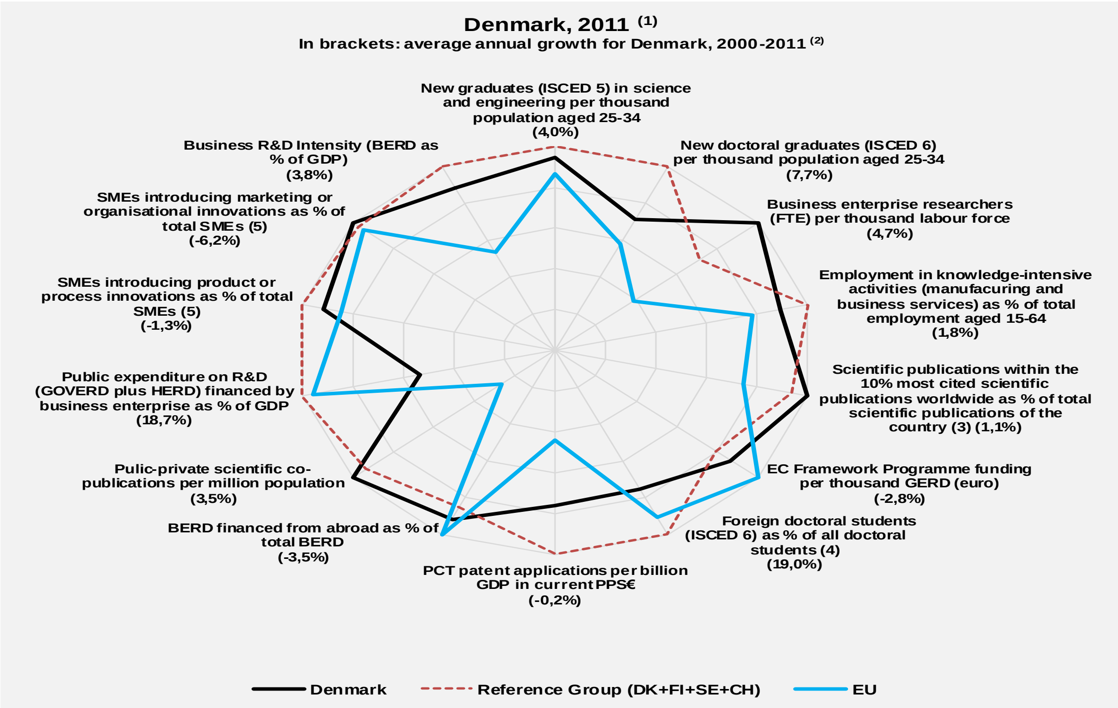
Having reached a public R&D intensity level considered optimal by the government, efforts are currently being focused on how to foster innovation in the business sector. Over the last decade, business R&D intensity has increased in Denmark to reach the level of the United States. In 2010, business expenditure on R&D increased by 5% (in nominal terms), in line with GDP growth thus leaving business R&D intensity unchanged. R&D expenditure by the major research-intensive firms in Denmark increased by 11% over the same period. R&D investment in Denmark is mainly carried out by Danish firms; foreign inward business enterprise research and development spending accounted for less than 7% of total BERD in 2007, while outward business R&D was insignificant.

Denmark still has a lower intensity of business R&D investment than other innovation leaders. Part of the reason is linked to Denmark's economic structure which has a relatively high share of medium-tech and low-tech sectors. However, over the last decade R&D intensity has increased in high-tech/medium high-tech and medium—low-tech/low-tech sectors.[26] At the same time there was a decreasing R&D intensity in some traditional sectors of the Danish economy, such as food products, medical instruments, and machinery and equipment. Moreover, the weights of many of the high-tech and medium-high-tech sectors in the Danish economy have decreased.[27]

[24] In the 2011 budget there was an increase for R&D of 4.7%. According to a recent survey (ERAC) the 2012 budget increased by 3.5%. However, a decrease of 3.6% is expected in the 2013 budget.
[25] Mainly due to a low application rate. The financial contribution success rate was the 5th highest in the EU.
[26] For most of the relevant sectors of the Danish economy, business R&D intensity increased over the last decade
[27] Particularly noticeable for the Radio, TV and communication equipment sector.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Danish R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) CH is not included in the reference group.

Denmark's research and innovation system benefits from a high level of funding, strong scientific production, and good human resources and mostly performs above the EU average. Denmark has a high tertiary education attainment rate and performs near the EU average on new graduates in science and engineering per thousand populations. A weaker point concerns the number of new doctoral graduates and there is also a lower share of foreign doctoral students than in the EU as a whole. Denmark has a high performance on business enterprise researchers in the labour force and there is a focus on technologies well adapted to the Danish industry profile (environmental technologies, health technologies, biotechnologies). Denmark's scientific production is strong and the country has one of the world's highest levels of scientific excellence (a share of 14.9% of total national scientific publications in the 10% most highly-cited scientific publications in the world) and the trend over the last ten years has been towards a greater quality.

Denmark is well integrated in scientific and cooperation networks across Europe, and also in technological cooperation networks. However, Denmark's scientific cooperation with other European countries[28], benefiting from the emerging European Research Area, is more intensive and broader in scope than its technological cooperation. A potential for enhancing the internationalisation of SMEs is suggested by the low share of Danish SMEs participating in the FP7 programme. The funding received under the EC framework programme in relation to total research spending in Denmark is also below the EU average.

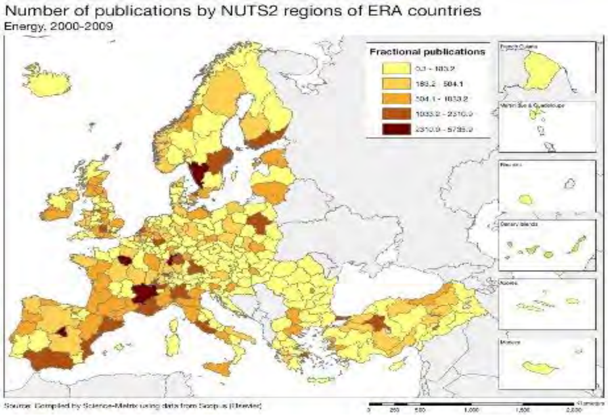
[28] Denmark's main scientific cooperation partners are the United Kingdom, Germany, Sweden and the Netherlands, but Danish scientists also cooperate extensively with researchers in Southern European countries.

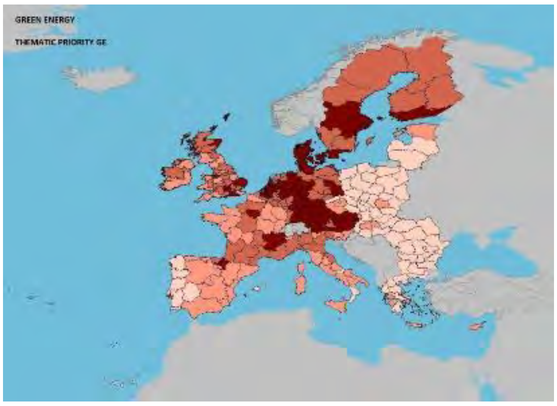
Denmark's scientific and technological strengths

The maps below illustrate six key science and technology areas where Denmark has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

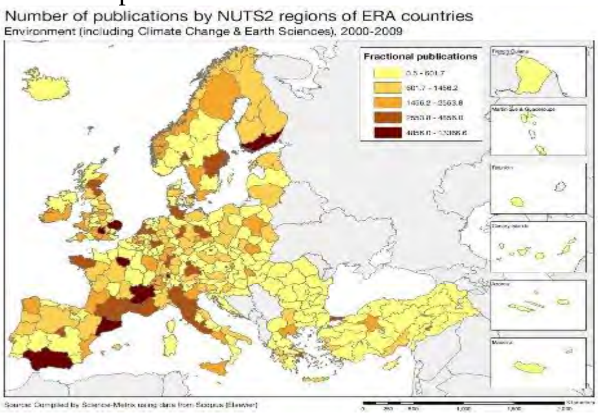
Strengths in science and technology at European level

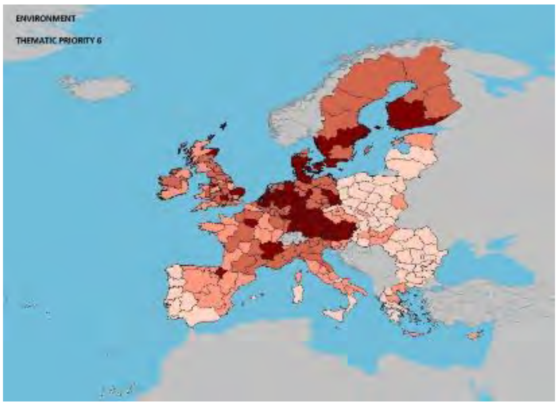
Scientific production **Energy** **Green energy** Technological production



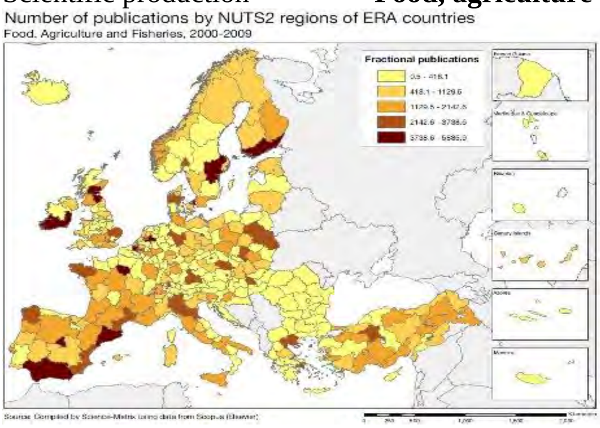


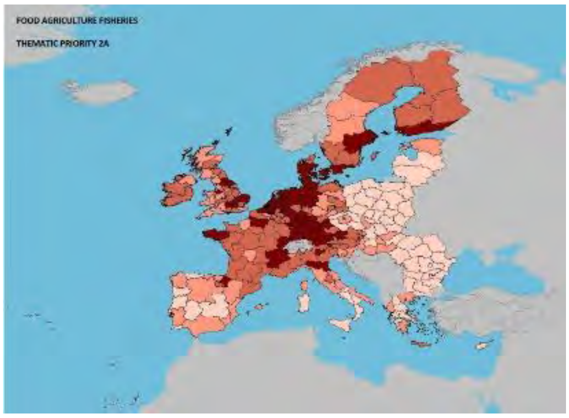
Scientific production **Environment** Technological production





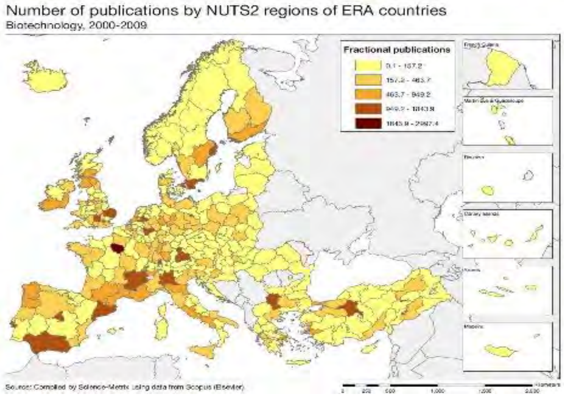
Scientific production **Food, agriculture and fisheries** Technological production

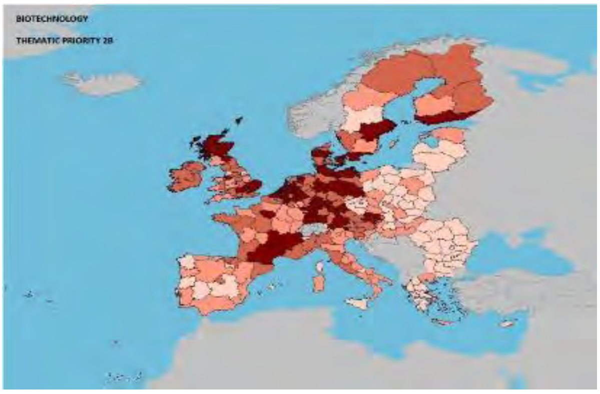




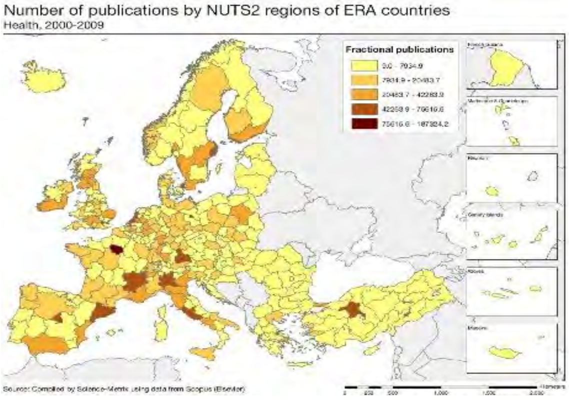
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

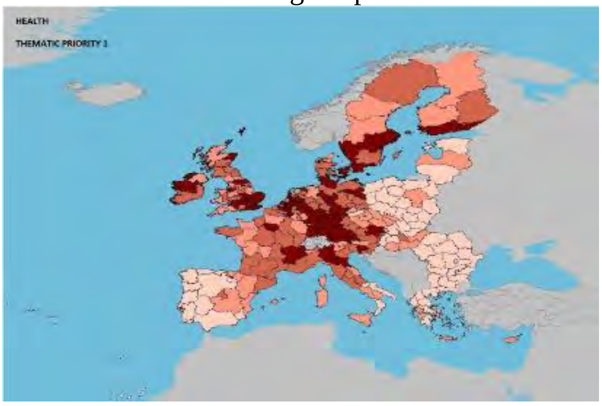
Scientific production **Biotechnology** Technological production



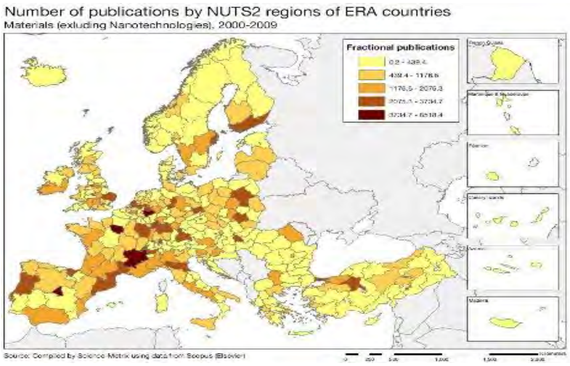


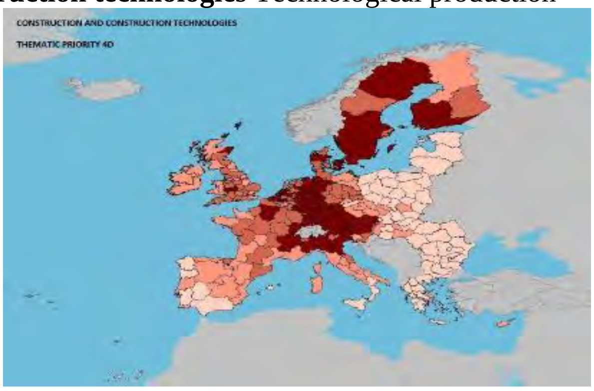
Scientific production **Health** Technological production





Scientific production **Materials** **Construction technologies** Technological production





Denmark shows a stronger performance in patenting than in scientific production. It has a high number of patent applications per inhabitant and it also has a growing number of highly-cited patents (reflecting technology breakthroughs). In scientific production Denmark only excels in food and agriculture, while in technological production (patenting) it has clear strengths at European level in energy (in particular green energy), environment, food and agriculture, biotechnology, health (in particular medical technologies) and construction technologies. Other fields of technology strengths include electrical machinery, engines, pumps and turbines, plastic products, and audio-visual products.

Denmark has scope for enhancing scientific strengths in areas related to these technology fields (mainly industry-led), as shown by the maps above. The high share of total Danish scientific publications in the 10 % most cited scientific publications worldwide shows that the quality of Danish scientific output is world-class. A weakness can be seen in the scale of scientific and technological production as science, technology and industry clusters need both high quality and a critical mass. There are opportunities to be found in an active use of European-wide instruments, such as the ESFRI infrastructure, in networking or smart specialisation scaling up dynamics and in enhancing potential clusters through the use of EU Structural Funds.

Policies and reforms for research and innovation

Denmark has recently launched reforms to boost innovation, in particular through the *Danish Globalisation Strategy*, the *Business Innovation Fund* and the proposal "Strengthening innovation in business". Furthermore, the 2010 "Enterprise package" has been extended to 2011 and a new "Competition package" was launched in 2011 with 40 initiatives to promote competition and productivity. Denmark has set a target for reducing the administrative burden for business. Although this target was met in 2010, the government has launched a new strategy for reducing the administrative burden still further. Denmark, already a leading country when it comes to e-government, has launched a new e-government strategy in 2011. From the end of 2012 all new enterprises will be equipped with basic tools for digital communication with the authorities.

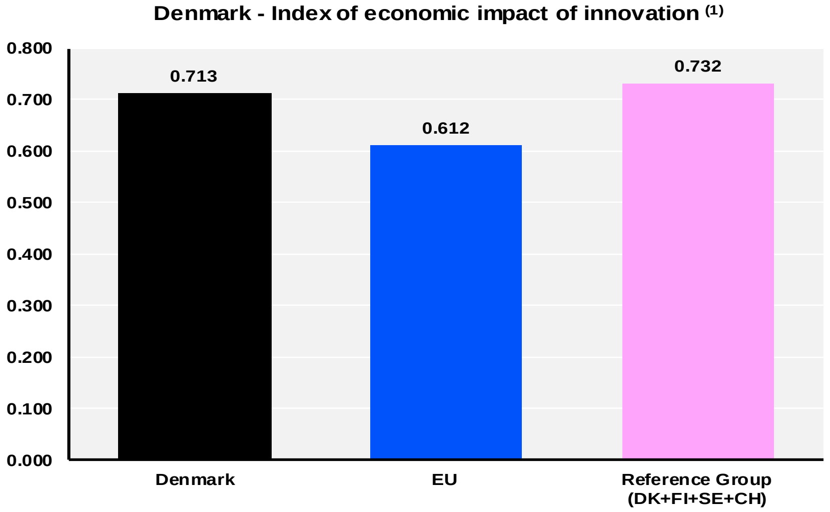
In 2009 and 2010, new innovation policy measures have been introduced in Denmark targeting private R&D investment, including increased public procurement of eco-innovations, support for large demonstration facilities, the launch of the Renewal Fund and a risk capital fund. Finally, the "Energy Strategy 2050", a long-term and broad national strategy for energy for the horizons 2020 and 2050, is also relevant in this context as it contains measures for boosting innovation in an area, which is a central challenge for Denmark and a global business opportunity for Danish firms. Furthermore, *Our Future Energy*, an energy agreement for Danish energy policy 2012-2020, was launched in March 2012. In December 2012 Denmark has adopted a new broad innovation strategy. This includes the identification of areas where Denmark has competitive advantages, in line with the EU Horizon 2020 programme.

There is a good opportunity for active supply-side and demand-side innovation in the areas where Denmark has competitive advantages, such as wind energy, organic chemistry, pharmaceuticals and biotechnologies. Such strategies should from the beginning be connected to European instruments, in particular the *European Innovation Partnerships*, *Horizon 2020* and ESFRI infrastructures. This would create stable and long-term framework conditions for the Danish industry to invest strategically in research and innovation.

Finally, an increase in R&D intensity would probably make it easier for Denmark to maintain its position among the most innovative and knowledge-intensive economies in the world. The mid-term review of the Europe 2020 objectives (in 2014-2015) could constitute an opportunity in this respect. Other Nordic countries (Sweden, Finland) have set R&D intensity targets of 4% and competitors in Asia have R&D intensity targets of up to 5% (South Korea). Given the low productivity growth in Denmark and the need for an evolution towards more broad innovation activities in firms, including investment in intangibles, Denmark would benefit in particular from combining the strategic focus of its innovation policy with increased public investment in R&D.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[29].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Danish SMEs are relatively dynamic, pursuing technology development with a higher intenstiy of patent applications in young firms than is found in the United States and with a high share of SMEs with new-to the-market products. The index of economic impact of innovation is at a clearly higher level than in the EU as a whole and close to the reference group of countries. A relative weakness in Denmark is a lower contribution to the trade balance of medium and high-tech product exports.

The quality of the innovation environment for firms in Denmark is well above the EU average. Denmark has good administrative support for business, a determined policy to promote creative and entrepreneurship skills in primary and secondary schools and a relatively high public procurement culture for advanced technology products as perceived by business leaders.

However, in some areas Denmark is lagging behind other innovation leaders, in particular in private funding of innovation (venture capital investment for the expansion and replacement phase, the presence of business angel groups and the perceived ease of access to loans), in some aspects of entrepreneurship (e.g. the fear of failure rate) and in the intensity of local competition and perceived buyer sophistication. Market mechanisms and indirect funding of R&D through tax incentives have played a larger role in Denmark than direct funding of business R&D, features which distinguish Denmark from the other Nordic countries.

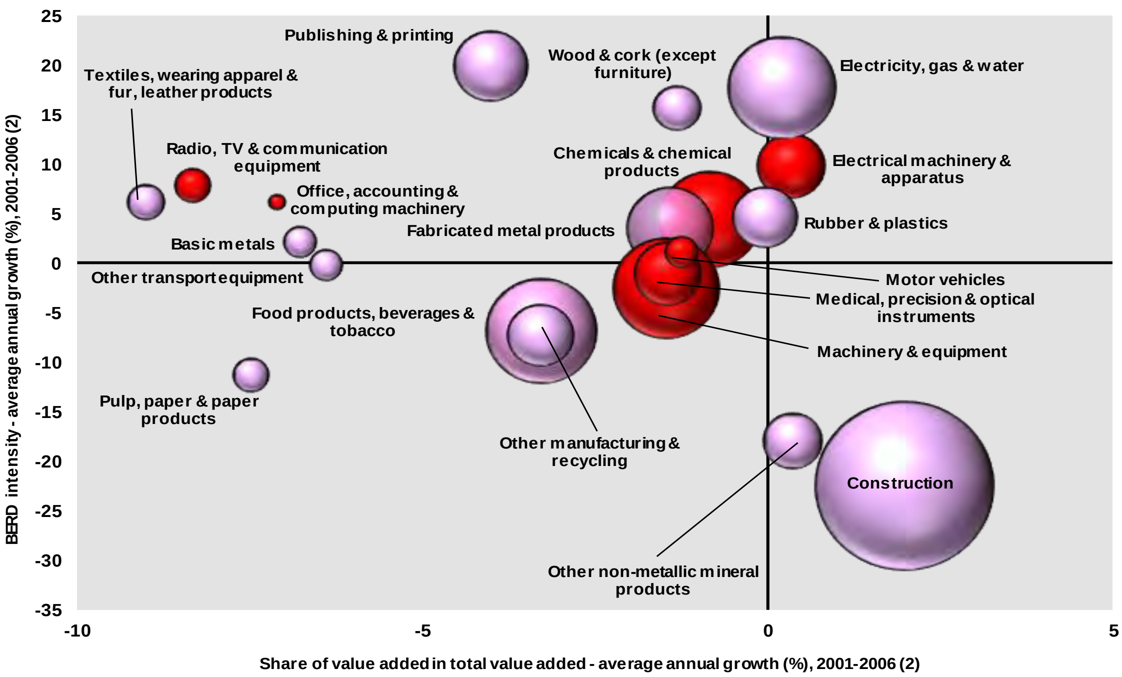
The Danish business environment is marked by a wide range of competition-friendly regulations (it is ranked 5th out of 183 economies on the ease of doing business indicator[30]). The innovation environment for firms in Denmark is well above the EU average and Denmark's R&D investment target of 3% of GDP had already been achieved in 2009. Compared to other innovation leaders, Denmark has a higher share of SMEs among its companies coupled with a relatively high business R&D intensity within SMEs. Denmark therefore has a clear potential to further increase its technology development via a structural change towards a higher share of knowledge-intensive sectors. In fact over the last ten years Denmark has caught up rapidly in terms of patent applications, license revenues and employment in knowledge-intensive activities.

[29] See Methodological note for the composition of this index.
[30] Source: World Bank *Doing Business* survey 2012.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates with the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Denmark - Share of value added versus BERD intensity - average annual growth, 2001-2006



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Publishing and printing': 2002-2006.

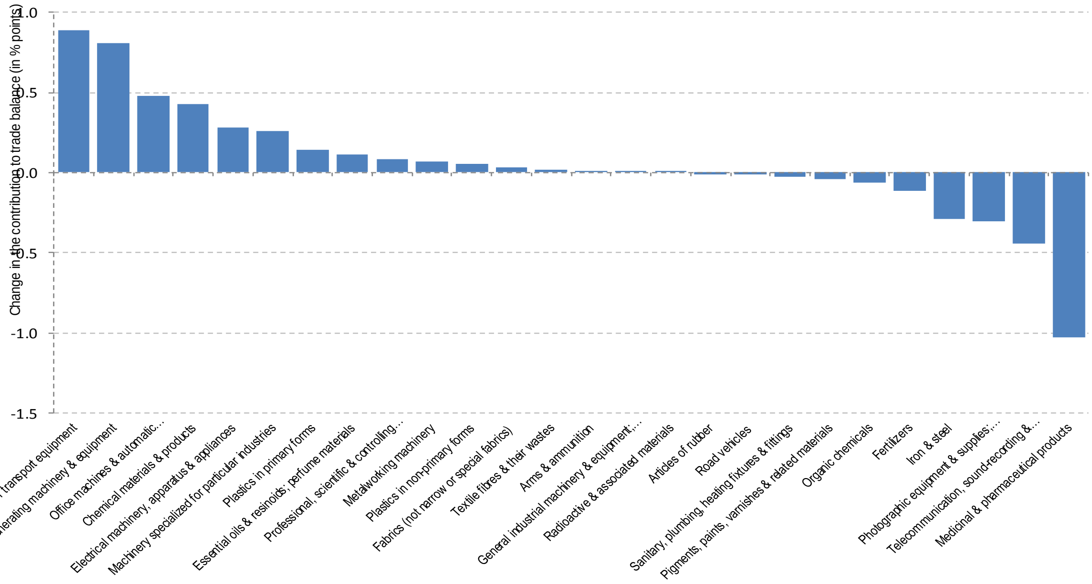
As shown by the graph above the share of value added of high-tech and medium high-tech sectors (red circles) in the Danish economy has decreased since 2001, despite a general increase in R&D intensity (R&D intensity declined only in machinery and equipment, and medical, precision and optical instruments). The only high-tech or medium-high-tech sector with an increase in its share of value added was electrical machinery and apparatus. In general productivity growth has been low. The Danish government recognises as a major challenge the need to increase the number of innovative companies and to accelerate productivity growth in the manufacturing and services sectors.

One possible reason for the low productivity growth is a relatively lower level of innovation in Danish manufacturing enterprises, a level which is far below the levels of other Nordic countries. Underlying factors can be linked to the weaker dimensions of Denmark's innovation environment (risk funding, entrepreneurship, competition and market sophistication) and to the limited internationalisation of Danish technology development and firms. However, it can also be linked to Denmark's industrial structure, which would have to change towards more knowledge-intensive sectors and larger firms to make it more innovation oriented. In this respect fast growing innovative firms represent a key asset and future potential for Denmark as has been illustrated in the previous part of this profile.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Denmark between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Within the framework of an increasing Danish export surplus, the contribution of the majority of high-tech (HT) and medium-tech (MT) products to Denmark's trade balance has not changed significantly between 2000 and 2010. However, inside the important sector of machinery and equipment there are several product categories, including power generating machinery and machinery specialised for particular industries, which showed a significant growth in their contributions to the trade balance. Electrical machinery and apparatus, a sector that has improved its research intensity, also expanded its contribution to the trade balance. Hence, there is an increasing specialisation of the country in the above mentioned products. The contribution of medicinal and pharmaceutical products to the trade balance has decreased significantly between 2000 and 2010. Overall the share of high-tech exports in total exports is below the EU average, but there is a relatively high share of knowledge-intensive services in service exports.

The Danish economy is characterised by a relatively low productivity growth, both in the services and the manufacturing sectors. Possible explanations are an economic structure with a high share of services, which tend to have lower productivity growth than manufacturing industries, a low level of local competition due to the small size of the market and an insufficient level of innovation in relation to the country's potential. Total factor productivity has hardly grown since 2000 implying that there was little contribution from innovation and human capital development to productivity growth. The employment rate and the quality of human capital, as evidenced by the tertiary education attainment rate of the population, are high in Denmark, but there was little progress on these indicators in recent years and even a decline since 2005. However, Denmark has improved its performance as regards the other Europe 2020 targets in recent years.

Key indicators for Denmark

DENMARK	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	1.00	0.93	1.25	1.14	1.06	1.31	1.27	1.39	1.60	1.72	2.09	:	:	7.7	*1.69*	7
Business enterprise expenditure on R&D (BERD) as % of GDP	1.50	1.64	1.73	1.78	1.69	1.68	1.66	1,80 (3)	1.99	2.21	2.09	*2.09*		*3.8*	*1.26*	3
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.73	0.73	0,76 (4)	0.78	0.78	0.76	0.80	0,76 (3)	0.85	0.94	0.96	*0.99*	:	*6.7*	*0.74*	3
Venture Capital (5) as % of GDP	0.11	0.18	0.13	0.11	0.14	0.40	0.08	0.53	0.21	0.22	0.18	0.15	:	3.1	0,35 (6)	12 (6)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	65.7	:	:	:	:	77.7	:	:	3.4	47.9	2
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	13.4	13.9	12.6	14.9	14.1	14.3	14.3	14.8	14.6	:	:	:	:	1.1	10.9	2
International scientific co-publications per million population	679	613	632	888	993	1081	1155	1261	1325	1438	1562	1692	:	8.7	300	1
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	171	166	162	180	197	:	3.5	53	1
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	6.9	7.3	7.0	7.6	7.4	7.8	7.4	8.1	7.3	6.8	:	:	:	-0.2	3.9	4
License and patent revenues from abroad as % of GDP	:	:	:	:	0.46	0.68	0.74	0.75	0.88	0.97	0.91	0.91	:	12.2	0.51	4
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	11.0	:	7.8	:	11.4	:	15.0	:	:	5.2	14.4	7
Knowledge-intensive services exports as % total service exports	:	:	:	:	63.0	65.1	67.0	67.0	67.4	60.8	63.3	:	:	0.1	45.1	3
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-4.13	-3.36	-3.69	-3.38	-3.88	-3.63	-4.56	-4.23	-3.52	-3.32	-3.83	-2.77	:	-	4,20 (7)	23
Growth of total factor productivity (total economy) - 2000 = 100	100	100	99	100	102	103	104	103	101	96	99	100	101	0 (8)	103	19
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	46.7	:	:	:	:	49.0	:	:	:	:	54.9	:	:	1.6	48.7	8
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	14.8	15.2	15.9	15.6	:	1.8	13.6	6
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	45.1	:	35.7	:	37.6	:	41.6	:	:	-1.3	38.4	11
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.48	0.42	0.47	0.72	0.73	0.84	0.86	1.20	1.28	:	:	:	:	13.0	0.39	1
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	1.86	2.01	1.87	2.50	2.12	2.28	1.97	1.84	1.41	:	:	:	:	-3.4	0.52	1
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	78.0	78.3	77.7	77.3	77.6	78.0	79.4	79.0	79.7	77.5	75.8	75.7	:	-0.3	68.6	4
R&D Intensity (GERD as % of GDP)	2.24	2.39	2.51	2.58	2.48	2.46	2.48	2,58 (3)	2.85	3.16	3.07	*3.09*	:	*4.6*	*2.03*	3
Greenhouse gas emissions - 1990 = 100	100	102	101	108	100	94	105	98	94	90	90	:	:	-10 (9)	83	14 (10)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	15.1	16.2	16.5	18.0	18.8	20.2	22.2	:	:	6.6	12.5	8
Share of population aged 30-34 who have successfully completed tertiary education (%)	32.1	32.9	34.2	38,2 (11)	41.4	43.1	43.0	38,1 (3)	39.2	40.7	41.2	41.2	:	2.0	34.6	10
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	16.5	17.2	16.7	16.8	16.3	17.6	18.3	18.9	:	2.0	*24.2*	7 (10)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2007 and the previous years. Average annual growth refers to 2007-2011.

(4) Break in series between 2002 and the previous years.

(5) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(6) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(7) EU is the weighted average of the values for the Member States.

(8) The value is the difference between 2012 and 2000.

(9) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(10) The values for this indicator were ranked from lowest to highest.

(11) Break in series between 2003 and the previous years.

(12) Values in italics are estimated or provisional.

Estonia

The challenge of upgrading Estonian industry by research and innovation

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Estonia. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 2.38% (EU: 2.03%; US: 2.75%) 2000-2011: +13.31% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:25.85 (EU:47.86; US: 56.68) 2005-2010: +11.7% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.45 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:46.48 (EU:48.75; US: 56.25) 2000-2010: +2.94% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Energy, Environment, Food and agriculture	*HT + MT contribution to the trade balance* 2011: -2.7% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

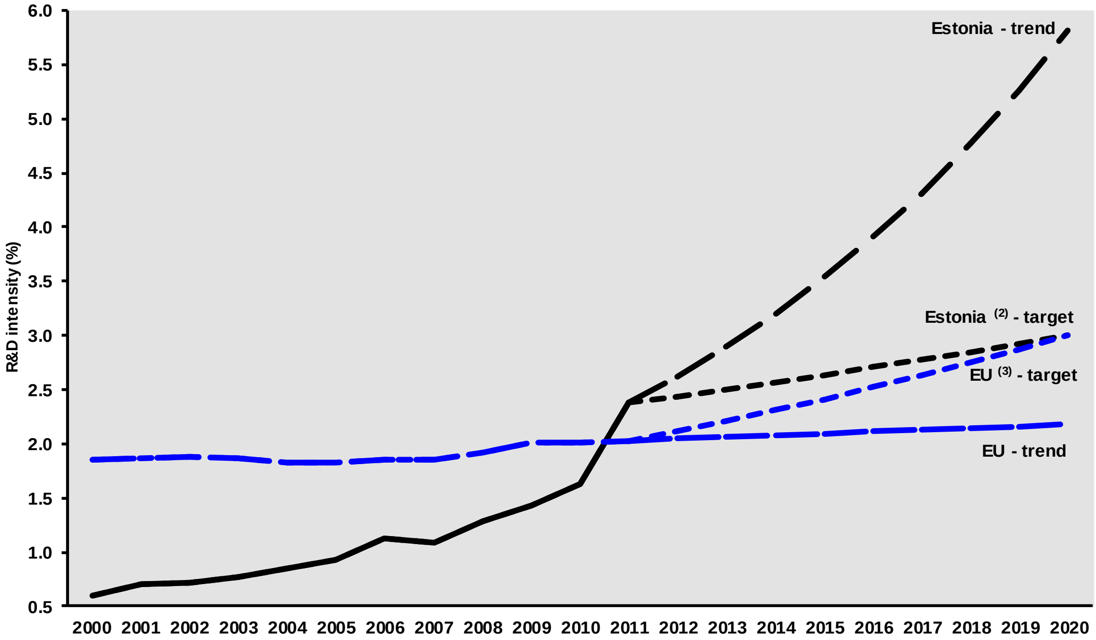
The development and performance of the Estonian research and innovation system over the past two decades has been outstanding, with policies driven by quality, excellence and competition. The development of R&I policies and of the system have been inspired by what is done in the Nordic and other European countries. This has worked so far, but in the longer run will not be sufficient. A further challenge for Estonia will be to develop its R&I system in ways that will make a difference for the economy at large, as demonstrated by the large remaining gaps illustrated in the table above, both in terms of quality of its science base and in its capacity to generate products competitive on the international market.

A rather significant challenge affecting the R&I system derives from the Estonian industrial sector, which is largely driven by basic subcontracting manufacturing. Therefore any effort to upgrade the role of Estonian industry in the global value chains, by R&I means is of utmost importance for raising productivity and the added value of the economy. This implies developing a broad range of supply and demand policies. In addition, as economic restructuring, diversification and transition to higher value-added output is taking place, skills shortages are becoming apparent creating the need to adapt university curricula and specialisations to the emerging economic fields. Moreover, the fragmentation of R&I could be addressed by governance related measures. The small size of the country is reflected in the small number of companies, lack of economies of scale or critical mass in many areas of research.

Through its policies, Estonia has been able to turn its small size into an advantage by means of specialisation. The two key strategies in place: "Knowledge-based Estonia 2007-2013" (the R&I Strategy) and "Europe 2020" (on general economic development in response to the Europe 2020 agenda) are ambitious and appropriately focused on guiding the country's development by strong commitment to sustainable economic development through R&I. This is expected to address the issue of a research and innovation system which, although performing remarkably well during the last two decades, has remained rather detached from a vast part of the Estonian economy. Therefore a further focus on areas that dominate the Estonian economy today now becomes necessary.

Investing in knowledge

Estonia - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the case of the EU and for 2000-2010 in the case of Estonia.
(2) EE: This projection is based on a tentative R&D intensity target of 3.0% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.

Estonia had an R&D intensity of 2.36%[31] in 2011, with a steep increase from 1.63% in 2010. The increase is significantly due to the private R&D sector expenditures, which doubled in 2011 compared to 2010 in absolute numbers. In relative terms, the business expenditures for R&D as percentage of GDP represent 1.40% in 2011, from 0.82% in 2010, with a remarkable overall annual growth rate of 24.4 between 2000 and 2011. Public expenditures on R&D reached a share of 0.87% of GDP in 2011. With an ambitious 3% R&D intensity target for 2020 (with a 2% milestone in 2015), Estonia takes a decisive commitment for achieving a key feature for an ambitious growth path towards a knowledge-based society.

The Estonia 2011 strategy foresaw a major boost in 2011 provided by front-loaded EU structural funds estimated at up to 1.2% of GDP. Currently 24.7% of the total Structural Funds available to Estonia is allocated to research, innovation and entrepreneurship, which is very close to the overall 25% average at EU level. The current rate of absorption of the funds dedicated to R&I and entrepreneurship is 57.1%. Notwithstanding the high level of public funding of R&D, reaching the 2020 R&D intensity target will depend both on the ability to attract R&D intensive foreign direct investment and a further significant growth in business R&D. Business R&D expenditure as a percentage of GDP has already increased from 0.14% in 2000 to 0.64% in 2009 to 0.81% in 2010. The expected leverage effect of the front-loaded EU structural funds for business R&D will be closely monitored.

The total number of Estonian participants in the 7th Framework Programme is so far 342 (out of 1567 applicants). They have in total received € 552 million. The rate of participant success is 21.83%, which is slightly below the EU average rate of success of 21.95%.

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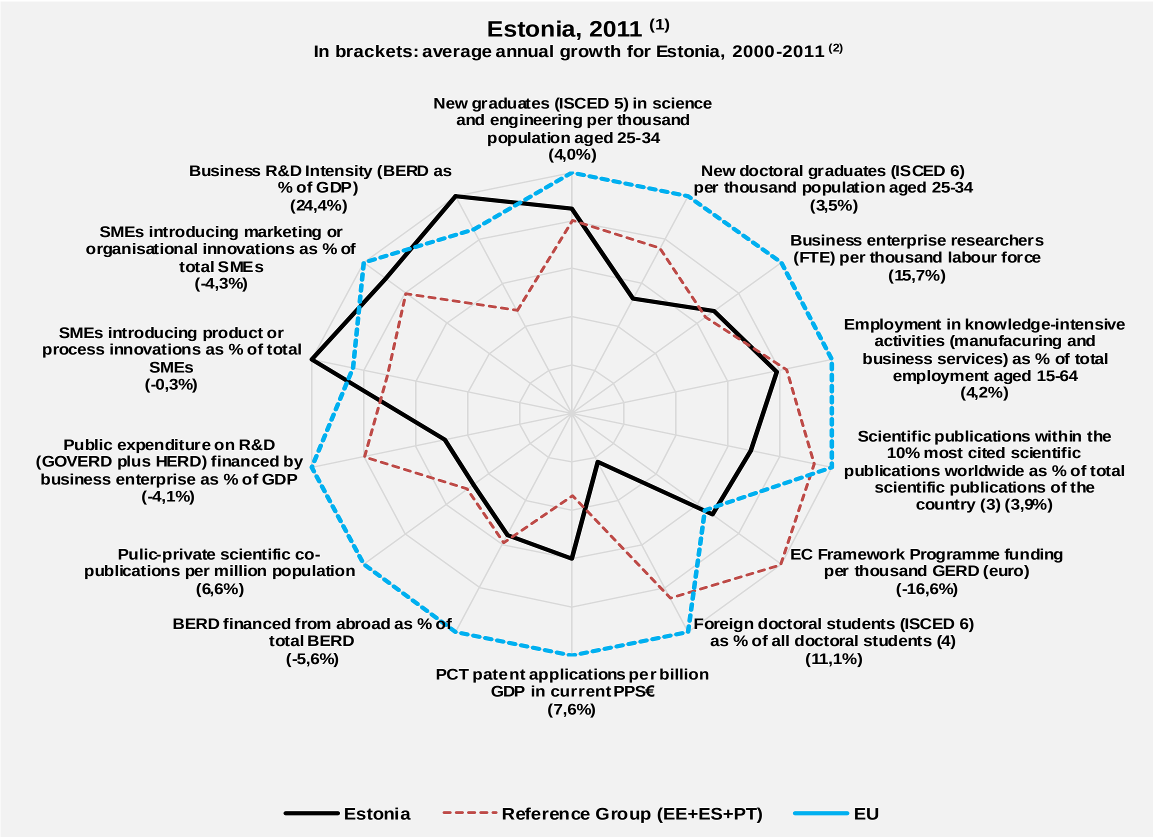
[31] According to Eurostat provisional data for 2011

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Estonia's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The graph above shows a performance above the EU average both in SMEs introducing innovation and in funding from the EC Framework Programme. However, Estonia remains for the time being below the EU average in all four large dimensions of its R&I system: human resources, scientific production, technology development and innovation. In the field of human resources for research and innovation, Estonia is suffering from a low number of new doctoral graduates and business enterprise researchers. The number of foreign doctoral students is particularly low, which however, could be explained by the small size of the country.

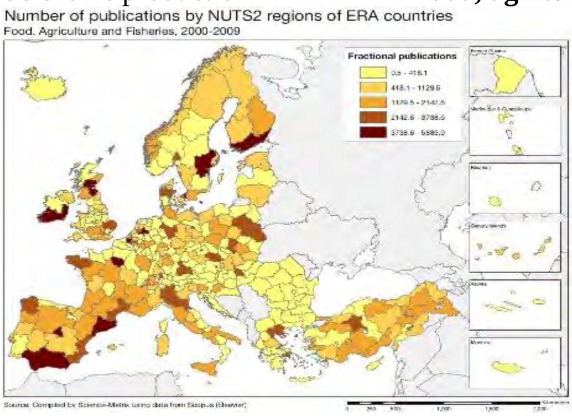
These indicators point at the need to enhance the quality of the higher education system and to address the non-absorption of highly-skilled graduates in firms. Estonia has improved its scientific quality and production but still faces the challenge of increasing the excellence and internationalization of its research institutions. Estonia has improved its performance in public-private cooperation although it still performs well below the EU average. Knowledge valorisation takes place in clusters, where SMEs, larger firms and public research organisations cooperate and compete. Business R&D intensity and PCT patent applications have increased, although they still remain below the EU average.

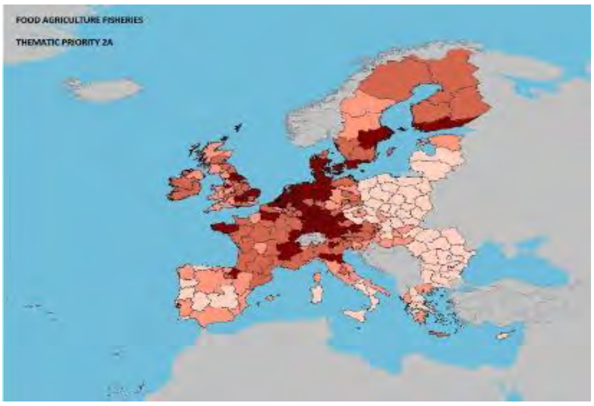
Estonia's scientific and technological strengths

The maps below illustrate six key science and technology areas where Estonia has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

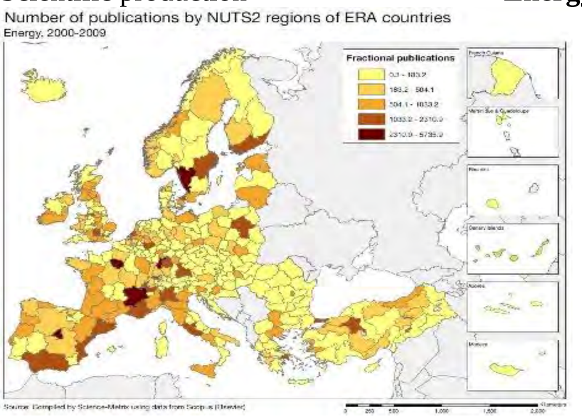
Strengths in science and technology at European level

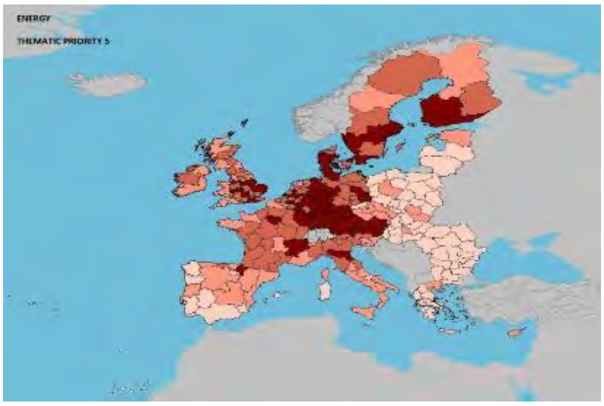
Scientific production **Food, agriculture and fisheries** Technological production



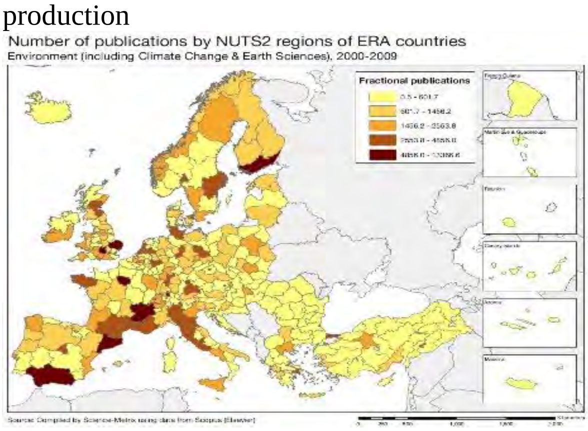


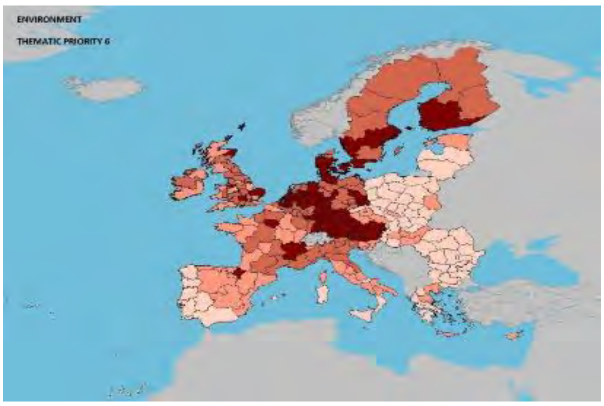
Scientific production **Energy** Technological production





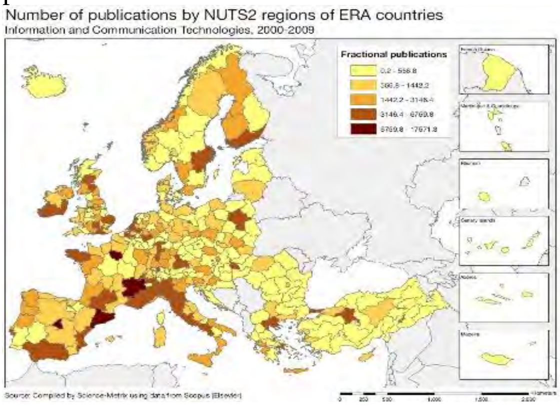
Scientific production **Environment** Technological production

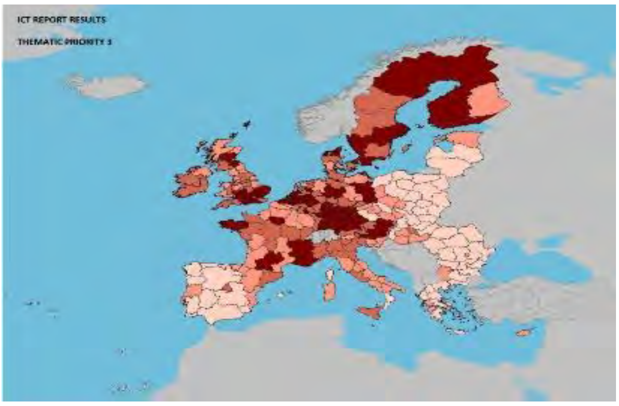




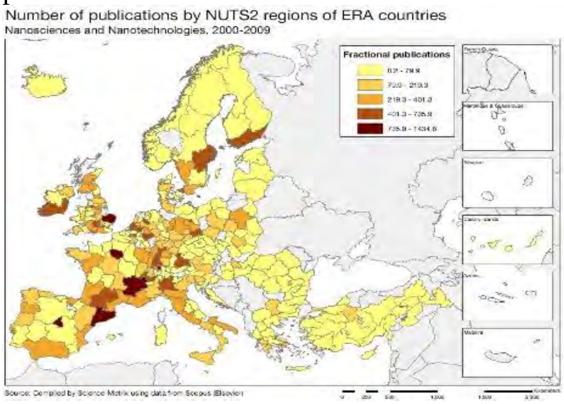
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

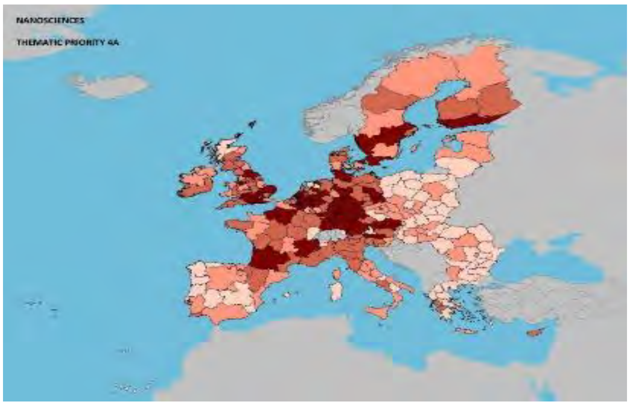
Scientific production **Information and Communication Technologies** Technological production



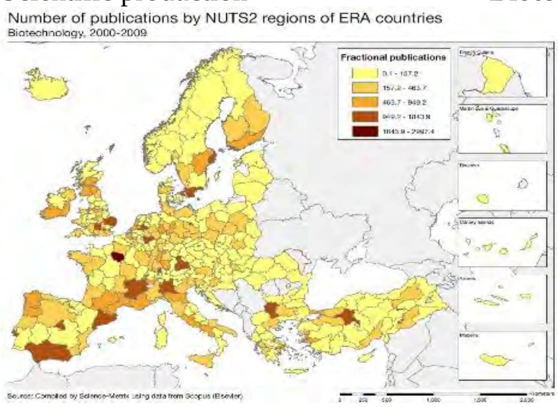


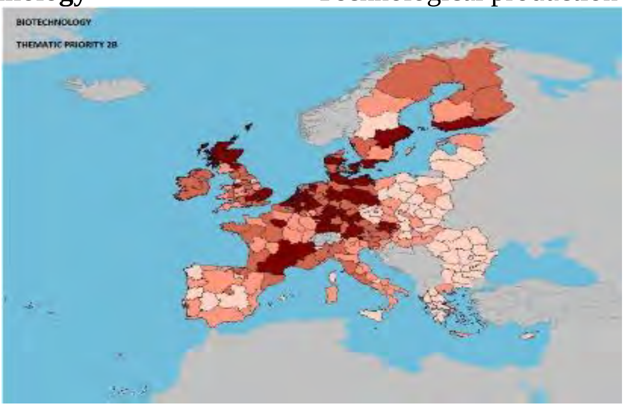
Scientific production **Nanosciences and nanotechnologies** Technological production





Scientific production **Biotechnology** Technological production





As illustrated by the maps above, Estonia has strong regional scientific and technological capacity in the fields of food, agriculture and fisheries, energy, and environment, as well as technological capacity in ICT, nanosciences and nanotechnologies, and biotechnology.

Regarding Estonia's scientific specialisation index, not visible in the maps above, the main scientific fields are energy, environment, food and agriculture while scientific quality is highest in transport, and food and agriculture (as reflected by the share of scientific publications in the 10% most cited scientific publications worldwide). In terms of technology specialisation, the main technology sectors are biotechnologies, new production technologies, nanotechnologies, environment and security.

Policies and reforms for research and innovation

Estonian research and innovation policy is based on collaboration led by the Research and Development Council. The council has an advisory nature and involves representatives of the public R&I sector, industry, the Ministry of Education and Research, and the Ministry of Economic Affairs and Communications. The two ministries are responsible for the implementation of economic policy, and research and innovation policy.

The Estonian authorities are addressing the challenges indicated at the beginning of this assessment through two key strategies that are already in place: "Knowledge-based Estonia 2007-2013" which is the Research and Innovation Strategy and "Europe 2020", a general economic development strategy in response to the Europe 2020 agenda. The strategies are ambitious and correctly focused on guiding the country's development by strong commitment to sustainable economic development through research, development and innovation, but they would have benefited from a more narrow sectoral focus and detailed objectives. Whereas the development and performance of the research and innovation system has been remarkable during the last two decades, it appears to have remained rather detached from a vast part of the economy. Therefore a further focus on areas that dominate the Estonian economy today has now become necessary. The development of a comprehensive innovation strategy consistent with industrial perspectives would help to identify knowledge-intensive sectors that could raise the country's position on the value chain.

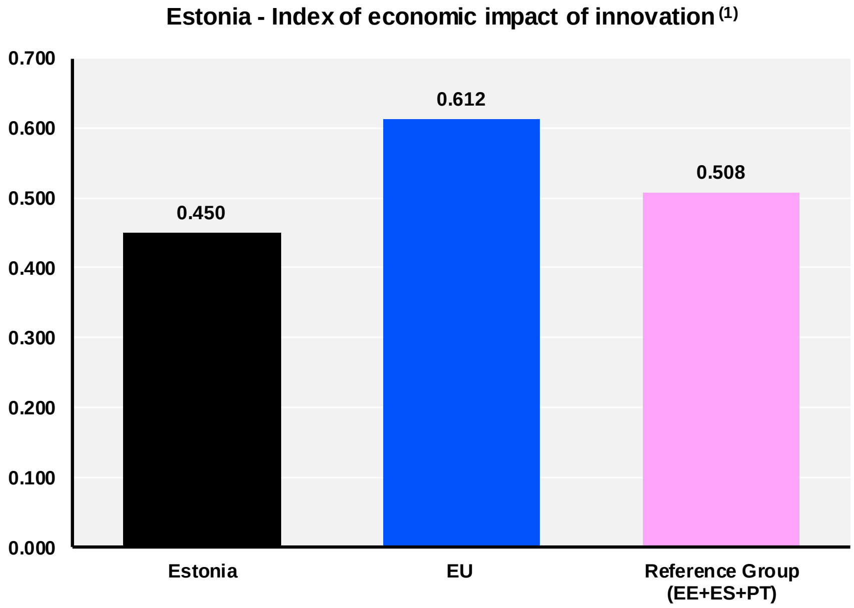
Regarding the particular challenge of skills shortage, the Government is trying to foresee future needs of different skills as well as attempting to reverse the brain drain by building up incentives for Estonian researchers to return to the country after having gained important professional experience abroad.

Overall cooperation between public sector research and business will need to be further encouraged. In general, public actors (i.e. universities and existing excellence centres) do not have sufficient incentives to promote the commercialisation of research results. Eight competence centres focused on industrial research and the creation of innovative products, have been created with the aim of promoting cooperation between academia and business. The Government plans to evaluate their activity, with a view to adjusting the financial support in relation to the actual progress.

The recent international peer review undertaken within the European Research Area Committee (ERAC) - providing input to the government for the renewal of the R&I strategy for 2014-2020 – highlighted less budgetary intensive measures such as knowledge transfer and suggested public-private schemes instead of direct funding tools. Estonia was recommended to further harness its R&I policy to drive structural change in the economy. The ongoing strategy process was recommended to be used to develop a more coherent and systemic policy mix. Increased funding was considered rather as a tool to extend the overall reach and variety of innovation instruments to non R&I performing companies. Currently, in the absence of a coherent strategy, it was noted that Structural Funds can even contribute to the complexity. Developing the new national R&I strategy by taking closely into account EU policy and funding instruments might have major synergies for a country with limited resources but relatively good administrative capacity.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[32].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Estonia has a slightly lower economic impact of innovation than its reference group. In particular, the economy is still less knowledge-intensive in terms of employment and trade. In this context, the *Competence Centres* and the innovation vouchers intended to encourage R&I activities in SMEs are steps in the good direction (the vouchers have been extended both in terms of value, currently € 4000 per voucher, and target group with the list of R&D providers extended to include competence centres). These measures increase the possibility of attracting foreign companies to Estonia and provide a stimulating environment and networks for innovative firms, boosting knowledge transfer between academia and businesses. Finally, the recent “start-up Estonia” pilot scheme is a new, supplementary policy instrument to motivate young people to start businesses.

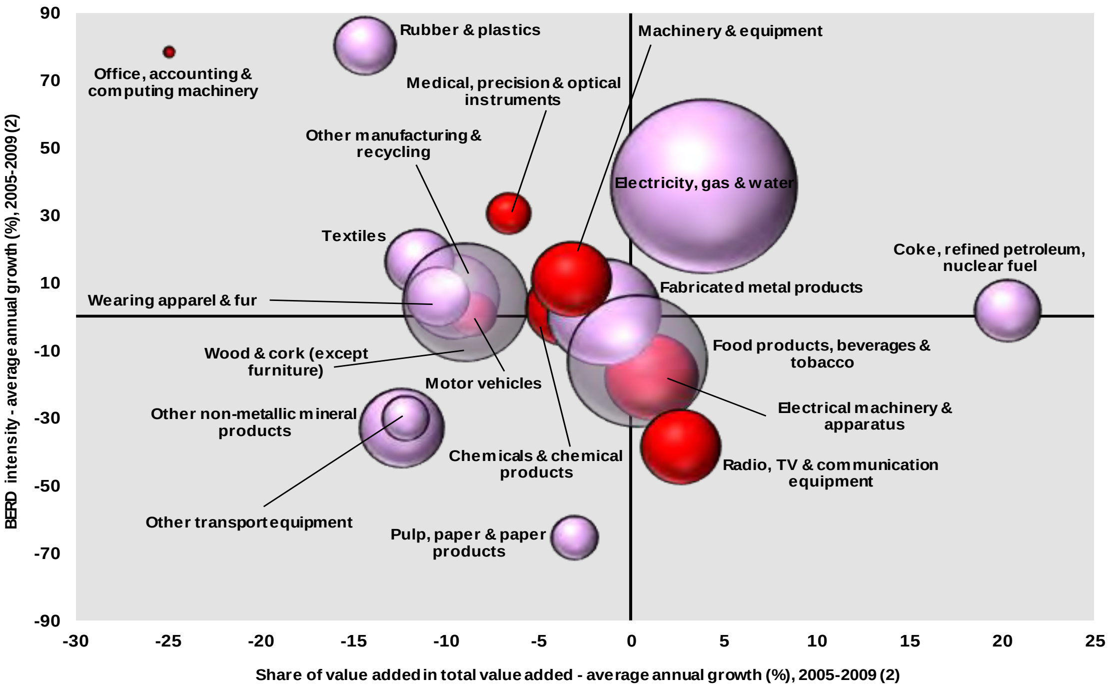
Estonia has an average position among EU Member States and a favourable position among new Member States regarding the perception of end business users on availability of both venture capital and access to loans, as well as on financing through local equity markets. The perception of end users regarding both government procurement of advanced technology products and intensity of local competition situates Estonia yet again in a leading position among new Member States and around the EU average. The share of public procurement advertised in the Official Journal relative to GDP was 8.40, i.e. ranking third in Europe after Bulgaria and Latvia. Estonia is also in third place in the EU regarding net foreign direct investment (FDI) inflows relative to GDP (according to 2008 data), immediately after Cyprus and Ireland. According to the Eurobarometer[33], the greatest fears of Estonians when starting a business are the uncertainty of not having a regular income, the risk of losing their property and the possibility of going bankrupt.

[32] See Methodological note for the composition of this index.
[33] Eurobarometer: Entrepreneurship in Europe and beyond, 2010

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Estonia - Share of value added versus BERD intensity - average annual growth, 2005-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Pulp, paper and paper products', 'Rubber and plastics', 'Wood and cork (except furniture)': 2006-2009.

Estonia is one of the countries that are catching up fast in terms of manufacturing industry: in 2011, manufacturing production represented 17.3% of total value added (compared to an EU average of 15.6%). Estonia is improving its competitiveness and has a clear potential to join the group of higher income countries specialised in labour-intensive industries[34]. In terms of trade and industry specialisation, Estonia is specialised in the manufacturing of electronic products, fabricated metal products, motor vehicles, electrical equipment, and machinery and equipment.

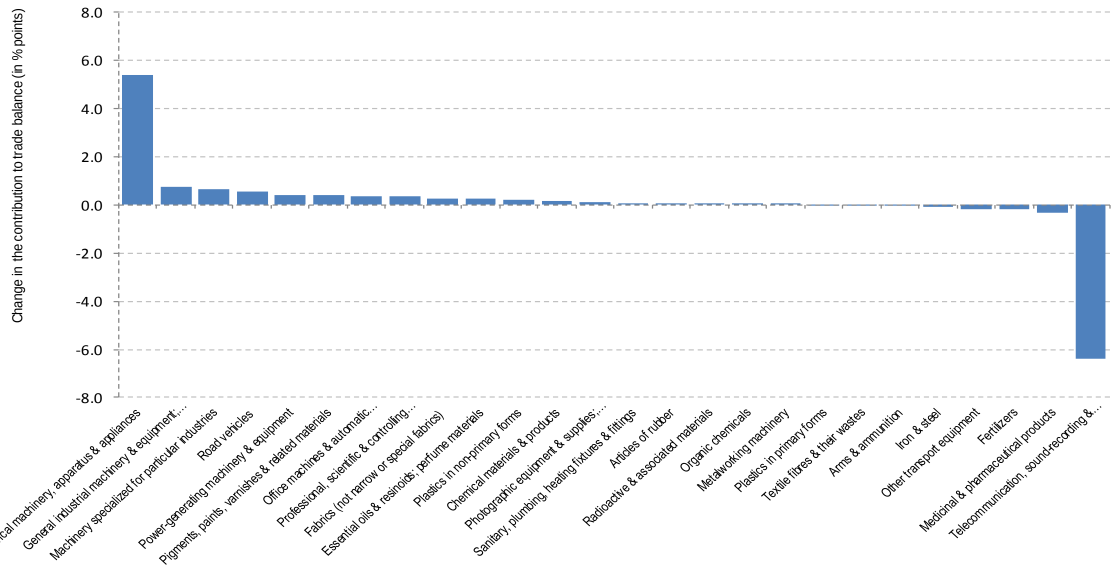
The graph above synthesises the structural change of the Estonian manufacturing sector over the period 2005-2009. It shows that the economic expansion has been to a certain extent related to lower-tech sectors or large consumer goods and services, in particular, coke, refined petroleum and nuclear fuel, and electricity, gas and water. However, there has been an increase in R&I investment in several industrial sectors of the Estonian economy, both in low-tech and traditional sectors such as rubber and plastics, textiles, wearing apparel and fur, and also in the high-tech sectors of office, accounting and computing machinery, medical, precision and optical instruments, and machinery and equipment.

[34] DG Entreprise, Industrial Performance Scoreboard, 2012

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Estonia between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The Estonian trade balance for all high-tech (HT) and medium-tech (MT) products combined was negative over the last decade; however, there is an increasing trend. At the same time there is a relative stagnation for the total trade balance over the same period. The data suggest a relative shift towards HT and MT in the trade balance of Estonia over the last few years.

The graph above shows the high-tech and medium-tech industries that have improved their contributions to the Estonian trade balance. This is particularly true for electrical machinery, road vehicles, general industrial machinery, machinery specialised for particular industries, and power generating machinery and equipment. In contrast, industries such as telecommunications and medicinal and pharmaceutical products are making decreasing contributions to the trade balance, indicating a possible loss in relative world competitiveness for these sectors. Over the last 15 years, the Estonian economy has made relative gains in world competitiveness as a result of innovation. This is shown by indicators such as knowledge-intensive services exports as % of total service exports. The composite indicator on structural change ranks Estonia in 17th place in the EU over the period 2000-2010 (see table below).

Estonia had a rather flat evolution of total factor productivity over the last decade, and is ranked 16th in the EU in this respect. Greenhouse gas emissions increased up to 2007 but then progressively declined and by 2009 were under the level of 2000. Estonia has also succeeded in increasing the share of renewable energy in gross final energy consumption and is currently ranked 6th in the EU for this indicator. The employment rate increased from 67.4% in 2000 to 70.4% in 2011.

Key indicators for Estonia

ESTONIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth[1] (%)	EU average[2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.64	0.81	1.01	1.21	1.11	0.70	0.76	0.81	0.85	0.83	0.90	:	:	3.5	*1.69*	19
Business enterprise expenditure on R&D (BERD) as % of GDP	0.14	0.24	0.22	0.26	0.33	0.42	0.50	0.51	0.55	0.64	0.82	*1.49*	:	*24.4*	*1.26*	7
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.45	0.45	0.46	0.48	0.50	0.49	0.61	0.55	0.70	0.76	0.79	0.87	:	*6.0*	*0.74*	6
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	14.9	:	:	:	:	25.9	:	:	11.7	47.9	19
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	5.5	4.9	6.6	5.5	7.0	7.3	7.6	7.5	7.5	:	:	:	:	3.9	10.9	17
International scientific co-publications per million population	192	176	197	265	329	381	376	451	503	537	673	734	:	12.9	300	12
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	19	22	26	28	25	:	6.6	53	18
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	1.2	1.1	0.8	1.2	1.0	0.6	1.5	2.0	2.0	2.3	:	:	:	7.6	3.9	12
License and patent revenues from abroad as % of GDP	:	:	:	:	0.03	0.04	0.04	0.05	0.11	0.13	0.11	0.10	:	17.5	0.58	17
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	11.9	:	13.7	:	10.2	:	12.3	:	:	0.5	14.4	15
Knowledge-intensive services exports as % total service exports	:	:	:	:	29.8	30.3	33.2	37.5	37.6	37.1	37.4	:	:	3.9	45.1	10
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.68	-6.00	-7.75	-8.64	-5.65	-4.61	-3.83	-4.18	-2.77	-1.53	-3.00	-2.70	:	-	4,20[3]	22
Growth of total factor productivity (total economy) - 2000 = 100	100	103	105	107	110	113	115	117	108	97	102	106	105	5[4]	103	13
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	34.8	:	:	:	:	39.8	:	:	:	:	46.5	:	:	2.9	48.7	12
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	9.5	10.2	9.8	10.7	:	4.2	13.6	20
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	46.4	:	45.8	:	43.9	:	45.6	:	:	-0.3	38.4	7
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.01	0.00	0.00	0.23	0.00	0.00	0.00	0.17	0.13	:	:	:	:	31.9	0.39	14
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.03	0.49	0.20	0.07	0.08	0.05	0.27	0.11	0.31	:	:	:	:	34.8	0.52	13
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	67.4	67.8	69.2	70.0	70.6	72.0	75.8	76.8	77.0	69.9	66.7	70.4	:	0.4	68.6	10
R&D Intensity (GERD as % of GDP)	0.60	0.70	0.72	0.77	0.85	0.93	1.13	1.08	1.28	1.43	1.63	*2.38*	:	*13.3*	*2.03*	7
Greenhouse gas emissions - 1990 = 100	42	43	42	46	47	45	44	52	48	40	50	:	:	8[5]	85	4[6]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	18.4	17.5	16.1	17.1	18.9	23.0	24.3	:	:	4.7	12.5	6
Share of population aged 30-34 who have successfully completed tertiary education (%)	30.8	29.5	28.1	27.6	27.4	30.6	32.5	33.3	34.1	35.9	40.0	40.3	:	2.5	34.6	13
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	26.3	25.9	22.0	22.0	21.8	23.4	21.7	23.1	:	-1.8	*24.2*	15[6]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) EU is the weighted average of the values for the Member States.

(4) The value is the difference between 2012 and 2000.

(5) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(6) The values for this indicator were ranked from lowest to highest.

(7) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Link training and education more effectively to the needs of the labour market, and enhance cooperation between businesses and academia. Increase opportunities for low skilled workers to improve their access to life-long learning. Foster prioritisation and internationalisation of the research and innovation systems."

Finland

Towards a Digital Service Economy by Broadening the Innovation Base

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Finland. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 3.78% (EU: 2.03%; US: 2.75%) 2000-2011: +1.12% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:62.91 (EU:47.86; US: 56.68) 2005-2010: +2.71% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.698 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:52.17 (EU:48.75; US: 56.25) 2000-2010: +0.49% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* ICT, Environment, Materials, Energy, Security, Food & agriculture, Health	*HT + MT contribution to the trade balance* 2011: 1.69% (EU: 4.2%; US: 1.93%) 2000-2011: +33.50% (EU: +4.99%; US:-10.75%)

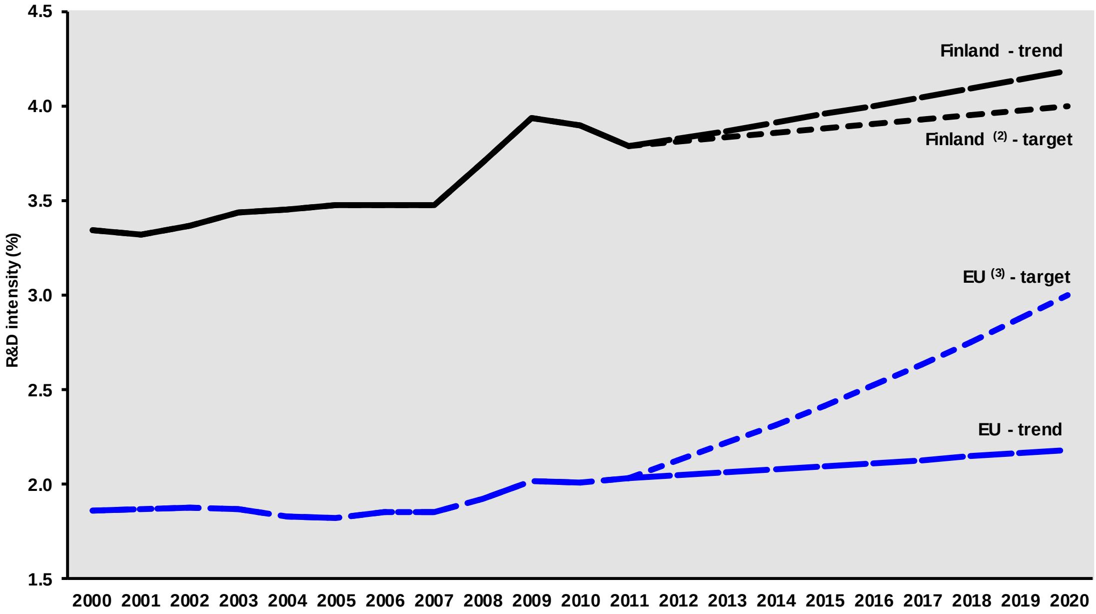
Finland has one of the world's highest R&D intensities. The country also performs very well in terms of scientific and technological excellence, with a strong positive evolution. The Finnish economy is knowledge-intensive, and has achieved an impressive and continuous change towards a stronger high and medium-high-tech specialisation. The country has several hot-spot clusters in key technologies at European and world scale, in particular in ICT, environment, materials, energy, security, and food and agriculture.

However, Finland's competitive position is facing challenges and its large export businesses have suffered. Considering its high level of R&D inputs, the country has a relatively low contribution of high-tech and medium-high-tech goods to the trade balance. Within the past few years, the decline of the important electronics (telecommunications) sector in particular, has created pressure for structural change in Finland. The decline of this sector is expected to be reflected in a decrease in business R&D investments - previously dominated by Nokia. Consequently, as part of the Europe 2020 strategy, the Council recommended to Finland to continue efforts to diversify its business structure, in particular by hastening the introduction of planned R&I measures to broaden the innovation base in order to strengthen productivity growth and external competitiveness. The extent to which the business and public sectors will be capable of absorbing new innovations from the ICT sector - and more concretely the available highly-skilled human resources - is considered a determinant for new growth.

To address these challenges, the Finnish government has intensified the reform of the national innovation system. In addition to general efforts in enhancing the efficiency and improving the internationalisation of its innovation system, current and planned policy reforms are targeted at increasing the number of high growth innovative firms as the major source of future employment growth. The introduced temporary R&D tax incentive from 2013 to 2015 represents a novelty in Finland and targets SMEs and cooperatives. Furthermore, a new tax incentive for private investors into start-ups has been introduced to increase the volume of domestic venture capital market. These actions are expected to support especially knowledge- and innovation-based young growth enterprises. The Finnish Government has also recently fostered innovation and country's transfer to a digital service economy by releasing non-sensitive public data.

Investing in knowledge

Finland - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) FI: This projection is based on a tentative R&D intensity target of 4.0% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.

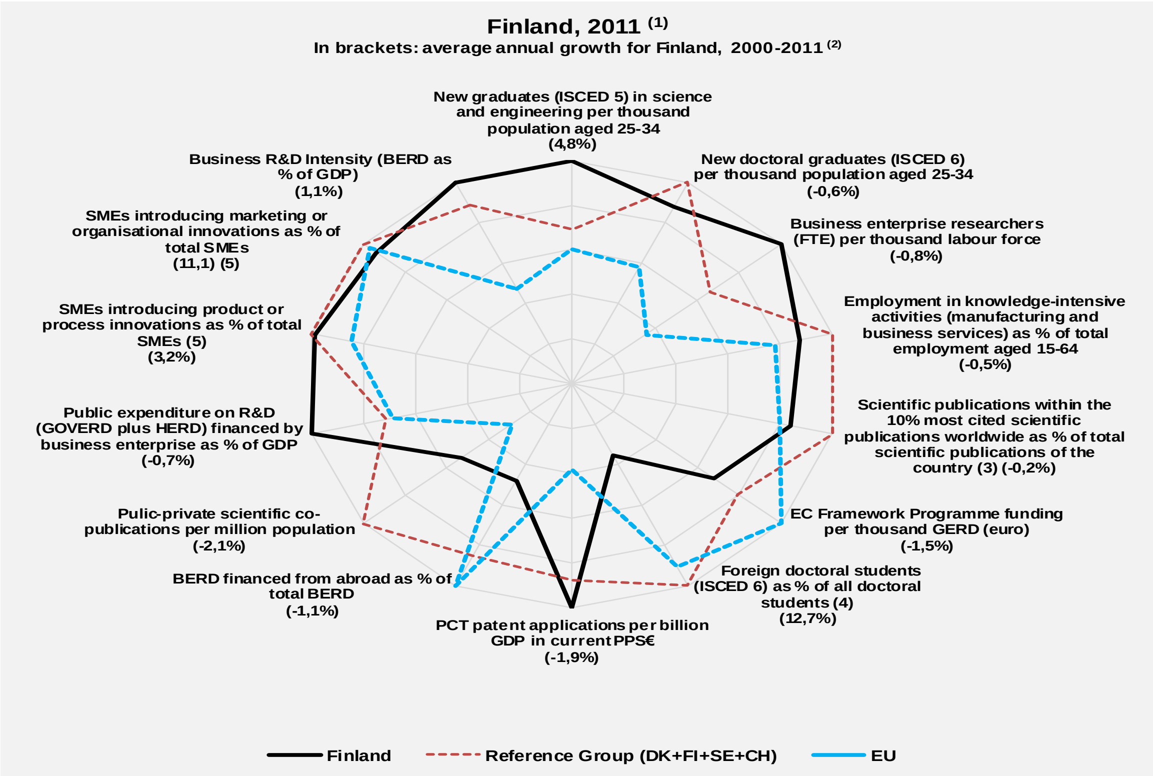
Total R&D expenditure (combining public and private R&D spending) decreased to 3.78% of GDP in 2011 (3.87% of GDP in 2010) which is, nevertheless, the highest value in the EU and close to Finland's national target for 2020 of 4 %. Public R&D investment is however expected to decline in 2012 and 2013, while the on-going decline of the R&D intensive ICT sector will have a negative impact on business R&D intensity. The public R&D budget for 2012 remained at around € 2 billion. According to the Government's multiannual budget framework adopted in March 2012 it will decrease by 1-2% in real terms by 2015. However, due to the R&D tax incentives put in place by end of 2012, the situation may change significantly as the total public support to R&D (direct and indirect) could increase by up to 5% (in real terms) in 2013 compared to 2012.

Finland is the top performer in the EU in terms of business R&D spending (2.67% of GDP in 2011). Aside from the electronics sector, many manufacturing and services sectors have increased their R&D intensities. However, business R&D investments are still highly concentrated in Nokia and a few other large firms. This makes the current good economic position more vulnerable than it appears. Moreover, high growth firms remain slightly less involved in R&D activities than the business sector as a whole.

Public and Private R&D investment receives co-funding support from the European budget. During the ERDF programming period 2007-2013, € 862 million are planned to be allocated to research, innovation and entrepreneurship in the Finnish regions (over half of all ERDF funds for Finland). The share of structural funds allocated to R&I has increased during recent years and 50.7% of the funds had been already committed by the end of 2010. Finland also has the objective to increase its participation in the 7th Framework Programme. Up to mid-2012, almost 1700 Finnish entities had participated in an FP7 project, with a total EC financial contribution of € 558 million and a success rate of 22.42% (slightly above EU average of 21.95%).

An effective research and innovation system building on the European Research Area

The spider graph below provides a synthetic picture of the strengths and weaknesses in the Finnish R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) CH is not included in the reference group.

Finland has overall a strong innovation performance and outperforms its reference group in terms of highly-skilled human resources, public and private investment in R&D and patent applications. However, the share of new doctoral graduates was lower in Finland than in the reference group in 2011. The main weakness of the Finnish innovation system lies in its low level of internationalisation (affecting both the public and private sectors): Finland performs below the EU average on inward BERD, share of foreign doctoral students and participation in EU excellence driven funding programmes. Another relative weakness lays in non-R&D related innovation, in particular the share of SME's introducing marketing and organisational innovations, where Finland also remains slightly below the EU average.

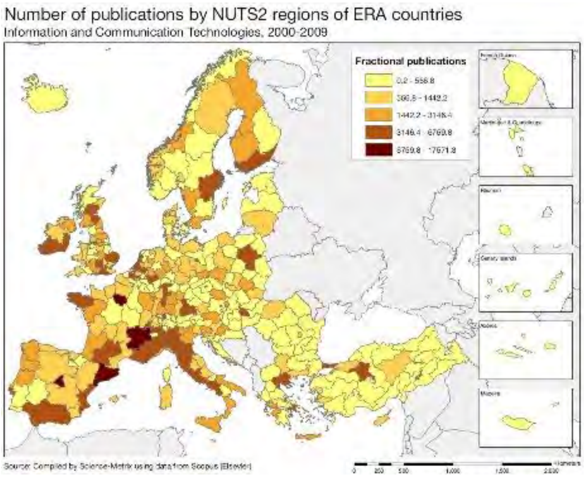
The on-going restructuring of the ICT sector is both a challenge and an opportunity for Finnish SMEs, as much of future innovation and growth depend on them. In 2011, the share of Finnish SMEs introducing product and process innovations was about at the same level with that of the reference group whereas the share of SMEs introducing marketing and organisational innovations was slightly lower than even the EU average. The graph does not fully take into account the on-going structural reforms that are expected to affect in particular the number of business sector researchers and business R&D intensity. In addition, the effect that the expected loss of R&D jobs in the private sector and the subsequent capacity to attract foreign researchers will have on linkages in the R&I system is unknown..

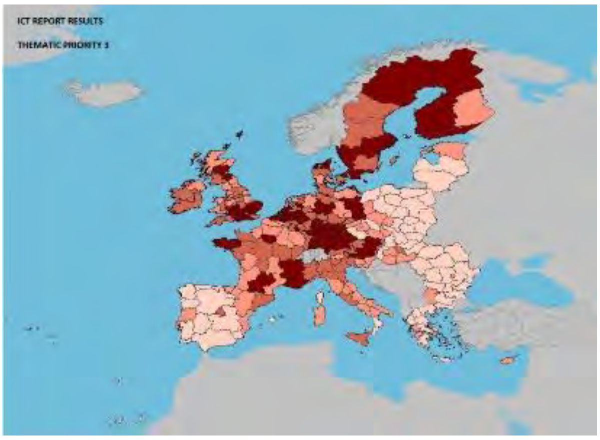
Finland's scientific and technological strengths

The maps below illustrate six key science and technology areas where Finland has real strengths in a European context. The maps are based on the numbers of scientific publications and patents produced by authors and inventors based in the regions.

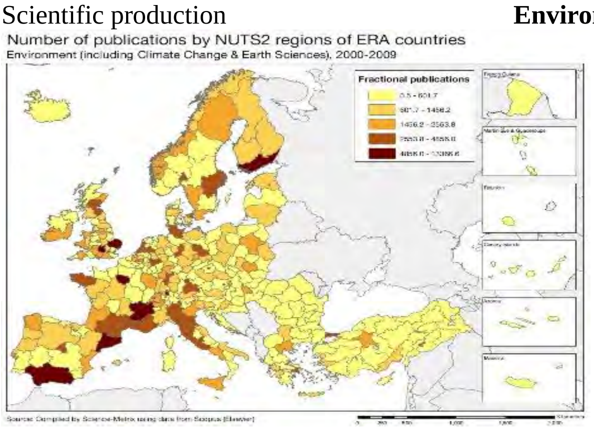
Strengths in science and technology at European level

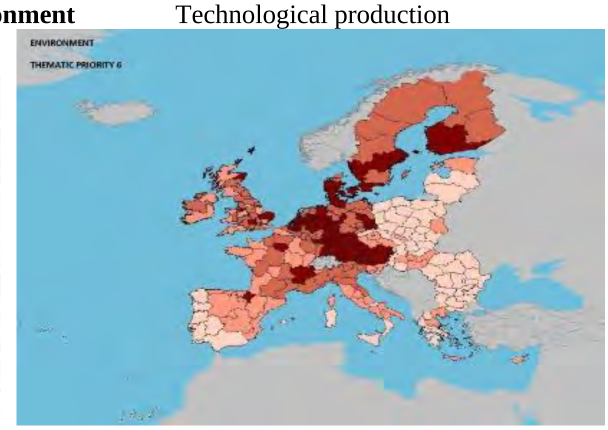
Scientific production **Information and Communication Technologies** Technological production



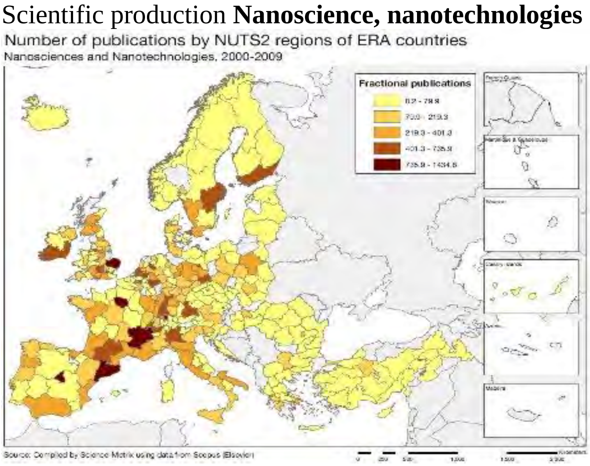


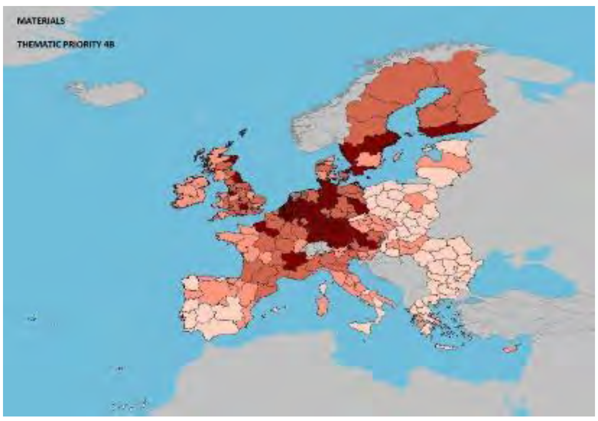
Scientific production **Environment** Technological production





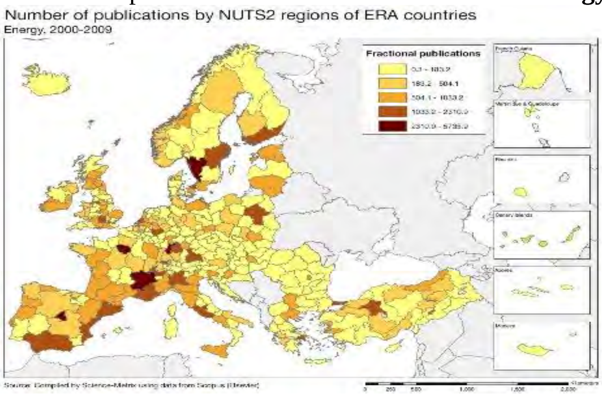
Scientific production **Nanoscience, nanotechnologies** **Materials** Technology production

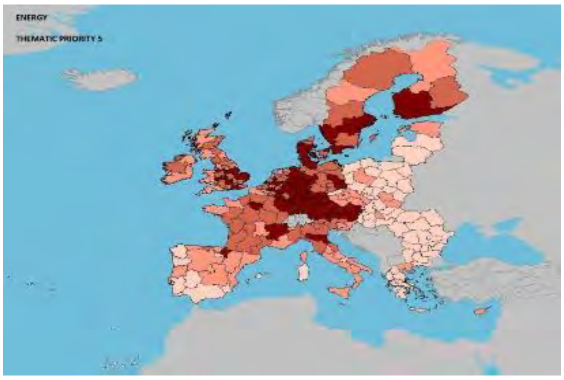




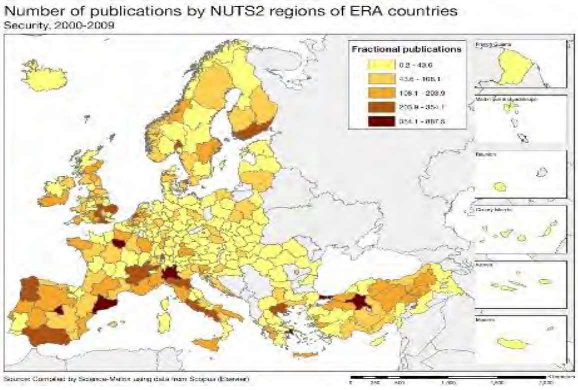
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

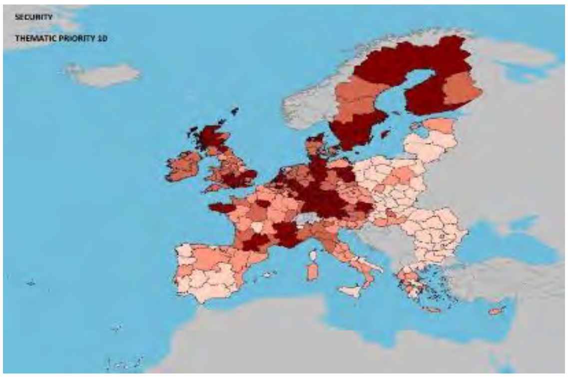
Scientific production **Energy** Technological production



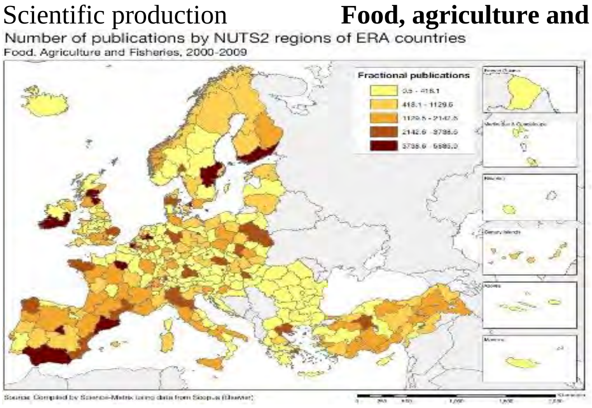


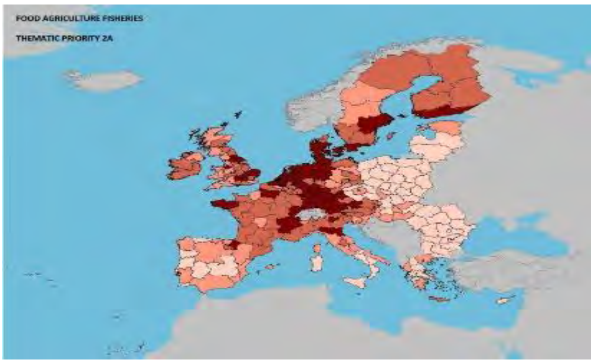
Scientific production **Security** Technological production





Scientific production **Food, agriculture and fisheries** Technological production





Finland has well performing hot-spot clusters in the following broad sectors: ICT (incl. services), environment (in particular environmental technology), materials (construction technology, metallurgy, nanosciences and new production technologies), energy, security, food and agriculture. Most regions in South and South-West Finland are performing well in all of these fields whereas other regions, especially in Northern Finland, are well represented in ICT, environmental technologies, materials and security. Apart from the above clusters, Finland has intensive patenting in machine tools, health, medical technology, pharmaceuticals and biotechnologies. In terms of technological specialisation world-wide, Finland stands out in the ICT and security fields whereas its scientific specialisation is dominated by the following fields: ICT, food and agriculture, environment and construction. In terms of scientific quality (as measured by highly-cited publications), Finnish research excels in nine fields including food and agriculture, security, environment and energy. It is also relevant to consider the matching between science and technology (mainly business-driven) in two of the fields where Finland has major technological strengths, ICT and security: in ICT, scientific and technological specialisations are converging whereas in the security field science quality and technological specialisation are already in line. Overall, a relatively clear correspondence is visible between scientific output and technological specialisation. However, the innovation base should be broadened to take full advantage of scientific quality. In this regard Finland would benefit from a diversification strategy.

Policies and reforms for research and innovation

The Finnish Research and Innovation policy reforms are outlined at the strategic level by the Prime Minister led Research and Innovation Council. The current policy guidelines cover 2011-2015 and despite a change of government in 2011, they are well in line with the more operational government programme, an indication of the overall continuity of Finnish policy. Due to exceptionally strong structural change in some key industrial sectors, most recently in the ICT field, the government is adapting and frontloading the measures to address the most urgent challenge namely the re-employment of R&I professionals, especially in the ICT sector, for sustainable growth.

The Ministry of Science, Education and Culture and the Ministry of Employment and the Economy are jointly preparing an operational and interlinked policy programme concerning Research and innovation with a view to introducing new measures to be taken into a mid-term review of the government programme in early 2013. The focus is expected to be on high-growth innovative enterprises and their framework conditions. The R&I incentives for SME's and private investors are new departures in the Finnish R&I policy. The strategy of the main public R&I funding agency (TEKES) has already been changed accordingly. There will also be a likely set of proposals for enhancement of research activities.

In 2012, the National Reform Programme also foresaw the mid-term revision of the current demand and user-driven innovation policy Action Plan 2010-2013. An independent expert group set by the Research and Innovation Council of Finland released a report concerning the structural reorganisation of government research institutions (PROs) in September 2012. The latter is considered important especially in the context of public sector innovations to societal challenges and enhancement of evidence-based decision-making. In the midst of domestic reforms, the relative weaknesses in internationalization (the challenges of attracting foreign experts and investments and linking into international R&I cooperation) are paid an increased attention as well. Finally, the beginning of 2013 will also see the conclusion of a high-level report on Finland's model for sustainable growth.

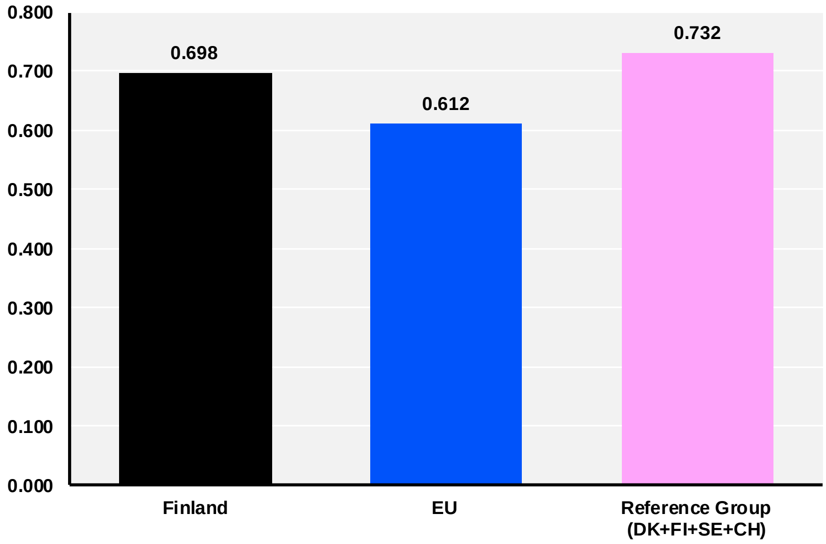
As regards sectors, the government has set up a Finnish ICT cluster expert task force to assess by the end of 2012 the potential for utilising ICT know-how in other industries in Finland, including the public sector. Also the four other Government strategic growth targeted programmes (environment, forest, welfare, creative industries) build heavily on the increased role of ICT – the traditional main driver of the country's productivity growth. If successful in boosting growth in other sectors, ICT is believed also to have the potential to diversify the Finnish economy while making a contribution to important external trade (i.e. services in manufacturing). The opening up of public data is strongly supported.

Finland’s innovation policy and measures in general are geared towards speeding up the development, commercialization and take up of new technologies. Key Enabling Technologies (KETs) are an integral part of public technology and innovation programmes funded by Tekes, and the Technical Research Centre of Finland (VTT). Finnish universities have competencies in all KETs. A new strategic programme on promoting Finnish clean-tech business has been launched in 2012 and other sectoral programmes will follow. Finally, specific measures provide support for the internationalization of the Finnish R&I system. For example, foreign-established companies are eligible for the Tekes funding and the mechanism for the public funding of universities is under revision with a view to supporting their internationalization. Most universities are introducing reforms of doctoral education and tenure track systems for teaching and research personnel, with the aim of enhancing the attractiveness of an academic career. The funding allocated to the tenure track system is decided by the universities themselves. The new funding model of universities is in operation in 2013. The structural development scheme of polytechnics will be implemented in 2014. Overall, the number and scale of reforms described in the 2012 Europe 2020 National Reform Programme (NRP) signal the continuous commitment to a broad and ambitious innovation policy to ensure growth and jobs for the ageing society in a globalised world.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[35].

Finland - Index of economic impact of innovation (1)



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Finland performs well above the EU average but slightly below the reference group in terms of the economic impact of innovation. Finland's relative weakness lays in a less knowledge-intensive export, in particular a lower knowledge-intensive service exports as share of total exports.

The stimulation of high-growth innovative companies in Finland remains a key policy priority in the new Government Programme. Despite Finland’s technological sophistication, its current performance in nurturing high-growth companies could be improved and in fact Finland is lagging behind its own objectives in this regard. This challenge is recognised by the Finnish authorities and new policies are expected in 2013.

The government’s decision to introduce R&D tax incentives from 2013 is a new initiative in Finnish R&D policy. This is in line with the new strategy of Tekes (Finnish Funding Agency for Technology and Innovation) to focus more on high risk innovative high-growth companies. Tax incentives will help start-ups and companies seeking primarily private financing and advice (a tax incentive for private investors). The government is also considering a separate tax incentive for companies making better use of their intellectual property rights (patent pool).

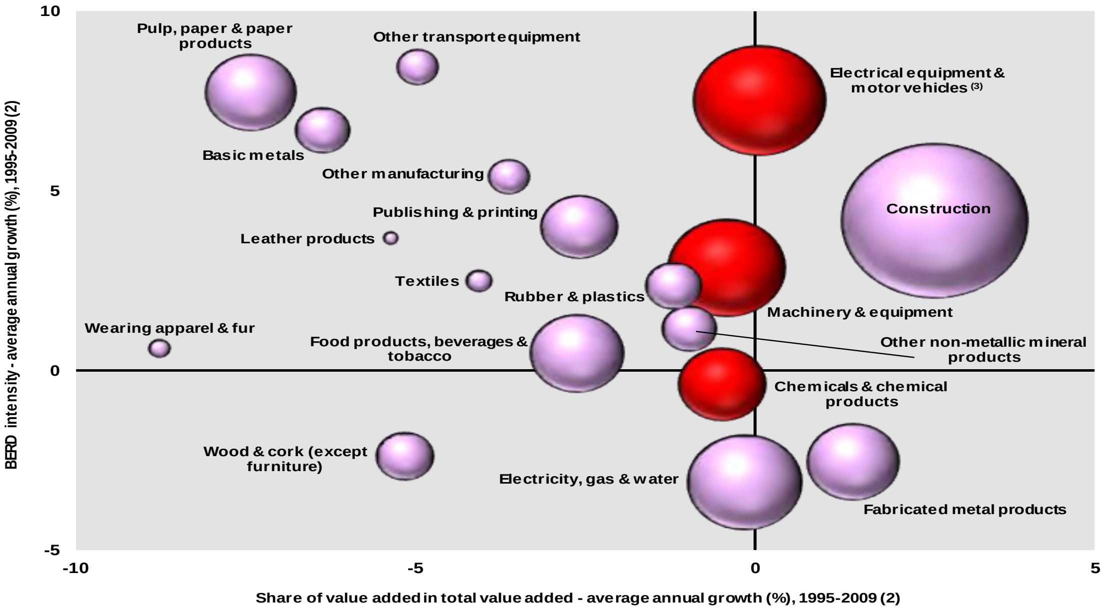
The focus of public R&D&I funding is being shifted to SMEs which are growth-oriented, job creating and are successfully establishing international connections. Several specific policy measures have been taken recently, such as: (1) A new joint service “Growth Track” provided by business development organisations, which is intended for enterprises aiming at rapid growth and internationalization; (2) the introduction by Tekes of a programme for funding young, innovative companies; (3) the renewal of Finnvera’s (Export Credit Agency of Finland) export guarantees schemes; (4) the expansion of the Vigo Accelerator Programme to six areas. (5) the focusing by Tekes of one third of company funding on young innovative enterprises (6) the wider use of financial engineering instruments to maximise the benefits of the EU Structural Funds.

[35] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Finland - Share of value added versus BERD intensity - average annual growth, 1995-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Leather products', 'Textiles', 'Wearing apparel and fur': 1995-2007.
(3) Electrical equipment and motor vehicles includes: 'Office, accounting and computing machinery', 'Electrical machinery and apparatus', 'Radio, TV and communication equipment' and 'Motor vehicles'.

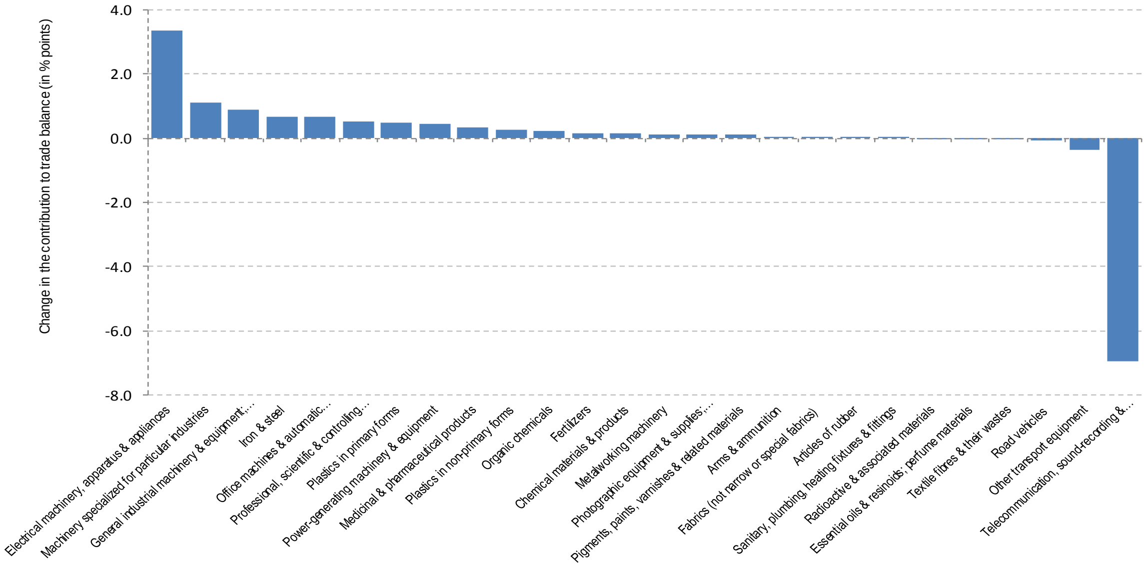
The Finnish manufacturing sector has achieved a clear upgrading of its knowledge-intensity over the last decade. Finland has undergone a period of important economic restructuring and has evolved from having a primarily pulp and paper and machinery driven manufacturing sector towards being a producer of electronics and now increasingly software and services. Simultaneously the services sector, including business services, has grown significantly. The three most R&D intensive manufacturing sectors (red bubbles) have maintained their contributions to value added in the Finnish economy remarkably well. Electrical equipment and machinery have continuously increased their R&D investments, although R&D investment growth in the chemicals sector has been slower. However, the recent ICT sector reorganisation is expected to reduce its share in both value added and BERD intensity whereas the shares of different R&D intensive IT services are expected to increase.

With regard to traditionally less R&D intensive industries (the other bubbles), the high R&D investment growth in the pulp and paper sector signals important efforts by the sector to renew itself by innovation. Some traditional Finnish pulp and paper companies have repositioned themselves close to the energy business. Similar renewal by R&D can be observed in basic metals – a sector leading the mining boom in the most rural parts of Finland. Finally, the graph illustrates that the economically important construction sector has increased R&D investments steadily. Since 2007 the government has been supporting the renewal of traditional manufacturing sectors with a specific public–private instrument (Strategic Centres for Science, Technology and Innovation).

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Finland between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Many Finnish industry sectors have increased their contribution to the trade balance, which is a sign of improved competitiveness in global markets. Also in real terms, the Finnish trade balance in HT and MT products grew significantly over the period 2000-2008, followed by a sharp fall both in imports and exports. This positive evolution of the HT and MT trade balance up to the economic crisis is consistent with the increased knowledge-intensity in most Finnish manufacturing sectors as shown in the previous graph. Different types of machinery (electrical, specialised and power-generating) have managed to improve their contribution to trade the most, reflecting their strong average annual growth of business R&D intensity over the last 15 years. The outstanding exception is the telecommunication sector (led by Nokia), which despite a strong fall in exports from 2009 onwards however still makes the second largest contribution to the Finnish trade balance in absolute numbers (after sector machinery specialised for different industries, and slightly before the sector for power-generating machinery).

The continuous improvement in Finland's competitiveness in most sectors is also reflected in its productivity level. As shown in the table below, Finland's total factor productivity is stable but with a room for improvement in its growth rate compared to other EU Member States. Technologies are oriented towards societal challenges (here environment and health), but there is a worrying decline in health-related technologies. Finland is making progress on all of the Europe 2020 objectives, including a slightly growing employment rate, better environmental protection with a higher share of renewable energy and more young people completing tertiary education. However, in 2011, a share of the Finnish population at risk of poverty or social exclusion slightly increased.

Key indicators for Finland

FINLAND	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	2.71	2.75	2.71	2.74	3.07	3.07	2.96	3.07	2.96	2.89	2.56	:	:	-0.6	*1.69*	4
Business enterprise expenditure on R&D (BERD) as % of GDP	2.37	2.36	2.35	2.42	2.42	2.46	2.48	2.51	2.75	2.81	2.72	2.67	:	1.1	*1.26*	1
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.95	0.94	0.99	0.99	1.01	0.99	0.98	0.94	0.93	1.10	1.15	1.15	:	1.9	*0.75*	1
Venture Capital (3) as % of GDP	0.19	0.15	0.20	0.20	0.07	0.10	0.11	0.46	0.25	0.21	0.22	0.20	:	0.2	*0,35 (4)*	8 (4)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	55.0	:	:	:	:	62.9	:	:	2.7	47.9	4
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	11.7	11.4	11.9	11.4	11.1	11.5	11.4	11.8	11.5	:	:	:	:	-0.2	10.9	7
International scientific co-publications per million population	558	502	530	776	855	909	980	1089	1124	1187	1266	1323	:	8.2	300	5
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	107	107	106	102	98	:	-2.1	53	4
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	12.1	11.7	10.7	10.6	11.6	10.9	11.6	10.3	9.5	10.2	:	:	:	-1.9	3.9	2
License and patent revenues from abroad as % of GDP	:	:	:	:	0.44	0.62	0.51	0.52	0.54	0.73	0.98	1.22	:	15.6	0.58	3
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	14.9	:	15.7	:	15.6	:	15.3	:	:	0.5	14.4	5
Knowledge-intensive services exports as % total service exports	:	:	:	:	19.5	26.1	17.1	24.4	40.0	37.9	35.9	:	:	10.7	45.1	11
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-0.58	-0.11	-0.32	0.17	-0.03	1.44	1.39	1.66	3.56	2.41	2.01	1.69	:	-	4,20 (5)	15
Growth of total factor productivity (total economy) - 2000 = 100	100	101	101	103	106	108	110	114	111	103	106	108	107	7 (6)	103	10
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	49.7	:	:	:	:	51.7	:	:	:	:	52.2	:	:	0.5	48.7	10
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	15.5	15.2	15.1	15.3	:	-0.5	13.6	7
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	37.0	:	44.7	:	41.8	:	44.8	:	:	3.2	38.4	9
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.44	0.59	0.49	0.43	0.39	0.49	0.52	0.45	0.51	:	:	:	:	1.9	0.39	5
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.75	0.85	0.67	0.72	0.66	0.65	0.65	0.55	0.56	:	:	:	:	-3.6	0.52	9
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	71.6	72.6	72.6	72.2	72.2	73.0	73.9	74.8	75.8	73.5	73.0	73.8	:	0.3	68.6	7
R&D Intensity (GERD as % of GDP)	3.35	3.32	3.36	3.44	3.45	3.48	3.48	3.47	3.70	3.94	3.90	3.78	:	*1.1*	*2.03*	1
Greenhouse gas emissions - 1990 = 100	98	106	109	120	114	98	113	111	100	94	106	:	:	8 (7)	85	20 (8)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	29.1	28.7	29.9	29.5	31.1	31.1	32	:	:	1.7	12.5	3
Share of population aged 30-34 who have successfully completed tertiary education (%)	40.3	41.6	41.2	41.7	43.4	43.7	46.2	47.3	45.7	45.9	45.7	46.0	:	1.2	34.6	4
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	17.2	17.2	17.1	17.4	17.4	16.9	16.9	17.9	:	0.6	*24.2*	6 (8)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"In order to strengthen productivity growth and external competitiveness, continue efforts to diversify the business structure, in particular by hastening the introduction of planned measures to broaden the innovation base…"

France

The challenge of structural change for a more competitive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in France. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	**Performance/economic output**
Research	*R&D intensity* 2011: 2.25% (EU: 2.03%; US: 2.75%) 2000-2011: +1.02% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:48.24 (EU:47.86; US: 56.68) 2005-2010: +3.54% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.628 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:57.01 (EU:48.75; US: 56.25) 2000-2010: +0.63% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Energy, ICT, Materials, Nanotechnologies, New Production Technologies, Environment	*HT + MT contribution to the trade balance* 2011: 4.65% (EU: 4.2%; US: 1.93%) 2000-2011: +1.66% (EU: +4.99%; US:-10.75%)

France is among the research-intensive countries in the world. It has a large, relatively strong and competitive science base, is well equipped in large world-class research infrastructures, and is well connected in Europe and internationally. France has, however, the potential to do better in terms of top-end research and high-impact scientific work.

The level of business R&D intensity remains relatively low in France in comparison with other R&D-intensive countries and has not increased substantially over the last decade. This reflects primarily the sectoral composition of the economy, where high-tech manufacturing sectors represent only a modest share. This is also the result of an insufficient engagement of enterprises of intermediate size in R&D activities. France has therefore the potential to reap much larger economic benefits from its scientific and technological strengths. In terms of human capital for R&I, the proportion of students pursuing doctoral studies is lower in France than the EU average. The innovation system would benefit from better promotion of research careers as well as better career opportunities for doctorate holders in the business sector and in the non-academic public sector. To have more of the best talents in doctoral studies and to have more doctorate holders in enterprises is the best way to improve the link between public research and enterprises, and to boost the French economy in innovative sectors. Finally, as successful innovation requires much more than scientific skills, it is important to further develop and expand innovation and entrepreneurship education programmes in higher-education curricula.

In recent years, France has substantially transformed its research and innovation (R&I) system so as to shape it according to some of the best international standards and practice - new funding and evaluation agencies and mechanisms[1], *Pôles de Compétitivité*, autonomy of universities, amplified research tax credit (CIR), programme *Investissements d'Avenir* and the strengthening of public-private cooperation and the valorisation of research results. These transformations are still unfolding and the positive effects of the reform on France's R&I capacity and performance and on the economy at large are expected to grow over time.

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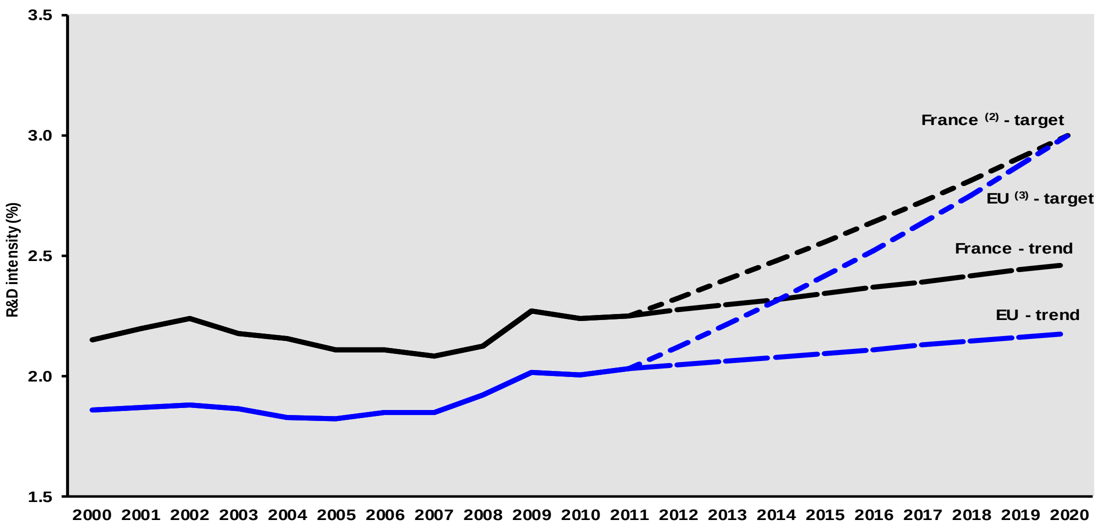
[1] Agence Nationale de la Recherche, OSEO, Agence d'Evaluation de la Recherche et de l'Enseignement Supérieur

Investing in knowledge

France - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2004-2009 in the case of France.
(2) FR: This projection is based on a tentative R&D intensity target of 3.0% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(4) FR: There is a break in series between 2004 and the previous years and between 2010 and the previous years.

France has set a national R&D intensity target for 2020 of 3%. In 2011, France's R&D intensity was 2.25%, with an average annual growth rate of 1% over the period 2004-2009[2] slightly above the EU annual average growth rate over the whole decade. However, this trend will not allow France to reach its target by 2020 as shown above, unless the reforms and the continuous prioritisation of R&D investment in the public budget allow for changing that trend.

France's public R&D budget has been increasing since 2007 (+7.3% in nominal terms, close to € 17 billion in 2011) despite severe budgetary constraints during the economic crisis. According to preliminary data however, this positive trend was reversed in 2012. In addition to the annual R&D budget, € 22 billion is being allocated (most of it as capital endowment) over the period 2010-2020 to research actors through the programme *Investissements d'Avenir*. Also, the research tax credit (CIR) has been considerably amplified since 2008 and represented € 4.7 billion of foregone tax revenue in 2009[3]. Finally, about 31% (€ 4.2 billion) of EU FEDER to France is used for R&D, innovation and entrepreneurship. France has been very successful in the 7th EU Framework Programme (the success rate of French applicants is one of the highest at 25.4%) with almost 8000 French participants in selected FP7 projects up to mid-2012, with a total EC financial contribution of € 3.1billion.

France is one of the rare countries where R&D expenditure of the business sector progressed in 2009, in spite of the economic crisis, a trend probably due in large part to the CIR. Together with a decline in GDP, this progress caused a marked increase in overall business R&D intensity from 1.33% in 2008 to 1.40% in 2009. In 2010 and 2011, business R&D intensity further progressed up to 1.43% of GDP. In terms of economic activities, business R&D expenditure in France is dominated by pharmaceuticals (14% of total business R&D expenditure), motor vehicles (14%), aircraft and spacecraft (11%) and radio, TV and communication equipment (10%)[4].

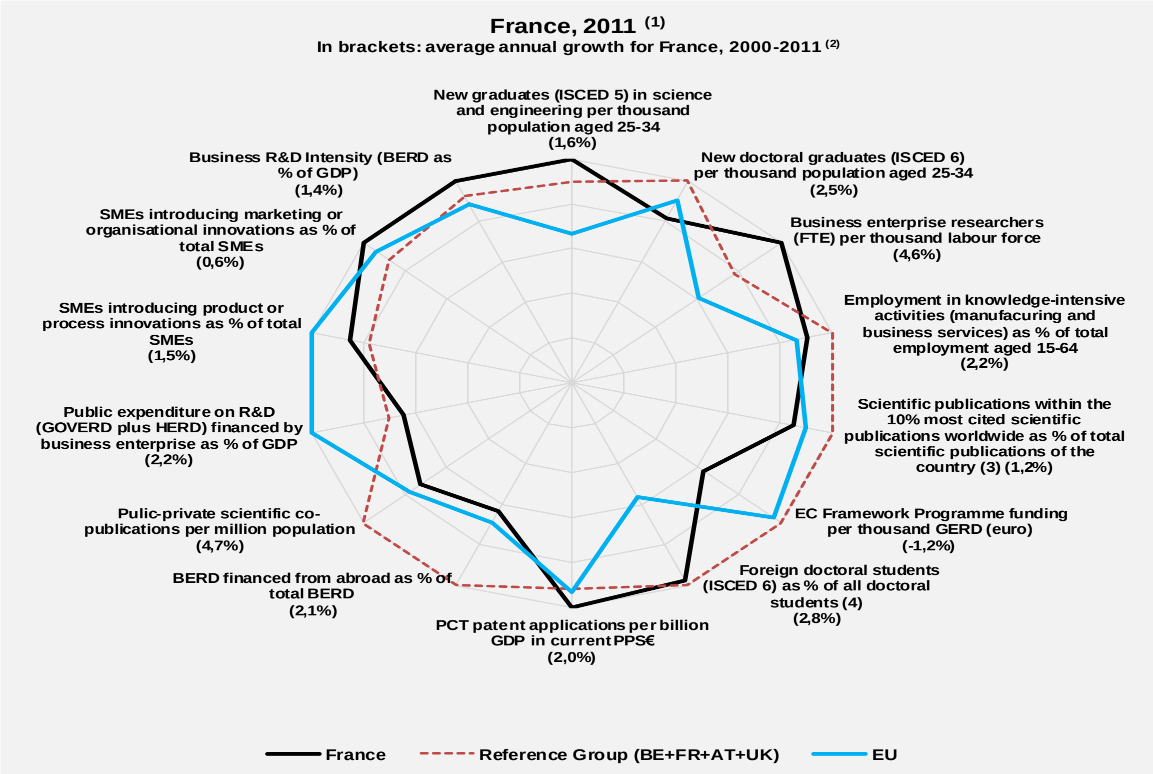
[2] Due to a break in series in 2004 and 2010, the annual average growth rate of R&D intensity in France can only be calculated over 2004-2009.

[3] Not included in the government R&D budget which amounted to 16.8 billion EUR in 2011. Estimations of the foregone revenue due to the research tax credit for 2010 and 2011: 5.05 and 5.1 billion EUR respectively; forecast: between 5.3 et 5.5 billion EUR each year in 2012 and 2013.

[4] 2007, latest year available, data from OECD, Business R&D expenditure (BERD) by economic activity (ISIC Rev. 3) based on 'product field' information.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of France's R&I system. Going clockwise, it provides information on human resources, scientific production, technology development and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

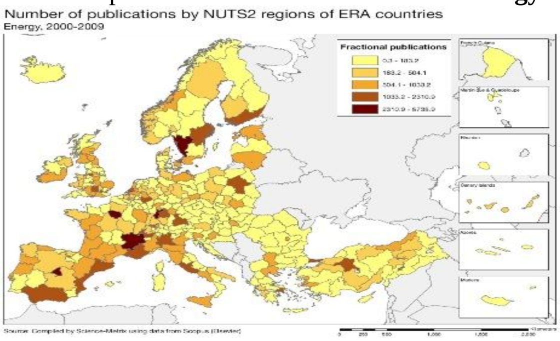
The graph clearly shows that France's weaknesses are in public-private cooperation and in innovation by SMEs where France's performance is below the EU average. In terms of human resources and scientific production, France performs better but it is noticeable that France has less doctoral graduates per population aged 25-34 than the EU average and is performing slightly below the EU average in terms of highly-cited publications. The limited amount of FP funding relative to total R&D expenditure in the country is largely a size effect, which is observed also in Germany, whereby countries with a large amount of domestic resources have necessarily smaller shares of resources coming from external sources. Also, the relatively limited share of business R&D funded from abroad reflects the much lower share of foreign affiliates in France's business R&D than is the case in the smaller countries of the reference group and in the United Kingdom.

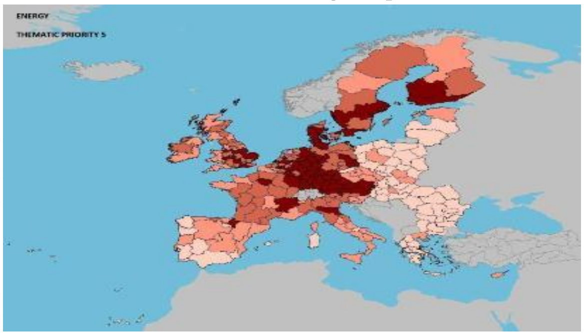
French universities and PROs are very well integrated in European networks where they play a central role. Altogether France's cross-border collaboration in science is high as witnessed by a good level of international scientific co-publications. In most scientific fields France hosts a number of large world-class research infrastructures of pan-European interest open to foreign-based researchers. France is also actively involved in the development of the new pan-European infrastructures of the ESFRI Roadmap and in the different Joint Programming Initiatives.

France's scientific and technological strengths at European level

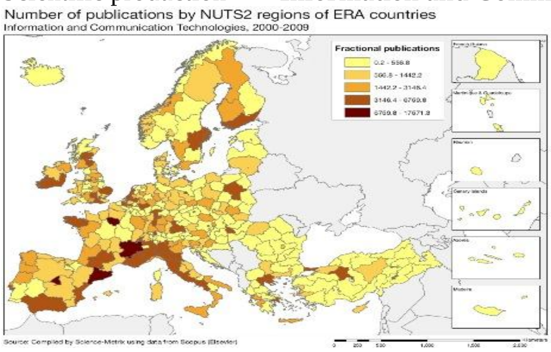
The maps below illustrate six key science and technology areas where France has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

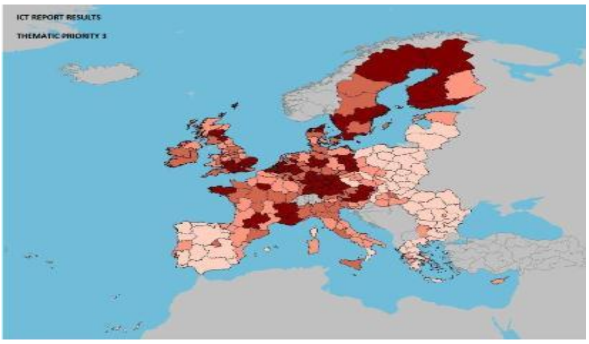
Scientific production **Energy** Technological production



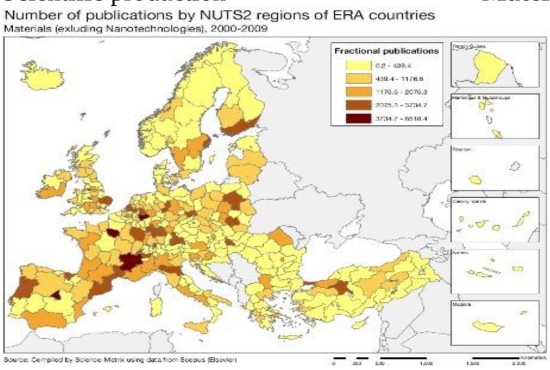


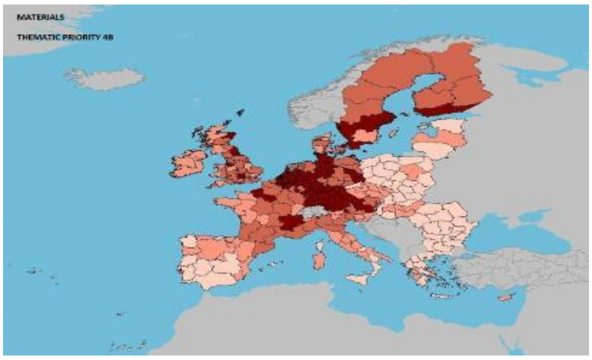
Scientific production **Information and Communication Technologies** Technological production



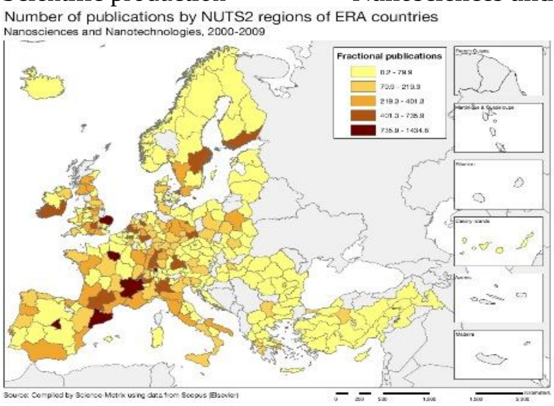


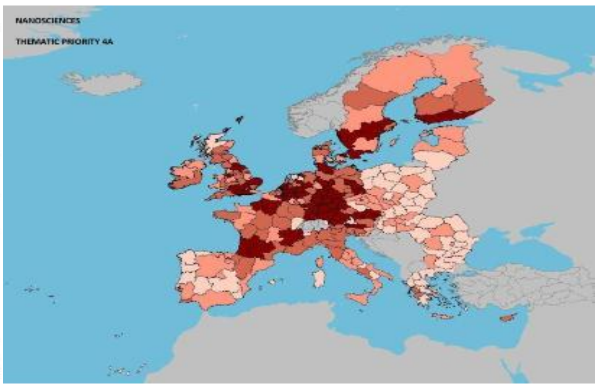
Scientific production **Materials** Technological production





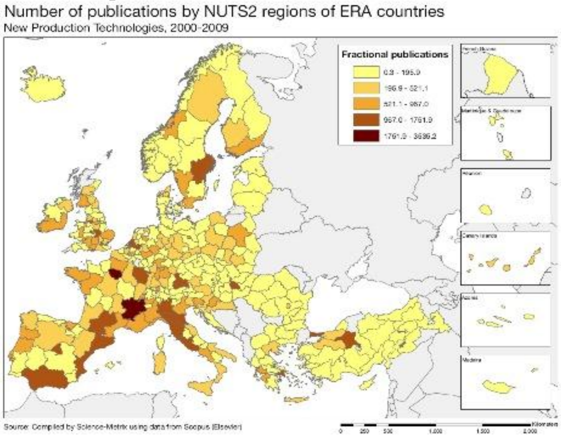
Scientific production **Nanosciences and Nanotechnologies** Technological production

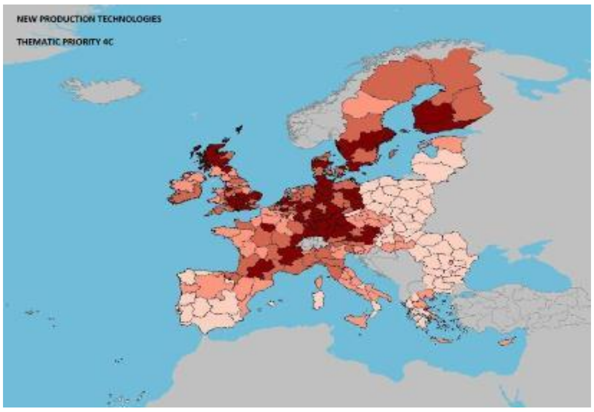




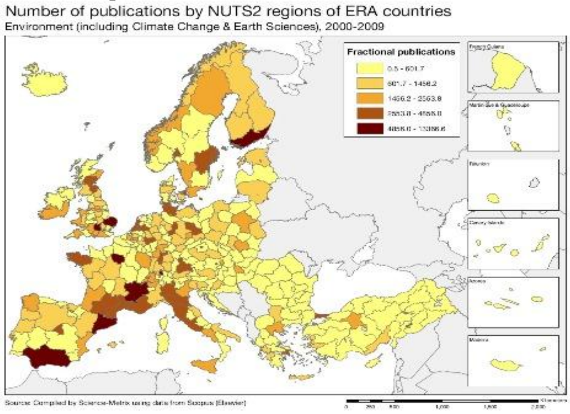
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

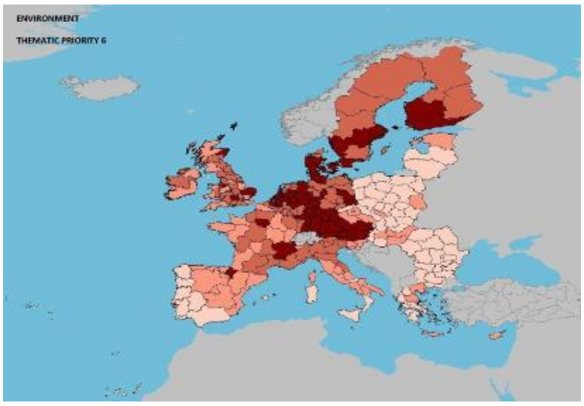
Scientific production **New Production Technologies** Technological production





Scientific production **Environment** Technological production





R&D activities are extremely concentrated in France. Two thirds of the country's total R&D expenditure is performed in 4 (out of 22) regions: about 40% in Ile-de-France (IdF), 12% in Rhône-Alpes (R-A), 8% in Midi-Pyrénées (M-P) and 6.5% in PACA. The scientific and technological production in all thematic fields is consequently the highest in these regions.

IdF is among the very top regions in Europe in the production of scientific publications in each and every FP7 Thematic Priority. R-A shares with IdF this top position in scientific production in Europe in ICT, materials, nanosciences and nanotechnologies, new production technologies (NPT), and other transport technologies[5]. R-A is also strong in Europe in the fields of energy, environment, health, biotechnologies, automobiles, and security. M-P specializes in aeronautics and space, NPT, nanosciences and nanotechnologies, ICT, and environment. The FP7 thematic priorities where more regions in France have a good level of activity are food and agriculture, energy, ICT, materials, nanosciences and nanotechnologies, NPT, environment (maps above), but also security and other transport equipment. Overall, France's scientific publications have their highest impact in materials and energy, followed by other transport equipment, food and agriculture, NPT, construction, environment, aeronautics and space.

Patenting activity is more evenly distributed across regions in France than scientific publications (maps above), despite the fact that IdF and R-A still dominate and are among the top regions in Europe in most fields. With the exception of these two regions, few French regions are among the top European regions which are dominated by the regions of Germany and the Netherlands. In France, there is a good match between the level of scientific activity and the level of patenting activity in a given field: French regions in dark on the left are also in dark on the right. However, there are a number of French regions with lower volumes of scientific production which maintain a good level of patenting activity, attenuating the sharp regional disparities that are observed in scientific production.

[5] i.e. other than aeronautics and space and automobile

Policies and reforms for research and innovation

The first National Strategy for R&I in France was adopted in 2009 for the period 2009-2012 and will be renewed every four years. It sets out fundamental principles and priority thematic axes, namely health and biotechnologies, environment, ICT, and nanotechnologies. Five Alliances coordinate PROs[6] and universities around five thematic areas (life sciences, environment, energy, ICT, social sciences and humanities) to strengthen the programming function of the system, optimize the distribution of human resources across themes and to play an important role in joint programming orientations at European level. Since 2008, budget programming has become multi-annual.

Since the law on the autonomy of universities was passed in 2007, all universities[7] have become autonomous in managing their budgets and human resources and have the possibility of owning their premises. The law reforms the governance of universities, by reinforcing the role and leadership of the President, reducing the size of the board and opening its membership to external people, from the business sector and local authorities in particular. The French authorities have intensively promoted the emergence of large world class poles of excellence in higher education and research with large financial support through the programme *Investissements d'Avenir* (*IA*) and the *Opération Campus*.

The share of project-based funding in total public R&D funding has been rising continuously with the creation of the *Agence Nationale de la Recherche* (ANR) in 2005. In addition, an increasing part of institutional R&D funding is based on the performance of the public research institutions. The latter are evaluated by the *Agence d'Evaluation de la Recherche et de l'Enseignement Supérieur* (AERES) set up in 2007 which also evaluates research units and higher education programmes and diplomas, and validates the personnel evaluation systems of research institutions.

The *Plan Carrières 2009-2011* creates a doctoral contract, raises young researchers' salaries, increases the promotion rate, introduces flexibility in the teaching/research balance, and offers "scientific excellence" bonuses and Chairs. Recruitment of academic staff is largely open to foreigners who represent ¼ and 1/6 of the newly recruited researchers and teacher-researchers respectively. Universities have been assigned a third mission, namely the positioning of their graduates in the labour market for which a dedicated office in each university has been created. Closer ties are being built between universities and enterprises. Universities are diversifying their sources of funding. Modules on entrepreneurship, enterprises and economic intelligence are being developed in universities.

Since 2005, France has adopted a number of important measures and taken steps to boost business R&D investment, in particular by SMEs, and to foster public-private collaboration and the exploitation of research results for commercial applications. These include the reformed *Crédit d'Impôt Recherche* (CIR), the *Pôles de Compétitivité*, the *Jeunes Entreprises Innovantes*, the Carnot Institutes, and several initiatives under the programme *IA* (e.g. *Instituts de Recherche Technologique, Société d'Accélération du Transfert Technologique*) which devotes 3.5 bn EUR to the valorisation of research results. France has also created the first investment and valorisation fund of patents in Europe, *France Brevets*, which aims at helping public and private research to valorise their patent portfolios.

France has also put in place a strong cluster policy since 2004 with the *Pôles de Compétitivité*. Regions have adopted regional innovation strategies. Their higher education, research and innovation strengths and weaknesses are analysed in STRATER documents published by the Ministry of Higher Education and Research in 2011.

Regarding demand-side measures, France has developed initiatives to support public procurement of innovation and facilitate SMEs' involvement in the public procurement process (e.g. *Loi de modernisation de l'économie 2008, article 26*, and several experiments developed by some of France's leading procurers).

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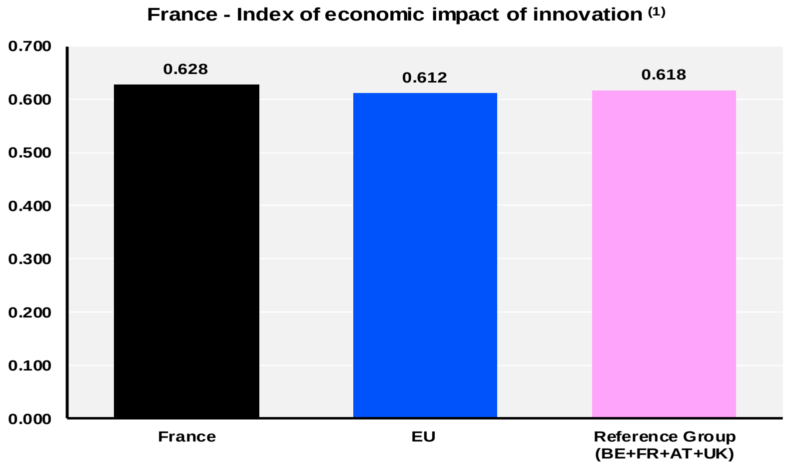
[6] Non-university Public Research Organisations

[7] With the exception of Antilles-Guyanne, Polynésie française and La Réunion.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[8].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

According to this index, the economic impact of innovation in France is comparable to its reference group, slightly above the EU average. Within this index, the contribution of high- and medium-tech products to the trade balance is particularly high in France compared to the EU average (see analysis by categories of products in the section 'Competitiveness in global demand and markets' below). In contrast, the share of knowledge-intensive exports in total services exports is much lower than the EU value, probably due in part to the important weight of tourism in France's economy. France's performance on the last three indicators (patent inventions, employment in knowledge-intensive activities in total employment and sales of new-to-market and new-to-firm products) is slightly above the EU average.

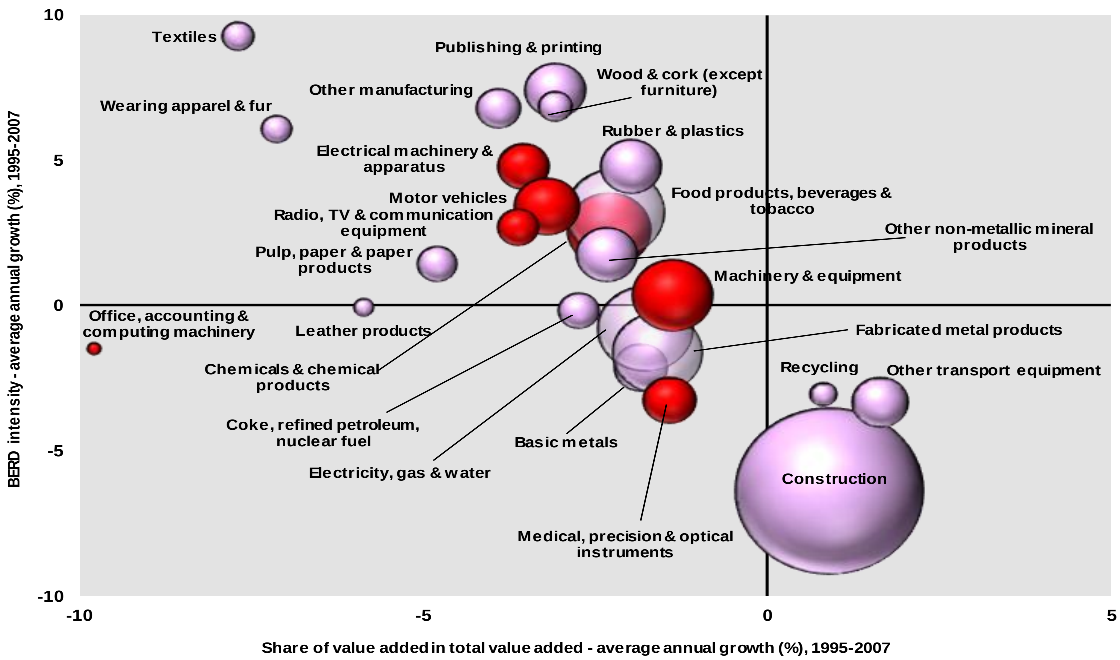
One key factor to increase the economic impact of innovation is of course the structural change that allows innovation-driven growth. High-growth innovative firms in particular play a catalytic role in this respect. Virtually all R&D performers in France are now using the CIR. It has been found to be an important element of the country's attractiveness for R&D activities of firms and allows firms that were not active in R&D to start R&D activities. Young Innovative Firms can in addition benefit from reduced social charges and taxes through the *Jeunes Entreprises Innovantes* (JEI) scheme. The vast majority of these firms are in services, primarily ICT services and S&T services[9] The public enterprise OSEO proposes a variety of financial instruments to finance innovation activities in SMEs and in enterprises of intermediary size (ETIs[10]) at all stages of development of the firm, in partnership with regions (through OSEO's network of regional agencies) and European funds. It will be an important element of the *Banque Publique d'Investissement* which is being created to support SMEs' and ETIs' investment capacity. The *Pôles de Compétitivité* have contributed to develop and strengthen links between SMEs and large firms. SMEs have been much and increasingly involved in the collaborative R&D projects of the *Pôles* and substantially benefit from the associated public funding. After two first phases focused on new collaborative R&D projects, the *Pôles* policy could now focus more specifically on the growth of the *Pôles*' SMEs and ETIs, in particular by promoting innovation and commercialisation activities. Demand-side measures have received less attention, although some initiatives have been taken to promote the use of public procurement for innovative products.

[8] See Methodological note for the composition of this index.
[9] OSEO, PME 2011 report. These services firms however, often serve manufacturing industries.
[10] *Entreprise de Taille Intermédiaire*, 250-5000 employees. This category of enterprises was officially created in France in the *Loi de Modernisation de l'Economie* (2008).

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

France - Share of value added versus BERD intensity - average annual growth, 1995-2007



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Note: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.

The graph above shows that almost all manufacturing sectors have seen their *weight in the economy* decrease substantially in France (horizontal axis) since 1995. The only exceptions are other transport equipment and recycling. This evolution, which reflects the trends toward a more service-oriented economy[11], is similar to the one observed at the level of the EU as a whole, but more pronounced. Since manufacturing high-tech and medium-high-tech sectors (coloured in red), are the most research intensive sectors in the economy, the shrinking of these sectors in particular has a negative effect on total business R&D intensity in France. In contrast, *the research intensity* (vertical axis) of a large majority of the manufacturing sectors has increased, including a majority of high-tech and medium-high-tech sectors. This of course brings the overall business R&D intensity upwards.

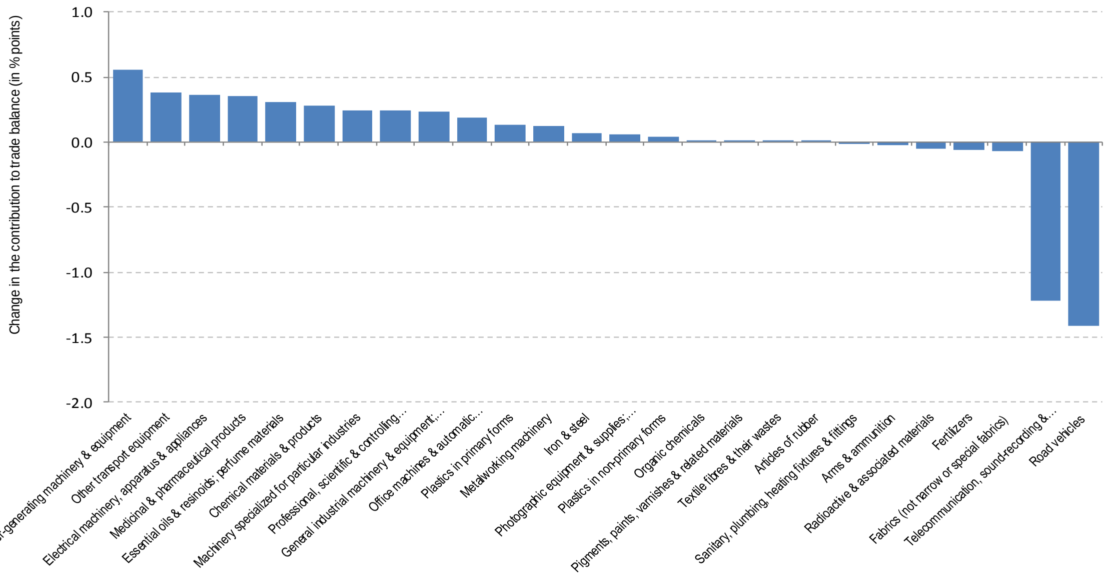
In total, the first effect has been stronger than the second - overall business R&D intensity decreased from 1.39% of GDP to 1.31% between 1995 and 2007. Since 2007, it has increased again to 1.38% of GDP. France's manufacturing industry is dominated by the food products, beverages and tobacco, and fabricated metal products sectors and not by high-tech and medium-high-tech sectors. This contributes to limit the R&D intensity of the business sector in France.

[11] Service sectors are not represented on the graph.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for France between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The trade balance in all high-tech (HT) and medium-tech (MT) products together remained positive in France over the whole decade, although this positive balance has continuously decreased since 2003. As to the total trade balance, it has become increasingly negative over the decade. HT and MT products have therefore been positively contributing to redress the trade balance in France, which indicates a relative specialisation of the country in these products in international trade. Because the erosion of the positive trade balance in HT and MT products has been slower than the deterioration of the overall trade balance, the positive contribution of these products has increased over the decade.

The graph above shows the increase of this positive contribution for the majority of HT and MT products (the largest increase concerns power-generating machinery and equipment and other transport equipment). This shows that the trade balance situation of these products has improved compared to the overall trade balance in France, indicating an increasing specialisation of the country in these products in trade. The previous graph had shown that the other transport equipment sector was one of the few manufacturing sectors whose share in total value added had increased. These two results highlight the particular importance that this sector has gained in France. In contrast, the trade balance in telecommunications apparatus and in road vehicles has deteriorated much faster than the overall trade balance, despite an increasing research intensity effort (previous graph).

Total factor productivity has basically not changed since 2000 in France, although it has progressed in 21 Member States and by 3% in the EU on average (table below). Regarding the Europe 2020 targets, France's weakest performance concerns greenhouse gas emissions, renewable energy (despite visible efforts in environment-related patenting activities) and employment rate.

Key indicators for France

FRANCE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	1.19	1.21	:	1.00	:	1.16	1.20	1.30	1.40	1.49	:	:	:	2.5	*1.69*	14
Business enterprise expenditure on R&D (BERD) as % of GDP	1.34	1,39 (3)	1.42	1.36	1,36 (4)	1.31	1,33 (5)	1.31	1.33	1.40	1.41	*1.43*	:	*1.4*	*1.26*	8
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.78	0.78	0.79	0.78	0,77 (4)	0.77	0.75	0.75	0.77	0.84	0,80 (6)	*0.79*	:	*1.8*	*0.74*	8
Venture Capital (7) as % of GDP	0.23	0.09	0.08	0.11	0.10	0.10	0.11	0.64	0.44	0.18	0.30	0.46	:	6.6	0,35 (8)	4 (8)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	40.5	:	:	:	:	48.2	:	:	3.5	47.9	9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	9.4	9.1	9.1	9.0	9.2	9.8	10.0	10.1	10.3	:	:	:	:	1.2	10.9	10
International scientific co-publications per million population	309	272	293	408	459	503	531	563	591	637	*660*	683	:	7.5	300	14
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	41	41	42	*45*	49	:	4.7	53	10
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	3.5	3.6	3.5	3.7	4.0	4.1	4.0	4.0	4.0	4.2	:	:	:	2.0	3.9	7
License and patent revenues from abroad as % of GDP	:	:	:	:	0.25	0.29	0.28	0.34	0.39	0.54	0.51	0.57	:	12.4	0.58	9
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	11.7	:	:	:	13.2	:	14.7	:	:	3.9	14.4	9
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	:	:	30.7	29.8	29.6	32.6	:	:	2.0	45.1	13
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	3.88	4.46	4.51	4.51	4.66	4.95	5.11	4.70	5.32	4.76	4.78	4.65	:	-	4,20 (9)	5
Growth of total factor productivity (total economy) - 2000 = 100	100	100	99	99	101	101	102	103	101	99	100	100	100	0 (10)	103	19
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	53.6	:	:	:	:	52.9	:	:	:	:	57.0	:	:	0.6	48.7	6
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	13.5	13.6	13.8	14.4	:	2.2	13.6	12
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	29.9	:	:	:	32.1	:	32.7	:	:	1.5	38.4	16
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.26	0.27	0.27	0.35	0.35	0.31	0.33	0.35	0.40	:	:	:	:	5.7	0.39	7
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.62	0.61	0.61	0.61	0.57	0.58	0.55	0.53	0.57	:	:	:	:	-1.2	0.52	8
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	67.8	68.5	68.7	69.7	69.5	69.4	69.3	69.8	70.4	69.4	69.2	69.2	:	0.2	68.6	12
R&D Intensity (GERD as % of GDP)	2.15	2.20	2.24	2.18	2.16	2.11	2.11	2.08	2.12	2.27	2,24 (6)	*2.25*	:	*1.0*	*2.03*	8
Greenhouse gas emissions - 1990 = 100	101	101	100	101	101	101	99	97	96	92	93	:	:	-8 (11)	85	15 (12)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	9.3	9.5	9.6	10.2	11.3	12.3	12.9	:	:	5.6	12.5	13
Share of population aged 30-34 who have successfully completed tertiary education (%)	27.4	29.5	31.5	34,9 (13)	35.7	37.7	39.7	41.4	41.2	43.2	43.5	43.4	:	2.8	34.6	8
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	19.8	18.9	18.8	19.0	18,6 (14)	18.5	19.2	19.3	:	1.2	*24.2*	8 (12)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2001 and the previous years.

(4) Break in series between 2004 and the previous years.

(5) Break in series between 2006 and the previous years. Average annual growth refers to 2006-2011.

(6) Break in series between 2010 and the previous years. Average annual growth refers to 2004-2009.

(7) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(8) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(9) EU is the weighted average of the values for the Member States.

(10) The value is the difference between 2012 and 2000.

(11) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(12) The values for this indicator were ranked from lowest to highest.

(13) Break in series between 2003 and the previous years. Average annual growth refers to 2003-2011.

(14) Break in series between 2008 and the previous years. Average annual growth refers to 2008-2011.

(15) Values in italics are estimated or provisional.

Germany

The challenge of maintaining a high innovation capacity for an export oriented economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Germany. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 2.84% (EU: 2.03%; US: 2.75%) 2000-2011: +1.28% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:62.78 (EU: 47.86; US: 56.68) 2005-2010: +3.88% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.813 (EU:0.612)	*Knowledge-intensity of the economy* 2010:44.94 (EU: 48.75; US: 56.25) 2000-2010: +1.04% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Automobiles, Environment, Energy, New production technologies	*HT + MT contribution to the trade balance* 2011: 8.54% (EU: 4.2%; US: 1.93%) 2000-2011: -0.70% (EU: +4.99%; US:-10.75%)

Germany has expanded its research and innovation system over the last decade. Investment in R&D has grown substantially since 2000 to reach 2.84% of GDP in 2011, which is already close to the 3% national target for 2020[12]. Public expenditure represents one third of investment in R&D. The government increased the public budget on research and innovation even during the 2009 economic crisis as part of a policy of prioritising spending on education and research. Business enterprise expenditure on R&D, which represents two thirds of investment in R&D, also grew as a % of GDP over the period 2000-2010.

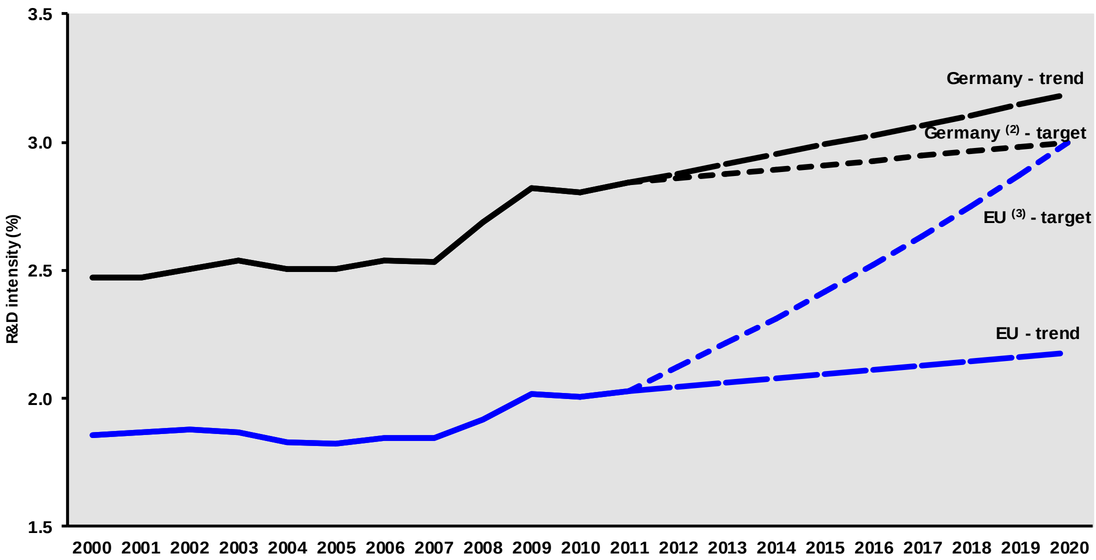
The increase in public and private expenditure on research and development in Germany has helped to maintain a high innovation capacity and a strong export performance. The German economy is based to a considerable extent on medium-high technology sectors such as automobiles, electro-technical products, machinery, and chemical products. However, over the last decade Germany has lost its strong market position in pharmaceuticals and in optical industries. Germany has only produced a few successful new players in high-tech industries in the recent past. The development of biotechnology and advanced computer science remains below potential. There is also still underexploited growth potential as regards innovative and knowledge-intensive service economy sectors. Germany has come through the current economic crisis relatively well, partly as a result of a strong export sector. However, the German market position as regards medium-high-tech products may be challenged in the future by new players such as the BRIC countries. An ageing population and fewer young people represent further challenges for the German economy.

The German ministry for research (BMBF) has employed the so-called *High-Tech Strategy* to address several important challenges. However, further structural reforms of the education, research and innovation system are required. In view of the demographic situation a particular focus on the quality of human resources is necessary and further incentives for excellence and internationalisation are needed. There is room for more public-private cooperation and for implementing targeted supply-side and demand-side measures to foster innovation and fast-growing innovative firms in Germany. Such measures should in particular be targeted at high-tech sectors such as ICT, biotechnology and medical technologies.

[12] In fact, Germany is planning to achieve its R&D intensity target of 3% in 2015.

Investing in knowledge

Germany - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) DE: This projection is based on a tentative R&D intensity target of 3.0% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.

With an R&D intensity of 2.84% in 2011 Germany is above the EU average and is already close to the 3% national target. The gap of 0.16 percentage points currently corresponds to € 4 billion (German GDP amounted to about € 2.5 trillion in 2011). About one third of German R&D investment comes from public sources and two thirds from private sources - a distribution that has remained fairly stable over the last decade. Based on this distribution an additional € 1.5 billion of public expenditure on R&D will be needed (compared to 2011) to reach the R&D intensity target of 3.0%.

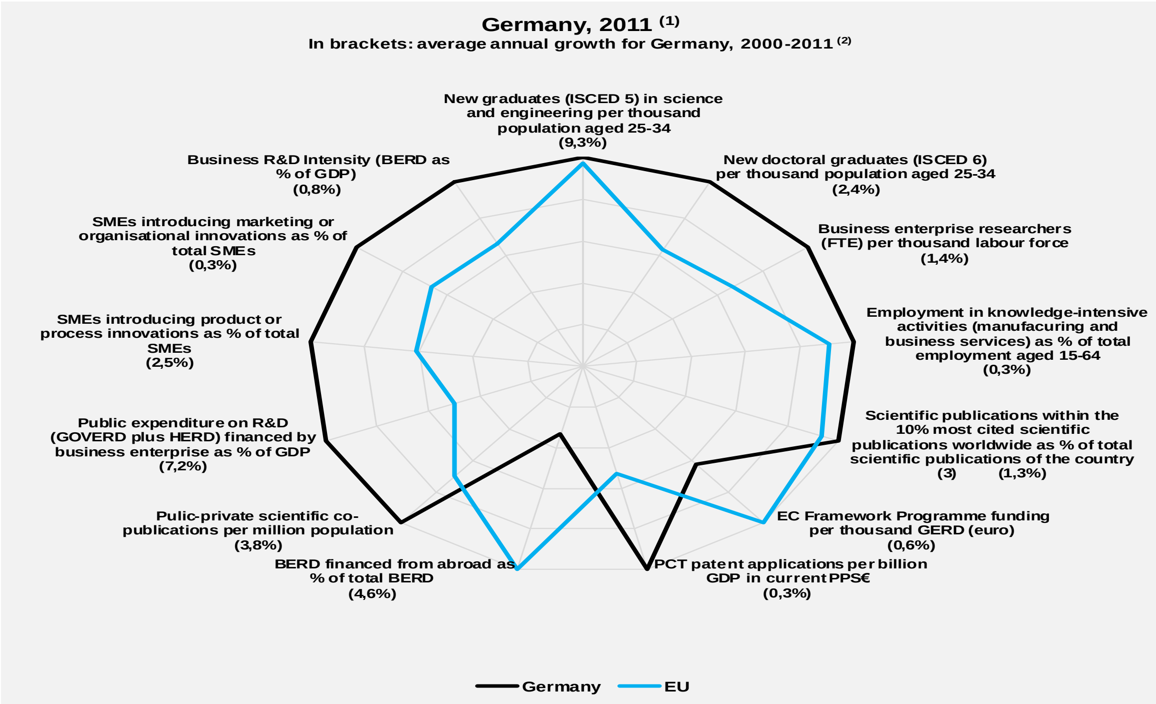
In the period 2000-2011 the federal public research budgets, which represent more than half of public spending on research, were expanded substantially. Federal spending on research and education increased by a further 7% in 2011 and by 12% in 2012. However, at Länder level, growth in R&D expenditure, including university expenditure on R&D was much lower. R&D intensities vary strongly between German Länder, ranging from 1.26% in Schleswig-Holstein and 1.27% in Saarland to 4.83% (2009) in Baden-Württemberg, the European region (NUTS II level) with the highest research intensity. Berlin (3.67%), Bayern (3.1%) and Hessen (3.05%) also have R&D intensities that are already above the German national target.

A recent survey of the Stifterverband für die Deutsche Wissenschaft revealed that internal R&D spending of the business sector is expected to amount to € 49.4 billion in 2011 (+5.1% in nominal terms compared to the year before) and € 49.9 billion in 2012 (+1.2%), implying a probable increase in real terms in 2011 of slightly below 3%, and if confirmed, a slight decrease in real terms in 2012. Research intensity is especially high in the automobile sector, which represents nearly one third of total German business R&D investment. A weak point of German R&D is the relatively low level of spending in high-tech areas such as pharmaceuticals and ICT.

Concerning EU funding Germany has allocated € 25.5 billion of ERDF Structural Funds to research, innovation and entrepreneurship with a 47.1% absorption rate. Germany counts 11 000 participants in the EU FP7 programme and receives the highest amount of FP7 funding in absolute terms (€ 4.3 billion). Its success rate of applications is above average (24% compared to an EU average of 20.4%), but FP7 funding as a % of GDP is below the EU average.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the German R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation, and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.

In general Germany's research and innovation system performs very well. However, the international dimension is below the EU average, in particular in relation to foreign investment in business R&D and EU Framework Programme funding. Possible explanations relate to the country size effect, as well as to the high level of German domestic public and private expenditure on R&D. Despite the easy access to and relative abundance of national funding for research, Germany could better use the opportunities offered within the ERA and more specifically within the Framework Programme.

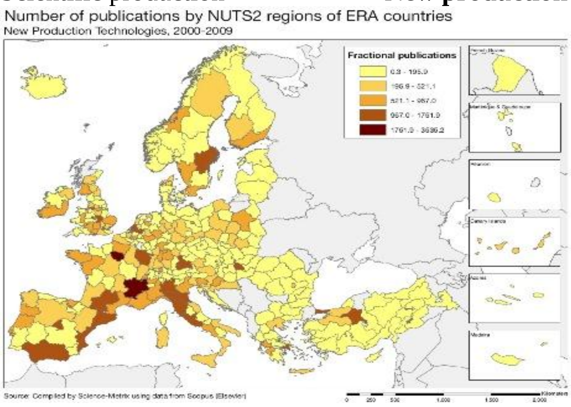
Germany has a particular strength in business R&D especially in innovative SMEs, many of which are world leaders in their particular small market segments. The high level of patenting is an indication of industrial leadership in several domains, most notably in medium-high-tech industries including engineering industries, automobiles and chemicals and also in environmental and energy technologies. Public-private co-operation in publications and in research is functioning well and is further supported by the federal government in the current new programme activities for innovation outlined in the "High Tech Strategy". While Germany performs well in terms of new doctoral graduates, its performance as regards new science and engineering graduates has only recently surpassed the EU average and there is the risk of slower growth in the long term as a result of the ageing of the population. The risk of a scarcity of qualified human resources could in the long term endanger the strong German export position in engineering and science based industries. In recent years there has been an increase in the number of students in science and engineering subjects (MINT), but efforts should be maintained to further reduce dropout rates and to increase the share of female professors, which in turn would attract more female students.

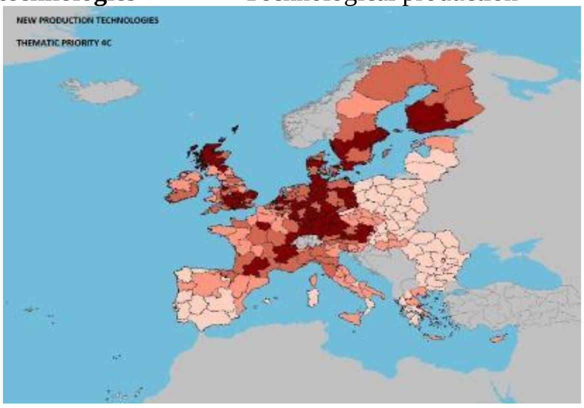
Germany's scientific and technological strengths

The maps below illustrate six key science and technology areas where German regions have real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

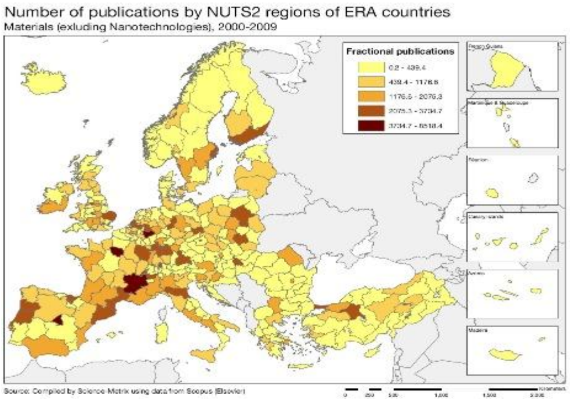
Strengths in science and technology at European level

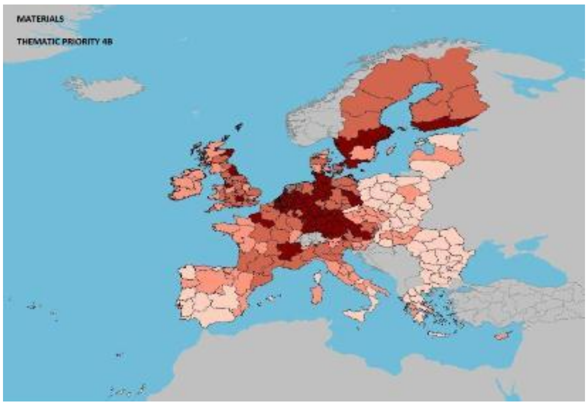
Scientific production **New production technologies** Technological production



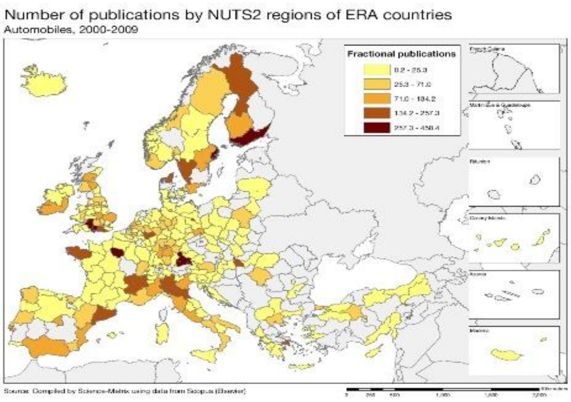


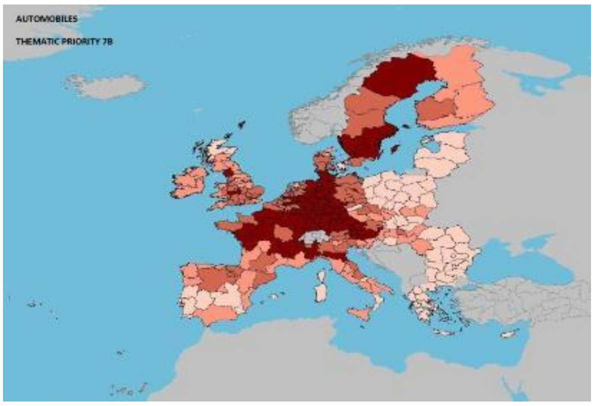
Materials





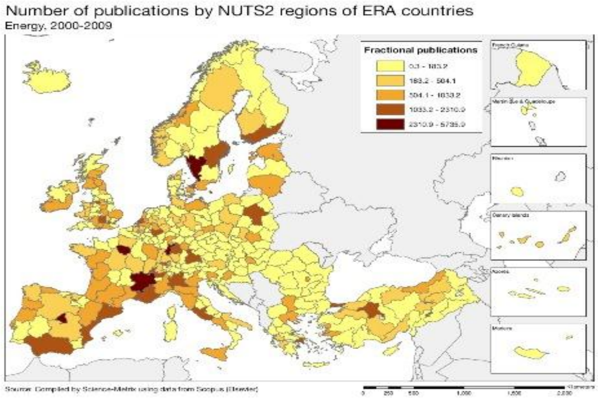
Automobiles

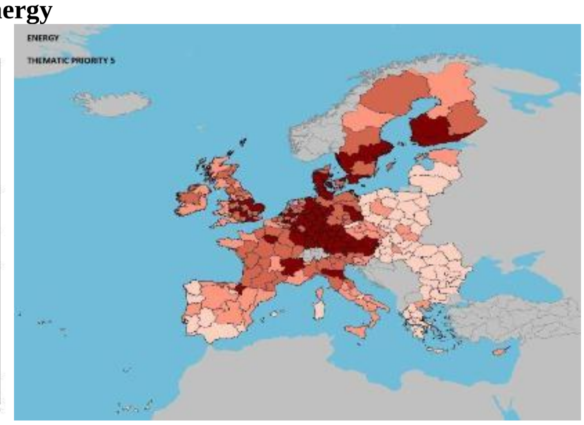




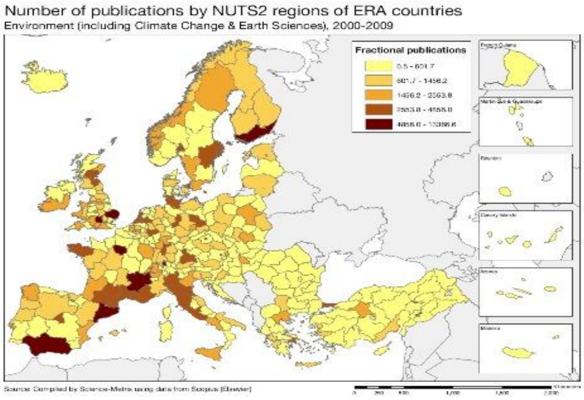
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

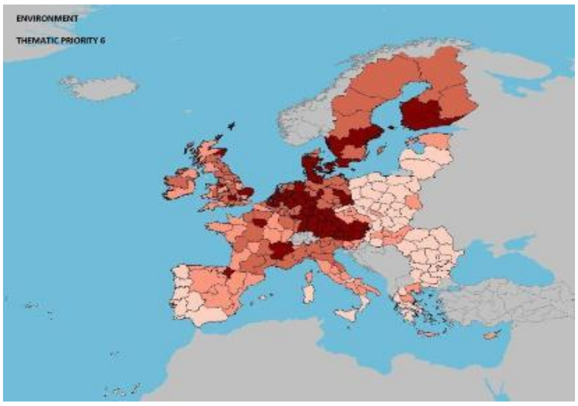
Energy



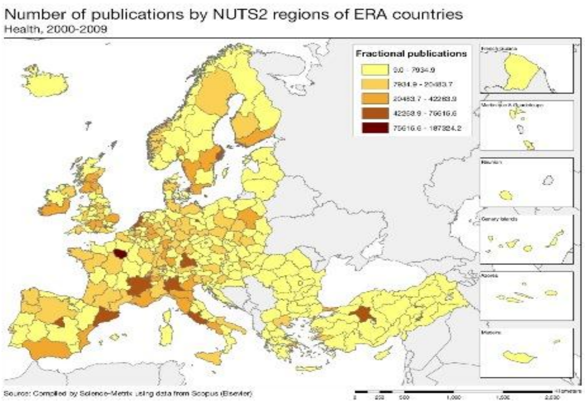


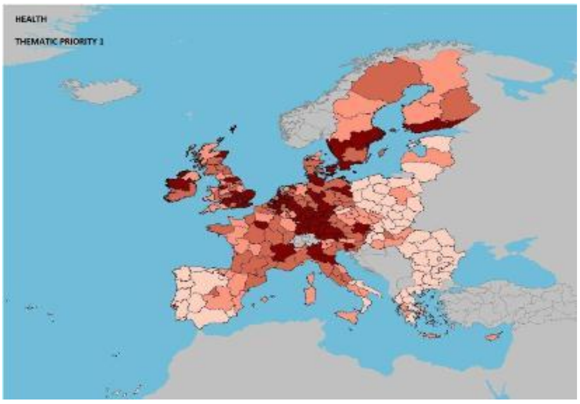
Environment





Health





As illustrated by the maps above, there is a notable difference in performance between scientific production (publications) and technological production (patents) in Germany. Levels of scientific publication vary across German regions with only a few regions on the same level as their main competitors in Europe. This is even true for sectors such as production technologies, materials, and automobiles, where German companies are among the world leaders. An explanation of the relatively weak scientific publication activity in Germany may be a language bias.

Patenting activities in Germany are very high in the areas referred to above. Energy, environment and health are other areas where patenting is particularly strong. The big public research institutes such as the Max Planck Society, the Fraunhofer Society, the Helmholtz society, and also the Leibniz institutes are specialised in these areas, work closely with universities and are generally highly ranked in recognised international comparisons. The regions of the south and the south-west of Germany are most active in patenting. Saxony and southern Brandenburg (Potsdam) in the New Länder as well as Berlin also show relatively high levels of patenting.

Policies and reforms for research and innovation

The *High-Tech Strategy 2020*, launched in August 2006 and updated in July 2010, is seen as an instrument to improve cooperation between science and industry, and to improve the conditions for innovation with a view to enhancing the international competitiveness of technology-intensive manufacturing products in key sectors of the German economy. The 2010 update of the *High-Tech Strategy* prioritises the targeting by public-private partnerships of prospective markets related to important societal challenges in 10 so called forward-looking projects ("Zukunftsprojekte"). Strategic priorities of the *High-Tech Strategy 2020* are health, nutrition, climate and energy security, and communication and mobility.

As regards *fiscal policies* Germany is one of the few countries that has not introduced R&D tax credits. The introduction of R&D tax credits is currently being considered at federal level as such credits tend to be requested by large international companies.

Germany is already quite close to achieving its national R&D intensity target of 3%. Only an extra 0.16 % of GDP or about € 4 billion are needed to reach the target. However, available data show an increasing disparity between R&D intensity in the northern Länder and the southern Länder. In fact R&D intensity is almost four times higher in Baden-Württemberg (the leading EU region) than in Mecklenburg-Vorpommern and Schleswig-Holstein. This disparity also applies to private investment in R&D.

The university system, which is the responsibility of the Länder, is considered to be underfinanced, given the recent strong increase in student numbers. In order to enable additional federal funding for universities, the Hochschulpakt (higher education pact), voluntary agreements between the federal and the Länder levels, has been set up. This pact was renewed in 2009 and additional resources were allocated in March 2011.

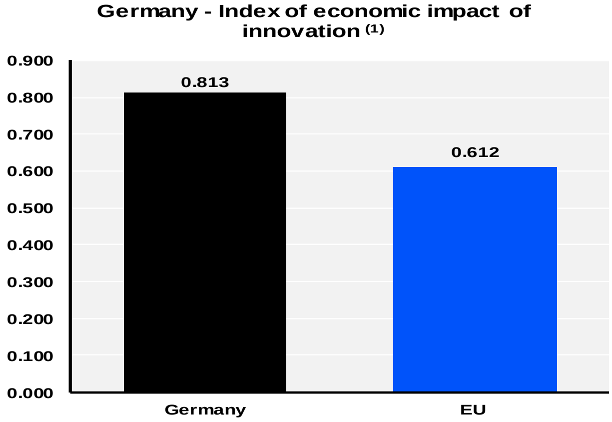
As regards human resources Germany has taken measures to remove restrictions on in-bound researcher mobility in view of a skills shortage in some science and technology domains. The federal government recently decided on a reform of the Immigration Act to facilitate the processing of residence permits, and on an action programme to ensure an adequate supply of labour, and on programmes for enhancing international mobility. The legal parameters for the employment of foreign graduates of German universities have been improved and the recognition of qualifications acquired abroad is being facilitated by new initiatives. This could help to increase the still relatively low share of foreign professors. Researcher salaries in Germany are above the EU average, but lag behind those in the United States and Switzerland. Recently the Constitutional Court issued a ruling on minimum wages for full professors in universities that could lead to increased salaries for those at the lower end of the wage scale.

A national pact to attract more women to science and engineering (*'Komm mach MINT-mehr Frauen in MINT-Berufen'*) was set up on the initiative of the Research Ministry (BMBF) in June 2008 and a second phase of this pact was launched in December 2011.

As regards the *knowledge triangle* and the fostering of innovation activities the Research Ministry (BMBF) and the Ministry for Economic Affairs (BMWI) are making attempts to focus better their activities. The BMBF fosters public/private partnerships by activities such as the 'Leading-edge cluster competition', which aims at the formation of business and science clusters to boost Germany's innovative strengths in specific areas and more recently (August 2011) the 'Research Campus', a competitive funding scheme to strengthen cooperation between companies and research organisations. The BMWI uses the *EXIST* programme to stimulate an entrepreneurial environment at universities and research institutions. This programme is aimed at increasing the number of technology and knowledge-based business start-ups. The programme is part of the federal government’s 'High-tech Strategy' and comprises sub-programmes on improving start-up business culture, stipends and knowledge transfers.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[13]..



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Germany has one of the highest economic impact of innovation in Europe. The German economy is more oriented towards knowledge-intensive sectors than the EU as a whole. This is reflected also in the composition of exports of goods and services and in the innovation activities of enterprises, including those of SMEs, which are clearly above the EU average. Innovative German enterprises have a good growth performance combined with a high level of technology development.

The distribution of business expenditure on R&D reflects the concentration of German industry in medium-high-tech sectors, with more than 30% of R&D spending carried out by the automobile sector alone. Other important medium-high-tech sectors in terms of R&D expenditure are machinery and equipment and chemicals excluding pharmaceuticals. These three sectors represent around 50 % of business expenditure on R&D in Germany. Spending levels are relatively lower in high-tech areas with pharmaceuticals, radio, TV and communication equipment, and medical precision and optical instruments together accounting for only around 20% of business expenditure on R&D. Research is furthermore concentrated in big companies and research intensity is lower in the services sector than in manufacturing. To assist SMEs in enhancing research and innovation a Central Innovation Programme for SMEs (ZIM, 'Zentrales Innovationsprogramm Mittelstand') has been set up in 2008 and will run till 2014.

Framework conditions for entrepreneurship in Germany have improved as indicated by an improved ranking for Germany in the World Banks *ease of doing business* index. Germany has also made progress in reducing the administrative burden related to reporting obligations in the business sector. In 2011, *The Bureaucracy Reduction and Better Regulation* programme has been extended to cover other compliance costs. However, Germany remains at around the EU average regarding the administrative burden of the regulatory framework.

Labour productivity in Germany is high and access to bank lending for SMEs is above the EU average. The quality of the infrastructure is good and the legal and regulatory framework is perceived by business as being appropriate. Remaining weak points concern the availability of broadband and the usage of e-government services. Furthermore the availability of venture capital in Germany (0.17% of GDP in 2011) remains below the EU average (0.35%).

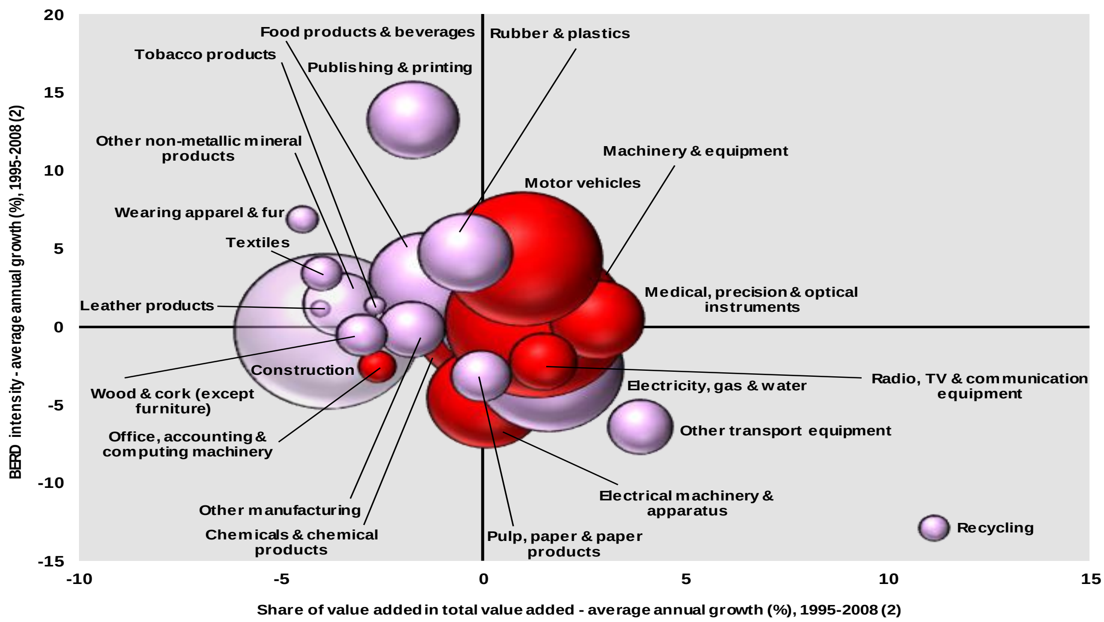
In the Global Competitiveness Report 2012-13 Germany is ranked highest among EU countries in capacity for innovation, second highest (after Finland) in company spending on R&D and 6th in the EU on university-industry collaboration on R&D.

13 See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Germany - Share of value added versus BERD intensity - average annual growth, 1995-2008



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Food products and beverages', 'Printing and publishing', 'Pulp, paper and paper products', 'Textiles', 'Tobacco products", 'Wearing apparel and fur', 'Wood and cork (except furniture)': 1998-2008.
(3) 'Basic metals', 'Coke, refined petroleum and nuclear fuels' and 'Fabricated metal products' are not visible on the graph.

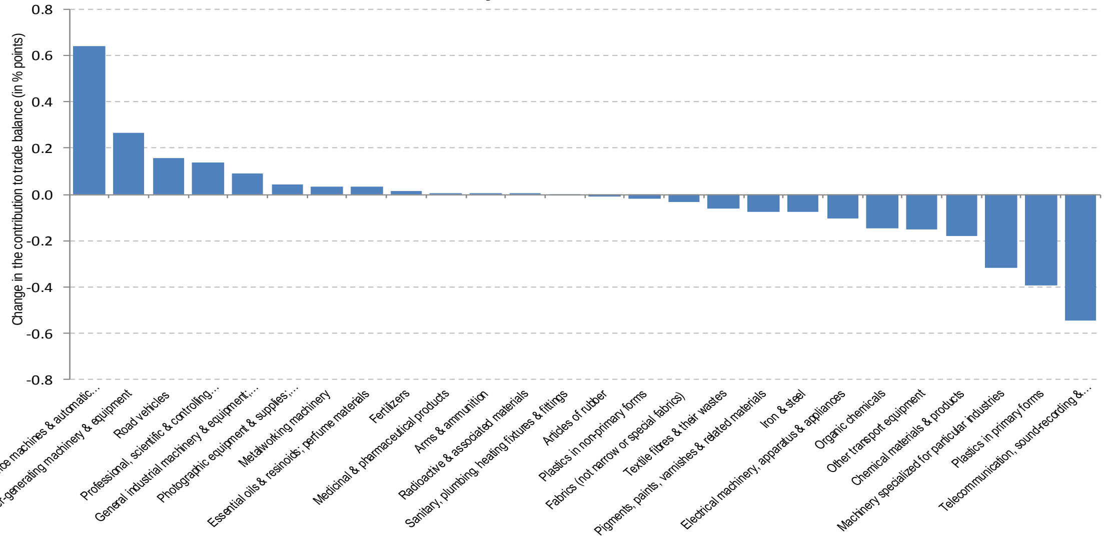
The German economy is characterised by a relatively strong manufacturing industry. Nevertheless, as in many countries, the share of value added of manufacturing industries in total value added is tending to decrease (illustrated by a leftward shift in the graph above). This is linked to rationalisation and a relative decline in the price levels of manufactured goods, the expanding services sector and also to globalisation and competition from lower wage, emerging economies.

Compared to other EU Member States the German manufacturing industries present an above average dynamic of upgrading knowledge through R&D. Growth in business research intensity since 1995 was moderate, but still faster than the EU average. The motor vehicles industry, a key sector of the German economy, has expanded its high research intensity further and has also succeeded in increasing its share of value added. A second important medium-high-tech sector, machinery and equipment, has expanded its share of the economy even more strongly, despite a more moderate growth in research intensity. The same is true for the high-tech sector medical, precision and optical instruments. The medium-high-tech sector electrical machinery and apparatus, has lost research intensity over the last 15 years, but maintained its share of value added. Office, accounting and computing machinery is the only high-tech sector with a decreasing share of value added. In this sector there was also a decline in research intensity over the last 15 years. The insufficient pace of modernisation in these knowledge-intensive industries endangers their medium-term competitive advantage.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Germany between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The German economy is strong and has high levels of exports of manufactured goods for an economy of its size. In fact, Germany is the third largest exporter worldwide[14], after China and the United States. In 2010 Germany was the economy with the largest export surplus in absolute terms. As regards trade in services, in 2010 Germany ranked second, after the United States. In real terms, the German trade balance in high-tech and medium-tech products is positive and has more than doubled over the last decade.

The evolution of the contribution of high-tech and medium-tech products to the trade balance in the decade 2000-2011 shows a mixed picture for Germany, with few sectors expanding their contribution to the trade balance, most sectors not changing their contribution significantly and about one quarter of high-tech and medium-tech sectors' decreasing their contribution. As regards the three largest German export industries, all classified as high-tech or medium-high-tech: machinery, in particular office machinery and power generating machinery has expanded its contribution to the trade balance, while road vehicles, today Germany's largest export industry, has also expanded its contribution, but to a lesser extent. The contribution of chemical products, Germany's third largest export industry, to the trade balance has shrunk over the same period.

Total factor productivity of the German economy increased since 2000 by 5% per annum. However, Germany has performed less well when it comes to up-skilling its labour force. The share of the population aged 30-34 who have successfully completed tertiary education has increased only moderately since 2000 and is now below the EU average[15]. Germany is also making progress towards the other Europe 2020 targets, backed up by a very high but decreasing level of patenting in areas of societal challenges, such as health-related and environment-related technologies.

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[14] In the period 2003-2008 Germany was the largest exporter but has been overtaken in 2009 by China and in 2010 by the USA

[15] If post-secondary non-tertiary education is included (ISCED 4), which Germany considers equivalent to higher education in its national target, Germany performs near the EU average, but growth in attainment still remains below average.

Key indicators for Germany

GERMANY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	2.12	2.13	2.13	2.14	2.23	2.59	2.53	2.52	2.65	2.64	2.68	:	:	2.4	*1.69*	3
Business enterprise expenditure on R&D (BERD) as % of GDP	1.74	1.73	1.73	1.77	1.75	1.74	1.78	1.77	1.86	1.91	1.88	*1.90*	:	*0.8*	*1.26*	4
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.73	0.75	0.77	0.77	0.76	0.77	0.76	0.76	0.83	0.92	0.92	*0.94*	:	*2.3*	*0.74*	5
Venture Capital (3) as % of GDP	0.19	0.13	0.06	0.03	0.05	0.06	0.04	0.34	0.29	0.10	0.19	0.17	:	-1.2	0,35 (4)	10 (4)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	51.9	:	:	:	:	62.8	:	:	3.9	47.9	5
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	10.5	10.7	10.7	10.6	10.7	11.3	11.5	11.4	11.6	:	:	:	:	1.3	10.9	6
International scientific co-publications per million population	297	273	292	413	465	512	536	581	599	643	681	715	:	8.3	300	13
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	65	63	66	73	76	:	3.8	53	9
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	7.2	7.2	7.3	7.6	7.7	7.8	7.8	7.9	7.1	7.4	:	:	:	0.3	3.9	3
License and patent revenues from abroad as % of GDP	:	:	:	:	0.20	0.26	0.24	0.25	0.30	0.54	0.45	0.40	:	10.1	0.58	11
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	17.6	:	19.2	:	17.4	:	15.5	:	:	-2.1	14.4	4
Knowledge-intensive services exports as % total service exports	:	:	:	:	48.8	49.8	51.1	54.0	55.8	53.9	56.7	:	:	2.5	45.1	5
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	9.23	8.35	7.61	7.92	7.90	8.00	7.78	8.48	8.90	7.67	7.76	8.54	:	-	4,20 (5)	1
Growth of total factor productivity (total economy) - 2000 = 100	100	101	101	100	101	101	104	106	106	100	104	105	105	5 (6)	103	15
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	40.5	:	:	:	:	41.9	:	:	:	:	44.9	:	:	1.0	48.7	14
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	14.9	15.4	15.3	15.0	:	0.3	13.6	9
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	54.4	:	52.8	:	53.6	:	63.2	:	:	2.5	38.4	1
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	1.03	1.00	0.98	0.84	0.79	0.78	0.81	0.80	0.90	:	:	:	:	-1.8	0.39	2
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	1.05	1.12	1.19	1.12	1.07	1.11	1.03	0.98	0.88	:	:	:	:	-2.2	0.52	5
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	68.8	69.1	68.8	68.4	68.8	69,4 (7)	71.1	72.9	74.0	74.2	74.9	76.3	:	1.6	68.6	3
R&D Intensity (GERD as % of GDP)	2.47	2.47	2.50	2.54	2.50	2.51	2.54	2.53	2.69	2.82	2.80	*2.84*	:	*1.3*	*2.03*	4
Greenhouse gas emissions - 1990 = 100	83	85	83	83	82	80	80	78	78	73	75	:	:	-8 (8)	85	9 (9)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	5.1	5.9	6.9	9.0	9.1	9.5	11.0	:	:	13.7	12.5	14
Share of population aged 30-34 who have successfully completed tertiary education (%) (10)	25.7	25.5	24.2	25.1	26.8	26,1 (6)	25.8	26.5	27.7	29.4	29.8	30.7	:	2.7	34.6	17
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	18.4	20.2	20.6	20.1	20.0	19.7	19.9	:	1.3	*24.2*	10 (9)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) Break in series between 2005 and the previous years. Average annual growth refers to 2005-2011.

(8) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(9) The values for this indicator were ranked from lowest to highest.

(10) Values in italics are estimated or provisional.

Greece

Focusing resources for a more knowledge-intensive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Greece. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

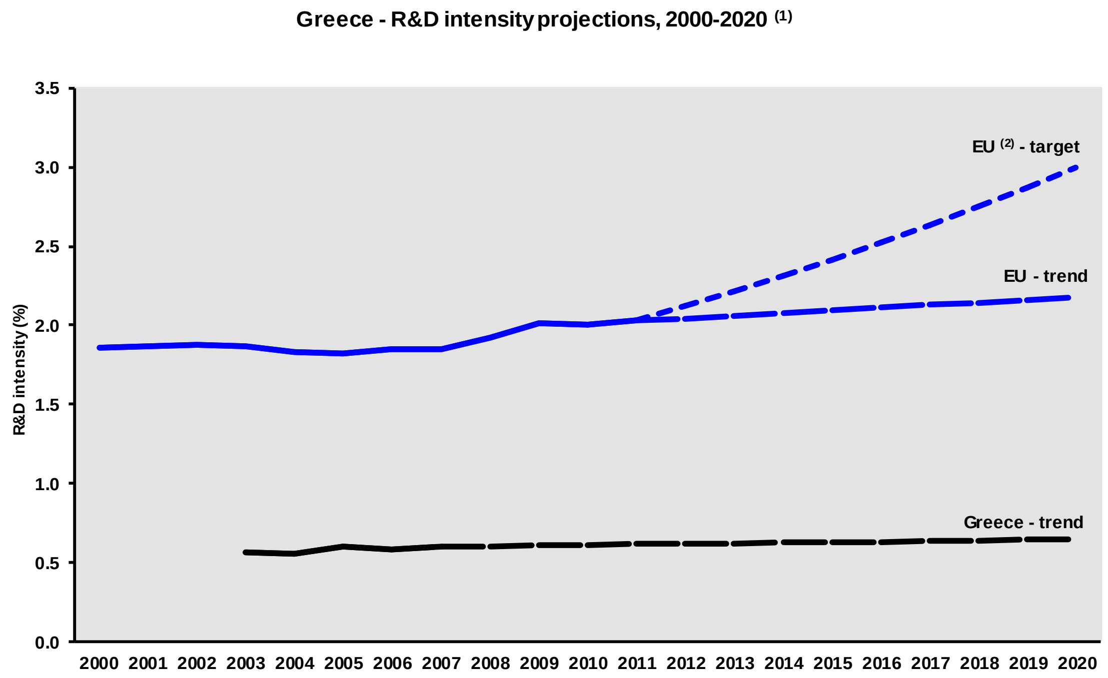
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.60% (EU: 2.03%; US: 2.75%) 2000-2011: +0.56% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:35.27 (EU:47.86; US: 56.68) 2005-2010: +2.53% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.345 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:32.53 (EU:48.75; US: 56.25) 2000-2010: +2.52% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food, agriculture and fisheries, Textiles, Services for computers, Manufacture of electrical motors generators and transformers	*HT + MT contribution to the trade balance* 2011: -5.69% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

Until the recent economic crisis, Greece grew at a faster rate than the economies of most of the other EU Member States and the United States, notably in the period immediately after joining the European single currency (between 2002 and 2005). Greece made clear progress in improving its scientific quality and it benefitted from an expanding global value chains. However, between 2001 and 2007 (the latest available year), R&D intensity in Greece never exceeded 0.60%, with a very low business R&D intensity (0.15% in 2000 and 0.17% in 2007). Overall R&D investment grew significantly over the period 2001-2006, but this did not result in any significant increase in R&D intensity because of almost equally strong growth in GDP over the same period. In addition to the problem of the low level of business investment in R&D, the efficiency and effectiveness of spending on R&D remains a challenge and the pace of implementation of reforms is slow.

Among the most pressing challenges, it can be noted: an integrated legal framework for research performers is lacking (the overall system is dominated by the universities); the articulation of R&I policy with other policies is weak, with feeble links between education, research and the business sector. Exploitation of research results by the business sector is very limited, with very low patenting activity. The knowledge-intensity of the economy is low (35.53 in 2010 compared to an EU average of 48.75).

The strategy defined in 2011 identifies six main research priorities focusing on sectors and technology areas that are either very important for the economy or addressing societal challenges: materials and chemicals; agro-biotechnology and food; ICT and knowledge intensive services; health and biomedicine; energy and environment; applied economic and social research, and research on cultural heritage. A reform of institutional research structures responds to the need to increase critical mass, focus the research agenda and avoid fragmentation. In this respect, Greece has in particular room for a further realignment of its research centres for an increased concentration of resources, as well as an improvement of the efficiency of the research sector and the development of its links with the business sector.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2001-2007 in the case of Greece.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) EL: An R&D intensity target for 2020 is not available.

The latest data available for Greece date back to 2007. R&D intensity in Greece was stagnating at around 0.60% and was marked by a particularly low business R&D intensity which increased at an average annual rate of 2.3% between 2000 and 2007. In 2011 Greece set an R&D intensity target of 2% to be achieved by 2020, but this target was cancelled at the end of 2011 due to the budgetary constraints and to the economic crisis. No new target has been announced.

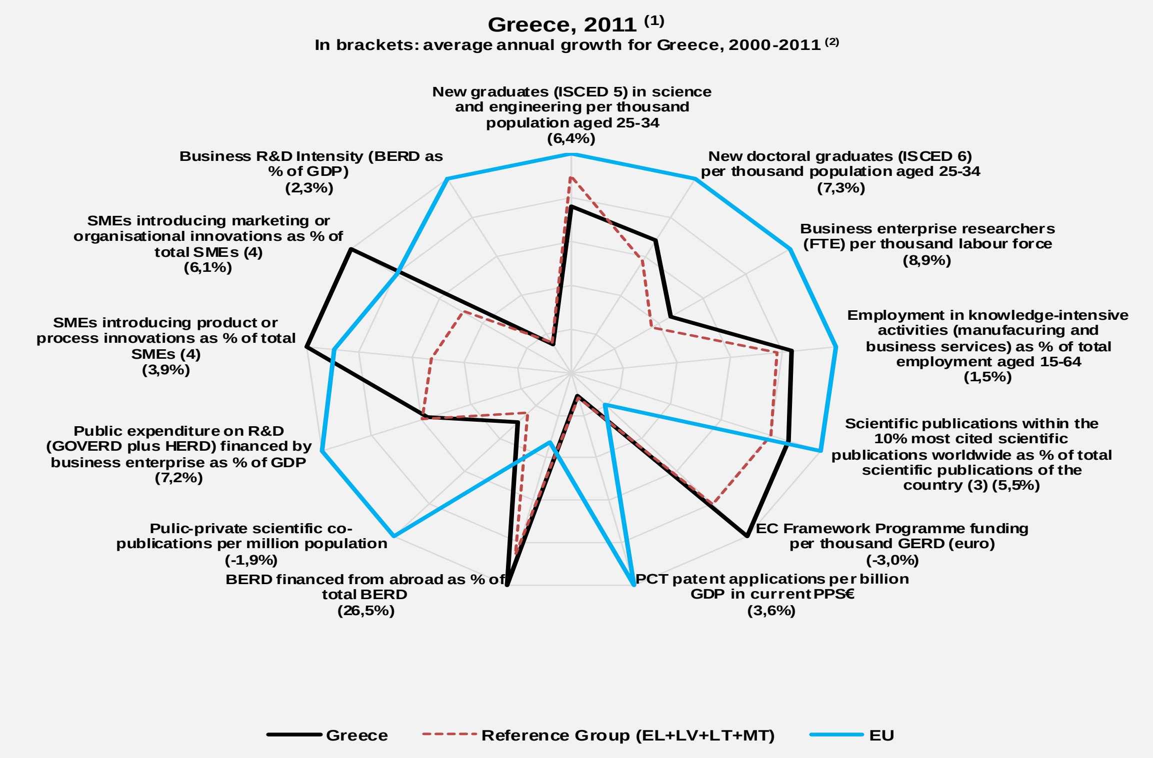
The bailout agreement with IMF, ECB and the European Commission, resulted in a consolidation programme and deep cuts to public expenditure and investment. In 2008 (the latest year available for Greece), the share of government budget for R&D in general government expenditure was 0.59%, significantly lower than the EU average of 1.52%. The percentage of business R&D financed by the government at 4.7% was also well below the EU average of 6.8%. National funding of R&I is complemented by EU funding. In terms of number of FP7 applicants and requested contribution, Greece is ranked in 7th place (2011 data). In terms of number of participations and budget share, Greece is ranked 9th with 1205 contracts.

The main supporting driving force behind the Greek research and innovation system is related to the Cohesion policy. The core Operational programme "Competitiveness and Entrepreneurship" has a total budget of € 1.52 billion of which the Cohesion policy provides € 1.29 billion (EC contribution). The Operational Programme has 3 strategic objectives for the period 2007-2013, with Research and Innovation as one of the major intervention areas[16].

[16] The three intervention areas are: (1) Accelerate the transition to the knowledge economy; (2) Development of healthy, sustainable and extrovert entrepreneurship and improvement of the appropriate framework conditions; and (3) Improve the attractiveness of Greece as an investment location respecting the environment and the concept of sustainability.

An effective research and innovation system building on the European Research Area

The spider graph below provides a synthetic picture of strengths and weaknesses in the Greek R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EL is not ncluded in the reference group.

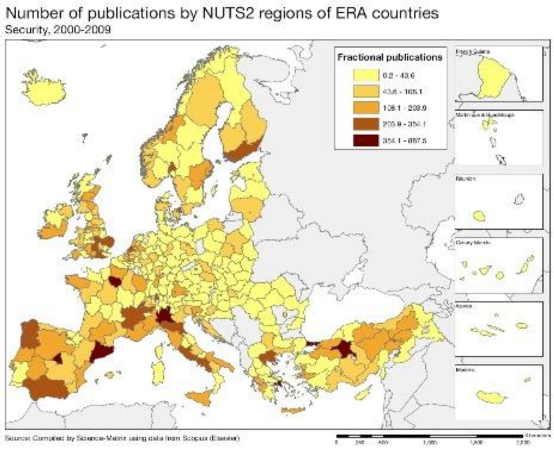
The innovativeness of the Greek economy depends heavily on imported technology and know-how. It builds on organisational and marketing innovations and until now very little on the production and exploitation of new knowledge, which may lead to difficulties in finding new sources of growth in a context of even increasing global competition. The graph above illustrates this.

Greece is below the EU average for most of the dimensions of its R&I system, namely in human resources, scientific production and technology development. However, it scores above the EU average for innovative SMES introducing marketing, organisational and product or process innovations. BERD financed from abroad as % of total BERD is well above the EU average, and before the economic crisis had an average annual growth rate of 26.5% for the period 2001-2007. Other indicators have shown positive catching-up dynamics before the economic crisis over the period 2000-2007: the quality of the scientific base grew as shown by an average annual growth of 6.2%, the number of researchers per thousand labour force and new doctoral graduates (ISCED 6) per thousand population aged 25-34 grew at a faster rate than the EU average. However, Greece suffered a net outflow of students to the United States before the economic crisis.

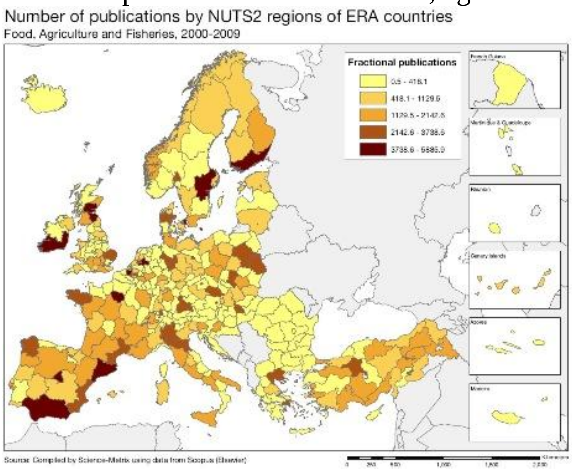
Greece's scientific and technological strengths

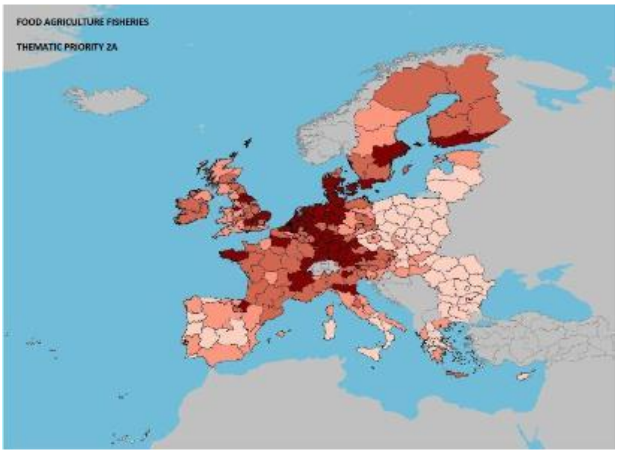
The maps below illustrate key science and technology areas where Greece has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

Security: scientific publications

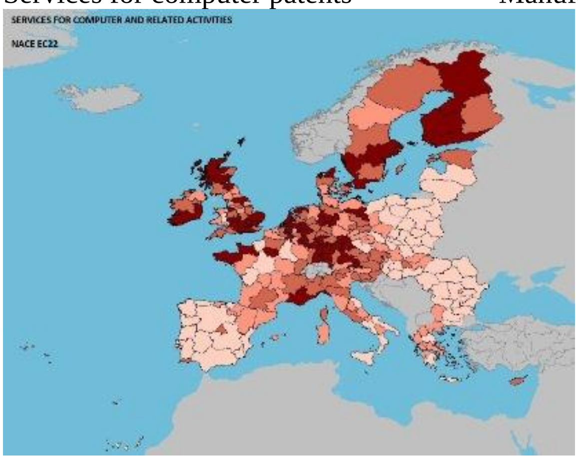


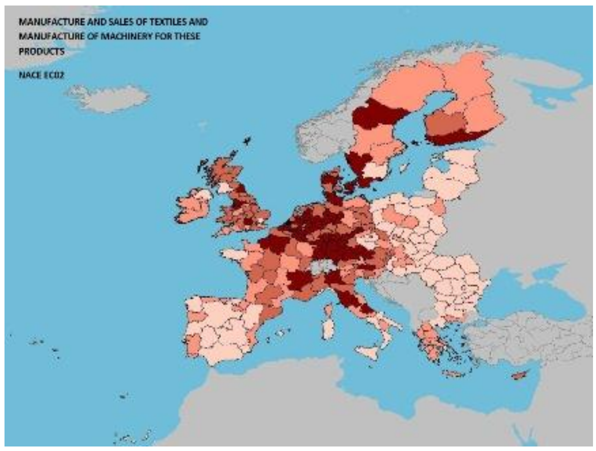
Scientific publications Food, agriculture and fisheries Technological patents



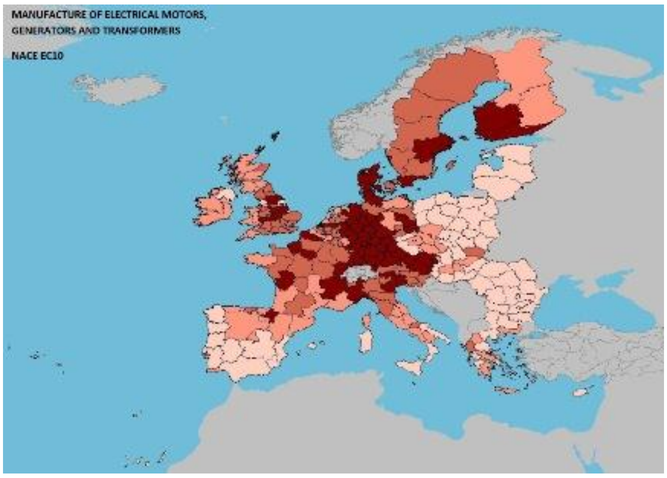


Services for computer patents Manufacture and sales of textiles patents





Manufacture of electrical motors generators and transformers patents



Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

Greece has a high level of scientific production in construction, ICT, security, aeronautics and space, transport, production and energy. From the point of view of scientific specialisation, only the first three themes together with automobiles can be considered as highly specialised. Greece's technological specialization is mainly in food and agriculture, space, construction, aeronautics and environment. This thematic analysis points at room for improvement in matching the science base and the knowledge needs of the Greek economy. Although there is an insufficient convergence of S&T specializations, there is a strong science base to build upon. The exceptions are the construction sector and the food, agriculture and fisheries sector, where convergence is well marked. Current trends indicate a lack of clarity regarding the country's areas of specialisation that could be addressed in the national/regional smart specialisation strategies under development, in particular in matching science and innovation bases.

Policies and reforms for research and innovation

The General Secretary of Research and Technology, appointed in May 2011, defined a new strategy for R&D and innovation. A number of main areas of strategic importance have been defined as national priorities: 1) agro-food, 2) information and communication technologies, 3) materials/chemicals, 4) energy-environment, and 5) health/biomedical sectors.

The process for meeting those priorities (and serving the country's research needs) is based on four dimensions: (1) strengthening and supporting the scientific/research personnel and research infrastructure; (2) encouraging links between the scientific/research community and businesses and entrepreneurs; (3) supporting bilateral, European and international collaboration; and (4) outreach and education for research in the community (particularly youngsters). Each of these dimensions will be implemented through a series of calls for proposals. In addition, a "Policy Mix Project" formed of six routes to stimulate private R&D investment is on-going.

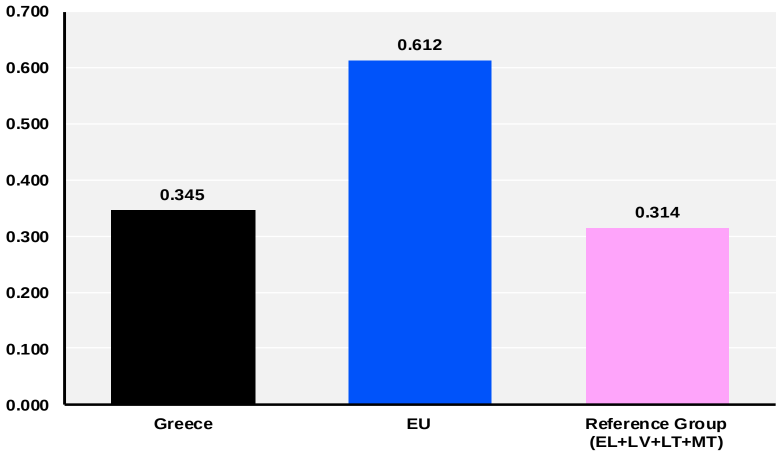
Existing and planned programs support R&I in enterprises, in particular in SMEs. The Operational Programme “Competitiveness and Entrepreneurship 2007-2013” aims at enhancing cooperation between SMEs and Research centres and universities. This framework is expected to increase the low propensity of SMEs to invest in R&I. A monitoring and evaluation of results would certainly be helpful to meet this crucial challenge for Greece. The success of these programmes is linked both to increasing the user-friendliness of the schemes and to significantly improving framework conditions that would increase the absorption by the private sector.

Public policies indeed face the challenge of shaping the conditions influencing business demand for R&D-based knowledge by opening up the internal market to competition, eliminating factors hampering entrepreneurship and shifting emphasis from supply to demand. An ambitious programme of reforms was launched in 2010 aiming to improve the enabling environment for R&D and innovation investment. The measures include significant improvements to the regulatory framework, the development of industrial areas and business parks, and a roadmap for removing the most important obstacles to entrepreneurship and innovation. In addition, the funding of clusters has become a promising dimension for improving the innovation climate. Following in the footsteps of the Corallia microelectronics cluster (funded with €35 million in 2008), the creation of new "knowledge intensive" clusters is foreseen in 2012. However, the deterioration of the Greek economic situation continues to discourage business investment.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[17].

Greece - Index of economic impact of innovation (1)



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

According to this index, the economic impact of innovation in Greece is slightly above its reference group, much below the EU average. Greece's performance on three of the five indicators is particularly low: patents inventions, contribution of high- and medium-tech products to the trade balance and share of knowledge intensive exports in services exports[18]. In contrast, the performance on sales of new-to-market and new-to-firm products is very good. One key factor to increase the economic impact of innovation is of course the structural change that allows innovation-driven growth. High-growth innovative firms in particular play a catalytic role in this respect.

Greece traditionally has a very low business R&D intensity which is directly linked to two main structural features of the economy: the small size of the firms and the sectoral composition of the economy (mostly low-tech and medium-low-tech sectors). Nevertheless, Greece has maintained a regular presence in the EU Industrial R&D Investment Scoreboard, since 2005, with four to six companies a year in the top 1000 R&D EU investors, mainly in three sectors: ICT, pharmaceuticals, and services (leisure, travel). These firms have increased their R&D investment in 2009 and 2010, by 5% and 3.2%, respectively.

The challenge is now to foster the creation and development of new innovative firms. Human resources and entrepreneurship provide strong building blocks for Greek firms. However Greek firms are lagging behind in relation to finance, business investment and intellectual assets. The low level of output from research activity and the need to increase the links between universities and industry are two of the key challenges facing the Greek R&I system. The private sector has a reduced share in total expenditure on R&D, reflecting the low demand for research-based knowledge from the business sector. A combination of factors including the predominance of low-tech sectors, significant institutional and bureaucratic obstacles and a volatile policy environment are orienting business activities towards less knowledge-intensive and lower value added segments of the economy.

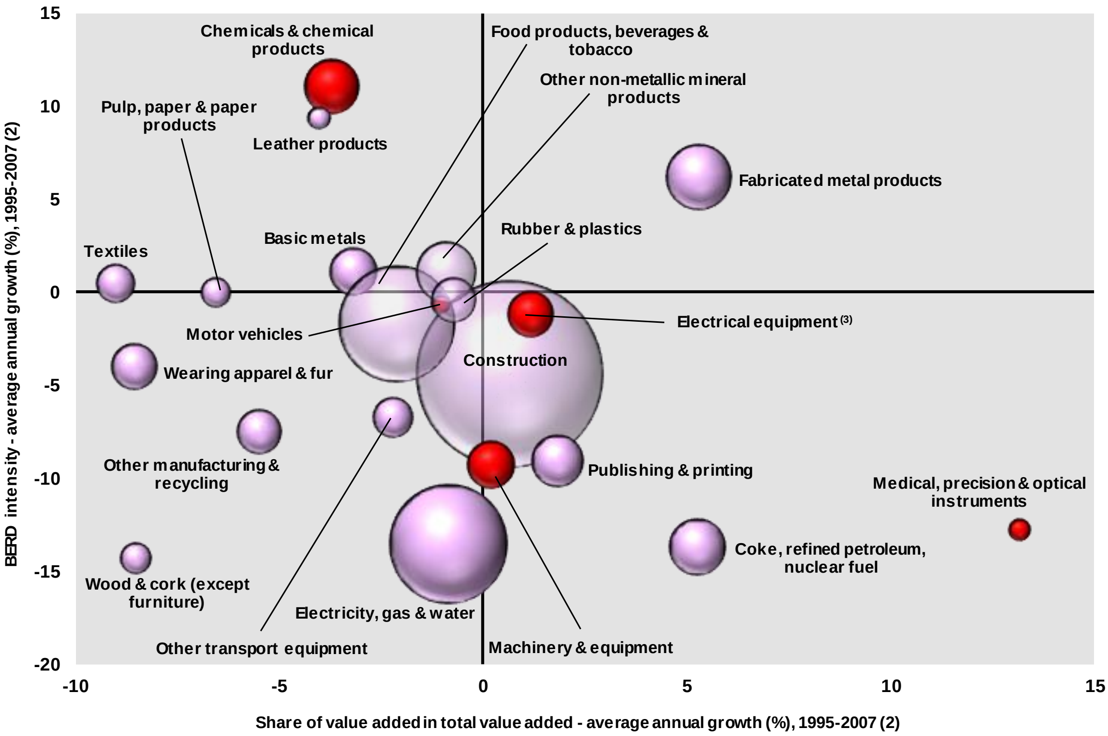
Restricted access to capital, especially for new firms, due to the reluctance of the financial system to finance innovation and to undertake risky investments, is also among the factors hindering mobilisation of resources for R&D. Greece has recently made good progress in simplifying procedures for start-ups and reducing overall costs. Launched in 2011, this new system has already supported the creation of 7000 new firms. It aims at improving framework conditions and facilitating growth at a time of rising unemployment and frozen hiring procedures in the public sector.

17 See Methodological note for the composition of this index.
[18] This is probably due to the importance of tourism in Greece's economy.

Upgrading knowledge and technologies in the manufacturing sector

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in the economy (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Greece - Share of value added versus BERD intensity - average annual growth, 1995-2007



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Wood and cork (except furniture)': 1995-2004; 'Coke, refined petroleum, nuclear fuel': 1995-2006.
(3) 'Electrical equipment' includes: 'Office, accounting and computing machinery', 'Electrical machinery and apparatus', and

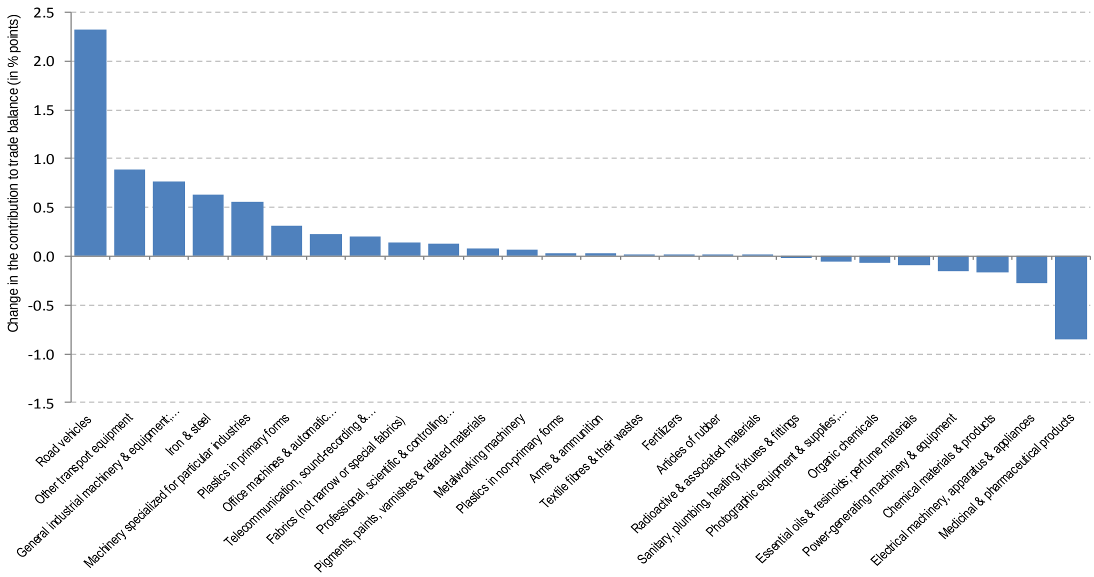
The Greek service sector accounted for 79% of value added in 2009 compared to a share of 10% for manufacturing. In 1995, the corresponding share for the service sector was 70% and for manufacturing was 12%. The construction sector dominates the manufacturing sector. It accounted for 6.01% of total value added in 1995, reaching a peak of 8.16% in 2001 before declining to 4.45% in 2009.

The graph above synthesises the structural change of the Greek economy over the 1995-2007 period. It shows that the economy has become slightly less industrialised and more services oriented. The small increase registered in business expenditures on R&D after 1995 (with a negative trend in the period post 2000) has been caused by the increase in the research intensities of a few individual sectors, in particular the chemicals and chemical products sector. With tourism in a dominant position, the service sector (not shown in the figure above) has overtaken all other sectors in terms of contribution to value added (following a similar trend to most of the other EU countries).

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Greece between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Over the period 1995-2009, the Greek economy gained slightly in world competitiveness. The world market share of Greek products and services was around 0.53% in 2009 compared to 0.42% in 1995, with a smaller share for more knowledge-intensive products. Nevertheless, the situation of the Greek trade balance in general has been negative and deteriorating rapidly with a peak registered in 2008. The trade balance in all high-tech and medium-tech products together followed the same pattern, remaining negative over the last decade and slightly decreasing the gap after 2008. To achieve this inversion of trend, and as shown in the graph above, most high-tech and medium-tech industries improved their contribution to the trade balance. This is the case for road vehicles, general industrial machinery and equipment, plastics in primary forms, iron and steel and machinery specialised for particular industries. In contrast, other transport equipment and fertilizers have reduced contributions to the trade balance while several sectors are stagnating. The strong specialisation of Greek industry in food processing industries, and at a lower scale, in textiles and chemicals, is only partially reflected in the trade balance thus highlighting the need to increase the competitiveness of the main sectors. This situation is also confirmed in the previous graph which shows that most of the manufacturing sectors have not increased their value added over the last 15 years.

Other features of the Greek R&I system are shown in the table below: employment in knowledge intensive activities (manufacturing and business services) as % of total employment is rather low (11.4% compared with EU average of 13.6%). Greek total factor productivity increased from 2000 until 2007, only to decrease afterwards and reach in 2012 a value inferior to the one registered in 2000. The employment rate decreased by three percentage points between 2000 and 2011; this leaves Greece with the lowest employment rate in the EU. A high percentage of the population is at risk of poverty or social exclusion (31% compared to an EU average of 24.2%).

Key indicators for Greece

GREECE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	:	:	:	:	0.75	0.73	:	1.43	0.83	:	1.15	:	:	7.3	1.69	18
Business enterprise expenditure on R&D (BERD) as % of GDP	0.15	0.19	0.18	0.18	0.17	0.19	0.18	0.17	:	:	:	:	:	2.3	1.26	26
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.39	:	0.38	0.37	0.40	0.40	0.42	:	:	:	:	:	1.3	0.74	23
Venture Capital [3] as % of GDP	0.14	0.07	0.03	0.01	0.003	0.001	0.01	0.04	0.10	0.02	0.005	0.004	:	-27.0	0,35 [4]	20 [4]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	31.1	:	:	:	:	35.3	:	:	2.5	47.9	13
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	6.2	5.7	6.6	7.4	8.1	8.8	8.2	9.5	9.5	:	:	:	:	5.5	10.9	15
International scientific co-publications per million population	175	166	177	254	303	339	399	436	450	509	512	544	:	10.9	300	17
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	17	16	15	15	16	:	-1.9	53	20
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.3	0.4	0.4	0.4	0.3	0.5	0.4	0.5	0.4	0.4	:	:	:	3.6	3.9	22
License and patent revenues from abroad as % of GDP	:	:	:	:	:	:	0.03	0.02	0.01	0.01	0.02	0.02	:	-1.4	0.58	24
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	11.0	:	25.6	:	:	:	:	:	:	53.0	14.4	3
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	48.0	50.6	3.8	55.8	4.7	5.4	:	:	-35.4	45.1	27
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-10.44	-9.03	-8.06	-7.89	-7.07	-5.39	-5.60	-5.49	-3.80	-5.71	-4.20	-5.69	:	-	4,20 [5]	27
Growth of total factor productivity (total economy) - 2000 = 100	100	103	104	108	110	109	112	113	111	107	103	100	99	-1 [6]	103	22
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	25.4	:	:	:	:	27.6	:	:	:	:	32.5	:	:	2.5	48.7	23
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	10.8	10.9	10.9	11.4	:	1.5	13.6	19
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	34.5	:	37.3	:	:	:	:	:	:	3.9	38.4	13
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.04	0.03	0.02	0.03	0.01	0.05	0.12	0.04	0.01	:	:	:	:	-11.4	0.39	23
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.07	0.08	0.09	0.06	0.03	0.08	0.05	0.12	0.05	:	:	:	:	-4.4	0.52	21
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	61.9	61.5	62.5	63.6	64.0	64.6	65.7	66.0	66.5	65.8	64.0	59.9	:	-0.3	68.6	27
R&D Intensity (GERD as % of GDP)	:	0.58	:	0.57	0.55	0.60	0.59	0.60	:	:	:	:	:	0.6	2.03	24
Greenhouse gas emissions - 1990 = 100	121	122	122	125	126	129	126	129	125	119	113	:	:	-8 [7]	85	23 [8]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	6.9	7.0	7.0	8.1	8.0	8.1	9.2	:	:	4.9	12.5	19
Share of population aged 30-34 who have successfully completed tertiary education (%)	25.4	24.9	23.4	22.8	24.9	25.3	26.7	26.2	25.6	26.5	28.4	28.9	:	1.2	34.6	18
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	30.9	29.4	29.3	28.3	28.1	27.6	27.7	31.0	:	0.0	24.2	22 [8]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Values in italics are estimated or provisional.

Hungary

Gearing reforms to removing obstacles to the growth of innovative companies

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Hungary. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	**Performance/economic output**
Research	*R&D intensity* 2011: 1.21% (EU: 2.03%; US: 2.75%) 2000-2011: +4.64% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:31.88 (EU:47.86; US: 56.68) 2005-2010: +2.03% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.527 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:50.23 (EU:48.75; US: 56.25) 2000-2010: +1.87% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Health, Environment, Automobiles, Biotechnology	*HT + MT contribution to the trade balance* 2011: 5.84% (EU: 4.2%; US: 1.93%) 2000-2011: +9.04% (EU: +4.99%; US:-10.75%)

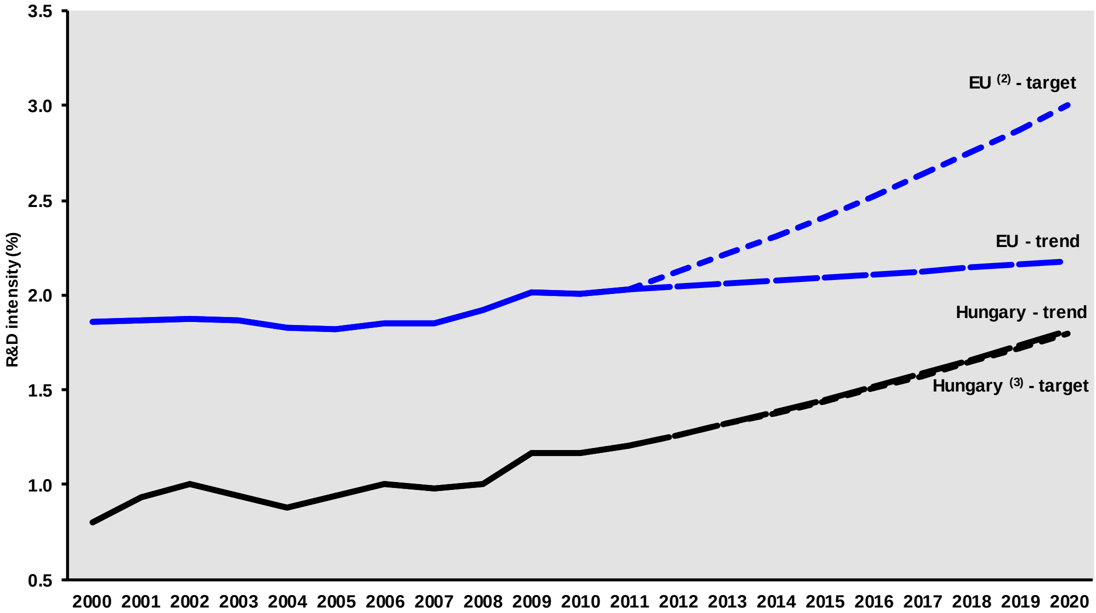
Over the last decade, the Hungarian research and innovation system has made clear progress in the level of private sector investment and in overall R&D intensity, as well as in scientific quality, patent revenues and structural change towards a more knowledge-intensive economy. In spite of the fact that public sector R&D intensity and the internationalisation of science is still less dynamic than the EU average, Hungary shows good progress among the countries with a similar industrial structure and knowledge capacity.

Hungary is still facing some key challenges in research and innovation. These include: a low level of innovation activity, especially by SMEs, together with a low degree of co-operation in innovation activities among the key actors; unfavourable framework conditions for innovation, in particular an unpredictable business environment, a high administrative burden and competition not conducive to innovation; an insufficient number of human resources for research (2015 forecast). Policy evaluation culture is weak in Hungary. According to basic principles stipulated in the Law of Research and Technological Innovation (2004), four external evaluations of funded support schemes were conducted between 2005 and 2011. The freeze of public funding in the second half of 2010 as well as the frequent changes in the structure of STI policy governance point however to some risks regarding the continuous policy commitment needed to further address these important challenges.

The newly-prepared innovation strategy is expected to provide specific well-targeted incentive schemes in support of innovative SMEs and of enterprises of intermediate size, with priority funding in the domains of the national thematic priorities. In addition, a specific scheme should support infrastructures and coordination activities within clusters of excellence in these domains. The principle of smart fiscal consolidation should re-establish the priority of public funding for research and innovation and lead to increasing levels of R&D intensity over the coming years.

Investing in knowledge

Hungary - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2004-2011 in the case of Hungary.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) HU: This projection is based on a tentative R&D intensity target of 1.8% for 2020.
(4) HU: There is a break in series between 2004 and the previous years.

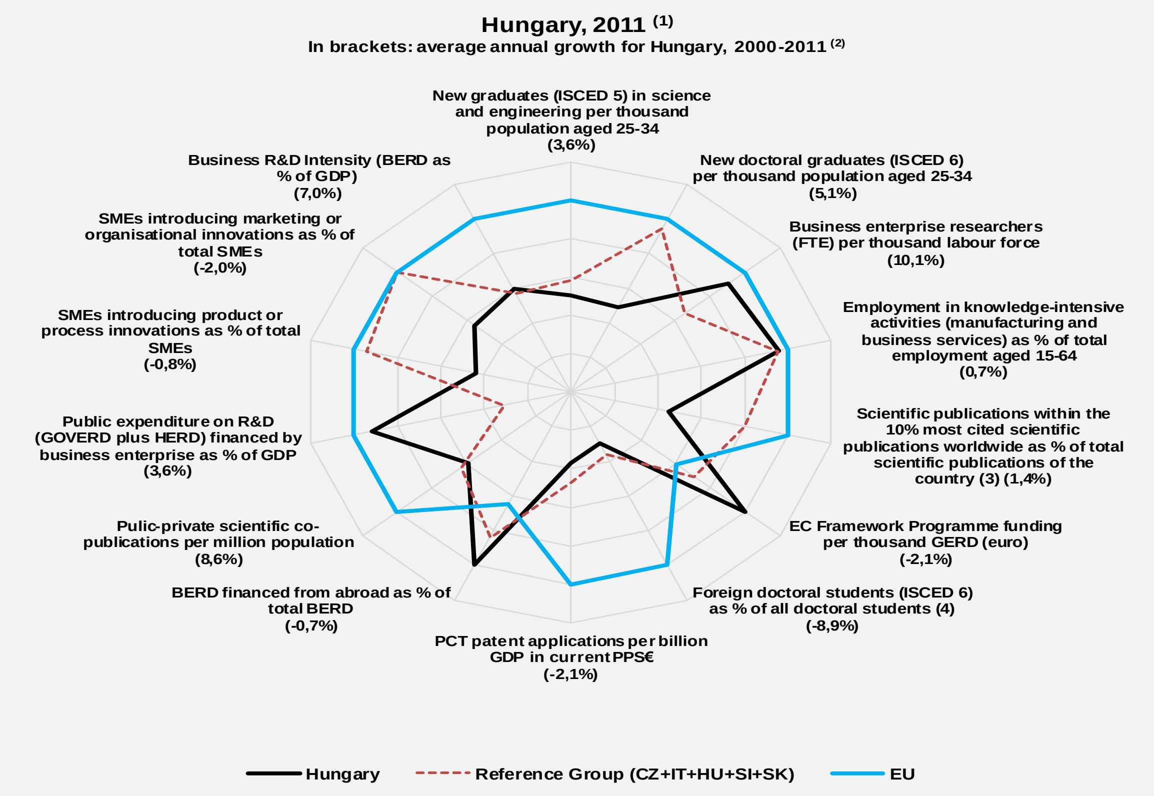
In the 2011 National Reform Programme, the Hungarian government set an R&D intensity target for 2020 of 1.8%. Hungary had an R&D intensity of 1.21% in 2011, up from 1.16% in 2010. An intermediary target of 1.5% by 2015 is set by the Science and Innovation Programme (as a part of the broader New Széchenyi Plan of January 2011). In 2010, 39.9% of total R&D expenditure (close to the EU average) was financed by government and 47.4% was financed by the business enterprise sector. This last figure reflects the increase in business R&D intensity from 0.41% in 2005 to 0.69% in 2010.

In Hungary, inward business investment in R&D as a % of total BERD decreased between 2003 and 2007 in contrast to the majority of European countries where internationalisation of R&D increased over the same period. However, the actual amount of inward business investment in R&D increased in nominal terms. Hungary has by far the highest ratio of inward FDI to GDP but only an average inward business investment in R&D intensity. Hungary, Spain and to a lesser extent Italy all suffered declines in intensity of inward investment in R&D over the period 1998-2007 (the latest period for which data are available).

Hungary has had a participant success rate of 20.4% in FP7 close to the EU average of 21.5%, and received more than € 114 million for 681 Hungarian participations in FP7 up to mid-2011. Hungary plans to invest € 2.16 billion of Structural Funds (2007-2013) in R&D and innovation, in particular in the regional growth poles with emphasis on enhancing R&D capacities.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Hungary's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

Hungary is below the EU average in almost all areas. However, the rate of BERD financed from abroad and EU FP7 funding per thousand GERD are higher than the EU average. The share of employment in knowledge-intensive activities is very close to the EU average.

Vulnerable areas include human resources, scientific production, innovation and technology production. Innovation activities in small firms are at a low level with only around 17% of Hungarian SMEs innovating by introducing a new product or a new process. This (with that of Latvia) is the lowest level in the EU. Only 5% of Hungarian scientific publications are in the top 10%-most cited scientific publications, compared to an EU average of 11.6%. Hungary has a low level of PCT patent applications with a decreasing trend. Hungary does better in terms of licence and patent revenue from abroad (not shown on the graph). This is probably due to the increased role of large foreign-owned enterprises in business R&D investment.

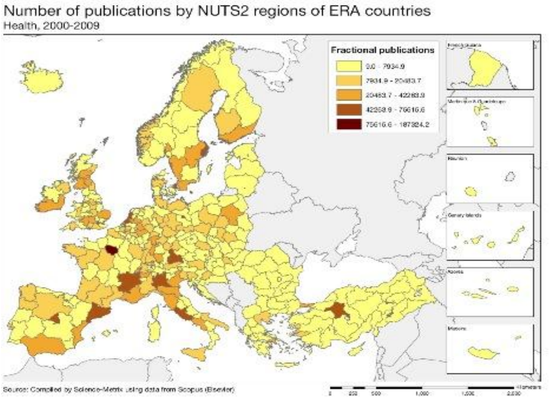
In the FP7, Hungary seems to be relatively well integrated in pan-European research collaborations. The top collaborative of Hungarian researchers are mainly with colleagues from Germany, the United Kingdom and France. The results of Hungarian participation to FP7 show a more intensive European cooperation of the public sector than of the industry.

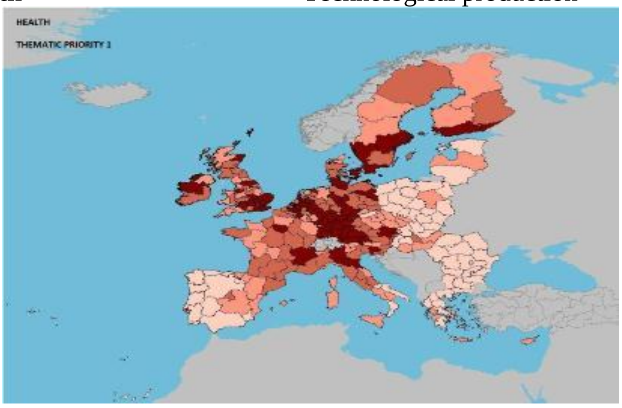
__Hungary's scientific and technological strength__

The maps below illustrate six key science and technology areas where Hungary has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

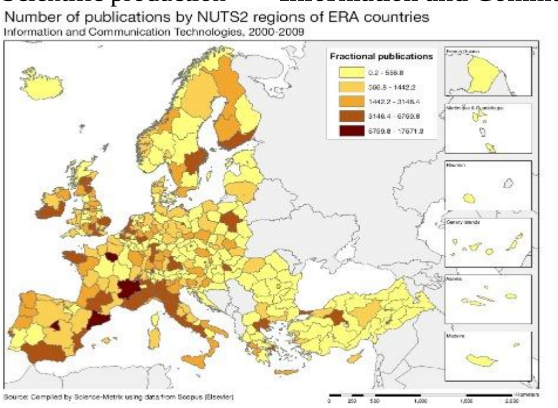
Strengths in science and technology at European level

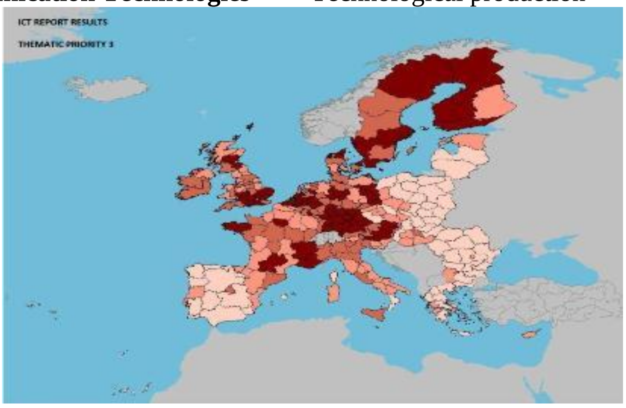
Scientific production **Health** Technological production



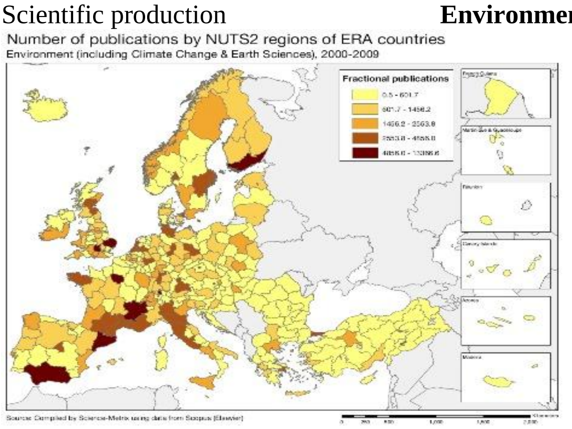


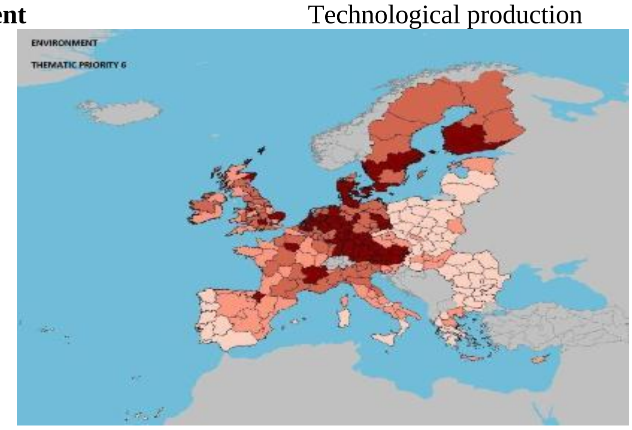
Scientific production **Information and Communication Technologies** Technological production





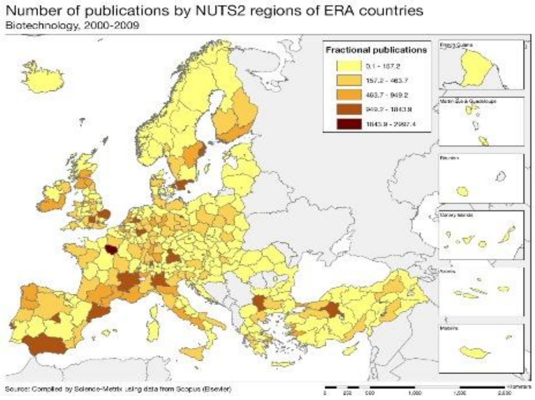
Scientific production **Environment** Technological production

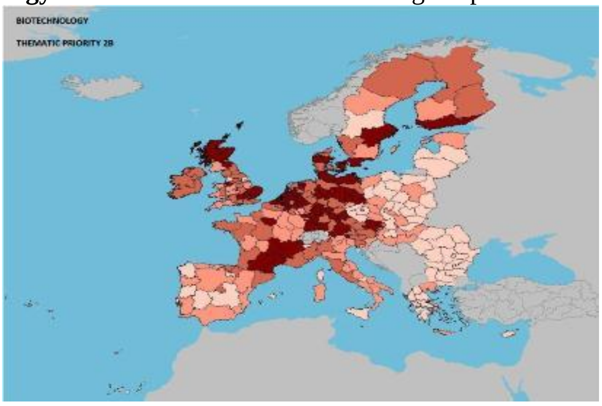




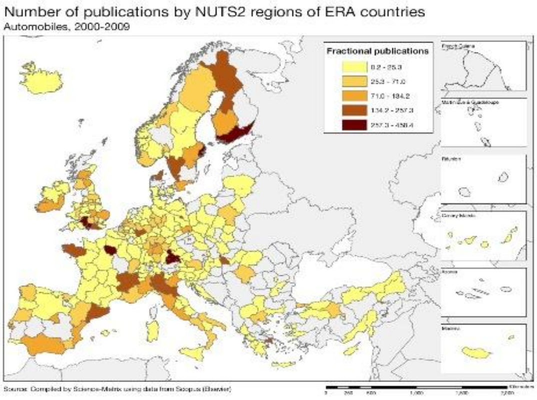
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

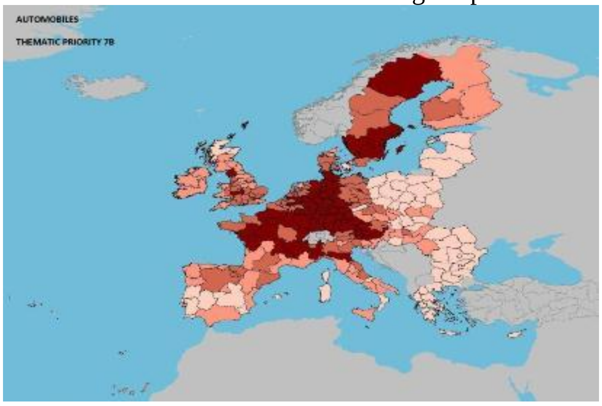
Scientific production **Biotechnology** Technological production



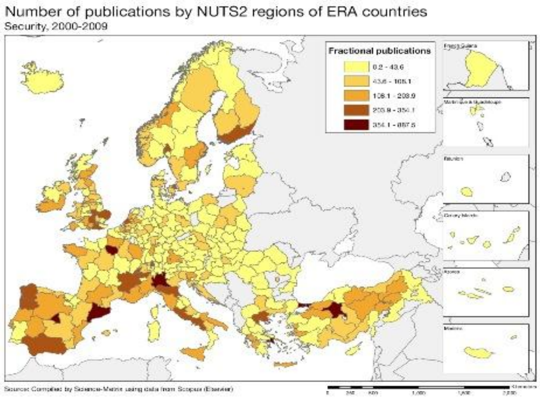


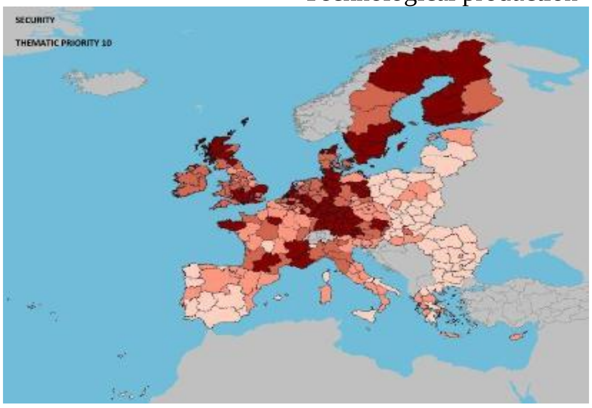
Scientific production **Automobiles** Technological production





Scientific production **Security** Technological production





As illustrated by the maps, in terms of scientific production, Hungary´s strengths lie in automobiles and in information and communication technologies. The relative specialisation in terms of patenting is in biotechnologies and health. A quantitative analysis of the number of EPO patents (2000-2010) by applicant classified by FP7 thematic priorities shows that Hungary has a significantly higher share in the domain of health (33.4%) than the EU average (12.8%).

The RTA (revealed technological advance) index confirms that Hungary, with 2.21, is second in the EU after Slovenia in this domain. In the case of environment, Hungary had a growth index of 1.21 between 2000 and 2009 compared to an EU average of 1.25. In the case of automobiles, Hungary has the second highest specialisation index in the EU (2.42 compared to the much lower EU average of 1.07).

Policies and reforms for research and innovation

It is noticeable that R&D intensity increased during the first years of the economic crisis, demonstrating the effectiveness of the R&I strategy. The new strategy on research and innovation, referred to in the 2012 National Reform Programme is currently under preparation. The issue of the low share of innovative enterprises needs urgently to be addressed. Support measures geared to removing obstacles to the growth of innovative companies are indeed expected under the Science and Innovation Programme of the New Széchenyi Plan. The scope and the financial effort implied are however not yet known.

Whereas the new Science and Innovation Programme stipulate that the current policy mix should be reconsidered, no action has been taken to date. Moreover, the new National Research and Innovation Strategy due to be adopted by the end of 2011 has been postponed until the end of 2012. The mid-term STI strategy (2007-2013) stresses the need to align national and EU policy goals. While the national STI policy mix is not explicitly aligned with the specific ERA pillars and objectives, there is no major disparity between the national policy goals and the ERA initiatives.

Research and innovation governance has been reorganised twice since 2009. The high-level STI policy co-ordination body, the Research and Science Policy Council which was created in September 2009 was disbanded in December 2010 and replaced by the National Research, Innovation and Science Policy Council. In June 2010, the government discontinued all funding by the Research Technological Innovation Fund (RTIF). EUR 58.2 million, representing 36.6% of the RTIF's budget has been blocked following budgetary cuts. Several schemes, co-financed with the EU Structural Funds were, however, reopened in 2011. Following the freezing of national public funding, no new schemes have been introduced from mid-2010 with the result that EU funding has become increasingly more important.

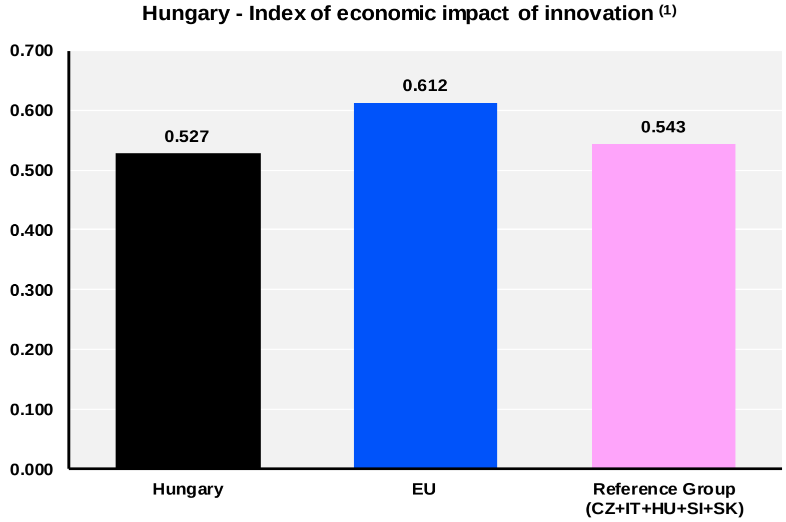
The stronger sectoral areas identified in the OECD review (2008) have been confirmed as the national thematic priorities of the new Science–Innovation Programme (January 2011). These are: transport mobility, automotive industry and logistics, health industries (pharmaceutical, medical instruments and balneology), information and communication technologies, energy and environmental technologies, and creative industries. The national innovation strategy (as currently drafted) should be aligned with the concept of smart specialisation and regional innovation strategies in order to ensure increased coordination and to avoid duplication or fragmentation of research and innovation policies. In addition to the metropolitan area of Budapest which is the dominant centre of domestic RTDI activities, six regional development poles have been defined with specific priority fields of science and sectors of industry. This will promote smart specialisation in the regions through spill-overs and technology transfer from the major poles by building on the strengths identified for each region or territory.

Private investment in R&D is primarily carried out by a small number of big foreign-owned enterprises making growth relatively vulnerable. The government is planning to introduce measures to encourage SMEs participation in innovation activities including non-technological innovation, to reduce the relatively high administrative burden and to strengthen the links and networks between public and private research.

A national roadmap for ESFRI is being prepared, with funding reserved for new and updated research infrastructures. The Hungarian authorities are ensuring all necessary support for the implementation of the national Operational Programme (OP): Economic Development for priority R&D and innovation aiming to encourage competitiveness (more than one third of the total budget is devoted to this programme), including the development of the Extreme Light Infrastructure project (ELI).

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[19]..



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The graph above shows that, in Hungary, the economic impact of innovation is lower than both EU average and reference group. In particular, the country shows significantly lower values on the patent applications and knowledge-intesive services export indicators compared to EU average.. In Hungary, innovation policy is mainly a supply side policy based on grants for innovation activities. So far, demand side innovation policy has only been taken into consideration by the government as a future option. For instance, in the New Széchenyi Plan, pre-commercial public procurement is a high priority for the future.

The dominant form of support is through grants for innovation activities. However, there are other tools in place as part of the national policy mix: venture capital, favourable loans, guarantees and tax incentives. Demand side innovation policy is also being taken into consideration as a future option, by the policy makers. The Science and Innovation Programme of the New Széchenyi Plan highlight pre-commercial procurement as a high priority. A strong decline is observed for venture capital as % of GDP which decreased by more than 75% between 2009 and 2010 (the highest decline in the EU).

Links between public sector and private sector research and also levels of cooperation on innovation activities by key actors are still weak. The share of innovative SMEs is rather low compared to other countries. Access to finance and in particular early stage financing is limited. This issue is closely linked to the financing needs of innovation intensive companies which are facing difficulties in finding sources of finance for their innovative projects. Also, there is a weak rate of commercialisation of inventions.

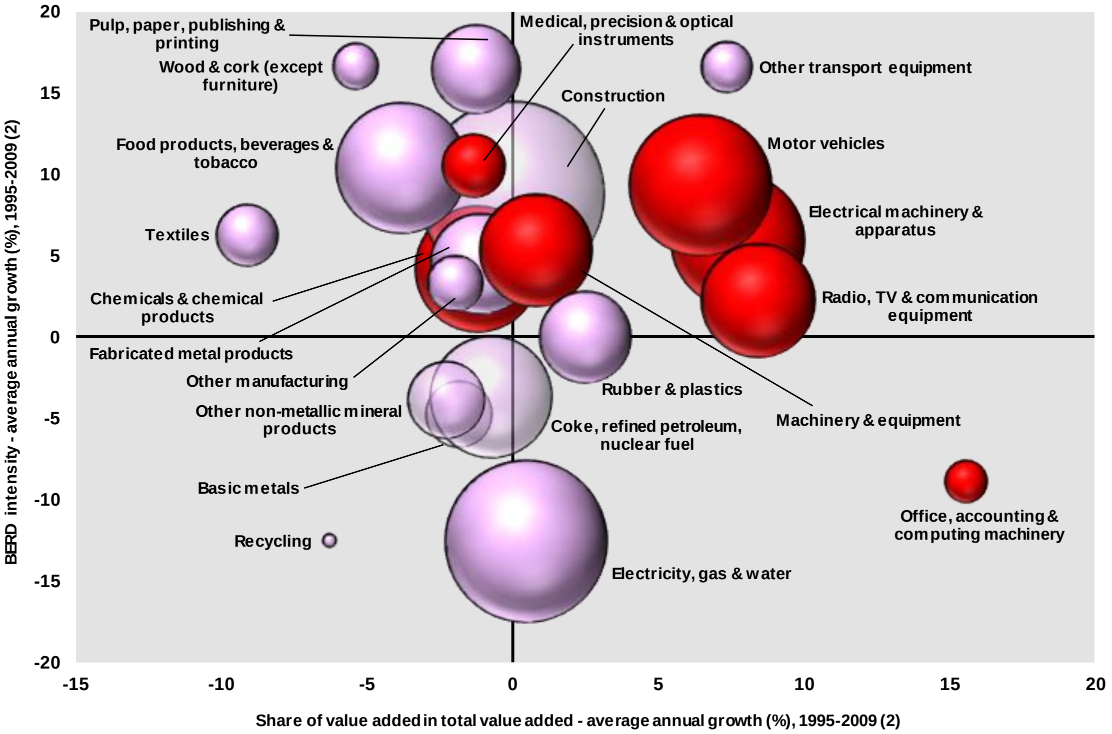
During the last two decades, the internationalisation of business R&D activities has accelerated significantly, with some new players emerging recently that have given rise to new patterns. Some industrial sectors in Hungary have increased their outward R&D activities. The wood, paper, printing and publishing sectors, and the non-metallic minerals sectors have become significantly more internationalised.

19 See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Hungary - Share of value added versus BERD intensity - average annual growth, 1995-2009



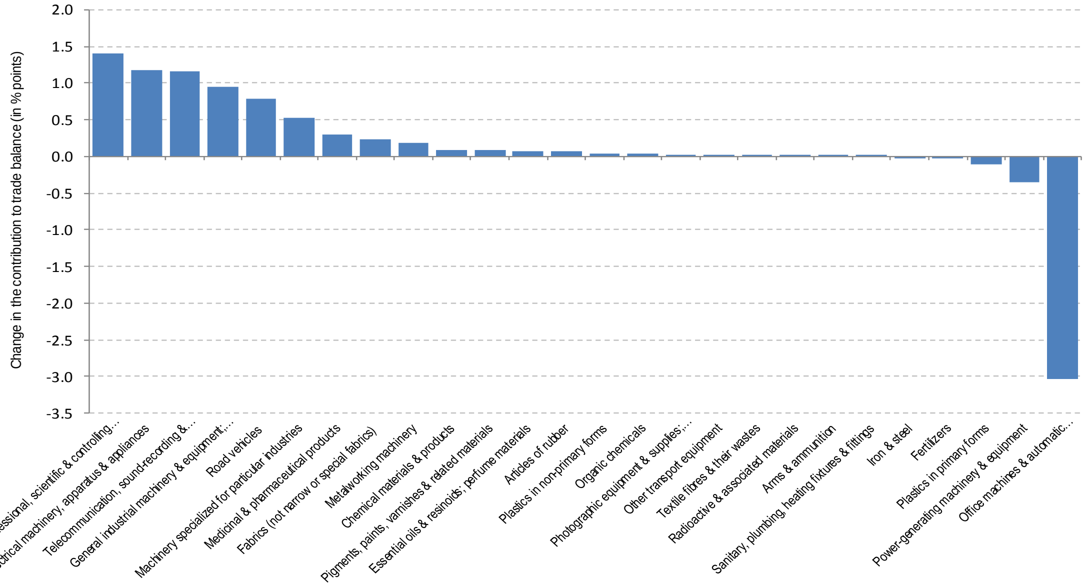
Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Wood and cork (except furniture)': 1999-2009; 'Recycling': 2000-2004.

Although manufacturing in Hungary is mainly concentrated in low skills sectors, there is a growing and promising trend of specialisation in high-tech sectors. From 1995, it can be noticed that almost all medium-high-tech and high-tech sectors, especially motor vehicles, electrical machinery and apparatus, and Radio, TV and communication equipment have increased their weights in the economy, as well as their R&D intensities. In Hungary business enterprise expenditure on R&D (BERD) in the motor vehicles sector accounted for 13.1% of all manufacturing BERD in 2009.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Hungary between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The graph above shows that several high-tech and medium-tech industries significantly improved their contributions to the Hungarian trade balance over the period 2000-2011, in particular telecommunications, scientific and controlling instruments, general industrial machinery and specialized machinery for particular industries, and road vehicles. This indicates a possible gain in relative world competitiveness in line with the increasing weight of these sectors in the economy (see previous graph). In contrast, the office machines and automatic data-processing machines industry suffered a severe reduction in its contribution to the trade balance.

In Hungary total factor productivity grew steadily between 2000 and 2006 and then fell significantly during the years of economic crisis. Regarding progress towards the Europe 2020 indicator targets, Hungary shows a mixed picture with good results for most indicators, such as R&D intensity and the share of population (aged 30-34) with tertiary education, share of renewable energy, greenhouse gas emissions and a slight decrease in the share of population at risk of poverty (although with a negative evolution since the crisis started in 2008. Also the employment rate has been slightly falling, particularly with the economic crisis. However, Hungary's best rankings within the EU are for the contribution of high-tech and medium-tech commodities to the trade balance, sales of new to market and new to firm innovations as % of turnover, and license and patent revenues from abroad as % of GDP. These are indicators which show the contribution of innovation to international competitiveness.

Key indicators for Hungary

HUNGARY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.50	0.53	0.64	0.68	0.56	0.67	0.63	0.66	0.71	0.86	0.82	:	:	5.1	*1.69*	21
Business enterprise expenditure on R&D (BERD) as % of GDP	0.36	0.37	0.36	0.34	0.36	0.41	0.49	0.49	0.53	0.67	0.70	0.75	:	7.0	*1.26*	15
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.40	0.48	0.58	0.54	0,48 (3)	0.50	0.50	0.47	0.46	0.48	0.45	0.43	:	-1.3	*0.74*	21
Venture Capital (4) as % of GDP	0.06	0.04	0.02	0.03	0.12	0.05	0.04	0.05	0.03	0.21	0.05	0.08	:	2.2	0,35 (5)	14 (5)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	28.8	:	:	:	:	31.9	:	:	2.0	47.9	14
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	4.4	4.1	4.8	5.1	5.3	4.9	5.3	5.5	4.9	:	:	:	:	1.4	10.9	22
International scientific co-publications per million population	210	182	190	266	287	311	310	333	333	352	359	387	:	5.7	300	20
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	22	23	25	31	31	:	8.6	53	15
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	1.7	1.5	1.4	1.3	1.4	1.4	1.3	1.6	1.4	1.4	:	:	:	-2.1	3.9	15
License and patent revenues from abroad as % of GDP	:	:	:	:	0.53	0.76	0.49	0.67	0.56	0.65	0.80	0.74	:	4.8	0.58	7
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	6.7	:	10.5	:	16.4	:	13.7	:	:	12.7	14.4	13
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	21.0	23.5	26.0	25.9	26.1	26.5	:	:	4.8	45.1	18
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	2.25	1.10	1.56	2.98	3.62	4.64	5.74	4.47	5.20	6.15	5.85	5.84	:	-	4,20 (6)	3
Growth of total factor productivity (total economy) - 2000 = 100	100	102	105	107	111	113	115	113	113	106	106	107	105	5 (7)	103	14
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	41.7	:	:	:	:	46.2	:	:	:	:	50.2	:	:	1.9	48.7	11
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	12.8	12.3	12.8	13.0	:	0.7	13.6	16
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	17.6	:	16.8	:	16.8	:	16.8	:	:	-0.8	38.4	23
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.08	0.04	0.08	0.05	0.12	0.08	0.06	0.19	0.13	:	:	:	:	7.5	0.39	13
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.40	0.27	0.20	0.27	0.27	0.29	0.16	0.27	0.21	:	:	:	:	-7.6	0.52	15
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	61.2	61.3	61.4	62.4	62.1	62.2	62.6	62.6	61.9	60.5	60.4	60.7	:	-0.1	68.6	26
R&D Intensity (GERD as % of GDP)	0.81	0.93	1.00	0.94	0,88 (3)	0.94	1.01	0.98	1.00	1.17	1.17	1.21	:	4.6	*2.03*	18
Greenhouse gas emissions - 1990 = 100	79	81	79	82	81	82	80	78	75	69	70	:	:	-9 (8)	85	7 (9)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	4.4	4.5	5.1	5.9	6.6	8.1	8.7	:	:	12.0	12.5	20
Share of population aged 30-34 who have successfully completed tertiary education (%)	14.8	14.8	14.4	16,3 (10)	18.5	17.9	19.0	20.1	22.4	23.9	25.7	28.1	:	7.0	34.6	19
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	32.1	31.4	29.4	28.2	29.6	29.9	31.0	:	-0.6	*24.2*	23 (9)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2004 and the previous years. Average annual growth refers to 2004-2011.

(4) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(5) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(6) EU is the weighted average of the values for the Member States.

(7) The value is the difference between 2012 and 2000.

(8) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(9) The values for this indicator were ranked from lowest to highest.

(10) Break in series between 2003 and the previous years. Average annual growth refers to 2003-2011.

(11) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Provide specific well-targeted incentive schemes to support innovative SMEs in the new innovation strategy"

Ireland

Prioritising increased public investment in research while better exploiting results

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Ireland. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 1.72% (EU: 2.03%; US: 2.75%) 2000-2011: +4.07% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:38.11 (EU:47.86; US: 56.68) 2005-2010: +5.39% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.69 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:65.43 (EU:48.75; US: 56.25) 2000-2010: +1.94% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food and agriculture, Medical technologies, Nanotechnologies, Biotechnology, ICT, New production technologies	*HT + MT contribution to the trade balance* 2011: 2.57% (EU: 4.2%; US: 1.93%) 2000-2011: +26.26% (EU: +4.99%; US:-10.75%)

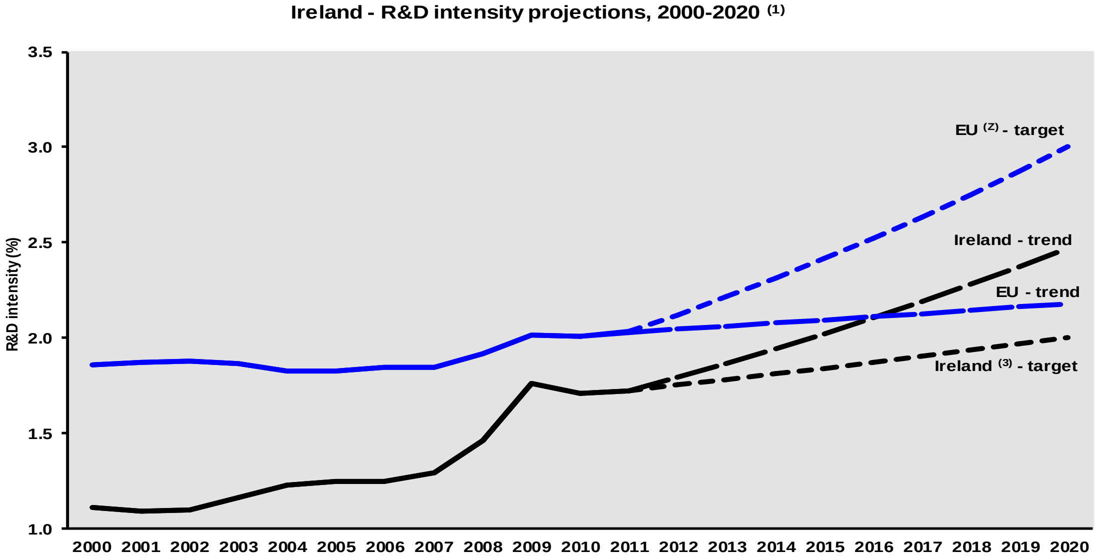
Ireland has expanded and consolidated its research and innovation system over the last decade. Investments in research and innovation have grown substantially. Public investment in research and innovation grew considerably until the financial crisis. Business enterprise investment in R&D continued to grow over the period 2000-2010 albeit at a lower growth rate than public investment.
The considerable increase in public and private R&D expenditure over the decade 2000-2010 has resulted in a clear shift to a knowledge-based economy including a shift towards services. The Irish economy has a high proportion of knowledge-intensive products and services, and this structure has not changed substantially over the last decade. Although the recession hit Ireland particularly hard, the economy has since partly recovered because of the strength of exports by firms in the high-tech sectors. These firms are mainly affiliates of MNEs.

In contrast, domestic firms in a number of sectors which do not have a propensity to export have struggled. Accordingly the main challenges are to return to the previous policy of increasing public R&D expenditure and to complement the policy of promotion of procurement of innovation with budgetary allocations to procurement authorities.[20]

Prior to the crisis, policy was based on a Strategy for Science, Technology and Innovation which articulates the ambition to be a leading knowledge economy. More recently the focus has been on accelerating growth and job creation. The government has also adopted the report of a research prioritisation group which recommended targeted research investment in 14 priority areas as well as a new IP protocol on putting public research to work for Ireland.

[20] Concrete measures were presented in Commission Communication Europe 2020 Ireland, June 2012

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) IE: This projection is based on a tentative R&D intensity target of 2.0% for 2020.

Ireland has a national R&D intensity target of 2.0% of GDP or 2.5 % of GNP, by 2020. In 2011, Irish R&D intensity was 1.72% of GDP, with a public sector R&D intensity of 0.56% and business R&D intensity 1.17%. Over the decade 2000-2010, R&D intensity in Ireland grew at an average annual growth rate of 4.9%, one of the highest growth rates in the EU. One of the main challenges for Ireland would be to return to a trend of increasing public investment in R&D which, if more related to business needs, would raise the R&D intensity of Irish firms. If this line were followed, the shift of the Irish economy towards a knowledge-based economy, already very visible, could be pursued over the years and a more ambitious target could be envisaged at the occasion of the mid-term review of the Europe 2020 targets (2014/2015). This would be more in line with the country's clear potential, illustrated by the trend in the growth above.

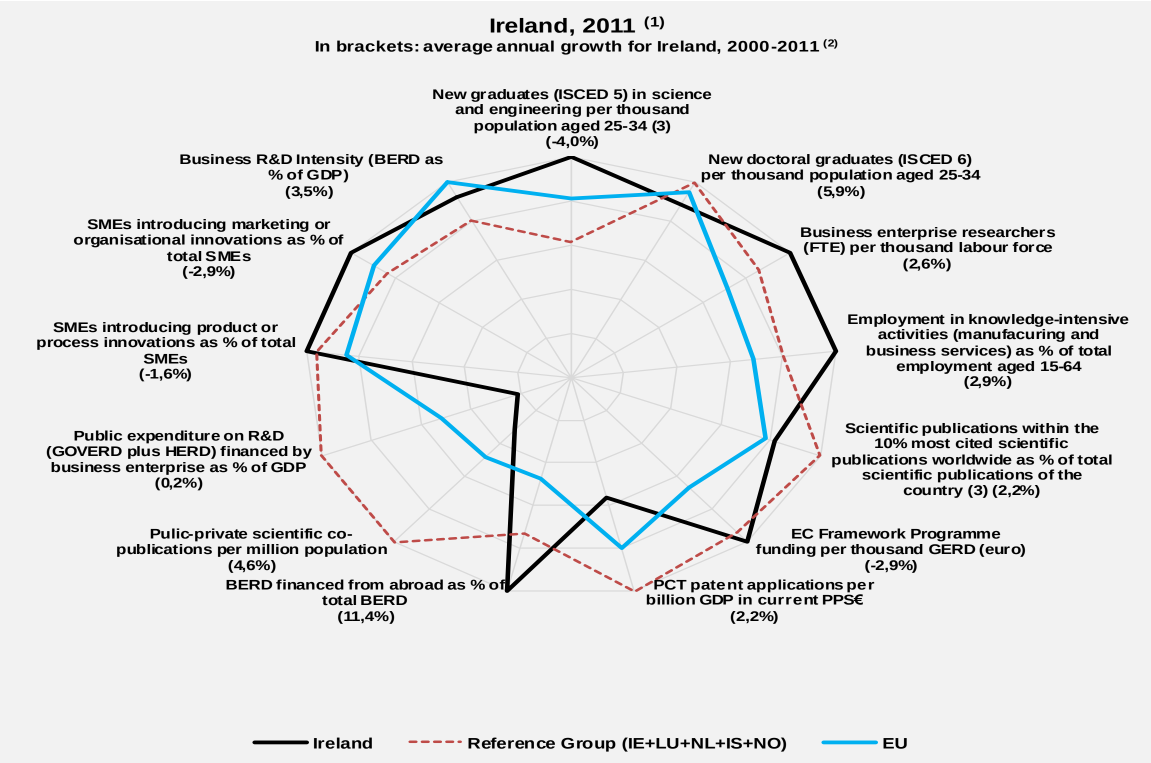
In absolute terms, public R&D funding reached a peak in 2008. R&D investment by firms appears not to have been seriously affected by the economic crisis. Where BERD is supported by government, Ireland has a relatively low level of direct support, according to the OECD. Indirect support was almost 3 times higher than direct support. Business R&D investment in real terms has continued to rise and reached a peak in 2010. Overall, firms have almost doubled their R&D investment in real terms over the period 2000-2010. The amount of GERD financed from abroad at 15.6% is almost twice the EU average and reflects the policy of attracting FDI with a large R&D component. In order to reach its national target by 2020, R&D intensity in Ireland would have to grow at an average annual rate of 1.1% over the decade 2010-2020. This growth would depend on sustained incentives to attract and boost business R&D investment.

Under the ERDF Programme, Ireland has been allocated €163.5 million for research, innovation and entrepreneurship. This represents 21.8% of the total FEDER funds for Ireland. Under FP7, beneficiaries from Ireland have received €412 million[21] of which €85 million went to SMEs. Overall, Irish applicants had a close to average success rate.

[21] According to CORDA 6 Nov 2012 I-cf. national estimate of €438 M in June 2012.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses in the Irish R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.

The graph shows in broad terms that the increase in funding for R&D (2000-2010 average annual growth) has triggered a stronger scientific production with increases in business expenditure on R&D, the number of new doctoral graduates, employment in knowledge-based activities and scientific publications in the most highly cited journals. The number of researchers employed in business has also grown. The relative weaknesses of the Irish R&I system are the relatively low (but growing) numbers of PCT patent applications and public-private co-publications as well as falling levels of SMEs introducing different forms of innovation.

Ireland had in 2010 a net inflow of students and engineers from the United States. According to UNESCO data, in 2010, 1201 students at graduate, masters or doctoral level left Ireland for studies in the United States, while 2545 students from the United States chose to study in Ireland. Ireland has engaged in the ESFRI process from the beginning and is supportive of 20 of the 44 areas identified in the original roadmap as well as being a participant in seven FP7 funded research infrastructure preparatory phase projects.

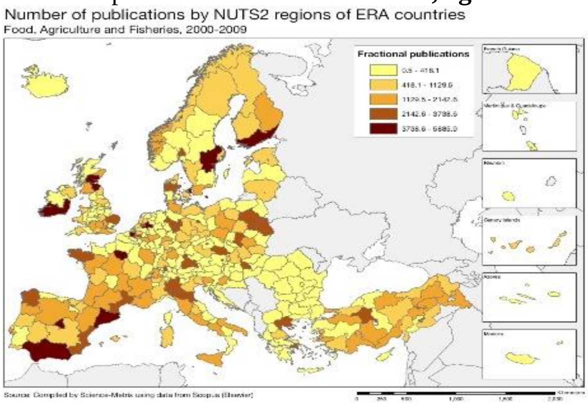
On knowledge transfer, Ireland has a relatively high efficiency with regard to the amount invested to generate each patent application, licence agreement and spinoff.

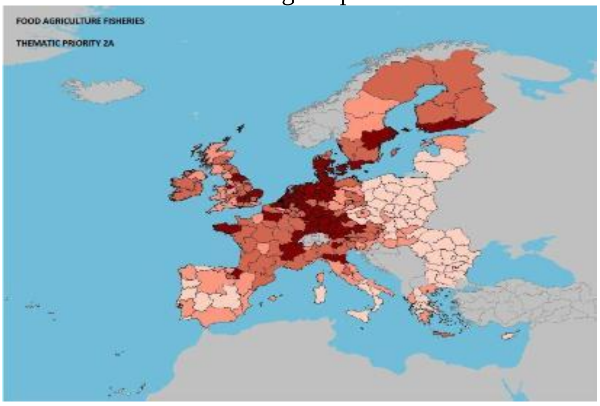
Ireland's scientific and technological strengths

The maps below illustrate several key science and technology areas where Irish regions have real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

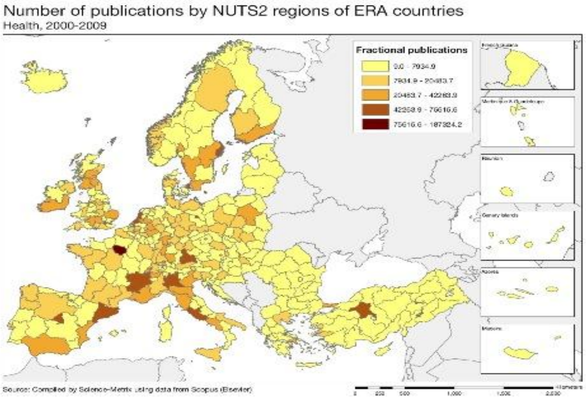
Strengths in science and technology at European level

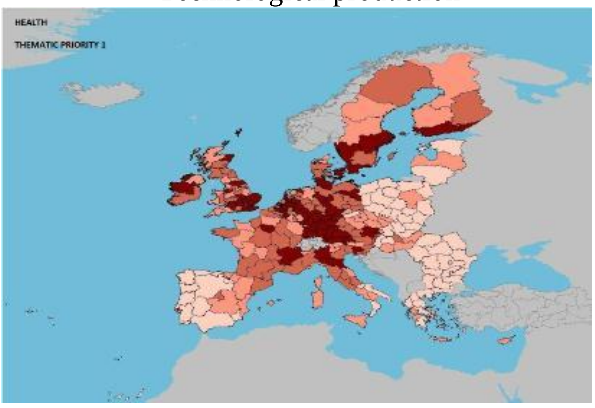
Scientific production **Food, agriculture and fisheries** Technological production



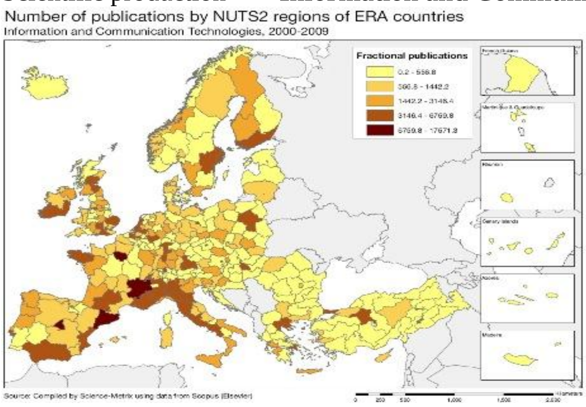


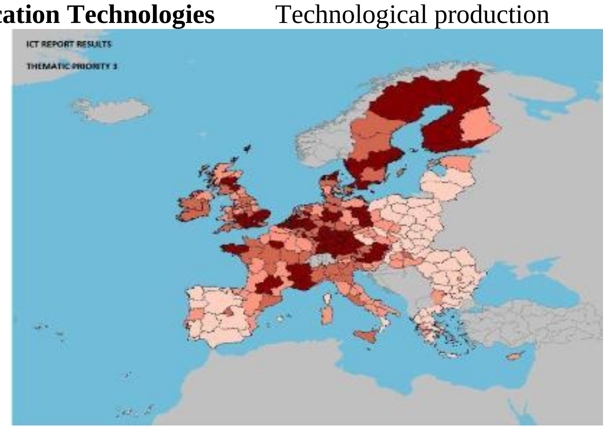
Scientific production **Health** Technological production





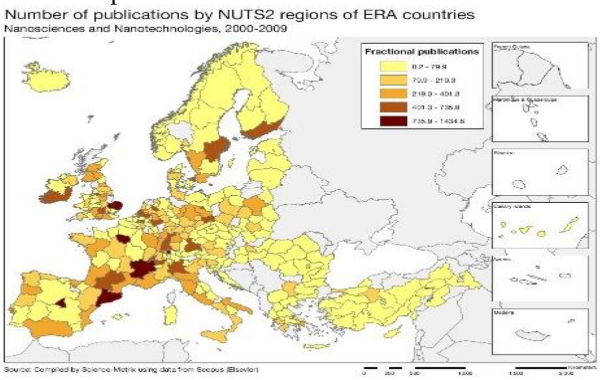
Scientific production **Information and Communication Technologies** Technological production

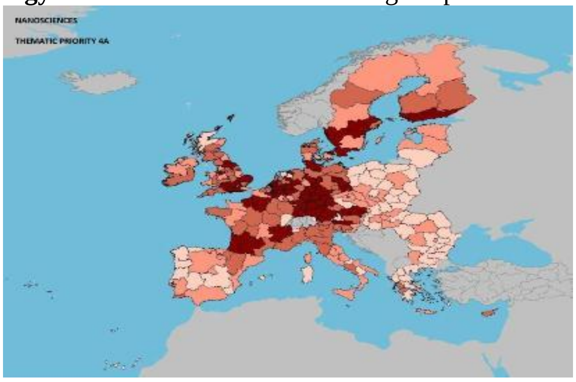




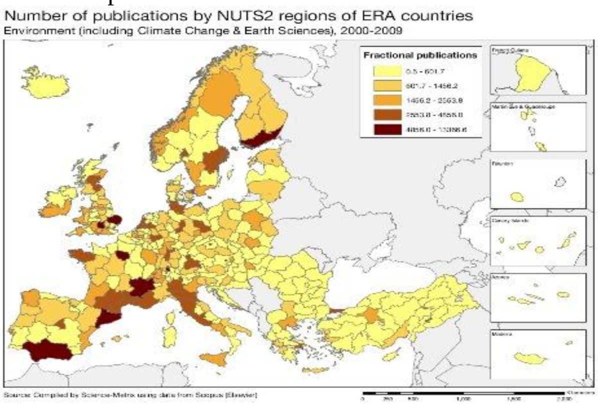
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

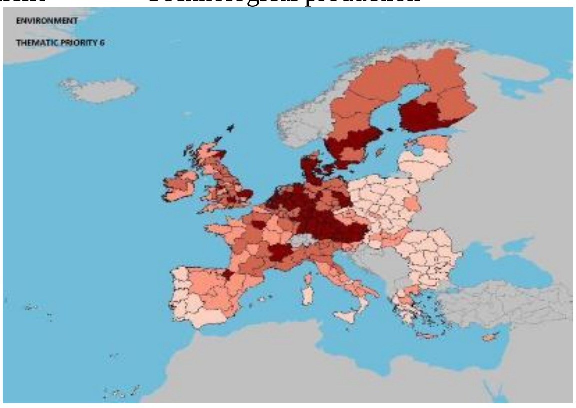
Scientific production **Nanotechnology** Technological production



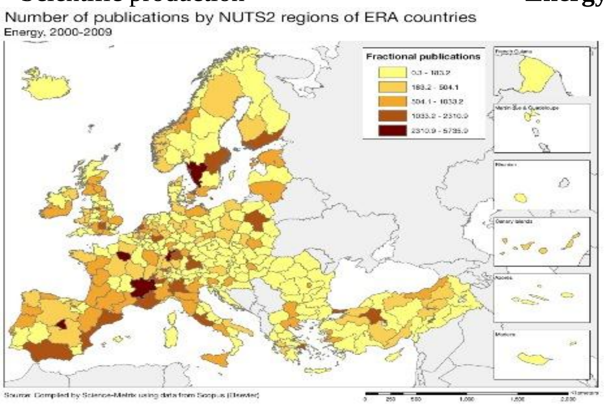


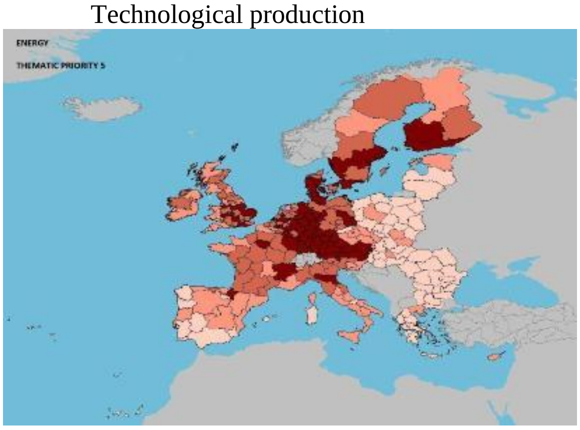
Scientific production **Environment** Technological production





Scientific production **Energy** Technological production





As illustrated by the maps above, in absolute numbers, in terms of scientific capacity, Ireland has strong regional clusters in the fields of food, agriculture and fisheries, ICT and nanotechnology. In terms of technology specialisation, Ireland is particularly strong in ICT. In fact, Ireland has a technological advantage in ICT comparable to that of the United States and well above the EU average and surpassed in the EU only by Sweden and Finland. In nanotechnology Ireland is third behind Singapore and the Czech Republic.

The main technology sectors in which the number of patent applications and patents granted by the EPO are in the 75-100 percentile are telecommunications, digital communications, computer technology, IT methods for management, medical technology, thermal process and apparatus, manufacture of medical and surgical equipment, and services for computer and related activities. These findings illustrate the comparative strengths and suggest the focus for R&I and industrial policies.

Policies and reforms for research and innovation

The Irish research system is centralised and regions and while research policies are set nationally they address regional aspects and needs and take account of effects of clustering which have led to regional specialisation. The significance of structural funds for Ireland has reduced and EDRF funds amounting to € 163.5 million for research, innovation and entrepreneurship over the period 2007-2013 represent less than 20% of the annual government budget for R&D. Ireland comprises two NUTS II regions. The Border, Midland and Western region's key challenge is to develop its Institutes of Technology as well as enhance the research, innovation and ICT infrastructure to promote enterprise development. The Southern and Eastern region has a commitment to developing incubator spaces in close proximity to the institutes of Technology

Prior to the crisis policy is based on a Strategy for Science, Technology and Innovation 2006-2013 which articulates the ambition to be a leading knowledge economy. Following the onset of the economic crisis this policy is being implemented in the context of the Framework for Sustainable Economic Renewal which, through an Action plan for Jobs, involves actions to deliver reform and create economic growth and which includes measures related to science technology and innovation. The Government's programme for national recovery stresses increased emphasis on delivering value from the State's investment in research with the approach being to fund the full spectrum of research in priority areas as identified in the National Research Prioritisation exercise. In addition a portion of funding will be retained for research for policy and research for knowledge.

Fiscal measures involving R&D tax credits were introduced in 2004 and provided a 25% tax credit for qualifying incremental expenditure covering the full spectrum from basic to applied research and experimental development. According to the OECD surveys on tax incentives, indirect support of business R&D in Ireland is almost three times higher than direct support. The fiscal incentives for carrying out R&D were complemented by an expansion of tax credits in 2010 to enhance investment in intellectual property (including software) by excluding royalty income from withholding tax.

More recently the Government has accepted a proposal for the prioritisation of research funding for activities related to areas of industrial strength. In addition emphasis is placed on increasing the innovation potential of indigenous firms and improving links between industry and higher education institutions.

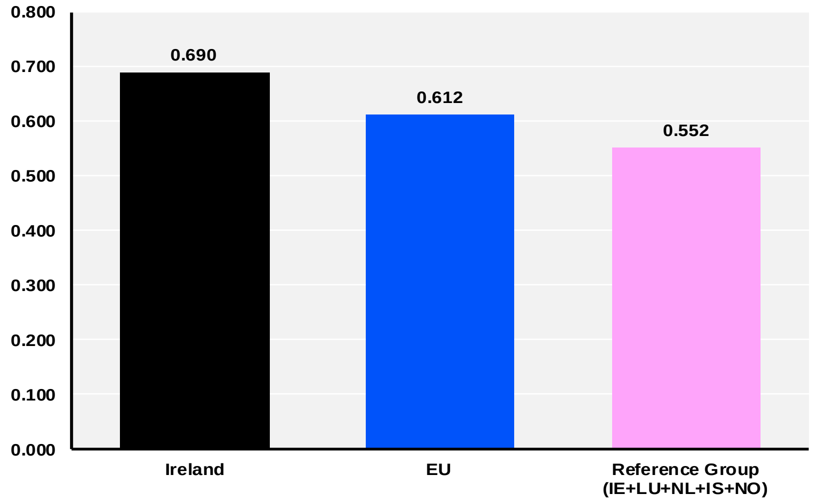
The existing national policies on IPR were reviewed by a task force and were found to be in line with international practice including that emerging at EU level from the Commission Recommendation C(2008)1329 and the Responsible Partnering initiative of the key stakeholders. This has recently been updated with a new IP protocol to clarify the rules on knowledge transfer in the context of collaboration between industry and higher education institutions.

In 2012 an Innovation task force was adopted Key areas for action include a better matching between supply and demand for innovation, a financial framework fostering innovation, high quality and broad human capital, and international projection. It also includes promotion of public procurement for innovative products and services. However, due to the need for strong fiscal consolidation, the implementation of this has been limited to the issuance of guidance.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[22].

Ireland - Index of economic impact of innovation (1)



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The high score of Ireland on this summary index is linked to its economic structure, with high volumes of activities both in several high-tech manufacturing sectors and in knowledge-intensive services. The share of the Ireland's employment in knowledge-intensive activities (19.8 %) and the share of knowledge-intensive services in services export are both the second highest of all EU Member States, after Luxembourg.

Foreign multinational firms perform a large part of the activity in the knowledge-intensive sectors, and in the last decade, foreign direct investments have continued in the more technology-intensive sectors. According to the OECD, Ireland has at 17.9% by far the highest technology balance of payments as a percentage of GDP and at 20% the fifth highest growth rate among the OECD countries for which data are available. This can be largely attributed to the high level of foreign direct investment in Ireland and the resultant intra-group transfers of technology.

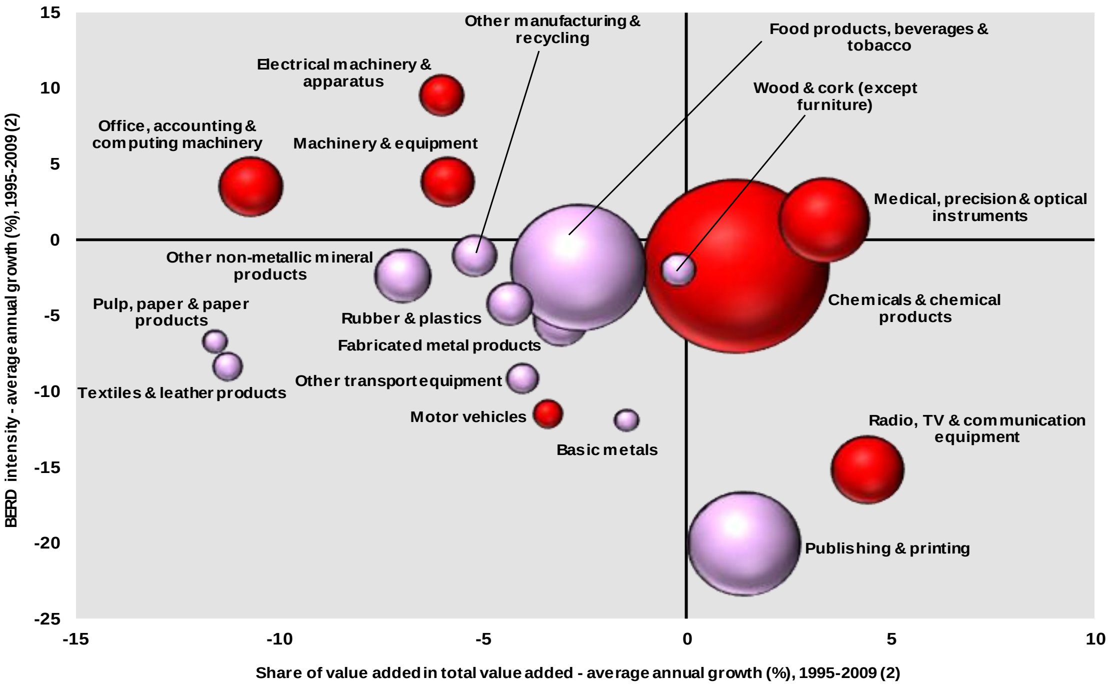
Ireland generally has favourable framework conditions for innovation, in particular in terms of time taken to start a business, barriers to entrepreneurship, and corporate taxation. In contrast it is below the OECD average in terms of percentage of self-employed persons, women entrepreneurs and entrepreneurs under 45 years of age. According to the OECD, barriers to entrepreneurship (including regulatory, administrative burdens and barriers to competition) were lower than in many other EU Member States. However, following the financial crisis, in 2010 the ease of access to capital in Ireland was the lowest of all OECD countries whereas previously Ireland had been ranked in 11th place. In contrast, in 2009 Ireland was still in 5th place in the OECD and 2nd in the EU (behind Sweden) in terms of venture capital investment as a percentage of GDP. Regarding the number of business angel networks and groups, Ireland is 3rd in a group of smaller and medium sized countries.

22 See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axe illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Ireland - Share of value added versus BERD intensity - average annual growth, 1995-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Basic metals', 'Fabricated metal products', 'Motor Vehicles', 'Other manufacturing and recycling', 'Other transport equipment', 'Publishing and printing', 'Pulp, paper and paper products', 'Wood and cork (except furniture)': 1995-2005; 'Electrical machinery and apparatus', 'Medical, precision and optical instruments', 'Office, accounting and computing machinery', 'Radio, TV and communication equipment': 1995-2007.

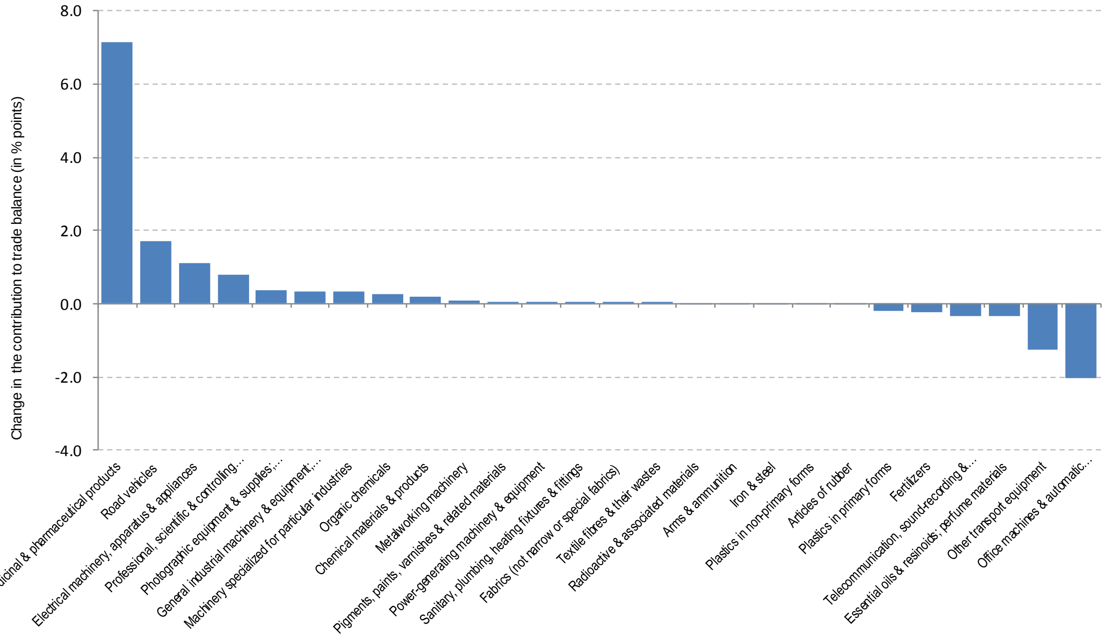
As recognised in Irish economic and industrial policy, the medium-term avenue for a more sustainable economy is to upgrade and move up on the value chain and internationalise its outreach. Compared to other countries, Ireland has scope to further increase both the R&D intensity in existing high-tech and medium-high-tech sectors and to increase knowledge intensity in more traditional sectors of the economy.

The graph above illustrates the structural change of the Irish economy over the last decade. It shows that the economic expansion over the period 2000-2006 was mainly related to chemicals and chemical products, medical, precision and optical instruments, and radio, TV and communication equipment. There have been increases in R&I investment in electrical machinery and apparatus, machinery and equipment, and office, accounting and computing machinery. This knowledge injection has translated into an increasing share of value added in medical, precision and optical instruments and chemicals and chemical products.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Ireland between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Ireland has a positive trade balance in high-tech and medium-tech products and has achieved a considerable growth with a fourfold increase over the last decade, which constitutes an impressive record. Total trade balance in the economy has also grown continuously. The graph above shows that most high-tech and medium-tech products and in particular medicinal and pharmaceutical products, road vehicles, and electrical machinery and apparatus have increased their contributions to the Irish trade balance over the period 2000-2010. A relative concern is the falling weight of products in office machines and telecommunications, and other transport equipment, which have also decreased their exports in real terms over the period 2000-2009. Looking at the previous graph, it is clear that since 1995, the radio, TV and communication equipment sector has not substantially upgraded its knowledge intensity in terms of average annual growth of business R&D. On the other hand, electrical machinery and apparatus has a lower average growth in value added but a higher average growth in R&D.

Total factor productivity growth in Ireland is in 2012 back to the pre-crisis level. The employment rate is below the EU average, it has also increased and subsequently fallen clearly with the crisis after 2009. The share of population at risk of poverty or social exclusion has risen as result of the economic crisis and is above the EU average. Regarding the other Europe 2020 targets in environment and education, greenhouse gas emissions have fallen but are still much higher than the EU average, and the share of renewable energy has increased but is still much lower than the EU average. Innovation has contributed to a rising number of patents in environmental and health-related technologies, with Ireland ranking respectively 11th and 7th within the EU.

Key indicators for Ireland

IRELAND	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.89	0.98	0.85	1.06	1.06	1.20	1.38	1.37	1.40	1.54	1.58	:	:	5.9	*1.69*	10
Business enterprise expenditure on R&D (BERD) as % of GDP	0.80	0.77	0.76	0.78	0.81	0.82	0.83	0.85	0.94	1.16	*1.17*	*1.17*	:	*3.5*	*1.26*	10
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.32	0.33	0.34	0.38	0.42	0.43	0.42	0.44	0.52	*0.60*	0.54	*0.56*	:	*5.3*	*0.74*	16
Venture Capital (3) as % of GDP	0.21	0.11	0.08	0.06	0.04	0.06	0.05	0.17	0.04	0.04	0.03	0.03	:	-15.9	0,35 (4)	18 (4)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	29.3	:	:	:	:	38.1	:	:	5.4	47.9	11
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	9.6	10.7	9.8	8.2	9.8	10.6	10.8	11.5	11.4	:	:	:	:	2.2	10.9	8
International scientific co-publications per million population	319	286	328	469	591	695	740	814	912	1004	1094	1131	:	12.2	300	8
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	29	26	22	29	34	:	4.6	53	12
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	2.3	2.5	2.3	2.2	2.4	2.4	2.4	2.7	2.9	2.8	:	:	:	2.2	3.9	11
License and patent revenues from abroad as % of GDP	:	:	:	:	0.19	0.38	0.41	0.46	0.57	0.75	1.40	2.29	:	42.9	0.58	2
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	10.1	:	12.6	:	11.0	:	9.3	:	:	-1.4	14.4	19
Knowledge-intensive services exports as % total service exports	:	:	:	:	36.4	68.7	70.5	67.0	33.7	71.8	73.1	:	:	12.3	45.1	2
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.37	-3.10	-1.78	-1.31	-0.27	-1.20	-0.92	-1.33	1.28	2.43	2.38	2.57	:	-	4,20 (5)	11
Growth of total factor productivity (total economy) - 2000 = 100	100	101	104	104	104	105	105	106	102	101	102	105	106	6 (6)	103	11
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	54.0	:	:	:	:	53.9	:	:	:	:	65.4	:	:	1.9	48.7	1
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	18.2	19.2	19.5	19.8	:	2.9	13.6	2
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	50.1	:	43.8	:	27.3	:	45.5	:	:	-1.6	38.4	8
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.10	0.04	0.07	0.04	0.10	0.05	0.08	0.09	0.24	:	:	:	:	11.5	0.39	11
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.52	0.74	0.50	0.61	0.54	0.54	0.40	0.60	0.59	:	:	:	:	1.5	0.52	7
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	70.4	71.1	70.7	70.6	71.5	72.6	73.4	73.8	72.3	67.1	65.0	64.1	:	-0.8	68.6	20
R&D Intensity (GERD as % of GDP)	1.11	1.09	1.10	1.16	1.23	1.25	1.25	1.29	1.46	*1.76*	*1.71*	*1.72*	:	*4.1*	*2.03*	13
Greenhouse gas emissions - 1990 = 100	123	127	124	124	123	126	125	124	122	112	111	:	:	-12 (7)	85	22 (8)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	2.2	2.7	2.9	3.3	3.9	5.1	5.5	:	:	16.5	12.5	21
Share of population aged 30-34 who have successfully completed tertiary education (%)	27.5	30.6	32.0	35.1	38.6	39.2	41.3	43.3	46.1	48.9	49.9	49.4	:	5.5	34.6	1
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	24.8	25.0	23.3	23.1	23.7	25.7	29.9	:	:	3.2	*24.2*	21 (8)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Values in italics are estimated or provisional.

Italy

The challenge of structural change for a more knowledge-intensive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Italy. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

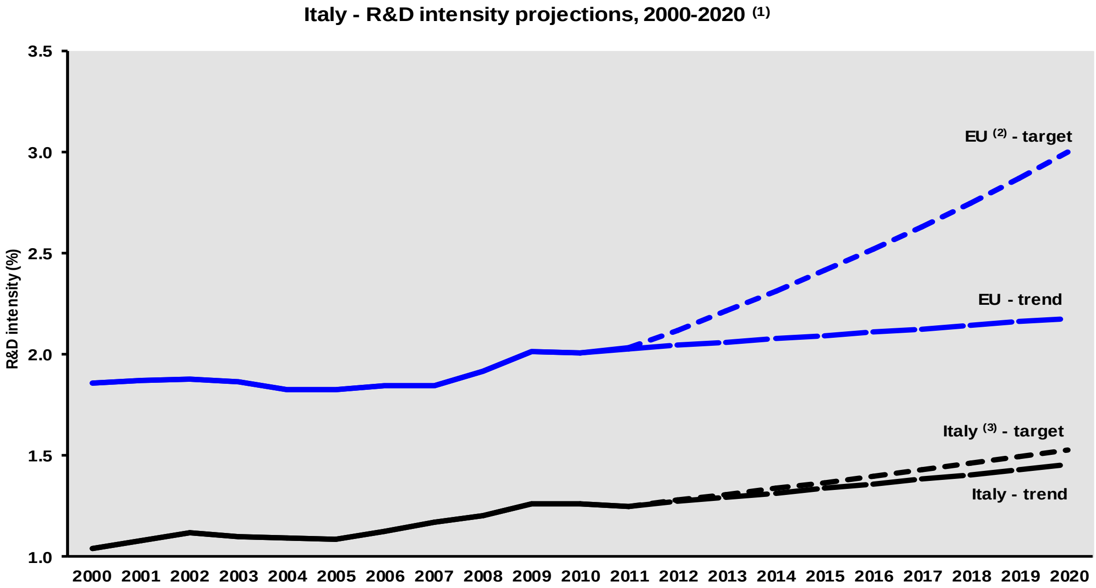
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 1.25% (EU: 2.03%; US: 2.75%) 2000-2011: +1.69% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:43.12 (EU:47.86; US: 56.68) 2005-2010: +3.56% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.556 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:35.43 (EU:48.75; US: 56.25) 2000-2010: +1% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Automobiles, Food and agriculture, ICT, Biotechnology, New production technologies	*HT + MT contribution to the trade balance* 2011: 4.96% (EU: 4.2%; US: 1.93%) 2000-2011: +8.13% (EU: +4.99%; US:-10.75%)

Over the last decade, Italian R&D intensity increased moderately, reaching 1.25% in 2011. Overall, the R&D intensity of both the public and private sectors increased over the last decade, but only to reach levels that remain very far from those of the countries at the technology frontier, thus suggesting a trend towards a specialisation in low technology-intensive products.

Without any doubt, the first priority for Italy in the field of R&I is to generate a strong momentum and commitment towards increasing its R&D intensity based on improved business framework conditions for innovation and economic structural change. The low degree of adjustment of the education system to the economic structure of the country and to the specific needs of industry is a structural weakness. There is also a lack of effective and timely implementation of the overall policy mix for R&I and education, in particular measures to support innovation and more specifically SMEs. Major challenges include the underinvestment of the private sector in R&D and innovation, largely due to the fact that the Italian economy is characterised by a large number of SMEs and micro firms in low knowledge intensity sectors (bearing in mind also the large differences between the North and the South of the country) as well as the low level of skills and insufficient performance of the higher education system in many regions.

To address these challenges, public support measures and framework conditions for R&D have been put in place (e.g. grants for industrial research, simplification of the IPR system) and a new governmental structure has been created to coordinate national R&D activities and links with R&D stakeholders. Since 2011, the new government has incorporated the objectives and priorities of EU 2020 in their main policies, with specific roles for R&D, innovation and human resources. A reduction of taxation for R&D activities is foreseen, extending regulation to intramural R&D (until now applied only to extramural R&D). A "Cohesion Action Plan" was launched in November 2011, aiming to improve the use of structural funds to create growth and jobs by concentrating resources on key domains (education, broadband, employment and transport networks) following the restructuring of the Operational Programmes.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) IT: This projection is based on a tentative R&D intensity target of 1.53% for 2020.

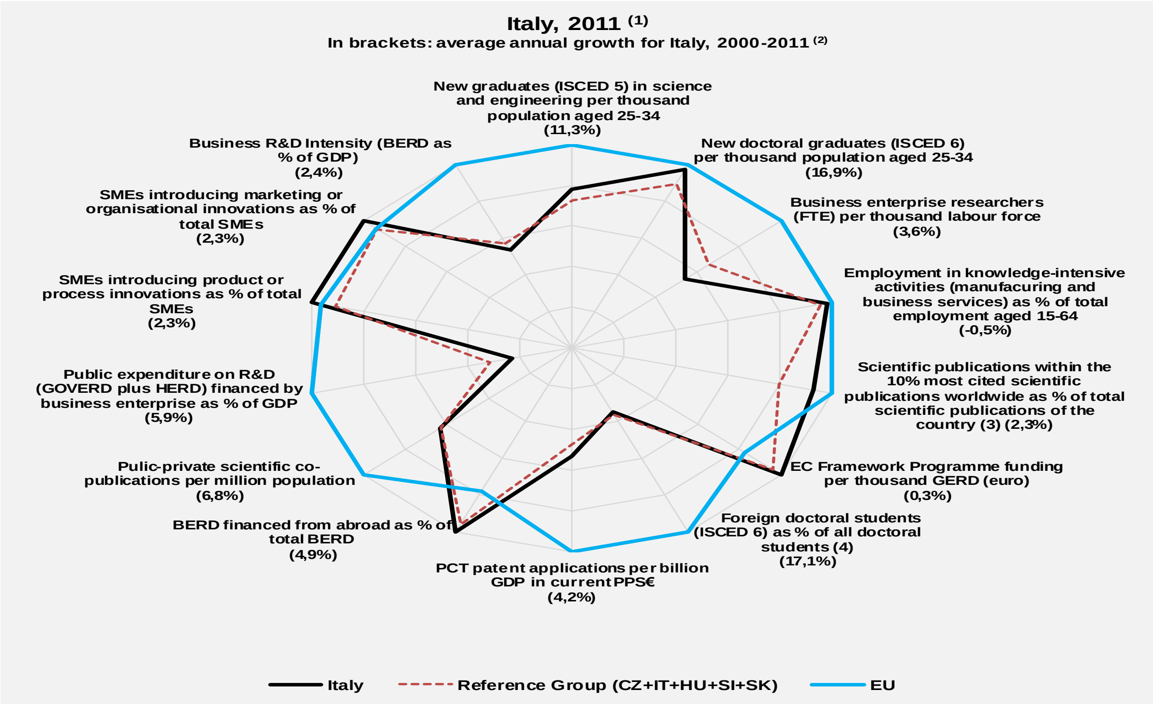
The Italian national R&D intensity target will be achieved if the current trend continues, but the target is not very ambitious. Italy set an R&D intensity target of 1.53% in the context of the Europe 2020 strategy, well below the current EU average, thus running the risk of the country falling far behind a moving technology frontier in some sectors of its economy. Over the 2000-2011 period, R&D intensity in Italy increased by an average of 1.69% annually, passing from 1.04% in 2000 to 1.25% in 2010. Both public sector and private sector expenditure on R&D have grown during the period, but at modest rates. The difference between Italy's R&D intensity and the EU average is mainly due to lower industrial R&D. In 2011 business R&D intensity in Italy was 0.68% compared to an EU average of 1.26%. Public sector R&D intensity is also lower than the EU average (0.53% for Italy compared to an EU average of 0.74% in 2011).

Public funding for R&D as a percentage of GDP has been decreasing over the last eight years, after a period between 2000 and 2004 in which a substantial increase was registered. The need to reduce the public deficit has imposed budgetary constraints. The trend shows also a decreasing public R&D budget in 2011 and 2012. Likewise, Italy has one of the lowest levels of public expenditure on education as a % of GDP in the EU (4.7% in 2009). In addition, Italy faces the problem of very low business investment in R&D. The low level of business R&D intensity is partly linked to the structural composition of the economy which has a low share of high-tech industries in total manufacturing, and partly the result of low R&D investment by Italian firms. The small size of Italian firms, 95% of which are small or micro enterprises, aggravates this situation. There is also a low presence of foreign-owned firms which has remained unchanged over the period 2001-2008.

Italian R&D performers have received almost € 2.2 billion in EC contributions under the 7th Framework Programme (8.27% of the total EC contributions). Italy counts three universities (Bologna, Milan and Rome) among the top 50 participant HES organisations in FP7 and two research institutes among the top 20 participant REO organisations. For the ERDF programming period 2007-2013, Italy has been allocated a total of € 27 billion for research, innovation, support for SMEs, information technologies and other measures to stimulate innovation and entrepreneurship. These funds will be crucial for the development and catching up of some of the regions. However, by January 2012 only 34% of the available structural funds for research and innovation related themes had been allocated.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Italian R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation, and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

Italy scores above the EU average for innovative SMEs introducing marketing, organisational and product or process innovations. Other positive aspects are the high growth rates observed for shares of new doctoral graduates (ISCED 6) (16.9%) and non-EU doctoral students (17.1%). Between 2000 and 2010, the total number of researchers (FTE) per thousand labour force has grown at an average annual rate of 4.2%.

However, Italy is suffering a net outflow of students and engineers to the United States.[23] The number of business researchers per thousand labour force in Italy has grown between 2000 and 2010, but is still well below the EU average highlighting the need to enhance the quality of the higher education system and to improve the correspondence between curricula and labour market needs. The Italian research and innovation system is relatively public-based, with only 53.6% of research performed by the business sector (compared to an EU average of 61.5% in 2010) and has a low level of knowledge transfer from public research institutions to firms.

Another structural weakness is the disparity between Northern and Southern regions in terms of innovation performance (the most innovative regions are Lombardia and Emilia Romagna). However, Italy is well integrated in the European research and innovation system. Together with Germany, France and the United Kingdom, Italy is among the highest producers of cross-border scientific co-publications (in absolute numbers).

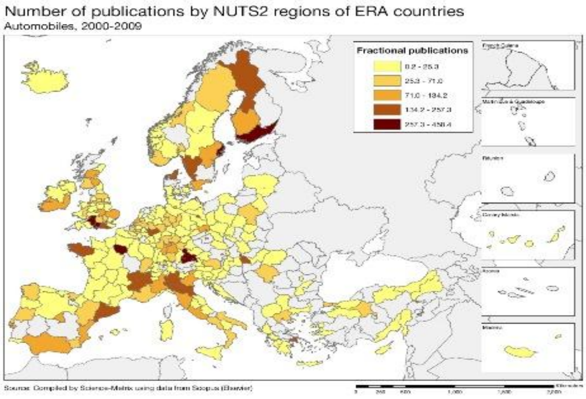
[23] In 2010, 4.036 students at graduate, master or doctoral level left Italy for studies in the United States, while only 423 students from the United States chose to study in Italy (UNESCO data, 2009),

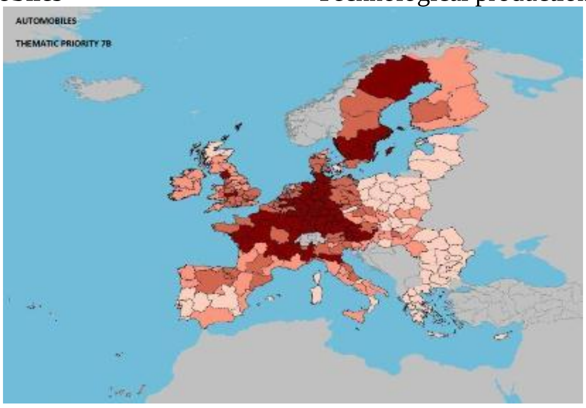
Italy's scientific and technological strengths

The maps below illustrate six key science and technology areas where Italy has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

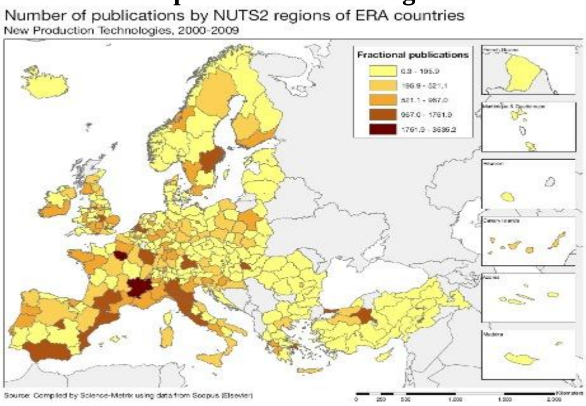
Strengths in science and technology at European level

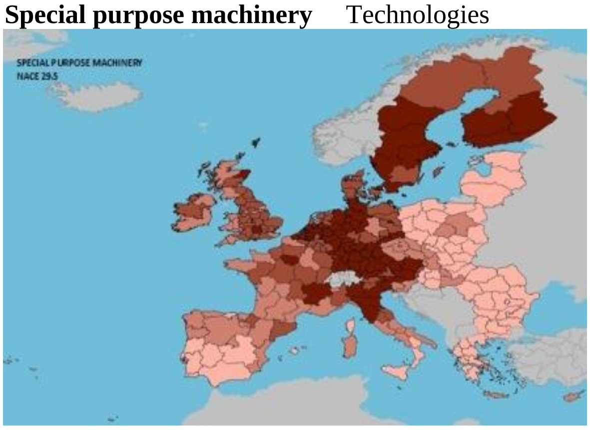
Scientific production **Automobiles** Technological production



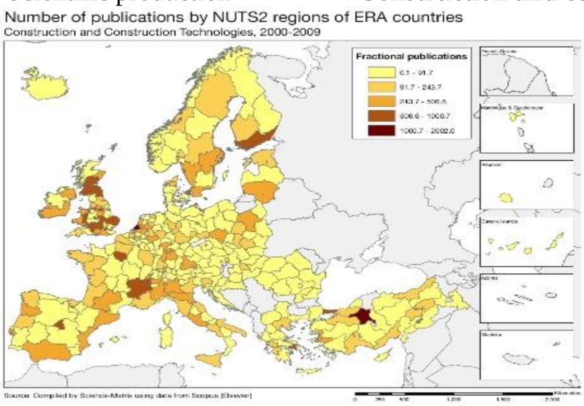


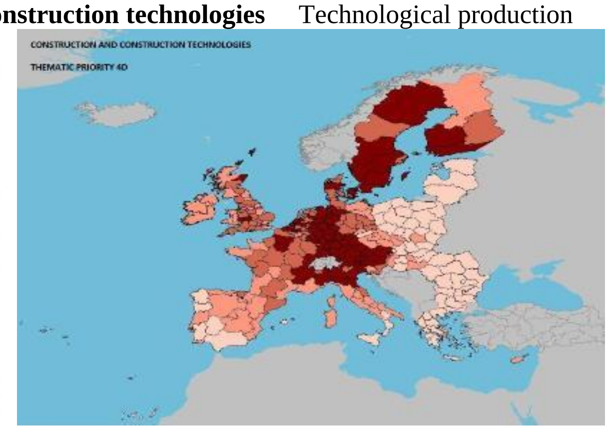
Science **New production technologies** **Special purpose machinery** Technologies





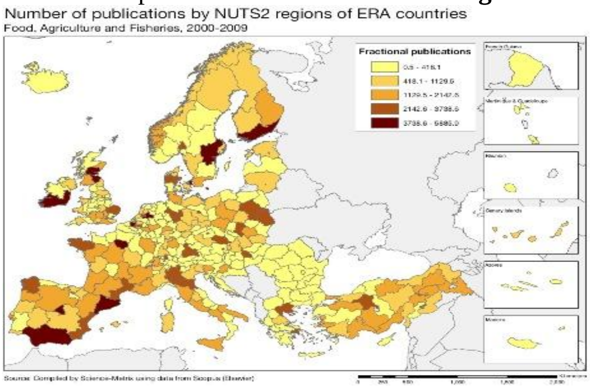
Scientific production **Construction and construction technologies** Technological production

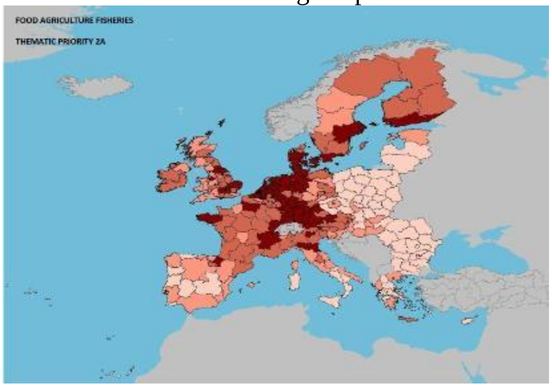




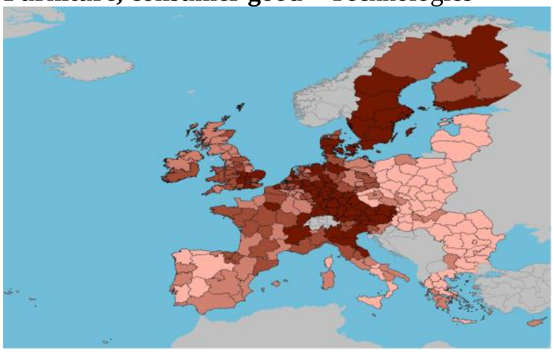
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

Scientific production **Food agriculture and fisheries** Technological production

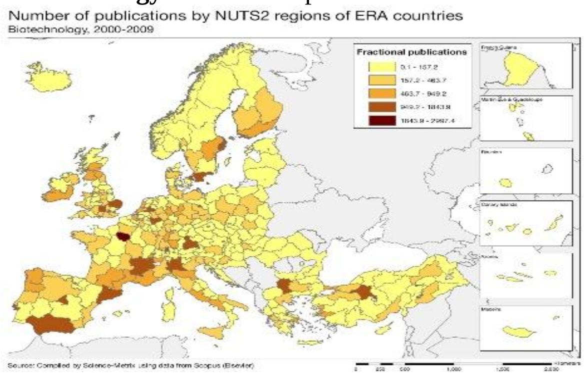




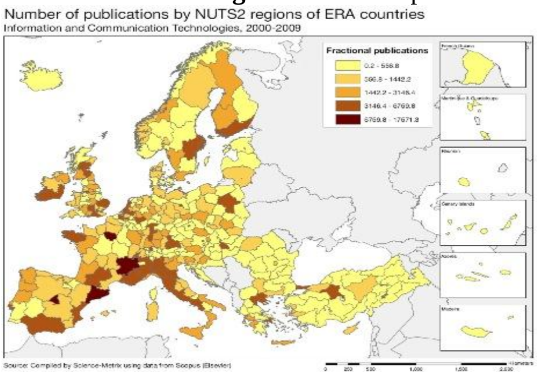
Furniture, consumer good Technologies



Biotechnology **S**cientific production



Information technologies Scientific production



Italy is still below the EU average in terms of scientific production and technology development. Some regions have strong scientific capacity in the fields of automobiles, food, agriculture and fisheries, construction and construction technologies, furniture and consumer goods, special purpose machinery and chemicals. Italy reveals science quality and technological specialization mainly in energy, automobiles and transport. Relative strengths in patenting reflect the weight of the traditional sectors together with construction.

A cluster policy has been in place in Italy since the 1990s. Italian industrial clusters have been concentrated in the low-tech and medium-tech sectors, but new clusters are also emerging in aerospace, biotechnologies (highly concentrated in Lombardia), renewable energies and mechatronics (in close collaboration with automotive and transports in general). The relative scientific and technological dynamics of the clusters can be observed from the publication and patenting activity at regional level, as illustrated by the maps above. Strengths in science and technology provide the potential for structural change towards more knowledge-intensity by injecting knowledge into existing and new industrial and services sectors. But in general, Italy has large and diversified innovation and science bases with only partial correspondence between science output and technological specialization. There is room for improvement in the matching of the science base with the needs of the industrial structure of Italy.

Policies and reforms for research and innovation

Italy has set an R&D target which is realistic, but lacking in ambition in view of the country's potential and challenges. The situation may improve under the new national programme for research and if successful at the occasion of the mid-term review of the Europe 2020 National targets (2014/2015). Procedures will be simplified while the approach will be more “market” oriented. The new “network contracts” could represent a positive element for supporting innovative clusters and stimulating cooperation. Positive steps have been taken in relation to the careers of researchers and in relation to increasing the numbers of graduates in science and engineering (as for example the case of Politecnico di Torino offering free tuition for female students, to incentivise female participation in scientific and technological education). The 2009-2013 National Research Programme acknowledges the obstacles that have made the development of a research policy in Italy difficult, and proposes an array of actions dedicated to removing those obstacles, while also making the best use of the positive characteristics of the existing productive structure. It provides a national framework for research activity carried out in Italy and assigns strategic value to public-private partnership for the development of the products and processes needed to maintain and improve the nation's competitiveness and level of exports, and to reduce national, economic and political dependence in sectors such as energy, environment and healthcare.

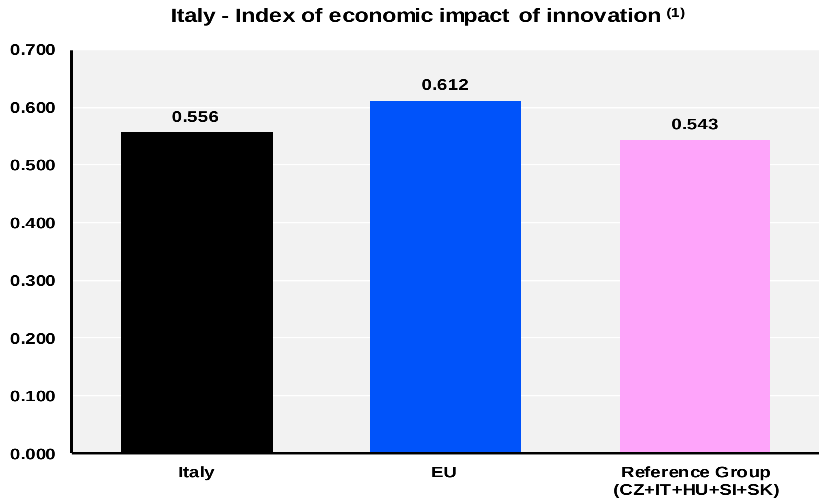
Some public support measures and framework conditions for R&I are in place (e.g. grants for industrial research, simplification of the IPR system). A new governmental structure has been created to coordinate national R&D activities and links with R&D stakeholders. In the higher education sector a recent reform of universities towards more performance based funding is being implemented. The new National Agency for the Evaluation of the University and Research (ANVUR) will evaluate research and education institutions. A five year evaluation exercise was launched to assess the research performance of universities and public research institutions. The reform of the public administration is on-going, aiming at better linking pay with performance, increasing mobility and introducing further competitive elements in the appointment of public managers. Furthermore, the *e-Government 2012 Plan*, launched in 2009, aims to modernise the public administration and to promote innovation through ICT. The information concerning the resources made available for R&D and innovation for 2011-12 is positive. Several interesting initiatives have been launched: 185 new JTIs projects involving 400 companies; agreement between MIUR and Agencies on venture capital for SMEs; contracts between networks of companies (to improve industrial collaboration); green public procurement, among other measures.

Since 2011, the new government has incorporated the objectives and priorities of EU 2020 in their main policies, with specific roles for R&D, innovation and human resources. With the aim of enhancing private R&D investment the government has introduced fiscal incentives such as a 35% tax credit, with a maximum of € 200.000 per firm and year, to encourage recruitment of highly-skilled young people. Support for public-private partnerships is foreseen in key sectors. In the context of economic change a larger company or a sector in crisis can receive support for projects of industrial conversion, and instruments have been put in place for the re-training of human resources. These policies have been implemented in the petrochemical and the chemical sectors.

Following the launching of a "Cohesion Action Plan", November 2011, aiming to improve the use of structural funds to create growth and jobs, resources are being concentrated on key domains (education, broadband, employment and transport networks) as part of the restructuring of the Operational Programmes. The biggest Operational Programme for R&D and innovation, PON, has been concentrated in three domains, with a budget of € 1150 million (data of March 2012). In relation to the European Digital Agenda, a task force from the ministry in charge of research and the regions is studying the economic viability of the project. Examples of focus include smart cities and communities aiming to strengthen synergies at regional level. An important step has been taken in the field of governance with the abolition of the need for a double evaluation (at national level) of the projects approved at community level. Progress towards the ERA and improving the impact of the structural funds for research and innovation, in the context of the 2011 Cohesion Action Plan, is dependent on implementation capacity.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[24].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The slightly lower level of economic impact of innovation in Italy is partly linked to an economic structure that has a relatively low concentration of knowledge-intensive sectors. In particular technology production and the share of knowledge-intensive services in total service export are clearly lower than the EU average. This effect concerns mainly the R&D-based innovation, as the Italian economy consists to a large extent of low knowledge-intensity sectors: e.g. footwear, textiles and clothing and mainstream manufacturing industries such as fabricated metal products, domestic appliances, and bicycles. However, Italy also has some specializations in technology-intensive sectors such as machinery, automotive and aerospace.

The Italian financial sector has done well since the beginning of the economic crisis, but a main issue of concern is the access to credit for SMEs. Italy has adopted important measures to liberalise services, in particular professional services, and to improve competition in the network industries. Nevertheless, the business environment in Italy remains complex due to inefficiencies in resource utilisation, procedures and institutional organisation. These have repercussions in particular on the time required to apply and concretise specific measures reducing drastically their potential benefits to the economy.

Concerning the business environment, SMEs also have to deal with heavy administrative burdens. The reduction of the administrative burden is therefore a priority and the target is 25% in line with the EU strategy. Several initiatives have been proposed to cut the burden and should be implemented in 2012. These aim at improving the ease of doing business. At the moment Italy is among the less attractive Member States in the EU in terms of ease of doing business (in fact, Italy is ranked 80th in the world) and is also one of the Member States that has improved its framework environment the least in the period 2006-2011.[25]

The complexity of the administrative procedures involved in supporting programmes for R&D and innovation causes significant delays which can have a very negative impact in the specific case of innovation when market advantages are considered.

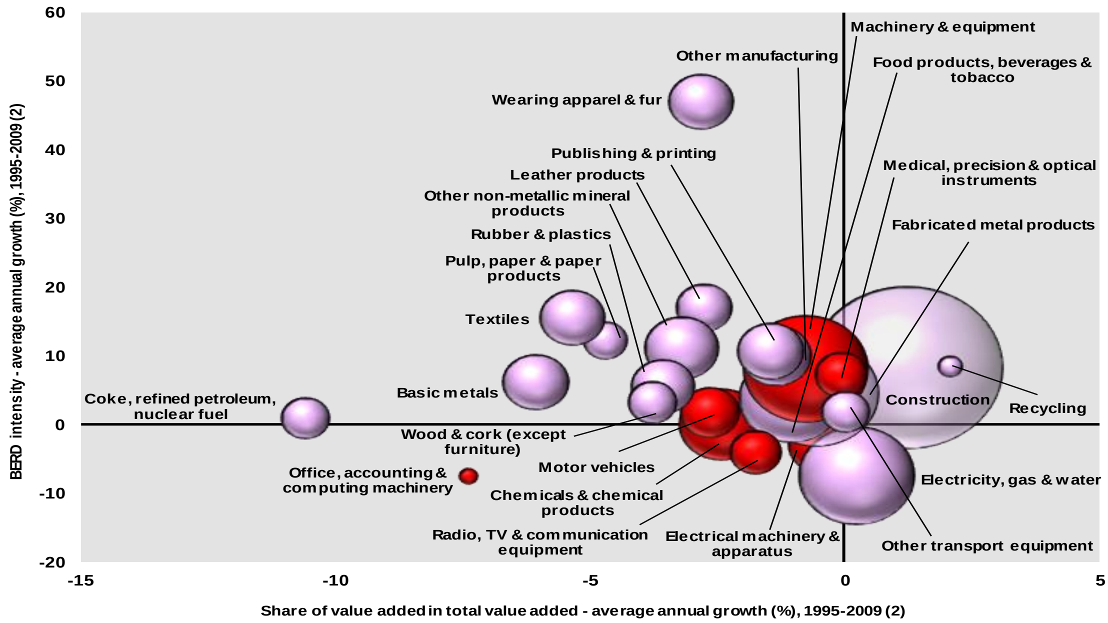
24 See Methodological note for the composition of this index.

25 Commission Staff Working Document "Industrial Performance Scoreboard and Report on Member States Performances and Policies", 2012

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Italy - Share of value added versus BERD intensity - average annual growth, 1995-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Electrical machinery and apparatus', 'Other manufacturing', 'Radio, TV & communication equipment', 'Recycling': 1995-2008.

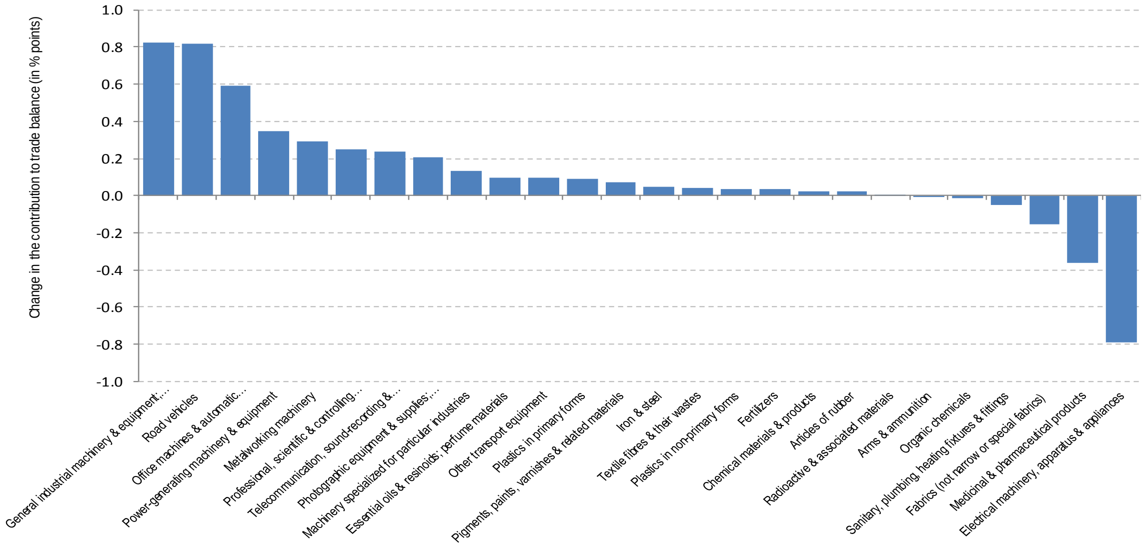
The graph above synthesises the structural change of the Italian economy over the last fifteen years. It shows that the economic expansion over the period 1995-2007 has not resulted in a general increase in knowledge-intensity in the manufacturing sector. The Italian economy has in parallel moved towards a higher share of services (illustrated by the left-ward move of the bubbles). Considering both manufacturing and services, employment in knowledge-intensive activities as percentage of total employment aged 15-64 has not increased over the period 2000-2010. Likewise, the combined share of value added in high-tech and medium-high-tech manufacturing and in knowledge-intensive services (KIS) in total value added actually decreased from 11.7% in 2000 to 10.3% in 2009.

Nevertheless, manufacturing still accounts for a larger share of the economy in Italy than in the EU, even if employment in manufacturing industries has decreased by 5% while employment in the services sector has increased by 23% over the period 1995-2009. The relatively high share of employment in manufacturing industries is mainly due to specialisation in some traditional sectors such as footwear, textiles and clothing and machinery, basic metal products and non-metallic mineral products. However, these sectors have lower R&D intensities in Italy than in other countries. According to the EU Industrial R&D Investment Scoreboard, Italy has been successful in maintaining its position in some strategic sectors. In the last 5 years, Italian firms in sectors such as automotive and parts, and aerospace, have remained among the top R&D investors, with only Germany and France showing more R&D investment in these sectors.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Italy between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Over the last 15 years, the Italian economy has slightly regressed in competitiveness. The efforts made in research and innovation to increase the knowledge base of the economy have been cancelled out by a decrease in total factor productivity (-5% since 2000) and by the stagnation of employment in knowledge-intensive activities. Nevertheless, Italy succeeded in keeping a positive trade balance until 2003. In 2004, the Italian trade balance deteriorated due mainly to the loss in competitiveness of low-tech products. The trade balance in all high-tech and medium-tech products together remained positive in Italy over the last decade, thus helping to redress the negative trend but not sufficiently to cancel it.

Indeed, most knowledge-intensive products and services have increased their contributions to the trade balance since 2000, as indicated on the graph above. However, electrical machinery, apparatus and appliances as well as medical and pharmaceutical products have decreased their contribution to the trade balance thus indicating a relative loss in world competitiveness. The previous graph has shown that although R&D intensity increased for most manufacturing sectors over the last 15 years, value added for these sectors has decreased. Considering the still important weight of the traditional manufacturing sectors in the Italian economy and the relative specialisation in these sectors, there is a clear need to upgrade the knowledge intensity of manufacturing sectors.

Relevant factors positively influencing structural change of the Italian economy are shown in the table below. The share of SMEs introducing product or process innovations is above the EU average while the share of employment in knowledge-intensive services slightly decreased and reached the Eu average. Italy is making efforts to develop technologies addressing societal challenges, in particular environment-related technologies (7,2% growth since 2000). Italy has registered good progress on all the Europe 2020 targets with the exception of a slightly falling employment rate, evident since the start of the economic crisis in 2007. The indicators on the Europe 2020 objectives illustrate the need to make the most of resources and to foster growth by investing in R&D, education and renewable energies.

Key indicators for Italy

ITALY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.45	0.45	0.51	0.73	0.98	1.12	1.21	1.29	1.56	:	:	:	:	16.9	*1.69*	11
Business enterprise expenditure on R&D (BERD) as % of GDP	0.52	0.53	0.54	0.52	0.52	0.55	0.55	0.61	0.65	0.67	0.68	*0.68*	:	*2.4*	*1.26*	18
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.52	0.55	0.57	0.57	0.55	0,52 [3]	0.54	0.52	0.52	0.55	0.54	*0.53*	:	*0.4*	*0.74*	18
Venture Capital [4] as % of GDP	0.13	0.09	0.08	0.06	0.04	0.05	0.08	0.11	0.20	0.09	0.06	0.07	:	-5.2	0,35 [5]	15 [5]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	36.2	:	:	:	:	43.1	:	:	3.6	47.9	10
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	8.4	8.3	8.6	8.5	9.0	9.5	9.6	9.9	10.1	:	:	:	:	2.3	10.9	12
International scientific co-publications per million population	192	178	198	276	315	343	368	407	423	449	476	500	:	9.1	300	19
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	26	26	29	32	33	:	6.8	53	14
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	1.4	1.5	1.7	1.8	1.9	2.1	2.3	2.2	2.0	2.1	:	:	:	4.2	3.9	13
License and patent revenues from abroad as % of GDP	:	:	:	:	0.04	0.06	0.06	0.05	0.17	0.18	0.18	0.17	:	21.5	0.58	15
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	11.9	:	9.1	:	11.8	:	14.9	:	:	3.8	14.4	8
Knowledge-intensive services exports as % total service exports	:	:	:	:	20.0	21.6	23.7	23.9	27.3	24.7	27.2	:	:	5.3	45.1	16
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	2.10	1.88	1.79	2.04	2.38	3.31	4.49	4.36	5.04	4.14	4.02	4.96	:	-	4,20 [6]	4
Growth of total factor productivity (total economy) - 2000 = 100	100	100	99	98	99	99	99	100	98	94	96	96	95	-5 [7]	103	26
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	32.1	:	:	:	:	33.1	:	:	:	:	35.4	:	:	1.0	48.7	20
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	13.6	13.5	13.7	13.4	:	-0.5	13.6	15
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	34.8	:	33.0	:	36.9	:	39.8	:	:	2.3	38.4	12
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.14	0.14	0.16	0.22	0.21	0.19	0.20	0.22	0.24	:	:	:	:	7.2	0.39	10
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.41	0.42	0.43	0.42	0.43	0.44	0.42	0.36	0.37	:	:	:	:	-1.1	0.52	12
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	57.4	58.5	59.4	60.0	61,5 [8]	61.6	62.5	62.8	63.0	61.7	61.1	61.2	:	-0.1	68.6	25
R&D Intensity (GERD as % of GDP)	1.04	1.08	1.12	1.10	1.09	1.09	1.13	1.17	1.21	1.26	1.26	*1.25*	:	*1.7*	*2.03*	17
Greenhouse gas emissions - 1990 = 100	106	107	108	111	111	111	109	107	104	95	97	:	:	-9 [9]	85	17 [10]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	5.3	5.3	5.8	5.7	7.1	8.9	10.1	:	:	11.3	12.5	15
Share of population aged 30-34 who have successfully completed tertiary education (%)	11.6	12.2	13.1	13.9	15.6	17.0	17.7	18.6	19.2	19.0	19.8	20.3	:	5.2	34.6	27
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	26.4	25.0	25.9	26.0	25.3	24.7	24.5	28.2	:	0.9	*24.2*	12 [10]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2005 and the previous years. Average annual growth refers to 2005-2011.

(4) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(5) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(6) EU is the weighted average of the values for the Member States.

(7) The value is the difference between 2012 and 2000.

(8) Break in series between 2004 and the previous years. Average annual growth refers to 2004-2011.

(9) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(10) The values for this indicator were ranked from lowest to highest.

(11) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Improve access to financial instruments, in particular equity, to finance growing businesses and innovation".

Latvia

A better partnership R&I-Business as a step forward towards competitiveness

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Latvia. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

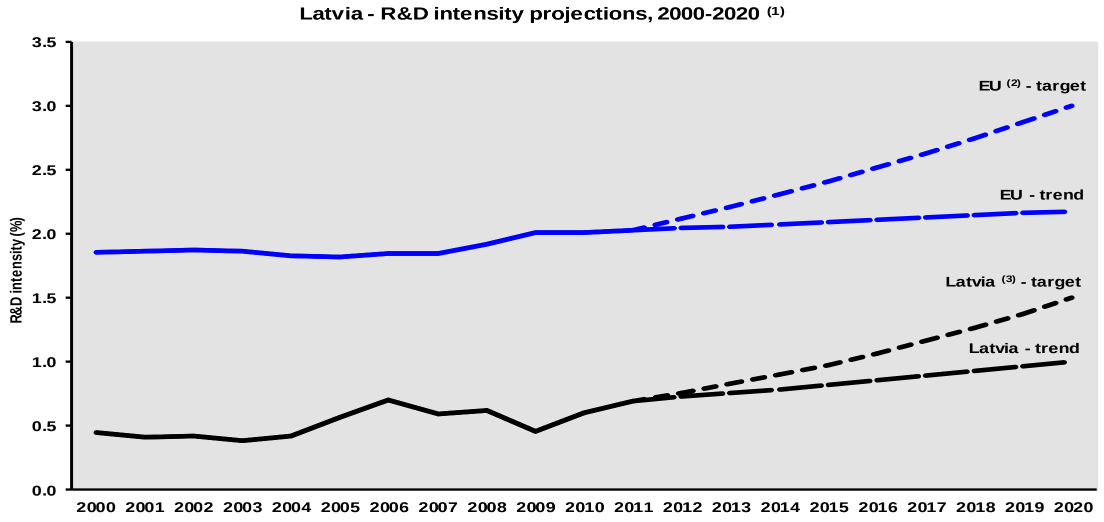
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.70% (EU: 2.03%; US: 2.75%) 2000-2011: +4.15% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:11.49 (EU:47.86; US: 56.68) 2005-2010: -0.15% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.248 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:34.38 (EU:48.75; US: 56.25) 2000-2010: +3.96% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Materials, Health, Nano-sciences, Environment, Energy	*HT + MT contribution to the trade balance* 2011: -5.42% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

Conscious of its current limitations in terms of research and innovation (R&I) and of the necessity to raise the level of its industry, Latvia adopted in 2005 a law on research activity aiming to boost its performance. Since 2008, however, Latvia has undertaken a rigorous fiscal consolidation, which has left behind some of the objectives and targets embodied in the law. A number of measures have been taken however, with the support of structural funds, in order to improve governance of the R&I system, to modernise the scientific infrastructure and attract foreign academics, and to improve the capacity of industry to innovate, in particular by developing the links between research and industry.

These measures still need to produce their full effect. Latvia's poor innovation performance still impairs its competitiveness. Latvia has one of the lowest business R&D intensities in the EU (0.19% in 2011). The national innovation system is overshadowed by low scientific performance, as measured by the share of scientific publications in the top 10% most cited which is only 4%, significantly below the EU average. There is little R&D investment by domestic companies or large foreign affiliates to support specialisation in knowledge-intensive and innovation-driven sectors.

As indicated by one of the Country Specific Recommendations Latvia should continue its reforms in higher education, by implementing a new financing model that rewards quality, strengthens links with market needs and research institutions, and avoids fragmentation of budget resources. Taking into account the thematic priorities and budgetary constraints, Latvia should improve the quality of its science base and rationalise its research and higher education institutions. The result obtained would be fewer but larger entities more able to build up critical mass in specialised areas of education and research, and a more focused use of resources. Moreover, in order to address the current challenges, Latvia would also get benefits from drawing up an R&I strategy for smart specialisation, that would facilitate a more efficient use of EU structural funds and improve the synergies between different EU and national policies, as well as increasing public and private investment in R&D.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) LV: This projection is based on a tentative R&D intensity target of 1.50% for 2020.

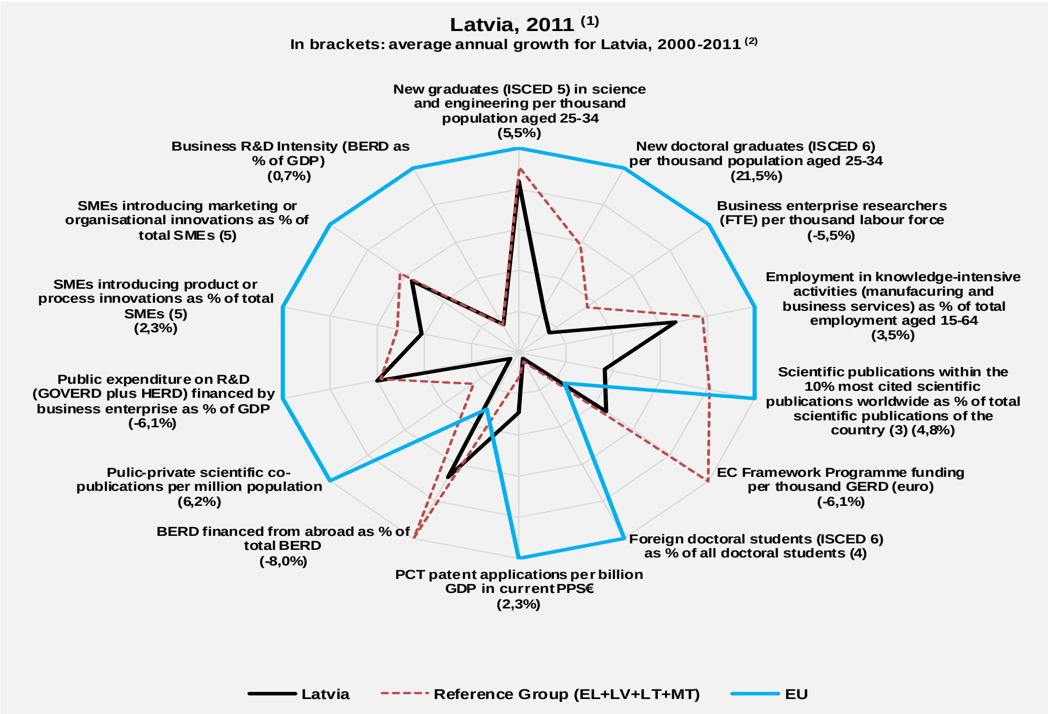
By the mid-2000s Latvia was faced with the realisation that it had to upgrade its Science and Technology infrastructure in order to become internationally competitive, to accumulate new knowledge and technology and to find high value added niches. In terms of research, Latvia had increased its government budget for R&D fivefold in absolute terms between 2000 and 2008. The financial crisis of 2008 had a major impact on the government budget for R&D, resulting in a 49% decrease between 2008 and 2009. Due to the country's rapid economic recovery, the public R&D budget has partially recovered in 2010 (with 27.3% increase compared to 2009). Moreover, in 2011 the public R&D funds have reached a level close to 2008, increasing by 48% compared to 2010 (HERD increased by 57.8%). Regarding innovation policy, Latvia does not have plans in the field of innovation procurement, is mostly supply led rather than demand-side led, and there are no tax incentives to support business R&D and innovation activities.

In strategic terms, Latvia has set a national R&D intensity target of 1.5%. In 2011, Latvia had an R&D intensity of 0.70%, with public R&D intensity amounting to 0.50% and business R&D intensity amounting to 0.19%. Latvia needs to increase the R&D intensity in both the public and the business sectors as a prerequisite to maintaining a performing R&I infrastructure and to boosting innovation in firms. Over the period 2000-2011, Latvia's R&D intensity has grown at an average annual growth rate of 4.2%. This growth rate is significantly higher than the EU average but still needs to be further increased if the country's 2020 R&D intensity target is to be achieved (in fact an average annual growth rate of 8.9% is required over the period 2011-2020 if the target of 1.5% is to be reached). The average annual growth rates of public sector R&D intensity and business sector R&D intensity over the period 2000-2011 are 5.97% and 0.69%, respectively. Latvia's participant success rate in the EC Seventh Framework Programme was 21.9%. The successful participants received a total EC financial contribution of € 26.4 million.

Structural Funds play a major role in the financing of R&I in Latvia (10% of the total ERDF–Cohesion Funds allocations for the 2007-2013 period). In 2010, R&I financing from the Structural Funds far exceeded national public funding for R&D and currently represents a third of total R&D expenditure in Latvia. The low level of business expenditure on R&D is seen as a critical challenge for Latvia. Business expenditure on R&D increased by 27% between 2009 and 2011. This increase is due in large part to the activities funded under Structural Funds programmes designed to improve the innovative capacity of industry. The growing share of Structural Funds in R&D funding is affecting the previous balance between institutional and competitive funding which is now inclining more towards project-based, competitive funding. A major issue for Latvia is the funding of R&D post 2013, in the period before the new round of Structural Funds becomes operational.

An effective research and innovation system building on the European Research Area

The graph below provides a synthetic picture of strengths and weaknesses of Latvia's R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) EL is not ncluded in the reference group.

One important aspect of the Latvian R&I system is the lack of highly qualified scientists and engineers, a lack which is correlated to the low numbers of new doctorates awarded and graduates in science and engineering. Moreover, it can be seen from the above graph that the share of researchers in business enterprise is extremely low and employment in knowledge-intensive activities is still below the EU average. In fact, Latvia suffers an important outflow of graduates and researchers to the United States and other countries, many scientists preferring to pursue their careers abroad. In addition to this the country is not attracting any significant numbers of non-nationals in the field of R&I.

The national innovation system is therefore severely affected by low scientific performance (the share of scientific publications in the top 10% most cited is 4%) and low licence and patent revenues. Moreover, the country needs to enhance the quality of the higher education system and to address the need to better attune Latvian research to the needs of local industry while reinforcing the capacity of the latter for developing research and innovation activities. As shown on the graph above, public-private scientific cooperation is very low and research and innovation investment by foreign affiliates in support of specialisation in knowledge-intensive and innovation-driven sectors has been diminishing. The modest results produced by the technology transfer contact points operating in several universities, in part due to the incomplete legal framework for protecting intellectual property rights, is also a factor that contributes to the low level of commercialisation of research results.

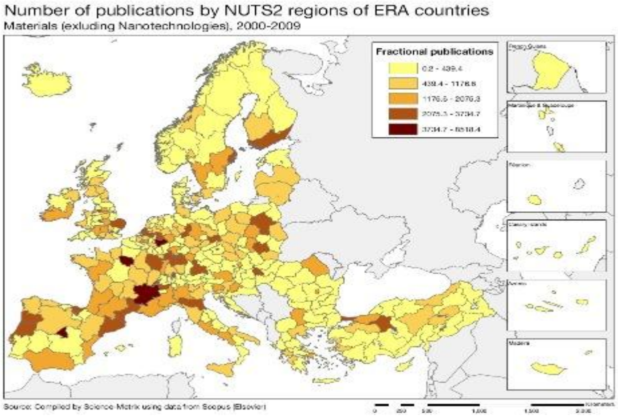
Latvia's scientific and technological strengths

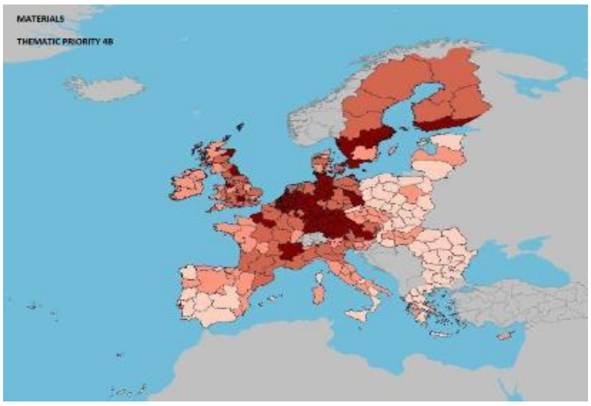
The maps below illustrate five key science and technology areas where Latvia has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

Scientific production

Materials

Technological production

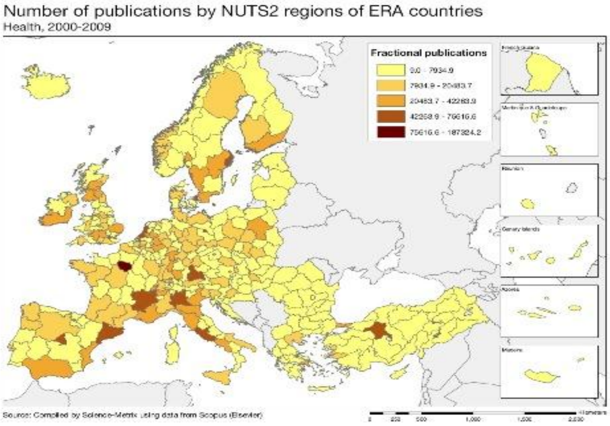


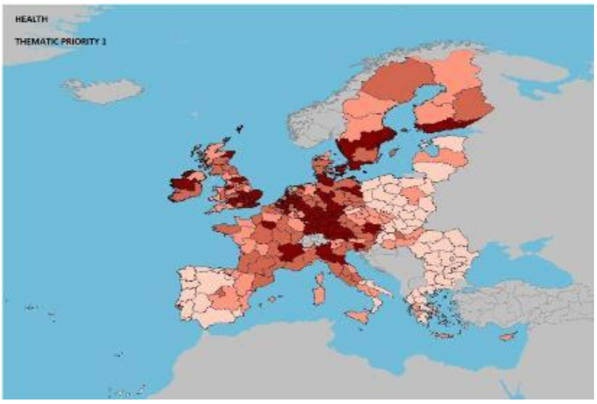


Scientific production

Health

Technological production

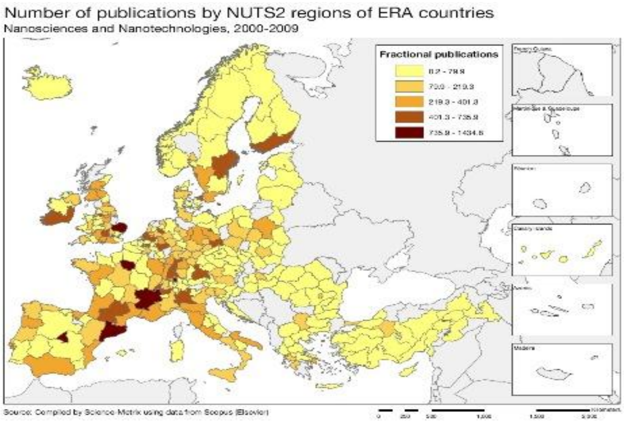


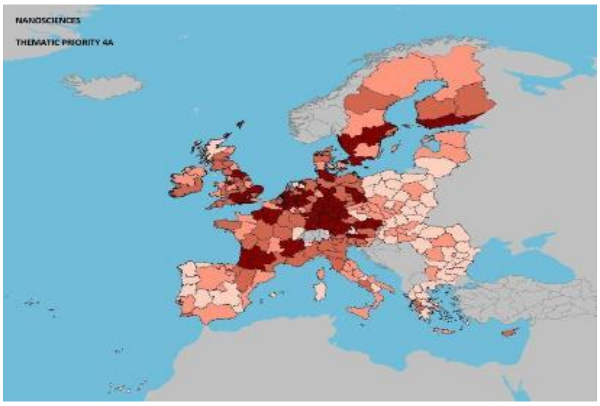


Scientific production

Nano-sciences & Nano-technologies

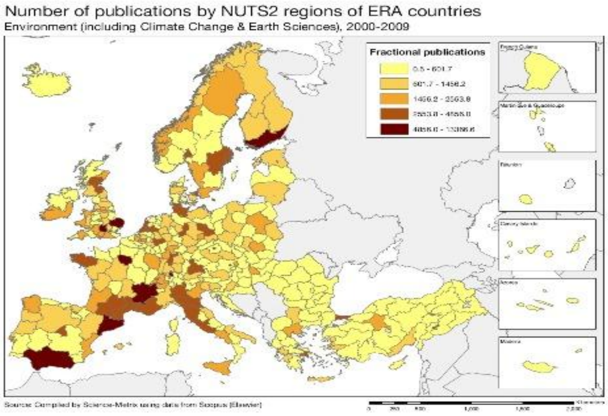
Technological production

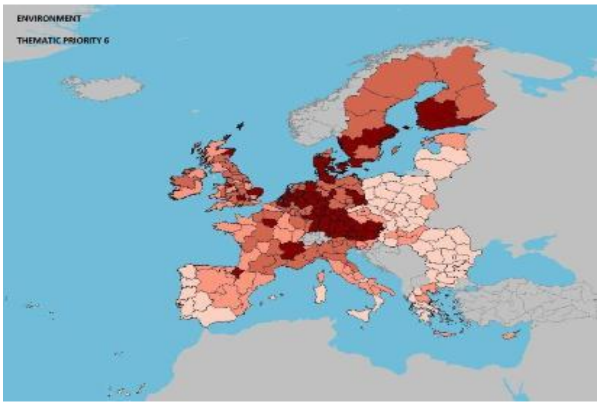




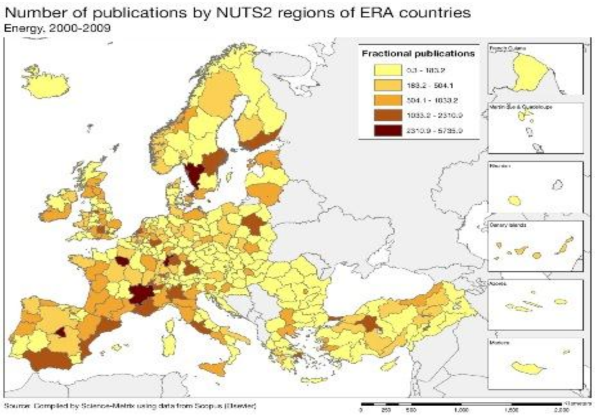
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

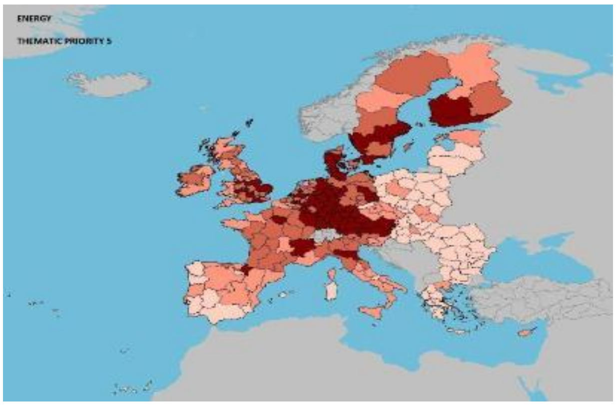
Scientific production **Environment** Technological production





Scientific production **Energy** Technological production





Latvia does not show any areas of particular excellence in terms of scientific or academic production. In terms of scientific capacity, no field appears to have reached any critical mass with the exception of materials. Latvia shows some activity in industry related technologies (surface technologies and coating, materials, engines, pumps and turbines, nano-sciences) and shows some strength in sectors such as IT methods for management, audio-visual, health, pharmacy, fine chemistry, and food chemistry. Latvia's scientific specialisation index, not shown on the maps above, shows that the country is relatively specialised in biotechnology, information and communication technologies, energy, other transport technologies (other than automobiles and aeronautics) and materials, materials being the main scientific field for Latvia.

Policies and reforms for research and innovation

The national research and innovation system faces a number of challenges:

- There is limited capacity to design, implement and coordinate research and innovation policy: Latvia has a complicated decision-making process for such a small country and the effectiveness of policy measures has been undermined by a lack of systematic evaluations.
- There is a lack of highly qualified scientists and engineers; the number of new doctorates awarded remains low and many scientists pursue their careers abroad.
- The scientific and research infrastructure is underdeveloped and the limited research and innovation resources available are spread too thinly to be efficient.
- The level of commercialisation of research is low: the technology transfer contact points operating in several universities produce modest results, in part due to the incomplete legal framework for protecting intellectual property rights.
- Cooperation between businesses and academics continues to be poor: companies are barely using the research potential of universities or state research institutes and their participation in the on-going competence centres programme is rather low.

In order to address these weaknesses, Latvia has taken the following steps:

- Governance is being improved by the setting up of a cross-departmental coordination centre under the Prime Minister.
- Measures have been taken to attract foreign academics, to increase the number of researchers and to attune the education system more to business needs by involving employers' organisations in the governance of universities and the assessment of vocational study programmes;
- Efforts are being made to modernise the scientific infrastructure — nine national research centres were established in 2011;
- Steps are being taken to promote commercialisation of science, encourage industrial innovation and support the development of innovative enterprises (business development involving new products and technologies, competence and technology transfer centres, innovation vouchers, etc.).

There have been quite a number of policy developments to support innovation. The most significant include:

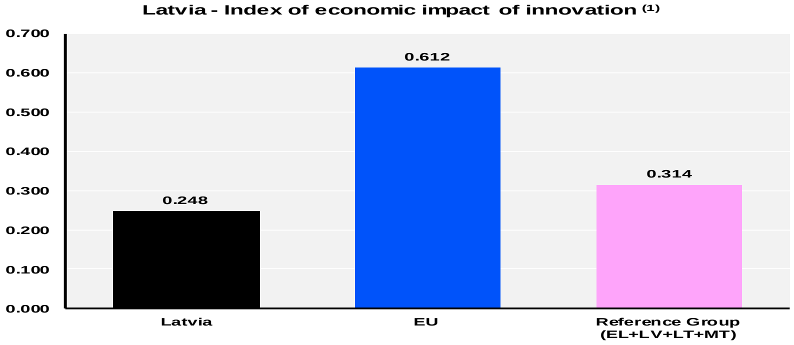
- Development of innovation financing tools such as risk capital and seed/starting venture capital funds as well as the development of mezzanine loans for risky projects;
- Development of 10 business incubators to support new entrepreneurs across the country;
- Lowering administrative fees, simplifying administrative procedures and reducing the time for registering a business for entrepreneurs;
- Development of a long-term cooperation platform for enterprises and scientists - a framework for efficient cooperation between scientists and entrepreneurs in order to improve the research infrastructure, to support joint research and to foster technology transfer.

Further efforts could be made to improve the quality of the science base and to rationalise research and higher education institutions in line with the thematic priorities and budgetary constraints. This would result in fewer but larger entities more able to build up critical mass in specialised areas of education and research, coupled with the progressive introduction of competitive funding based on independent evaluation. In order to address the current challenges and to qualify for EU funding in the post 2013 period, Latvia would benefit from drawing up a research and innovation strategy for smart specialisation, so that EU Structural Funds can be used more efficiently and synergies between different EU and national policies, as well as public and private investment, can be increased.

Currently, Latvia is developing a National Industrial Policy (NIP) to be presented in 2013. The NIP will include inter alia specific measures for cross-cutting innovation policy implementation. Moreover, in order to increase the quality of Latvian research, the government has signed, at the end of 2012, an agreement with the Nordic Council of Ministers for an evaluation of its scientific institutions.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[26].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

According to this index, the economic impact of innovation in Latvia is below its reference group, much below the EU average. Among the five indicators of the index, Latvia's performance is particularly low in patent inventions, contribution of high- and medium-tech products to the trade balance (see section 'Competitiveness in global demand and markets' below) and sales of new-to-market and new-to-firm innovations. In contrast, the share of knowledge-intensive exports in total services exports is relatively good. One key factor to increase the economic impact of innovation is of course the structural change that allows innovation-driven growth. High-growth innovative firms in particular play a catalytic role in this respect.

In this regard, the government is in the process of implementing a series of specific measures to improve the business environment. These include reducing the administrative burden on business, ensuring the appropriate e-services for business, providing on-line business registration, reducing the procedures and the time taken to obtain a construction permit, improving legislation for investor protection and providing greater transparency. In addition, a framework for more efficient cooperation between scientists and entrepreneurs is being developed to encourage innovation.

Access to financing within Latvia also needs to be improved. Most of the support programs available for SMEs and start-ups are financed mainly from EU Structural Funds and are rather fragmented and lack coherence. Programmes offering loans and guarantees to manufacturing industry as well as the microcredit programme for SMEs have had moderate success. Moreover, only a small part of the available venture capital funds has been invested so far.

In recent years, the use of Structural Funds to finance innovation support measures such as business R&D, the development of technology centres and technology transfer points has increased. In particular, the Competence Centre programme (also funded by the Structural Funds) aims to better develop links between Research and Industry in order to implement common, knowledge-intensive industrial research and product development projects. Core participants at Competence Centres are industry representatives who are responsible for defining R&D agendas and implementing research results. (At this time, there are at least 11 scientific institutions and 72 companies (mostly SMEs) involved in six Competence Centres.)

Overall, Latvia could benefit from a further strengthening of the growth potential of its economy through a range of structural reforms that would also help to improve its competitiveness and to move it towards a knowledge-based economy. Particular attention could be paid to the following: promoting a coherent industrial policy, improving public procurement and the performance of public administration, continuing to reduce the public burden and improve the absorption of EU funds.

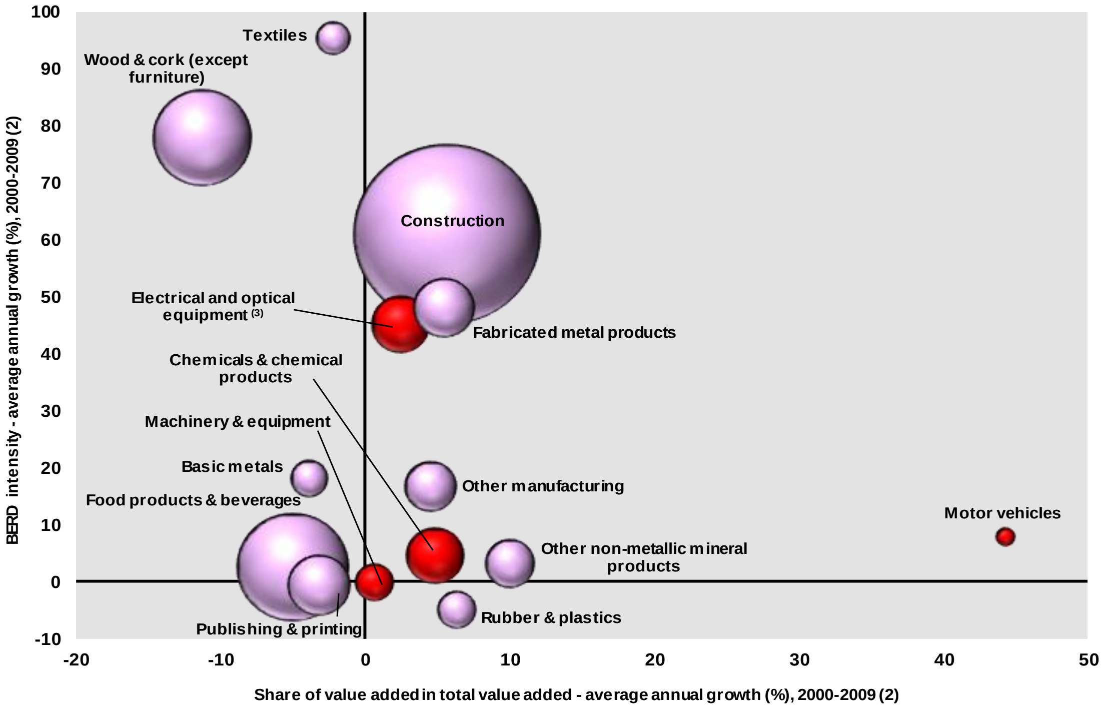
The business environment could also be further improved by encouraging companies to innovate and to better exploit the resources offered by universities, by improving access to finance, by creating a more competitive environment, by increasing the supply of highly-skilled labour and by improving (re)training schemes.

[26] See Methodological note for the composition of this index.

Upgrading knowledge and technologies in the manufacturing sector

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors represented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Latvia - Share of value added versus BERD intensity - average annual growth, 2000-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: Eurostat
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Textiles': 2000-2005; 'Basic metals', 'Machinery and equipment', 'Other non-metallic mineral products': 2000-2006; 'Construction', 'Other manufacturing': 2001-2006; , 'Fabricated metal products', 'Rubber and plastics': 2003-2005; 'Motor vehicles', 'Wood and cork (except furniture)': 2004-2006.
(3) 'Electrical and optical equipment' includes: 'Office, accounting and computing machinery', 'Electrical machinery and apparatus', 'Radio, TV and communication equipment' and 'Medical, precision and optical instruments'.

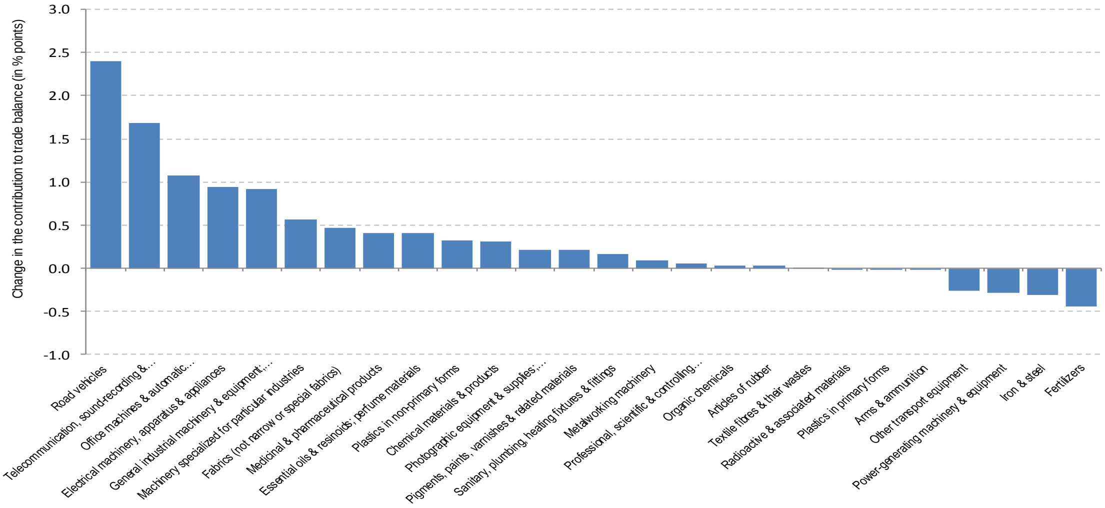
Latvia has been moving from more traditional industrial activities towards more knowledge-intensive industry. The contribution of manufacturing to Latvia's total gross value added (14.12% in 2011) is lower than the EU average (15.5% in 2011). Latvia is specialised in sectors with low and medium-low research intensities such as metal processing and machinery, wood and wood products, and food processing. Latvia's economic structure is highly biased towards small enterprises in traditional sectors such as sawmilling and wood planning as well as fish processing.

According to the results of the 2011 EU Industrial R&D Investment Scoreboard, there are no Latvian companies in the top 1000 EU companies listed by the publication, pointing to the fact that there are no large R&D intensive firms in a Latvian economy that is mainly characterized by SMEs and microenterprises.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Latvia between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Over the last 10 years, Latvian trade has been dominated by imports. This has led to a negative trend in the country's trade balance at global level and for high-tech (HT) and medium-tech (MT) products. Following a descending evolution of the trade balance over the period 2000-2008, a slight increase occurs in 2009 but the following years show another decline. The improvement in the trade balance for 2009 was the result of a significant decrease in imports while exports remained constant.

With regard to the contribution of HT & MT products to Latvia's trade balance, the graph above shows that the majority of products have positive evolutions. These evolutions are more evident in the case of road vehicles, telecommunication, sound-recording and reproducing equipment and office machines and automatic data-processing machines. Even if the absolute values are still negative, these products show a decrease in the level of imports while the level of exports was maintained or increased. On the other hand, products with descending evolutions of their contributions to the trade balance, such as other transport equipment, power-generating machinery and equipment, iron and steel and fertilizers, show both an increase in imports and a decrease in exports.

Overall, Latvia has made some progress towards the Europe 2020 targets, but there is still room for improvement in a significant number of areas. Total factor productivity which decreased substantially in 2009 due to the economic crisis increased significantly between 2010 and 2012. The effects of the economic crisis can also be seen in a much lower employment rate and in an increase in the share of population at risk of poverty or social exclusion after 2008. The share of population at risk of poverty or social exclusion in Latvia increased from 33.8% in 2008 to 40.1% in 2011, a value that is significantly higher than the EU average of 24.2%. In 2010 Latvia was the one of the Member States with the lowest levels of greenhouse gas emissions. At the same time, Latvia had one of the highest shares of renewable energy in total energy consumption in the EU.

Key indicators for Latvia

LATVIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.12	0.11	0.16	0.20	0.26	0.36	0.33	0.46	0.43	0.53	0.40	1.05	:	21.5	*1.69*	25 [3]
Business enterprise expenditure on R&D (BERD) as % of GDP	0.18	0.15	0.17	0.13	0.19	0.23	0.35	0.19	0.15	0.17	0.22	*0.19*	:	*0.7*	*1.26*	24
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.27	0.26	0.25	0.25	0.23	0.33	0.35	0.40	0.46	0.29	0.38	*0.50*	:	6.0	*0.74*	19
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	11.6	:	:	:	:	11.5	:	:	-0.2	47.9	27
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	2.7	2.1	2.0	3.0	2.0	5.3	3.6	2.2	4.0	:	:	:	:	4.8	10.9	23
International scientific co-publications per million population	73	63	79	88	102	123	111	119	138	133	131	178	:	8.5	300	26
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	2	2	2	3	2	:	6.2	53	27
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.9	0.6	0.6	0.7	0.7	1.0	0.9	0.7	0.8	1.1	:	:	:	2.3	3.9	17
License and patent revenues from abroad as % of GDP	:	:	:	:	0.05	0.07	0.05	0.04	0.04	0.03	0.05	0.04	:	-6.0	0.58	21
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	5.1	:	3.3	:	5.9	:	3.1	:	:	-7.8	14.4	27
Knowledge-intensive services exports as % total service exports	:	:	:	:	35.7	35.3	35.3	34.6	34.9	35.8	35.3	:	:	-0.2	45.1	12
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-14.39	-14.44	-14.84	-14.33	-12.34	-10.47	-9.59	-8.87	-6.08	-2.83	-4.98	-5.42	:	-	4,20 [4]	26
Growth of total factor productivity (total economy) - 2000 = 100	100	105	109	114	118	122	124	124	113	99	101	110	111	11 [5]	103	8
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	23.3	:	:	:	:	30.1	:	:	:	:	34.4	:	:	4.0	48.7	22
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	8.2	9.1	9.6	9.1	:	3.5	13.6	24
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	14.4	:	17.2	:	15.8	:	:	2.3	38.4	25
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.03	0.11	0.00	0.00	0.04	0.00	0.07	0.02	0.00	:	:	:	:	-5.1	0.39	23 [6]
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.34	0.12	0.22	0.20	0.21	0.41	0.16	0.18	0.11	:	:	:	:	-13.3	0.52	18
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	63.5	65.1	67.0	68.9	69.3	70.3	73.5	75.2	75.8	67.1	65.0	67.2	:	0.5	68.6	16
R&D Intensity (GERD as % of GDP)	0.45	0.41	0.42	0.38	0.42	0.56	0.70	0.60	0.62	0.46	0.60	*0.70*	:	*4.2*	*2.03*	22
Greenhouse gas emissions - 1990 = 100	39	41	41	41	42	42	44	46	44	41	45	:	:	6 [7]	85	2 [8]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	32.8	32.3	31.1	29.6	29.8	34.3	32.6	:	:	-0.1	12.5	2
Share of population aged 30-34 who have successfully completed tertiary education (%)	18.6	16.8	17,3 [9]	18.3	18.5	18.5	19.2	25.6	27.0	30.1	32.3	35.7	:	8.4	34.6	16
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	45.8	41.4	36.0	33.8	37.4	38.1	40.1	:	5.9	*24.2*	25 [8]

Source: DG Research and Innovation - Economic Analysis Unit
Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.
(2) EU average for the latest available year.
(3) Rank in 2010.
(4) EU is the weighted average of the values for the Member States.
(5) The value is the difference between 2012 and 2000.
(6) Rank in 2007.
(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.
(8) The values for this indicator were ranked from lowest to highest.
(9) Break in series between 2002 and the previous years. Average annual growth refers to 2002-2011.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Continue reforms in higher education, inter alia, by implementing a new financing model that rewards quality, strengthens links with market needs and research institutions, and avoids fragmentation of budget resources. Design and implement an effective research and innovation policy encouraging companies to innovate, including via tax incentives, upgrading infrastructure and rationalising research institutions."

Lithuania

Developing a stronger and thematically focused science base

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Lithuania. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.92% (EU: 2.03%; US: 2.75%) 2000-2011: +4.13% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 13.92 (EU:47.86; US: 56.68) 2005-2010: +2.62% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.223 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 35.28 (EU:48.75; US: 56.25) 2000-2010: +5.04% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Other transport technologies (other than automobiles and aeronautics), Construction technologies, Energy	*HT + MT contribution to the trade balance* 2011: -1.27% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

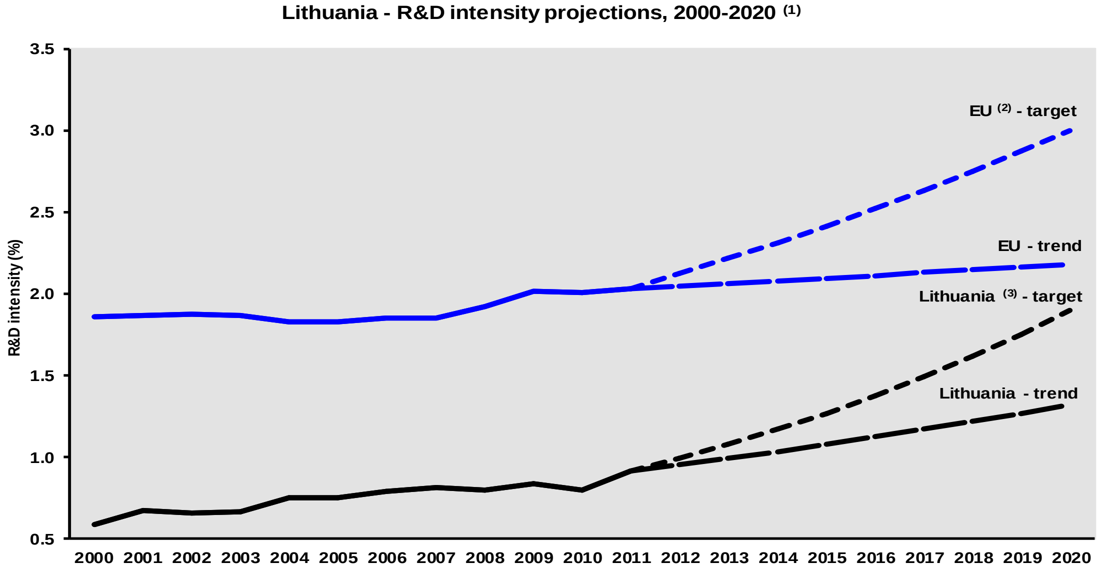
The main strengths of Lithuania's research and innovation (R&I) system are the size of its public research sector and the good supply of new graduates.

In contrast, R&D activities are very limited in the business sector: almost 3/4 of all R&D expenditure in Lithuania is performed by the public sector. Lithuania has one of the lowest business R&D intensity in the EU. Business investment in R&D will only improve if the quality, relevance and openness to the private sector of the science base and of higher education in Lithuania increase. The Lithuanian science base is insufficiently competitive and is not well connected to European networks. Due to unattractive research careers, the science base is also threatened by an insufficient supply of human resources. Links between education, research and the private sector are very weak.

In order to improve the situation, Lithuania has been conducting over the last years an ambitious reform of its science base: autonomy and new governance of universities, reorganisation of the network of public research institutions, increase in the share of project-based funding and of performance-based institutional funding, increase in researchers' salaries and dedicated schemes to attract local and international talents, creation and development of five clusters (called "Valleys") integrating higher education institutions, research institutions and businesses in identified scientific and technology areas. However, this important reform is not accompanied by the same degree of government commitment in budgetary terms. Consequently, as part of the Europe 2020 process, it was recommended that Lithuania should minimise cuts in growth-enhancing expenditure (the category of expenditure to which R&D expenditure belongs).

The reinforced innovation policy is expected to strengthen the links between higher education institutions, research institutions and businesses. S&T parks are created to act as a link between businesses and public laboratories by providing a number of innovation services and infrastructures, in particular in relation to knowledge transfer and intellectual property rights. Altogether, the reform of the science base is expected to make the Lithuanian research and innovation system more efficient and better performing in the years to come.

Investing in R&D



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) LT: This projection is based on a tentative R&D intensity target of 1.90% for 2020.

Lithuania's R&D intensity substantially increased in 2011 to reach 0.92% of GDP, after five years of relative stagnation at around 0.8%. However, this is still less than half of Lithuania's R&D intensity target of 1.9% for 2020. Most of this increase in 2011 took place in the public sector and is due to progress in implementing R&D-related projects financed with EU Structural Funds. The business sector finances only about 28% of total R&D expenditure, one of the lowest shares of business funding in the EU. The economic crisis severely hit the national R&D budget which has been cut by half nominally between 2007 (€ 95.7 million) and 2010 (€ 47 million). It slightly increased in 2011 and was planned to increase in 2012-2013. Overall, the share of the R&D budget in total government expenditure has dramatically declined from 1.09% in 2004 to 0.43% in 2010.

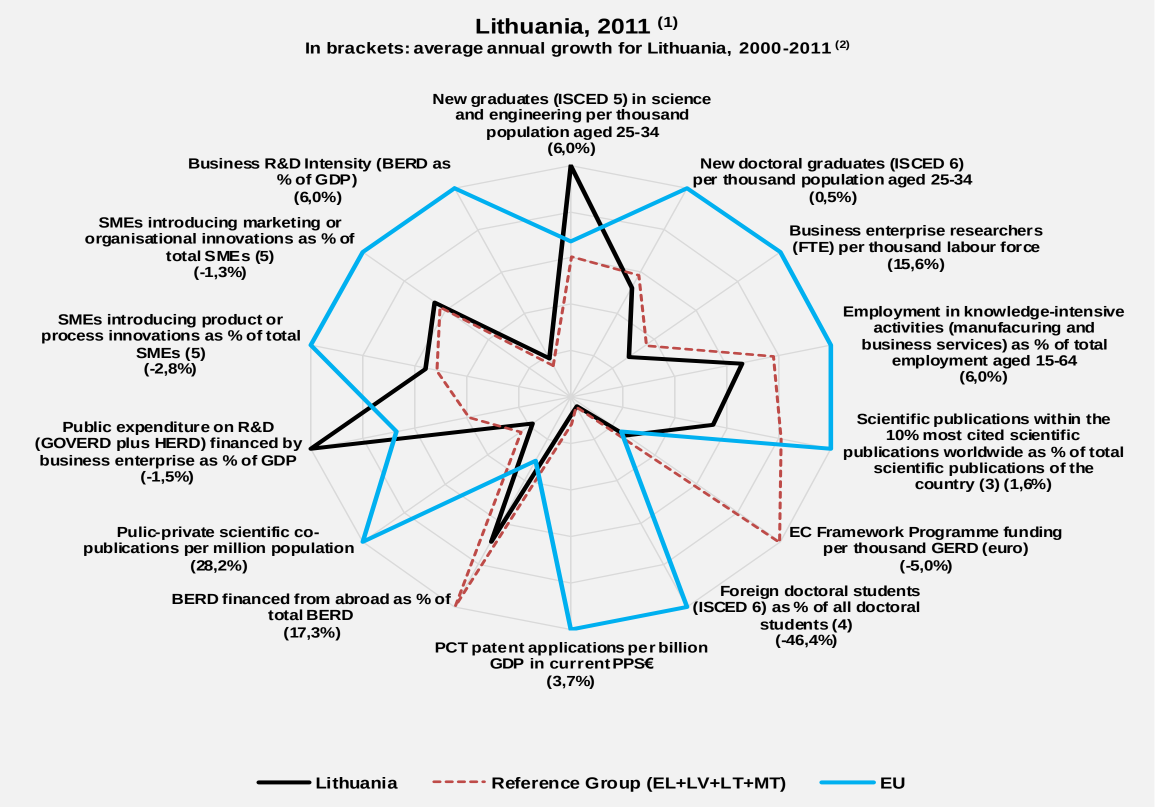
Continuity in public funding of R&D has been ensured by Structural Funds, with € 1511 million (22.3%) of ERDF funds earmarked for research, innovation, ICT and entrepreneurship for the period 2007-2013, and with a good absorption rate. In 2011-2012, Lithuania simplified the use of Structural Funds in favour of RTDI. Lithuania also benefited by about € 33.8 million from the EU FP7 for 280 Lithuanian participants from 2007 to early 2012. There was a good success rate for Lithuanian applicants (19.4% vs. 21.5% for the EU). Additional government support for investment in R&D and in new technologies is provided through R&D tax incentives - in place since 2008.

After some progress in the early 2000s, business R&D intensity has hardly changed between 2006 (0.22%) and 2011 (0.24%). Business financing of R&D was seriously affected by the economic crisis, decreasing by 11% in nominal terms between 2007 and 2009. It increased again by 3% in 2010 and by another 11% in 2011, i.e. just above the 2007 level. Business R&D has been most affected in the services sector with a decrease of 30% in nominal terms between 2008 and 2009. On the other hand it increased in the manufacturing sector by 13% between the same two years[27]. Professional, scientific and technical activities, human health and social work activities, and financial and insurance activities are the most affected services sectors. Among manufacturing sectors, R&D expenditure in wood, paper and printing increased by a factor of 4.8 and also increased in food products, beverages and tobacco, pharmaceuticals, and in computer, electronic and optical products, but decreased by more than 40% in fabricated metal products.

[27] Data from Eurostat, Business R&D expenditure (BERD) by economic activity based on the 'main activity' of the firm.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Lithuania's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) EL is not ncluded in the reference group.

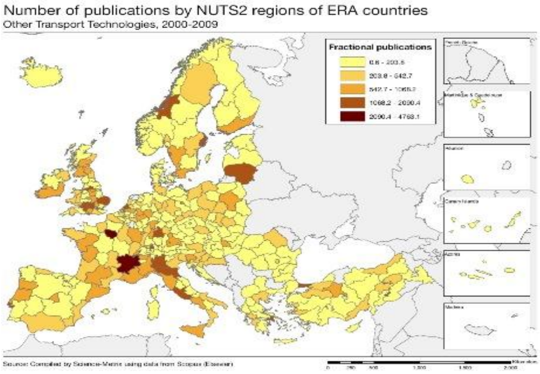
The graph shows that Lithuania's performance faces challenges in all four dimensions (human resources, scientific production, technology development, and innovation), for most of the main R&I indicators. Particular strengths are the number of new graduates in science and engineering (S&E) per population aged 25-34, the FP7 funding received compared to total R&D expenditure in Lithuania (at EU average), and the financing of business R&D expenditure from abroad (mainly EU Structural funds). The level of patenting activities and the level of public-private collaboration provide room for improvement, although business financing of university research has appeared recently to be relatively strong.

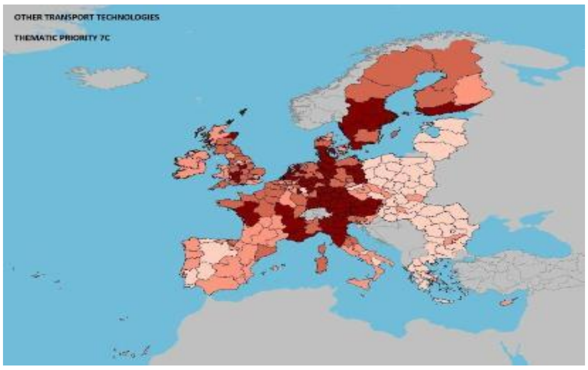
This leads to two observations: (i) Lithuania's R&D relies to a larger extent than the EU average on EU funds, be it Structural Funds or FP7 funds; (ii) a large share of the young population receives tertiary education in S&E in Lithuania, which is also reflected in the good share of total knowledge-intensive activities in total employment in Lithuania (close to the EU average). However, when it comes to doctoral level, the number of new doctoral graduates per thousand population aged 25-34 is considerably below the EU average, an indication that doctoral studies and the research system in Lithuania are less attractive for students.

Lithuania's scientific and technological strengths at European level

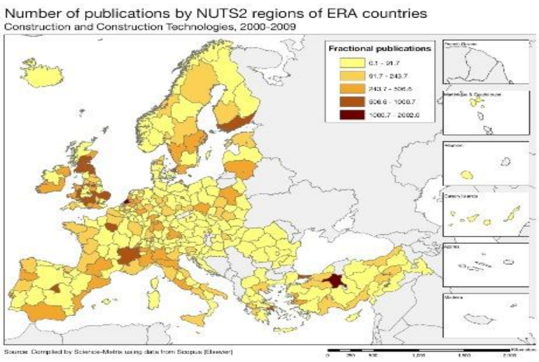
The maps below illustrate three key science and technology areas where Lithuania has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

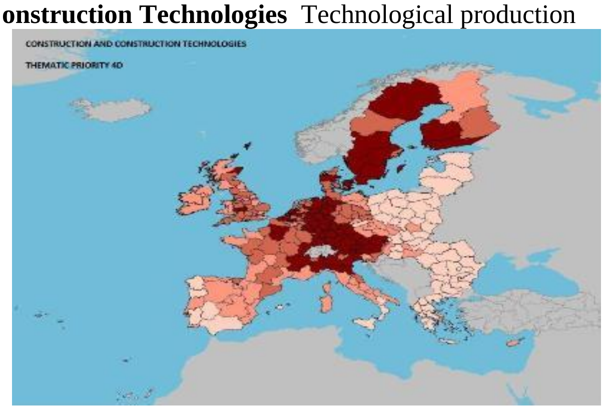
Scientific production **Other Transport Technologies** Technological production



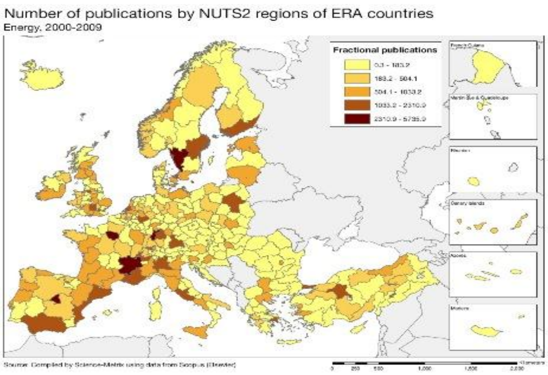


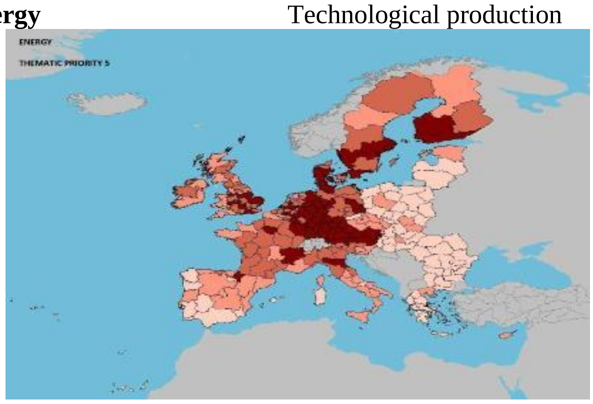
Scientific production **Construction and Construction Technologies** Technological production





Scientific production **Energy** Technological production





Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

In terms of volume of scientific publications, Lithuania performs best in other transport (i.e. transport other than automobiles and aeronautics) technologies. In this thematic area, Lithuania's volume of scientific publications is among the highest of all NUTS 2 regions in Europe (the country of Lithuania is classified as a NUTS 2 region). In construction technologies and in energy, Lithuania's volume of scientific publications is approximately in the median of NUTS 2 regions. In all other thematic areas, Lithuania is among the regions of Europe with low levels of scientific publishing. Patenting activity[28] in Lithuania is extremely low and does not show any statistically significant technological specialisation. In all thematic areas, the volume of patents invented in Lithuania places Lithuania among the NUTS 2 regions with the lowest volumes of patents in Europe.

[28] At the European Patent Office.

Policies and reforms for a more efficient science and technology system

Reforms of the science base in Lithuania started to be implemented only recently after several years of discussions. The on-going reforms are far-reaching and on the whole drive the research system towards what is accepted as international good practices. Autonomy and a new mode of governance are given to universities. The network of public research institutions has been re-organised and rationalised. The share of project-based funding has considerably increased and institutional funding is increasingly allocated in relation to the performance of the research institutions. Researchers' salaries have increased and dedicated schemes to attract local and international talents are now implemented. Most importantly, the creation and development of five clusters (called "Valleys") integrating higher-education institutions, research institutions and businesses in identified scientific and technology areas is meant to increase linkages between higher education, science and businesses and improve knowledge transfer and the valorisation of research results in the country.

Lithuania's R&I strategy is described in the 2010-2020 National Innovation Strategy adopted in 2010. It contains an analysis of strengths, weaknesses, opportunities and threats to the national R&I system and proposes a vision and a series of objectives for the system. From the thematic point of view, however, the Strategy cannot be considered a specialisation strategy. Specialisation features more clearly in the 5 Joint Research Programmes in 5 "R&D and economic sectors" which cover all R&D activities[29], the 5 thematic Valleys, the 12 National Integrated Programmes in 12 knowledge-intensive economic sectors, and the 6 National Science Programmes in 6 scientific fields. The Structural Funds are used extensively in particular for the construction of the Valleys. Through these thematic efforts, Lithuania aims both to build on its RDI strengths and to develop its research and innovation capacity in some key high-tech areas.

Government policy towards trans-national collaboration, internationalisation of science and opening the national research system to researchers from other countries is still under-developed. The lack of policy attention to opening up the national research system stems from the need to first address the national problems related to unattractive career paths for researchers and limited research capacity. Also, some ERA-related policies and objectives, such as increasing the mobility of researchers, are seen as a threat to the weaker research and innovation systems of countries like Lithuania.

Joint design and coordination of programmes remains low on the political agenda but nevertheless exists. The Baltic Sea Region Starts programme is aimed at fostering R&D and business-related trans-national collaborations of clusters through networks of SMEs. In the context of this programme, StarDust runs 5 trans-national pilot projects on clean water, well-being and health, sustainable transport, digital business and services, and design of living spaces. A financial mechanism agreed with Norway, supports Lithuania's Green Innovation Programme which is focused on SMEs.

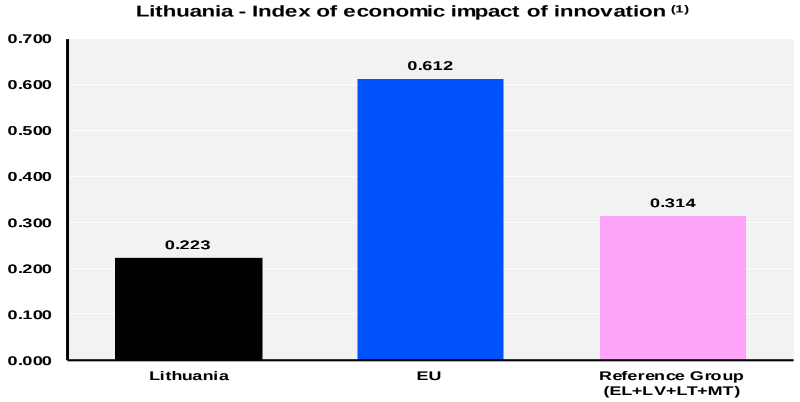
The country’s involvement in existing international infrastructures is modest. Regarding the promotion of the research system's attractiveness for non-national researchers, some measures have been taken. In 2010 the Lithuanian Research Council started implementing the Global Grant Scheme, which is for the first time available to non-national world class researchers. Within the Researchers' Careers Programme, several schemes are implemented to encourage the return of Lithuanian researchers from abroad and to attract foreign researchers.

Public procurement of innovative products and services is being developed. A new programme to partly finance the recruitment of scientists in firms has been launched. Measures have been taken to both facilitate and lower the costs of starting up new businesses. These measures include, in particular, business vouchers and a new legal entity called "small partnership". Measures have also been taken to improve the business environment and reduce the administrative burden of firms.

[29] Material, physical and chemical technologies; engineering and ICT; biomedicine and biotechnologies; natural resources and agriculture; creative and cultural industries

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[30].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

According to this index, the economic impact of innovation in Lithuania is below its reference group, much below the EU average. Among the five indicators of this index, Lithuania's performance is particularly low in patent inventions, knowledge-intensive services exports and sales of new-to-market and new-to-firm innovations. One key factor to increase the economic impact of innovation is of course the structural change that allows innovation-driven growth. High-growth innovative firms in particular play a catalytic role in this respect.

Over the last years, Lithuania has put in place a number of measures to improve the situation. Support for research and innovation activities in SMEs relies on the R&D tax credit, an intensive use of Structural Funds through a large and diversified set of schemes and instruments, support for the formation of clusters, public support of enterprises for IP protection costs, innovation vouchers to buy R&D from public research performers, and the development of the Valleys that are expected to provide a stimulating environment and networks for new innovative firms. Six agencies are active in the public support of innovation and businesses[31]. The abundance of support schemes, instruments and agencies might need to be rationalized and simplified.

Developing clusters that integrate higher education institutions, research institutions and firms is at the centre of innovation policy in Lithuania, involving in particular the 5 Valleys mentioned above in broad S&T areas. The objectives of the Valleys are to strengthen the public infrastructures for R&D and higher-education, to concentrate human resources geographically and to strengthen public-private cooperation. S&T parks are created in the Valleys to act as a link between businesses and public laboratories by providing a number of innovation services and infrastructures, in particular in relation to knowledge transfer and intellectual property rights. In addition, a new pilot scheme to launch joint public-private projects is being implemented by MITA.

Currently, a barrier to the creation of innovative firms is the difficulty that individuals have in financing the prototyping and business plan design phase in order to be able to solicit finance from private investors for the creation of new innovative businesses. Also, in order to improve the capacity of the country to exploit research results commercially, there is an urgent need to develop an entrepreneurship and innovation culture and skills in the higher education and public research sectors, as well as to provide the right incentives and training for researchers in the public sector to engage in knowledge transfer and commercialisation activities.

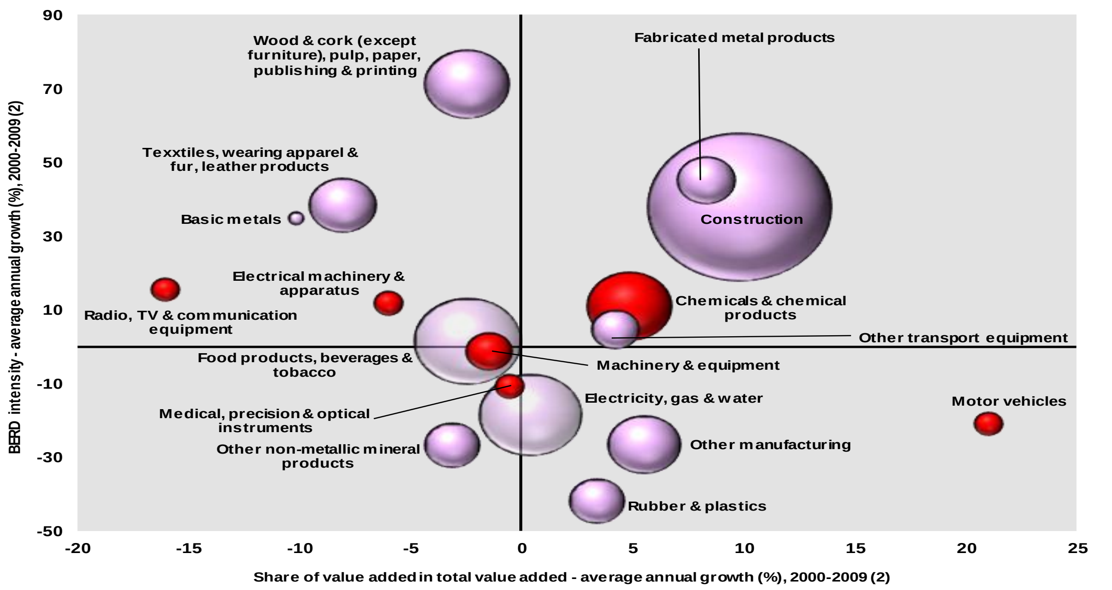
30 See Methodological note for the composition of this index.

31 The Agency for Science, Innovation and Technology (MITA), the Lithuanian Business Support Agency (administration of EU Structural Funds), Lithuanian Innovation Centre, INVEGA (loans, guarantees), Invest Lithuania (investments consultancy), Enterprise Lithuania.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Lithuania - Share of value added versus BERD intensity - average annual growth, 2000-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Textiles, wearing apparel and fur, leather products': 1997-2008; 'Food products, beverages and tobacco': 1997-2009; 'Medical, precision and optical instruments', 'Other transport equipment': 2000-2008; 'Basic metals': 2002-2007; 'Electrical machinery and apparatus', 'Radio, TV and communication equipment': 2002-2008; 'Wood and cork (except furniture), pulp, paper, printing and publishing': 2002-2009; 'Fabricated metal products', Other manufacturing': 2003-2008; 'Motor vehicles': 2004-2008; 'Construction': 2005-2008.

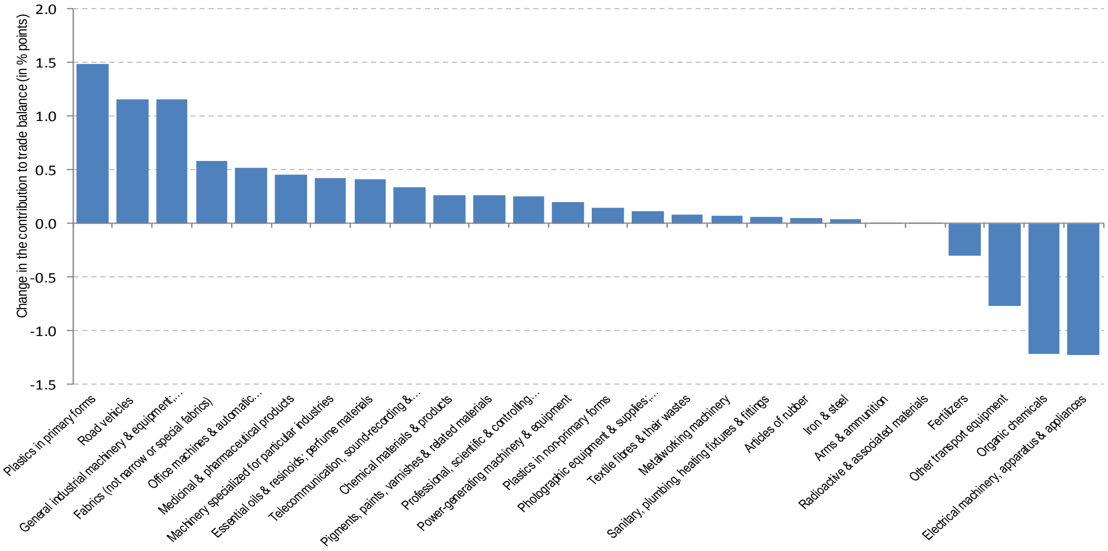
The graph above shows that Lithuania's manufacturing industry is dominated by low-tech and medium-low-tech sectors, which are intrinsically less research intensive than high-tech and medium-high-tech sectors (coloured in red above). The only sizeable medium-high-tech sector is chemicals (including pharmaceuticals). All other high-tech and medium-high-tech sectors in Lithuania are small and for some of them large part of the activity is import and re-export. This sector structure necessarily limits the overall level of business R&D intensity in the country. It should be noted that data on the effect of the crisis in 2009/10 are not yet available, notably the construction sector has declined significantly since.

Structural change towards a more research-intensive economy is mainly driven by high-tech and medium-high-tech manufacturing sectors. In Lithuania, no clear trend emerges for these sectors: the weight in the economy of two of these sectors has increased (motor vehicles and chemicals (including pharmaceuticals), but for three others the weight has decreased. Research intensity has increased in three of these sectors, while it has decreased for the two others. In total, the effect of the evolution of high-tech and medium-high-tech manufacturing sectors on overall business R&D intensity in Lithuania has been limited. The chemical sector (including pharmaceuticals) is clearly the most important medium-high-tech/high-tech sector in Lithuania, in terms both of current size and of evolution (positive evolution in research intensity and in economic weight).

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Lithuania between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

HT and MT products have been making a negative contribution to the trade balance in Lithuania. This indicates a relative de-specialisation of the country in these products in international trade. However, the negativity of this contribution has continuously diminished since 2004 (except in 2011), a sign that the situation of Lithuania regarding trade in HT and MT products has improved compared to other products.

The above graph shows the HT and MT products which have most improved their contribution to the Lithuanian trade balance between 2000 and 2011: plastics in primary forms, road vehicles, and general industrial machinery and equipment. In contrast, the contribution to the trade balance of fertilizers, organic chemicals, and electrical machinery has strongly deteriorated. The previous graph showed the increasing share of the rubber and plastics and motor vehicles sectors in total value added in Lithuania and the decreasing share of the electrical machinery sector. Taken together, these results indicate the growing importance of the rubber and plastics and motor vehicles sectors in the Lithuanian economy, and conversely, a relative decline of the electrical machinery sector.

Total factor productivity (TFP) grew very rapidly in Lithuania between 2000 and 2007, dropped with the crisis in 2009 but recovered in 2010-2012 (table below). Despite the considerable 2009 fall, Lithuania is still ranked third in the EU in terms of TFP growth between 2000 and 2012. Regarding Europe 2020 targets, Lithuania's position is best in greenhouse gas emissions (although Lithuania's performance has deteriorated compared to 2000) and tertiary education rate of the population aged 30-34. Following a marked and rapid improvement between 2005 and 2008, the share of population at risk of poverty increased again during the economic crisis to 9 points above the EU average.

Key indicators for Lithuania

LITHUANIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.87	0.53	0.79	0.52	0.63	0.69	0.71	0.81	0.81	0.87	0.88	0.92	:	0.5	*1.69*	20
Business enterprise expenditure on R&D (BERD) as % of GDP	0.13	0.19	0.11	0.14	0.16	0.15	0.22	0.23	0.19	0.20	0.23	*0.24*	:	6.0	*1.26*	22
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.46	0.47	0.55	0.53	0.59	0.60	0.57	0.58	0.61	0.63	0.56	*0.68*	:	3.6	*0.74*	11
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	12.2	:	:	:	:	13.9	:	:	2.6	47.9	26
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	5.3	3.6	3.2	3.3	4.9	3.5	5.5	5.7	6.0	:	:	:	:	1.6	10.9	20
International scientific co-publications per million population	77	64	80	109	141	164	174	192	213	224	219	265	:	11.9	300	23
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	4	5	7	8	10	:	28.2	53	22
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.2	0.2	0.3	0.2	0.3	0.4	0.3	0.4	0.6	0.3	:	:	:	3.7	3.9	25
License and patent revenues from abroad as % of GDP	:	:	:	:	0.003	0.01	0.002	0.0004	0.002	0.001	0.002	0.002	:	-9.9	0.58	27
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	9.7	:	12.4	:	9.6	:	6.6	:	:	-6.1	14.4	26
Knowledge-intensive services exports as % total service exports	:	:	:	:	14.9	14.3	12.3	11.8	12.2	15.4	13.7	:	:	-1.4	45.1	25
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.87	-7.44	-6.60	-6.58	-7.56	-5.79	-5.83	-5.11	-2.30	-1.62	-1.10	-1.27	:	-	4,20 [3]	21
Growth of total factor productivity (total economy) - 2000 = 100	100	107	111	118	123	126	129	132	130	114	118	122	123	23 [4]	103	3
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	21.6	:	:	:	:	27.3	:	:	:	:	35.3	:	:	5.0	48.7	21
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	7.5	8.1	8.7	8.9	:	6.0	13.6	25
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	25.3	:	19.7	:	21.9	:	21.4	:	:	-2.8	38.4	21
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	:	:	:	:	-8.8	0.39	24 [5]
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.01	0.00	0.00	0.00	0.03	0.03	0.02	0.06	0.04	:	:	:	:	19.3	0.52	23
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	65.6	64.2	67.2	68.9	69.0	70.6	71.6	72.9	72.0	67.2	64.4	67.2	:	0.2	68.6	17
R&D Intensity (GERD as % of GDP)	0.59	0.67	0.66	0.67	0.75	0.75	0.79	0.81	0.80	0.84	0.80	*0.92*	:	*4.1*	*2.03*	19
Greenhouse gas emissions - 1990 = 100	39	41	42	42	44	46	47	51	49	40	42	:	:	3 [6]	85	1 [7]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	17.1	16.9	16.9	16.6	17.9	20.0	19.7	:	:	2.4	12.5	10
Share of population aged 30-34 who have successfully completed tertiary education (%)	42.6	21.2	23,4 [8]	25.2	31.1	37.9	39.4	38.0	39.9	40.6	43.8	45.4	:	7.6	34.6	7
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	41.0	35.9	28.7	27.6	29.5	33.4	33.4	:	-3.4	*24.2*	24 [7]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) EU is the weighted average of the values for the Member States.

(4) The value is the difference between 2012 and 2000.

(5) Rank in 2007.

(6) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(7) The values for this indicator were ranked from lowest to highest.

(8) Break in series between 2002 and the previous years. Average annual growth refers to 2002-2011.

(9) Values in italics are estimated or provisional.

Luxembourg

The challenge of fostering the emergence of a genuine R&I ecosystem

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Luxemburg. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 1.43% (EU: 2.03%; US: 2.75%) 2000-2011: -1.34% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:19.84 (EU:47.86; US: 56.68) 2005-2010: +1.29% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.589 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:64.75 (EU:48.75; US: 56.25) 2000-2010: +1.4% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Space, Automobiles	*HT + MT contribution to the trade balance* 2011: -3.35% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

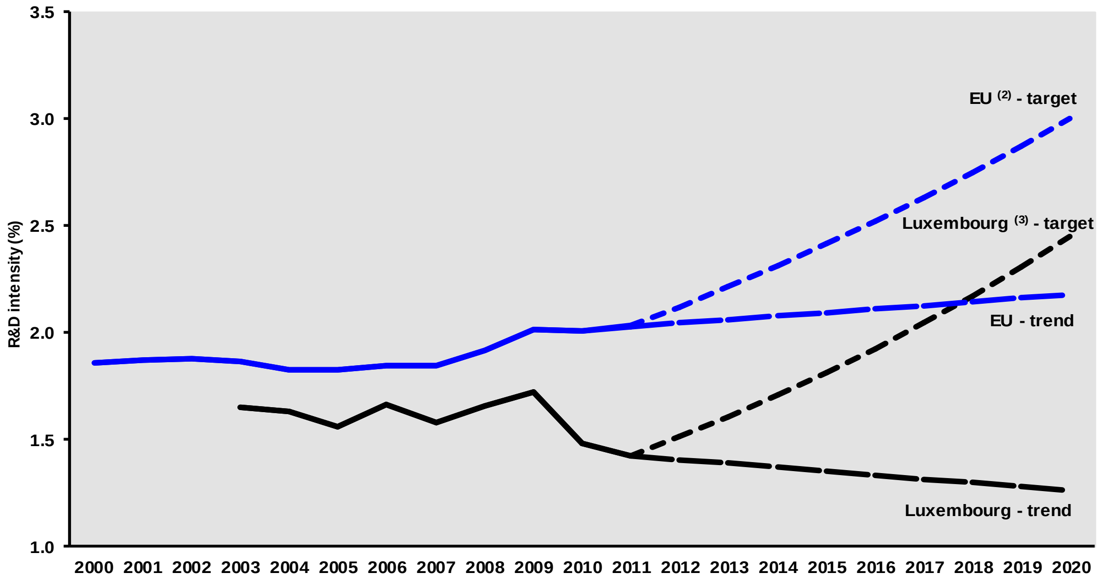
Luxembourg is rapidly building up its public research capacities, from a situation where, 25 years ago, the public research system was non-existent - the oldest public research centres were set up in 1987 and the University of Luxembourg was established in 2003. Public sector R&D intensity has steadily increased from 0.12% of GDP in 2000 to 0.45% of GDP in 2011 but remains well below the EU average of 0.74%. Luxembourg's scientific performance as measured by the share of its scientific publications which are among the top 10% most cited publications worldwide (10.1%, not far from the EU average of 10.9%) is impressive considering that its public research system has only been in existence since the mid-1980s.

However, as reflected in the decrease of business R&D intensity (from 1.53% in 2000 to 0.98% in 2011) and in the limited level of cooperation between public research institutions and firms, the Luxembourgish research and innovation ecosystem remains very weak. Its public components are not yet able to play any decisive role in fostering innovation-led growth. While the prosperity of the Luxembourgish economy in the last decades has been based on the expansion of the financial sector, its large dependence on this sector is a strong structural risk. In addition to its "sovereignty niches" on which the financial sector expansion is based, the Grand-Duchy crucially needs to develop "competence niches" as a springboard for innovation-led growth.

The Government's resolve to make investment in RDI part of a long-term policy for Luxembourg's economic development and diversification has been translated into continued budgetary efforts as shown by an increase of 38% in real terms of the government budget allocation to R&D between 2008 and 2011. R&D project funding targets thematic priorities selected through a foresight exercise. Many actions are developed to foster public-private cooperation and more generally business R&D and innovation, including for instance a cluster programme, the setting up of business incubators, and the specification of IP/spin-off requirements in the performance contracts of public research organisations.

Investing in knowledge

Luxembourg - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) LU: This projection is based on a tentative R&D intensity target of 2.45% for 2020.

Luxembourg is not at all on track to reach its R&D intensity target for 2020 of 2.3% – 2.6%, as its R&D intensity is on a declining trend. This declining trend is explained by the sharp decrease in business R&D intensity (from 1.53% of GDP in 2000 to 0.98% in 2011). Public sector R&D intensity on the contrary steadily increased from 0.12% in 2000 to 0.45% in 2011. This fourfold increase reflects the willingness of the Grand-Duchy to build up its public research capacities from a situation where, 25 years ago, the public research system was in fact non-existent. In fact, the first public research centres were created in 1987 and the University of Luxembourg was established in 2003. These efforts have continued in recent years as shown by an increase of 38% in real terms of the government budget for R&D between 2008 and 2011.

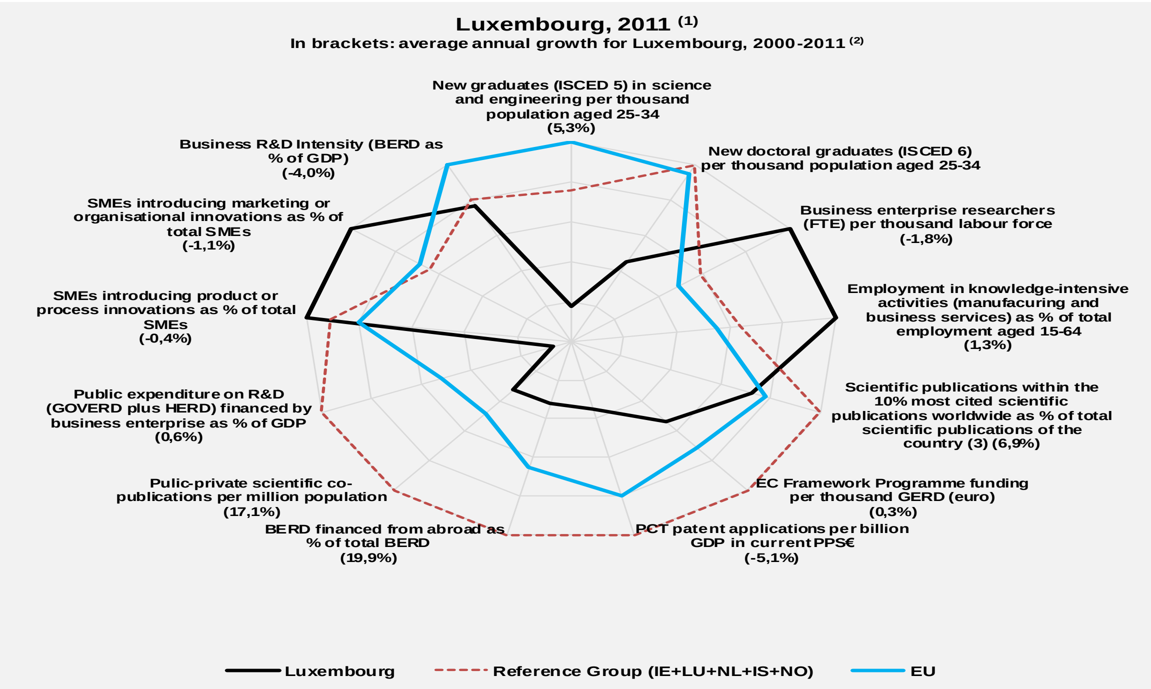
If Luxemburg is to reach its 2020 R&D intensity target, the contribution from the private sector should increase. Only 45% of Luxembourgish private investment in R&D is made in the manufacturing sector, compared to 23% in financial services and about 30% in other services[32]. The level of R&D investment in financial services tripled between 2003 and 2007; however thereafter it dropped by 27% between 2007 and 2009.

Private and public R&D investment can also receive support by co-funding from the European budget, in particular through successful applications to the seventh Framework Program for research and the Structural Funds. Up to early 2012, 124 Luxembourgish participants had been partners in an FP7 project, with a total EC financial contribution of € 31 million. This represents € 61 per head of population, which is 35% higher than the EU average. The success rate of Luxembourgish applicants is 19.5%, in line with the EU average success rate of 21.6%. Moreover, over the FEDER programming period 2007-2013, € 19 million (37.7% of the total FEDER fund for Luxembourg) was allocated to research, innovation and entrepreneurship in Luxembourg.

[32] However it must be borne in mind that these other services include *R&D services* to the manufacturing sector.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Luxemburg's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.

The situation of the Luxembourgish research system is marked by the contrast between public sector R&D and private sector R&D:

- The Luxembourgish public research system is very young, but is developing fast (see section *Investing in knowledge* above). Its scientific performance as measured by the share of its scientific publications which are among the top 10% most cited scientific publications worldwide[33] is positive and the share of business enterprise researchers is impressive. This is mainly due to a policy of attracting outstanding foreign researchers to work in Luxembourg.
- Taking into account the structure of the Luxembourgish economy (marked by the lowest share of manufacturing in all EU Member States), Luxembourg business R&D intensity (close to the EU average) has to be considered as being in fact relatively high. This high level is explained by the combination of significant R&D activities in the financial sector with the long-standing presence in the Grand-Duchy of several large R&D centres of multinational manufacturing companies (such as ArcelorMittal, Goodyear and DuPont de Nemours) and of smaller "home-grown" technologically innovative companies (such as IEE, Paul Wurth and Rotarex).

The performance of Luxembourg on the two indicators on cooperation between public research institutions and firms is well below the EU average, reflecting the current disconnections between the long–standing private sector R&D centres and a public research system which is in the course of development.

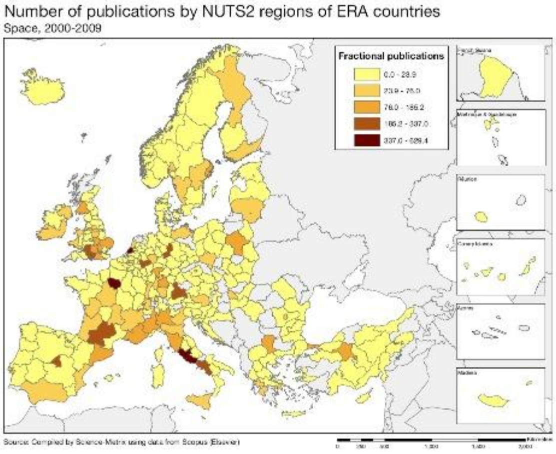
[33] 10.1%, not far from the EU average of 10. 9% and similar to the performances of France and Italy

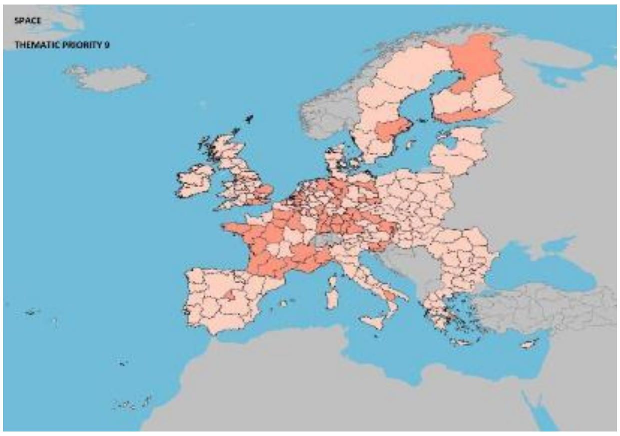
Luxembourg's scientific and technological strengths

The maps below illustrate six key science and technology areas where Luxembourg has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

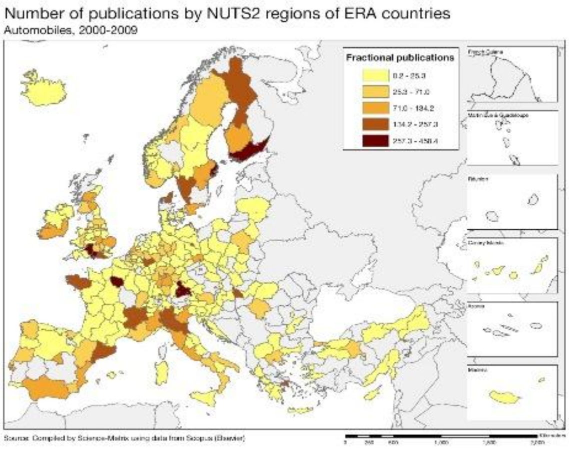
Strengths in science and technology at European level

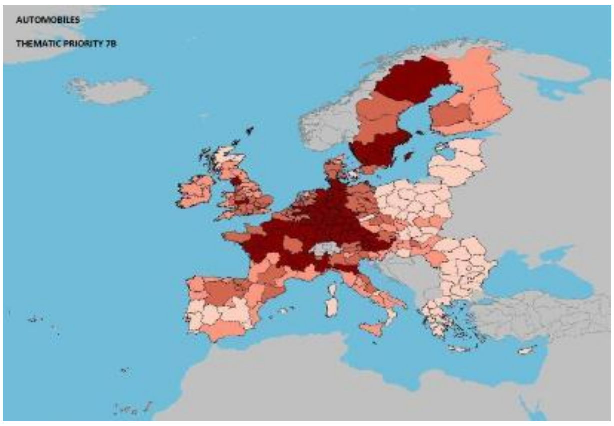
Scientific production **Space** ***Technological production***



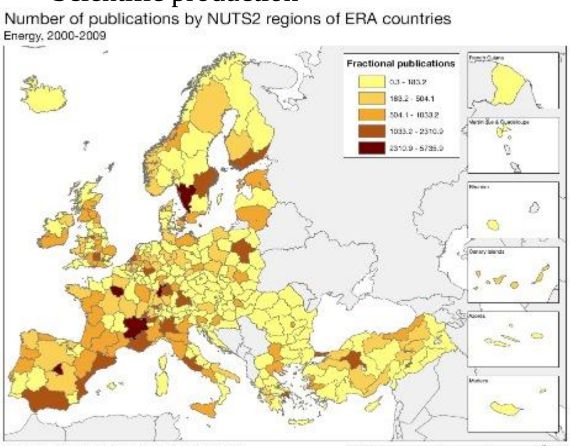


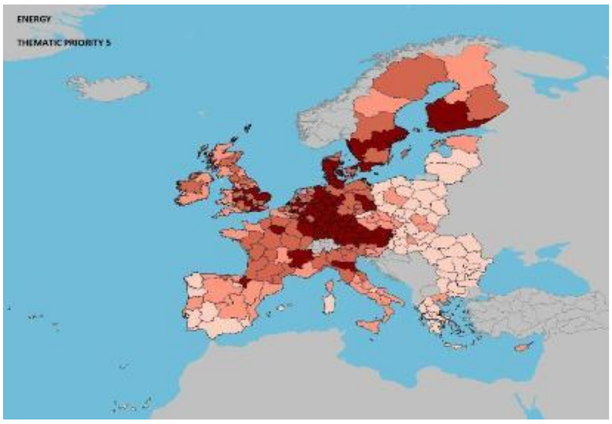
Scientific production **Automobile** ***Technological production***





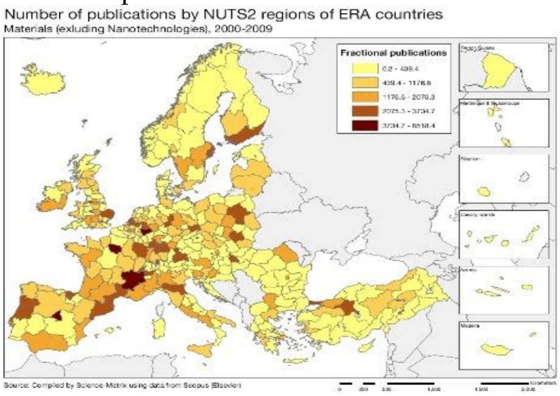
Scientific production **Energy** Technological production

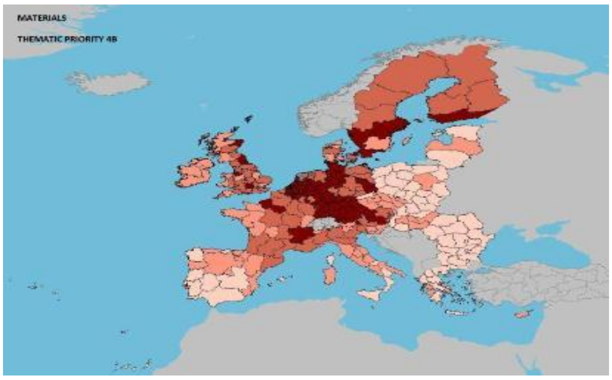




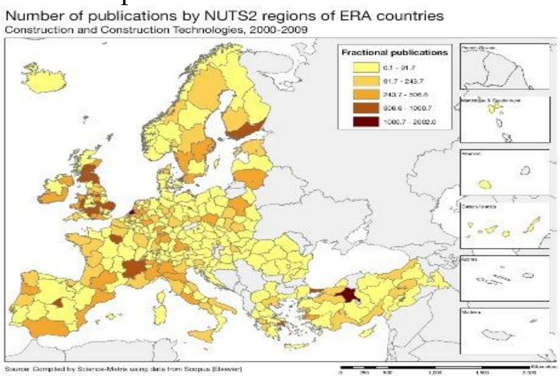
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

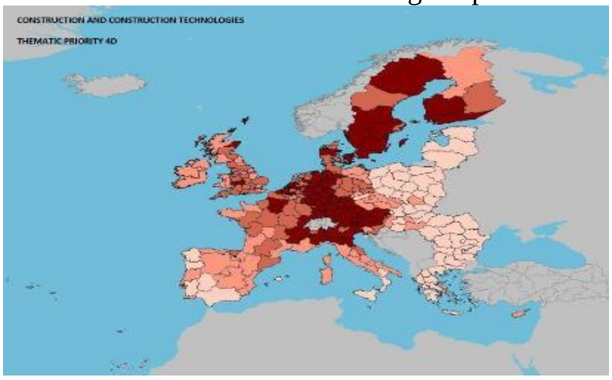
Scientific production **Materials** Technological production



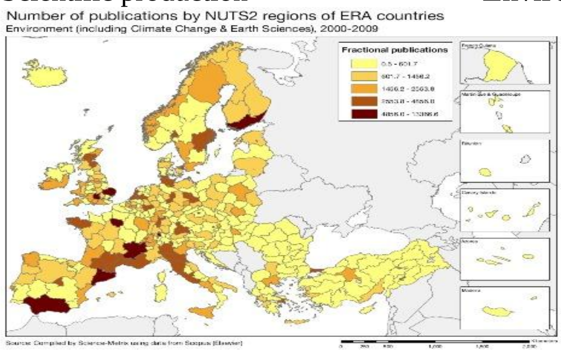


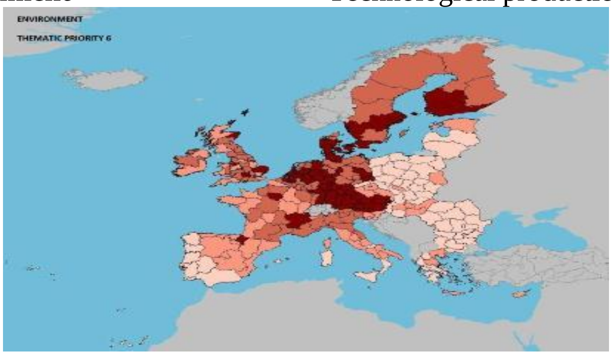
Scientific production **Construction** Technological production





Scientific production **Environment** Technological production





Due to the limited size of its public research system, Luxembourg does not have any visible strengths on the "Scientific production" maps. However, specialisation indices calculated on the basis of the number of scientific publications (classified by FP themes) reveal three areas of specialisation for Luxembourg: ICT (specialisation index of 2.67), socio-economic sciences (specialisation index of 1.92) and environment (specialisation index of 1.65).

Based on EPO patents classified in the same way, Luxembourg has very strong specialisation in two areas:

- Space (RTA[34]: 5.7): The creation in Luxembourg in 1985 of the Société Européenne des Satellites (SES), a landmark for satellite telecommunications and now a major player in this sector, has led to the development of a Space-related industrial cluster in Luxembourg.
- Automobiles (RTA: 5.25): This reflects the presence of a very significant cluster of technologically innovative companies supplying the automotive industry (such as IEE and Delphi Automotive Systems).

Other areas of technological specialisation are energy (RTA: 1.63), materials (RTA: 1.49), construction (RTA: 1.45) and environment (RTA: 1).

[34] Revealed Technological Advantage

Policies and reforms for research and innovation

The steady increase in the public R&D budget reflects the government's resolve to make investment in RDI part of a long-term policy for Luxembourg's economic development and diversification. Luxembourg's national RDI strategy is founded on multi-annual planning and focuses on targeted priorities. Following the establishment of the public research centres (PRCs) and of the University between 1987 and 2003, key steps have been the OECD review of Luxembourg's national research system in 2006 and a Foresight Study in 2006-2007 that identified the thematic domains which now make up the CORE public research funding programme. A major result of the OECD review was the recommendation to implement performance contracts between the Ministry and the National Research Fund (FNR), the University, the PRCs and Luxinnovation. A second set of contracts was executed for the period of 2011-2013, following the initial set for 2008-2010. The CORE programme 2008-2013 of the FNR National concentrates its funding on five priority fields: innovation in services, sustainable resource management, new functional and intelligent materials and surfaces and new sensing applications, biomedical sciences, and societal changes for Luxembourg. In 2011, the programme funded 28 projects at a cost of € 16.2 million.

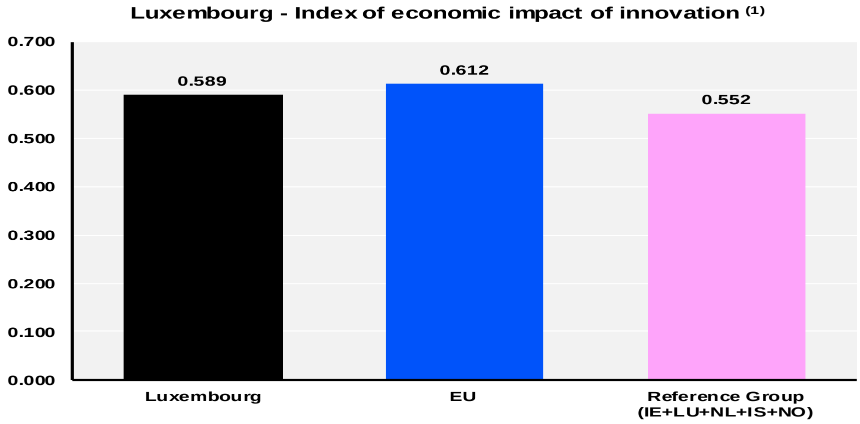
Human resources are a key focus of Luxembourgish research policy. At the end of 2011, the aid programme for research training of the FNR (AFR 2008-2013) had supported 442 and 106 young researchers in their PhD and post-PhD studies respectively. Programmes ATTRACT and PEARL 2008-2013 of FNR aim at attracting young and top researchers to work in the country; the cost involved was € 3.8 million in the years 2008-2010 with € 13.7 million foreseen for 2011-2013.

Many initiatives have been developed to foster private R&D, public-private cooperation, innovation and entrepreneurship:

- The law of 5 June 2009 provides state aid for the private sector with a special focus on SMEs and services sector innovation. The law of 18 February 2010 provides public aid to the private sector in the field of eco-innovation. The law on IP tax incentives (21 December 2007) encourages companies to patent and license the results of their R&D work, and also fosters spin offs and start-ups based on IP.
- Recent reform measures have encouraged the development of small innovative companies. These measures include: IP/spin-off requirements in PRCs performance contracts, the creation of a Master's degree in Entrepreneurship and Innovation, the setting up of business incubators, the creation of a partnership with a business accelerator located in Silicon Valley (Plug and Play Tech Centre) in order to help start-ups in Luxembourg to gain access to the United States market.
- The massive (€565 million) infrastructure project Cités des Sciences aims at reinforcing relations between research, education and innovation, by hosting on one site all the major public R&D institutes of Luxembourg, as well as private and start-up companies, a new technical school, the university campus, the National Archives and some cultural centres. It will provide facilities for public-private partnerships and a business incubator.
- Luxembourg has set up a cluster programme around five thematic clusters (in materials, ICT, space, bio-health, eco-innovation).
- The Luxembourgish government founded a Luxembourg Future Fund to support the diversification and sustainable development of the economy. The Fund will invest directly or via other funds in innovative SME's in a start-up or development phase in technology sectors (ICT, clean technologies…). The Luxembourg state will invest € 120 million in the Fund via the Société Nationale de Crédit et d'Investissement and the European Investment Fund will contribute a further € 30 million. In addition, the government will invest in health sciences and technology via an existing private fund.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[35].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The share of the Grand-Duchy's employment in knowledge-intensive activities (24. 8 %) is the highest of all EU Member States and nearly the double of the EU average. The share of knowledge-intensive services in services export is also the highest of all EU Member States. These situations are due to a very strong specialisation in the financial services sector, which has been Luxembourg's main growth engine since the early 1980s. Its expansion has allowed the Luxembourgish economy to flourish despite the decline of its key manufacturing sectors, especially the steel industry. The limited role of high-tech and medium-tech manufacturing in the Luxembourgish economy explains the low scores of the Grand-Duchy on the other indicators parts of the index. Manufacturing represents only 6.5% of total value added, the lowest share of all EU Member States.

It is however uncertain to what extent the financial sector will be able to continue to play such an important role in driving Luxembourgish prosperity in the future. Even if financial activities around the world would remain as buoyant after the crisis as they were before, the question arises as to whether Luxembourg will be able to preserve and continue to develop the competitive advantages in terms of fiscal, legislative and regulatory environment, that have made it an attractive environment for this type of activity. Thus, although the Luxembourgish financial sector is relatively healthy, the large dependence of the economy on this industry is a strong structural risk.

As indicated by the OECD in its 2007 review of Luxembourg, it is therefore crucial for the Grand-Duchy that, in addition to its "sovereignty niches" on which the financial sector expansion is based, it also develops "competence niches" as a springboard for innovation-led growth, both in areas of existing activities or in new areas that can contribute to the much-needed diversification of its economy.

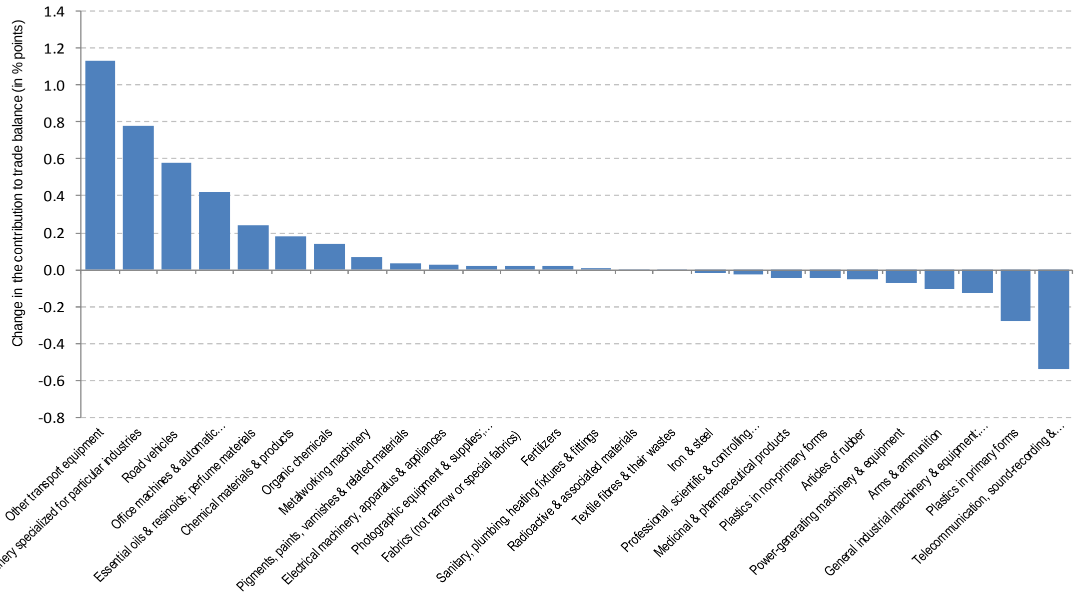
The development of a top-quality public research base is a key building block for such a strategy. Good framework conditions for innovation are also required. The situation of the Grand-Duchy in this regard is relatively good. Credit tightening has been less pronounced in Luxembourg than elsewhere in the Eurozone and SMEs continued to enjoy good access to finance. In Luxembourg early stage venture capital investment as a % of GDP is close to the EU average. Luxembourg has the third highest score of the EU Member States in the "International property rights index" compiled by the Property Rights Alliance.

35 See Methodological note for the composition of this index.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Luxembourg between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Although its goods balance is structurally in deficit, Luxembourg has a large trade surplus thanks to its very strong position in financial services, especially in asset management. Thanks to the continuing expansion of its exports of financial services, Luxembourg has gained market shares overall since 2000. Luxembourg also gained market shares in non-financial services, while it lost shares in goods markets[36]. This has led to a situation where the fees earned by asset managers alone constitute around half the total of Luxembourgish exports. Non-financial services represent about 30% of Luxembourgish exports, while the share of goods in Luxembourgish exports has been reduced to about 20%, down from 45% in 1995.

Luxembourg has a trade deficit in high-tech and medium-tech products which has grown slightly over the last decade. However, the evolution between 2000 and 2010 of the contribution of HT and MT products to the trade balance is positive for many product sectors, as shown in the graph above. However, taking into account the limited role the manufacturing and export of HT and MT products plays in the Luxembourgish economy, the graph above has to be interpreted with caution. For instance, the fluctuations of the trade balance in the other transport equipment category are in fact driven by the large yearly variations of the level of imports in the subcategory aircraft and associated equipment, spacecraft (including satellites) and spacecraft launch vehicle, parts thereof.

[36] Luxembourgish exports of goods increased during the first decade of the millennium by an annual average of 3.5% in value and 1.4% in volume, well below world levels.

Key indicators for Luxembourg

LUXEMBOURG	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	:	:	:	:	:	:	:	:	:	:	0.81	:	:	:	*1.69*	22
Business enterprise expenditure on R&D (BERD) as % of GDP	1.53	:	:	1.47	1.43	1.35	1.43	1.32	1.29	1.31	1.00	*0.98*	:	*-4.0*	*1.26*	14
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.12	0.15	:	*0.18*	0.20	0.21	0.23	*0.26*	0.37	0,42 (3)	0.48	*0.45*	:	*4.0*	*0.74*	20
Venture Capital (4) as % of GDP	:	:	:	:	:	:	:	0.11	0.98	0.22	0.21	0.52	:	46.1	0,35 (5)	3 (5)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	18.6	:	:	:	:	19.8	:	:	1.3	47.9	22
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	5.9	6.5	3.1	4.9	5.4	7.8	7.7	9.1	10.1	:	:	:	:	6.9	10.9	13
International scientific co-publications per million population	118	132	119	243	338	375	565	636	790	1072	1257	1428	:	25.5	300	3
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	19	25	30	33	36	:	17.1	53	11
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	2.8	1.5	1.5	1.2	2.0	1.5	1.7	1.1	1.7	1.7	:	:	:	-5.1	3.9	14
License and patent revenues from abroad as % of GDP	:	:	:	:	0.59	0.78	0.92	0.77	0.62	0.75	0.91	0.78	:	4.1	0.58	6
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	15.6	:	12.4	:	8.9	:	8.3	:	:	-10.0	14.4	21
Knowledge-intensive services exports as % total service exports	:	:	:	:	75.4	78.4	81.3	81.8	78.9	76.9	78.3	:	:	0.6	45.1	1
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.68	-5.31	-5.31	-3.78	-4.55	-5.11	-4.26	-5.16	-5.52	-3.61	-4.44	-3.35	:	-	4,20 (6)	24
Growth of total factor productivity (total economy) - 2000 = 100	100	97	97	95	95	97	97	98	93	87	87	86	84	-16 (7)	103	27
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	56.3	:	:	:	:	59.5	:	:	:	:	64.7	:	:	1.4	48.7	2
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	23.8	25.1	26.1	24.7	:	1.3	13.6	1
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	49.1	:	44.7	:	41.5	:	47.9	:	:	-0.4	38.4	3
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.79	0.29	0.30	0.43	0.71	0.55	0.52	0.23	0.36	:	:	:	:	-9.3	0.39	8
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.01	0.07	0.30	0.10	0.18	0.11	0.15	0.14	0.16	:	:	:	:	42.9	0.52	16
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	67.4	67.7	68.2	67.2	67.7	69.0	69.1	69.6	68.8	70.4	70.7	70.1	:	0.4	68.6	11
R&D Intensity (GERD as % of GDP)	1.65	:	:	1.65	1.63	1.56	1.66	*1.58*	1.66	1.72	1.48	*1.43*	:	*-1.3*	*2.03*	15
Greenhouse gas emissions - 1990 = 100	75	79	85	88	99	101	100	95	94	90	94	:	:	19 (8)	85	16 (9)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	0.9	1.4	1.4	2.7	2.8	2.8	2.8	:	:	20.8	12.5	26
Share of population aged 30-34 who have successfully completed tertiary education (%)	21.2	23.9	23.6	17,3 (10)	31.4	37.6	35.5	35.3	39.8	46,6 (11)	46.1	48.2	:	1.7	34.6	2
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	16.1	17.3	16.5	15.9	15.5	17.8	17.1	16.8	:	0.6	*24.2*	4 (9)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2009 and the previous years. Average annual growth refers to 2009-2011.

(4) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(5) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(6) EU is the weighted average of the values for the Member States.

(7) The value is the difference between 2012 and 2000.

(8) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(9) The values for this indicator were ranked from lowest to highest.

(10) Break in series between 2003 and the previous years.

(11) Break in series between 2009 and the previous years. Average annual growth refers to 2009-2011.

(12) Values in italics are estimated or provisional.

Malta

Building up a knowledge-based economy in a specialisation strategy

Overall performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Malta. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

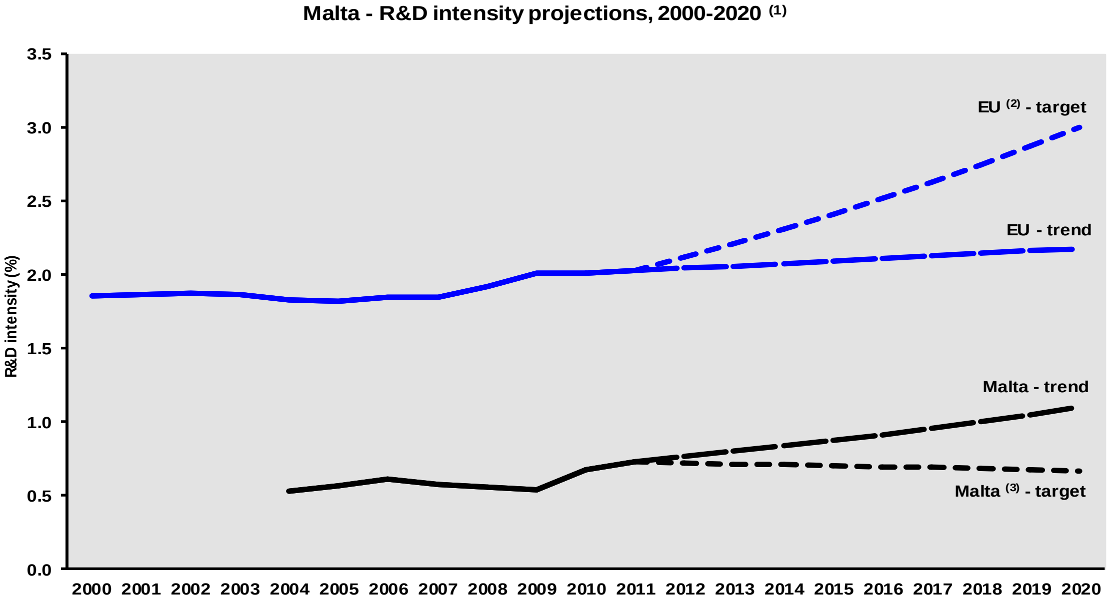
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.73% (EU: 2.03%; US: 2.75%) 2000-2011: +4.68% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 17.53 (EU:47.86; US: 56.68) 2005-2010: +4.07% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.35 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 54.45 (EU:48.75; US: 56.25) 2000-2010: +2.67% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* ICT, Bio-medical technologies	*HT + MT contribution to the trade balance* 2011: 0.92% (EU: 4.2%; US: 1.93%) 2000-2011: -14.37% (EU: +4.99%; US:-10.75%)

The stated aim of the Maltese government is to build a knowledge -based economy with research and innovation at its core. This can only be achieved in the long term and its success will depend on the implementation of the policies outlined in the draft National Strategic Plan for Research and Innovation -2020. However, it is clear that progress is being made. This is shown by the increase in R&D intensity from 0.63% in 2010 to 0.73% in 2011, an increase which is underpinned by significant increases in public and private expenditure on R&D. The total number of researchers (full-time equivalent) has also increased, by 19% between 2009 and 2010. Performance and economic output indicators all show positive development over the last decade, in particular the indicator on structural change of the economy which has increased at almost six times the rate of the EU average.

However, Malta remains amongst the lowest ranked Member States in some key areas. In 2010, Malta had 3.3 researchers (full-time equivalent) per thousand labour force compared to an EU average of 6.5. Only four Member States had lower values. Malta has the lowest public expenditure on R&D as % of GDP in the EU (0.25% compared to an EU average of 0.75% in 2010). Although 59% of R&D expenditure in Malta is performed by business enterprise (a share which was only slightly lower than the EU average of 62% in 2010), more than 80% of all business enterprise expenditure on R&D is spent by foreign-owned companies.

Malta's key challenges are to build up R&I capacity, to move towards a self-sustaining R&I system (which implies specialisation in order to achieve a critical mass) and to create an enabling environment for research to market, innovation and entrepreneurship, particularly for SMEs. A fundamental challenge for Malta is to stimulate indigenous private sector R&I. The strategic principles adopted to address these challenges are outlined in Malta's draft National Strategic Plan for Research and Innovation 2020. These include increased focus on priority areas, specialisation in a select number of areas of economic importance, coordinating public and private resources, expanding the science, technology, engineering and mathematics human capital base and building strong links between knowledge institutions and business.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D Intensity for 2000-2011 in the the case of the EU and for 2004-2011 in the case of Malta.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) MT: This projection is based on a tentative R&D intensity target of 0.67% for 2020.

Malta's R&D intensity increased from 0.67% in 2010 to 0.73% in 2011. This means that Malta has already achieved its R&D intensity target for 2020 and if the current trend continues should reach an R&D intensity of more than 1% in 2020. The increase in R&D intensity between 2009 and 2010 was mainly due to an increase of 41% in R&D performed by the higher education sector. Funding of R&D by each of the three main sources (government, business and abroad) has increased by 20% or more between 2009 and 2010.

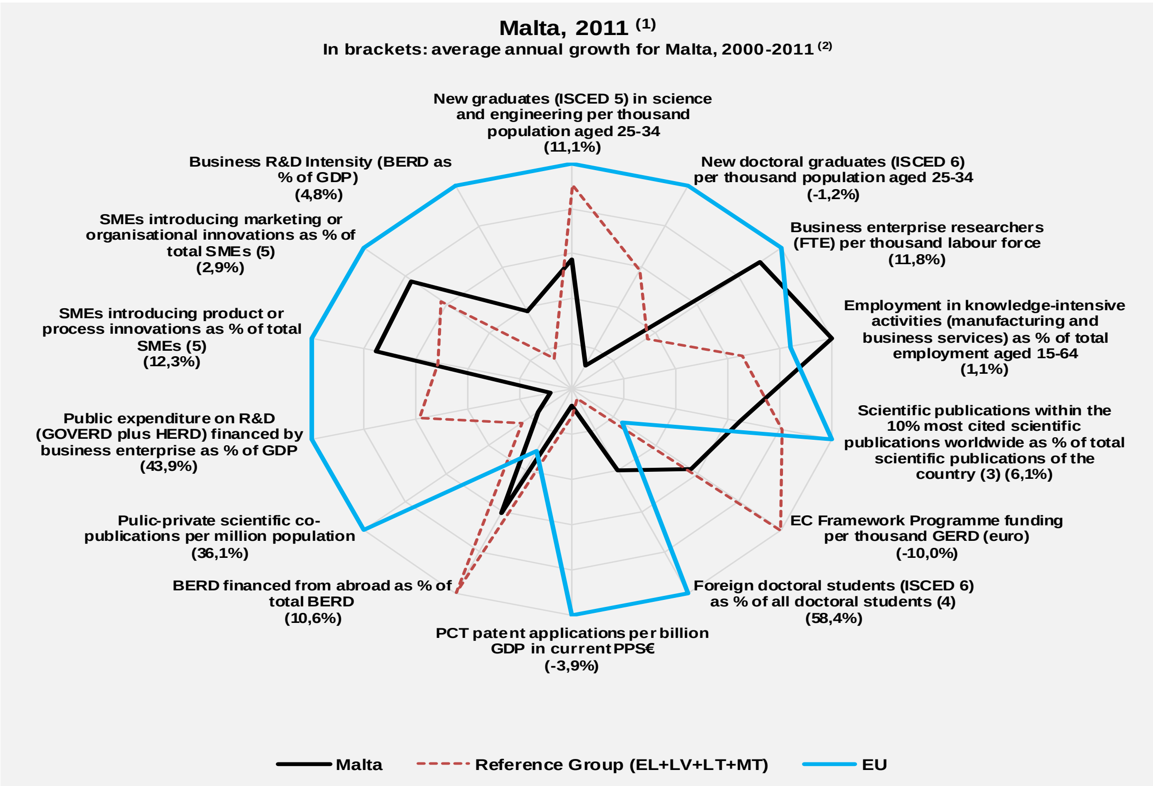
In spite of the economic crisis, public expenditure on R&D increased by 35.1% between 2009 and 2010. This was due to an increase of 4.2 million euro in higher education expenditure on R&D. Government intramural expenditure on R&D decreased slightly between 2009 and 2010. Government funding of R&D has increased steadily between 2005 and 2010 at an average annual real growth rate of 7.7%. However, the government budget for R&D which increased from € 9.4 million to € 14.3 million between 2009 and 2010 has decreased by 19% between 2010 and 2011. This development is a cause for concern in view of the likely negative impact on future R&D intensity.

Malta is ranked nineteenth in the EU in terms of business enterprise expenditure on R&D as % of GDP with a value of 0.37% in 2010 compared to an EU average of 1.23%. The share of R&D performed by business enterprise in Malta has decreased from 66% in 2005 to 59% in 2010. R&D financed by business enterprise increased in real terms between 2005 and 2010 at an average annual growth rate of 6.3%. Most of Malta's business R&D is carried out by a small cluster of foreign-owned companies. 43% of R&D carried out by foreign-owned companies is performed by US owned companies.

Malta relies heavily on support from the EC Framework Programme and Structural Funds for the achievement of its R&I objectives. FP7 projects in Malta have been awarded €11(1) million to date. The success rate of Maltese applicants for FP7 funding is 19.1% compared to an EU average of 22.0%. Malta will also receive around € 60 million for innovation and RTD from the Structural Funds 2007-2013. One of the objectives of the draft National Strategic Plan for R&I 2020 is to put in place an appropriate national framework to exploit opportunities for participation in EU R&I funding programmes.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Malta's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) EL is not ncluded in the reference group.

Despite a clear strategy, Malta is still below the EU average for most indicators. Although the supply of human resources for science and technology is below both the EU and the reference group averages, the average annual growth in the numbers of graduates per thousand population aged 25 -34 is quite high. Malta's share of employment in knowledge-intensive activities is higher than the EU average reflecting the dominance of high-tech multinationals in the private sector.

Knowledge creation as reflected in the production of highly-cited scientific publications and public-private scientific co-publications and in the number of PCT patent applications is far below the EU average indicating a low scientific base, although the establishment of the University of Malta Knowledge Transfer Office in 2009 is already contributing to the reversal of this trend. Indeed, since its inception, the office has taken over the maintenance of the 3 patents owned by University and oversaw the filing of 8 additional patents with the Malta Patent Office, the UK IP Office and WIPO.
Malta's reliance on the EC Framework Programme as a source of funding is shown in its above average level of EC funding. Innovative activity by SMEs is above the reference group average but below the EU average.

Malta's scientific and technological strengths

Malta, which is the smallest Member State in the EU in terms of population, produces the smallest number of scientific publications in the EU and is in the lowest size category for publications in every field of science. Historically, Malta makes very few patent applications to the EPO, however a positive trend can be noticed over the last decade. The expansion of Malta's science, technology, engineering and mathematics human capital base and the building of links between knowledge institutions and the private sector as outlined in the draft National Strategic Plan for Research and Innovation should stimulate more activity in these areas.

R&D in Malta is concentrated around a cluster of large firms specialising in ICT, manufacture of machinery, manufacture of chemicals and medical instruments and the generic pharmaceuticals industry. E-gaming is an emerging area which has attracted a number of international companies to Malta. The setting up of a new Life Sciences Centre (to be named the BioMalta Campus) is designed to develop Malta into a regional centre of excellence in life sciences and the bio-medical industry. The Life Sciences Centre will seek to attract foreign direct investment into research and development and innovation in the biotechnology and life sciences sectors and will provide support to the local industrial community. The Life Sciences Centre will be operational in 2014.

Policies and reforms for research and innovation

Malta's draft National Strategic Plan for R&I 2020 responds adequately to the country's challenges in the field of R&I. It is strongly business oriented and aims to build up R&I capacity by concentrating efforts on areas of economic importance. Resource concentration and smart specialisation in specific sectors is a key a part of the Maltese R&I strategy. The Plan proposes a set of tailored aid schemes for enterprises to provide support for particular target groups such as SMEs and start-ups. A new commercialisation programme to help technology owners move their technologies closer to market was launched in 2012. Efforts are being made to use government expenditure on R&D to leverage an increase in business R&D expenditure, particularly through a varied set of incentives to promote R&D and innovation in the enterprise sector.

A first draft of the National R&I Plan was issued for public consultation in late 2011 and work on the updating and finalisation of this plan is currently on-going.

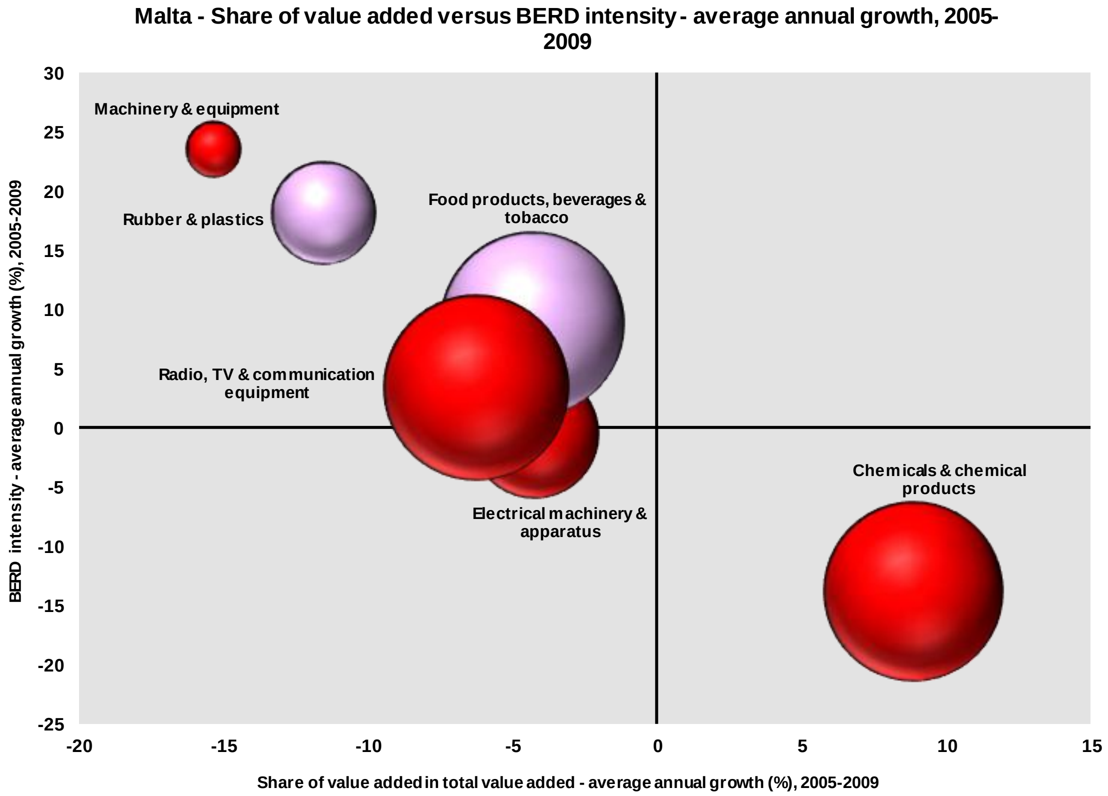
The draft Plan proposes to address the serious shortfall in human capital for R&I by investing in human resource development at all levels of education. Scholarship schemes supporting post-graduate studies in Malta and abroad are in place and are synchronised with areas of national priority. The draft Plan proposes the setting up of fiscal incentives to highly qualified and skilled foreign workers who are required for industrial sectors of economic importance and to those persons carrying out research or marketing an invention or technology in Malta. Malta is investing in the construction of a new National Interactive Science Centre in order to enhance science-related education and training. It will help to expand the science, engineering and technology human capital base. The Centre will open in 2014.

The European Research Area (ERA) dimension in Malta's national research and innovation system is limited in the extent of policies and measures specifically addressing this aspect. Some success has been achieved through the putting in place of a legal framework for inward mobility of third country researchers and the very good participation rates in the sixth and seventh EC Framework Programmes. International cooperation is one of the pillars of the draft National Strategic Plan for R&I, and a number of priority measures to be implemented in the short term are identified.

Malta aims to support both research based and non-research based innovation through identifying key issues and opportunities and providing an appropriate enabling and support framework to potential innovators. The draft National Strategic Plan for R&I recommends several measures for the support of innovation, including an innovation voucher scheme, a risk fund to enable the pooling of private funding to support start-up companies, as well as established companies aiming at expansion and an investment readiness programme to enable SMEs to innovate by addressing the lack of availability of risk capital for businesses at their seed, start-up and early-growth stages.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.



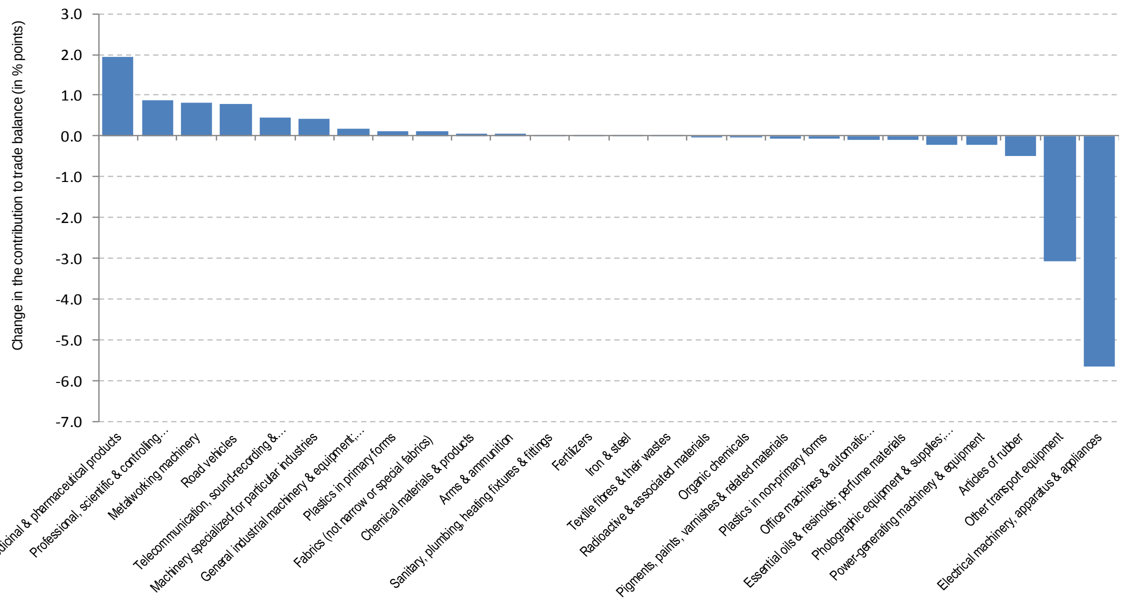
Source: DG Research and Innovation - Economic Analysis unit
Data: Eurostat
Note: (1) High-Tech and Medium-High-Tech sectors are shown in red.

In Malta, the services sector accounts for around 80% of total value added. The share of manufacturing in total value added has declined steadily over the last decade to 13.6% in 2010. Between 2005 and 2009 the shares of value added decreased for all of the sectors on the graph with the exception of chemicals and chemical products. Although the share of value added for chemicals and chemical products increased, BERD intensity (business expenditure on R&D as % of value added) decreased because business expenditure on R&D for this sector stagnated between 2005 and 2009. BERD intensity for machinery and equipment increased by almost 25% per annum between 2005-2009. In fact, BERD intensity is showing positive progress for all sectors with the exception of chemicals and chemical products.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Malta between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The overall contribution of high- tech and medium-tech products to the trade balance was positive for each year over the period 2000-2010. Electrical machinery, apparatus and appliances is the sector with the most significant increase in its contribution to the trade balance. Medicinal and pharmaceutical products also show a notable increase. The sector with the biggest decrease is other transport equipment followed by power-generating machinery and equipment. The contributions of most other sectors have either slightly positive or slightly negative evolutions.

Growth in total factor productivity for Malta has been negative throughout the last decade (see Table below). Malta's employment rate has increased from 57.2% in 2000 to 61.5% in 2011 although this is still well below the EU average of 68.6%. Malta has ambitious targets for 2020 in terms of addressing greenhouse gas emissions and the share of renewable energy in energy consumption. However, it is still too early to assess the impact of the measures being taken to achieve these targets.

Key indicators for Malta

MALTA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.13	0,22 [3]	0.15	0.09	:	0.09	0.07	0.15	0.18	0.31	0.19	:	:	-1.2	*1.69*	27
Business enterprise expenditure on R&D (BERD) as % of GDP	:	:	:	:	0.35	0.38	0.41	0.38	0.37	0.34	0.42	*0.49*	:	*4.8*	*1.26*	19
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	:	0.20	0.18	0.18	0.19	0.21	0.20	0.19	0.20	0.25	*0.24*	:	*2.4*	*0.74*	27
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	14.4	:	:	:	:	17.5	:	:	4.1	47.9	25
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	4.4	4.9	0.4	2.8	3.6	6.2	8.2	5.3	7.1	:	:	:	:	6.1	10.9	19
International scientific co-publications per million population	60	72 [4]	71	106	103	219	198	177	244	208	292	328	:	16.5	300	22
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	2	1	2	6	8	:	36.1	53	23
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.4	0.7	0.3	0.5	0.4	0.8	0.7	1.1	1.0	0.3	:	:	:	-3.9	3.9	26
License and patent revenues from abroad as % of GDP	:	:	:	:	0.05	0.80	2.25	0.69	0.52	0.571	0.36	0.30	:	28.7	0.58	12
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	22.2	:	28.6	:	15.2	:	7.4	:	:	-16.7	14.4	24
Knowledge-intensive services exports as % total service exports	:	:	:	:	12.5	12.0	15.4	17.8	14.5	13.3	13.6	:	:	1.5	45.1	26
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	5.07	5.71	4.43	4.69	4.42	7.72	7.52	9.46	10.73	9.61	3.21	0.92	:	-	4,20 [5]	17
Growth of total factor productivity (total economy) - 2000 = 100	100	96	98	97	95	96	97	97	99	97	98	98	99	-1 [6]	103	23
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	41.8	:	:	:	:	47.4	:	:	:	:	54.5	:	:	2.7	48.7	9
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	15.7	15.7	16.0	16.2	:	1.1	13.6	5
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	14.4	:	:	:	25.9	:	29.0	:	:	12.3	38.4	18
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.00	0.00	0.00	0.00	0.15	0.11	0.27	0.19	0.00	:	:	:	:	8.9	0.39	11 [7]
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.00	0.16	0.00	0.15	0.04	0.00	0.00	0.19	0.00	:	:	:	:	2.8	0.52	15 [7]
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	57.2	57.2	57.7	57.8	57.9	57.9	57.6	58.5	59.1	58.8	60.1	61.5	:	0.7	68.6	24
R&D Intensity (GERD as % of GDP)	:	:	:	:	0.53	0.57	0.62	0.58	0.56	0.54	0.67	*0.73*	:	*4.7*	*2.03*	21
Greenhouse gas emissions - 1990 = 100	128	134	136	145	144	149	148	154	152	148	149	:	:	21 [8]	85	26 [9]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	0.1	0.1	0.2	0.2	0.2	0.2	0.4	:	:	26.0	12.5	27
Share of population aged 30-34 who have successfully completed tertiary education (%)	7.4	12.9	9.3	13,7 [9]	17.6	18.4	21.6	21.5	20.9	21.0	21.5	21.1	:	5.5	34.6	25
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	20.2	19.1	19.4	19.6	20.2	20.3	21.4	:	1.0	*24.2*	13 [9]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2001 and the previous years. Average annual growth refers to 2001-2010.

(4) Break in series between 2001 and the previous years. Average annual growth refers to 2001-2011.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) Rank in 2007.

(8) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(9) The values for this indicator were ranked from lowest to highest.

(10) Break in series between 2003 and the previous years. Average annual growth refers to 2003-2011.

(11) Values in italics are estimated or provisional.

The Netherlands

A 'Top sector's' business policy fostering industrial renewal and promoting innovation

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in the Netherlands. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

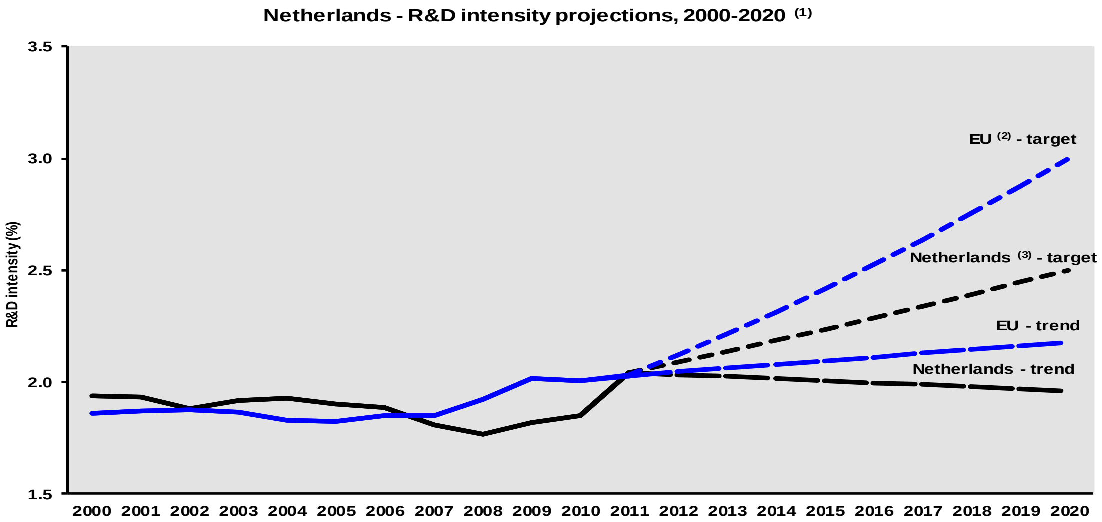
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 2.04% (EU: 2.03%; US: 2.75%) 2000-2011: -0.45% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 78.86 (EU:47.86; US: 56.68) 2005-2010: +2.72% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.565 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 56.22 (EU:48.75; US: 56.25) 2000-2010: +0.48% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food and agriculture, Energy, ICT, Nanotechnology, Security, Health	*HT + MT contribution to the trade balance* 2011: 1.68% (EU: 4.2%; US: 1.93%) 2000-2011: +53.81% (EU: +4.99%; US:-10.75%)

The Dutch research and innovation (R&I) system has succeeded in maintaining its innovative capacity during the years of financial crisis, with a high efficiency and effectiveness of public R&D investment, an improved S&T excellence from a high existing level and the development of hot-spots in key technologies, in spite of a stagnating R&D intensity. These efforts are reflected in the competitiveness of the Dutch economy, which benefits from a positive contribution of high-tech and medium-tech products to the trade balance. The Dutch economy is very knowledge-intensive, although a warning signal may be the very slow rate of structural change over the last decade. Dutch enterprises, and particularly SMEs, are less innovative than the EU average. The business R&D investment rate is only 70% of the EU average in 2010 and the rate of SMEs innovating in-house (0.73) is at a lower level than the EU average.

Compared to other Member States with similar economic development, the Dutch R&I system has a relatively low level of business expenditure on R&D and innovation which is overly concentrated in a reduced number of multinational firms performing R&D. An additional challenge is a weaker connection between, on the one hand, the Dutch science base (which ranks amongst the world's best performers in terms of output and openness) and, on the other hand, the business sector (which has an average or below average innovative performance according to the Innovation Union Scoreboard). The share of science and engineering graduates (both total and doctorates) in the population aged 25-34 is markedly lower than the EU average and this raises the question of how the Netherlands will be able to assure the future supply of highly skilled human resources necessary to keep an innovation-based economy running.

The recent 'top sectors' business policy addresses directly the issue of underinvestment from the Dutch private sector by the creation of 'top consortia' in innovation involving actors from public research, universities and innovative enterprises and by stimulating knowledge transfer. The Dutch economy needs indeed to foster industrial renewal, faster growing and more innovative sectors which would stimulate increased investment in private R&D and innovation while safeguarding accessibility beyond the strict definition of top sectors and preserving fundamental research. From 2011, the new business policy introduced a sectoral approach implemented by public-private partnerships in the field of research, education and innovation in order to have closer links between science and business.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2000-2010 in the case of the Netherlands.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) NL: This projection is based on a tentative R&D intensity target of 2.5% for 2020.
(4) NL: There is a break in series between 2011 and the previous years.

In 2000-2010, R&D intensity has fluctuated between a minimum of 1.77% (2008) and a maximum of 1.94% (2000). In 2011, the Netherlands had an R&D intensity of 2.04%. The Netherlands set the target to increase R&D intensity to 2.5% by 2020. R&D intensity will have to increase at an average annual growth rate of 3.2% over the current decade if the 2020 target is to be reached. Meeting that target constitutes a challenge, considering recent trends.

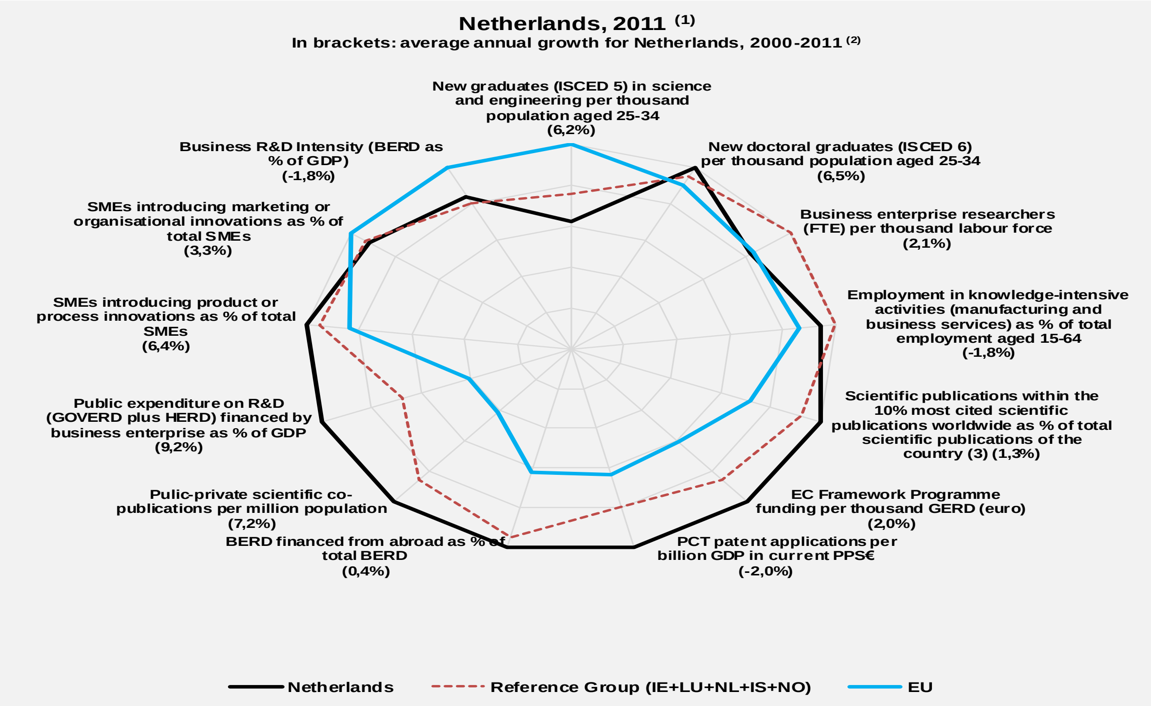
The research system in the Netherlands is characterized by a relatively low R&D intensity in the private sector and a relatively high R&D intensity in the public sector. In this context, it was worrying that in the 2011 and 2012 public budgets, R&D investment decreased by 3.7% and 4.1% respectively. A further decrease of 3.3% is planned for the 2013 budget. This decrease is concentrated within the category of applied research, due to a negative trend since the last four years. This however reflects at least partly a shift from direct to indirect funding of R&D, with a stronger weight given to tax incentives for enterprises performing R&D. If we add foregone tax revenues to the budget expenditures, the variation in respect to the previous year is indeed much more positive (2011: -0.2%, 2012: +0.7%; 2013foreseen at -2.3%) Other measures include specific schemes for SMEs and support for public-private partnership in key technologies.

These measures respond to the most outstanding challenge for the R&I system in the Netherlands, namely falling business R&D investment, which in 2010 stood at 0.87% of GDP, well below the EU average of 1.23%. This gap has been addressed by successive governments during the last decade through R&I policies with the aim of creating an attractive climate for R&I intensive firms, including firms from abroad. The Netherlands has a very large services sector and a relatively small manufacturing sector, oriented predominantly towards medium technology intensive industries. Furthermore, business R&D investments are concentrated in a limited number of large multinational firms. Over the last decade research and innovation has become increasingly international and EU Member States having a concentration of R&D in MNEs are particularly affected by an outsourcing of R&D activities in global value chains.

The Netherlands has been successful in its participation in FP7 with an EC contribution of € 1.8 billion up to mid-2012, representing 6.8% of total EC funding. The success rate was 25.65%, which is the second highest among the Member States. The Netherlands is ranked the 5th Member State in numbers of participants and in the 6th position in budget share. The top collaborative links in FP7 are with Germany, the United Kingdom and France. For the 2007-2013 period, the Netherlands has been allocated nearly € 818 million of ERDF Structural Funds for R&I and entrepreneurship (almost half of the ERDF funds) and plans to invest some € 214 million to support business and in particular SMEs.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Netherland's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.

The Dutch R&I performance stands out in terms of scientific quality, internationalisation, technology development and public-private cooperation. It has high levels of international co-publications, scientific publications, public-private co-publications, PCT patenting, BERD financed from abroad and licence and patent revenues from abroad (as % of GDP).

The Netherlands has a strong and much internationalised research system. The Netherlands is ranked second in the world in terms of highly-cited scientific publications (behind Switzerland and equal to Denmark) and the trend is positive. Many Dutch universities score high in international university rankings and in FP7 success rates. The researchers and research institutions of the Netherlands cooperate extensively with partners in the EU and beyond. The Netherlands is amongst the top EU Member States in terms of international scientific co-publications, and this trend of internationalisation is growing. In the EU, Dutch researchers cooperate mainly with colleagues from Germany and the United Kingdom. An increasing number of Dutch research programmes aimed at talented scientists are open to non-resident applicants. A good example of portability of grants is the Rubicon programme. The Netherlands has a long-standing tradition of participating in joint programmes at the European and international level, in particular through international agencies. It also participates in a large number of ERA-NETs and pan-European research infrastructures.

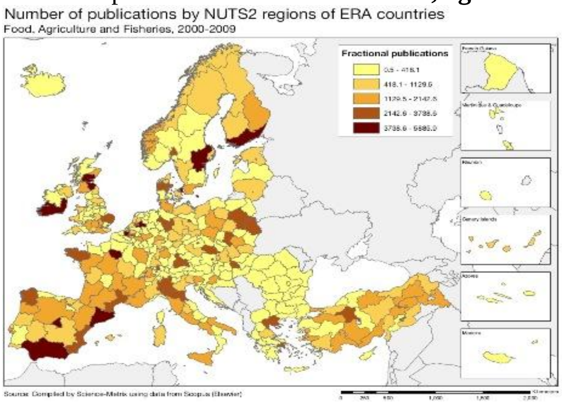
The main weakness of the Dutch R&I system is in the area of business innovation and in particular innovation by SMEs. There is room to further improve the diffusion of the results of this excellent science and technology base into the national economy itself. Business R&D and business innovation in SMEs would benefit from this. Also, a worrying trend is the very low level (much below the EU average) of new tertiary graduates in Science and Engineering relatively to the population aged 25-34 in the Netherlands. This is a potential threat to the Dutch R&I system.

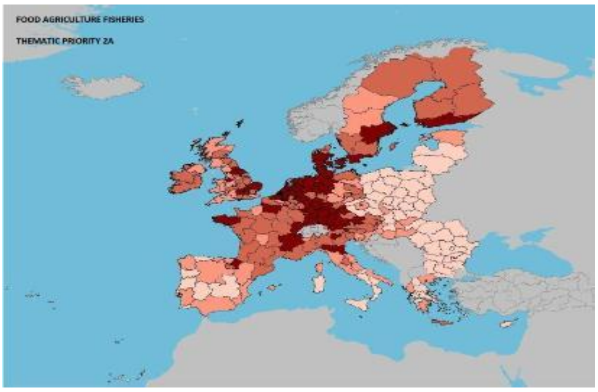
The Netherland's scientific and technological strengths

The maps below illustrate several key science and technology areas where Dutch regions have real strengths in a European perspective. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

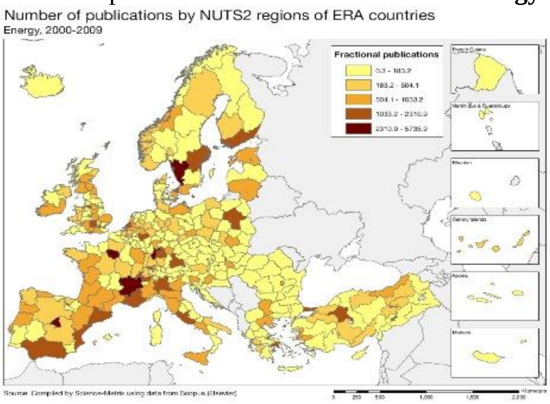
Strengths in science and technology at European level

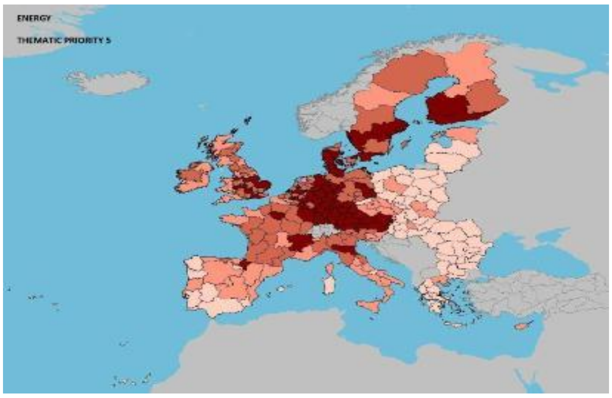
Scientific production **Food, agriculture and fisheries** Technological production



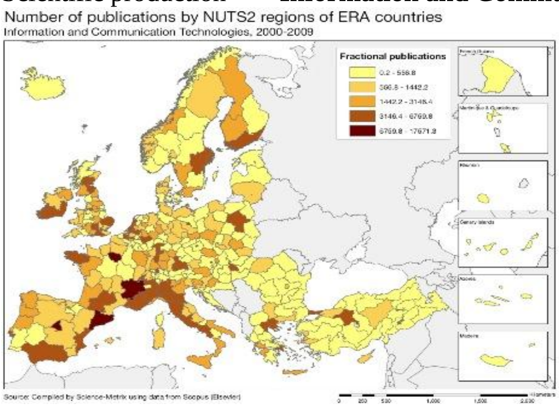


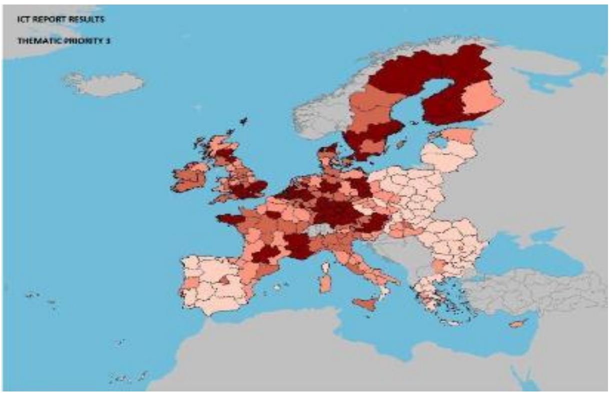
Scientific production **Energy** Technological production





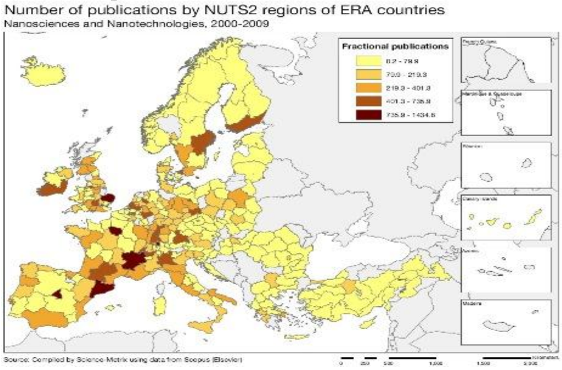
Scientific production **Information and Communication Technologies** Technological production

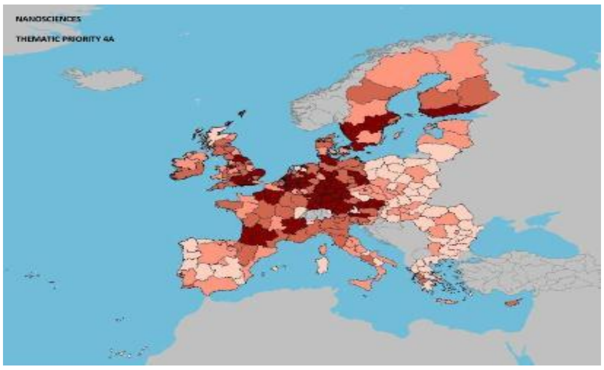




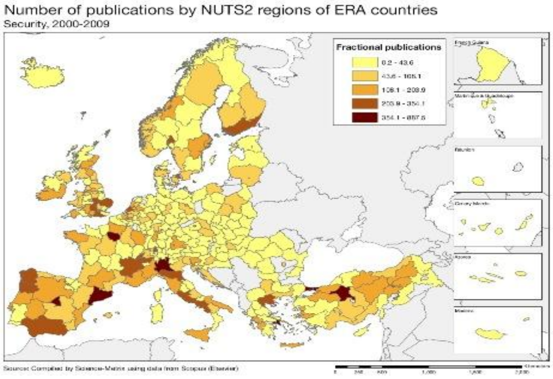
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

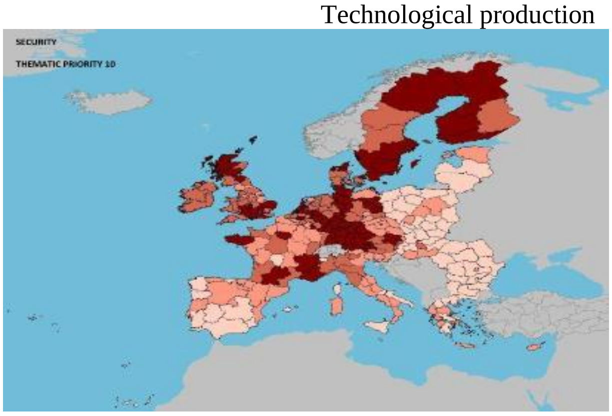
Scientific production **Nanotechnology** Technological production



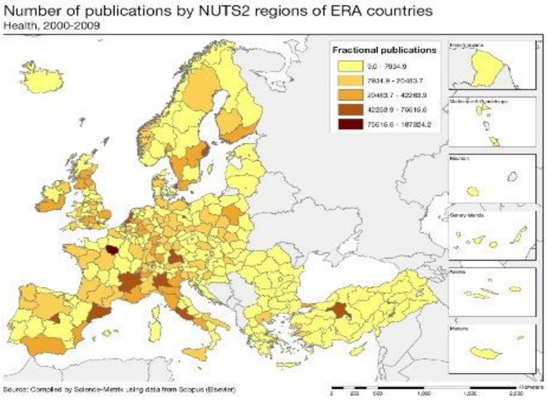


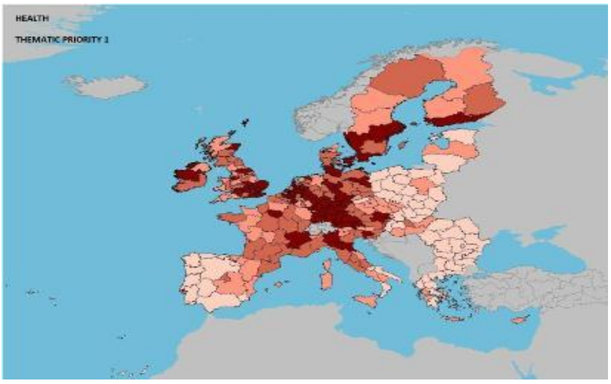
Scientific production **Security** Technological production





Scientific production **Health** Technological production





The maps above illustrate the strengths of Dutch science and technology production in absolute numbers in food agriculture and fisheries, energy, ICT, nanotechnology, security, and health. In general, there is a good correspondence between science and technology strengths. These sectors coincide to a large extent with the top sectors of the Dutch enterprise policy 'To-the-Top'.

In terms of specialisation, the Netherlands has globally the highest research intensity in health, with a specialisation index of 1.35. The specialisation patterns between 2000 and 2010 show that the Netherlands is among the first three most specialised countries in the world in audio-visual technology, basic communications processes, semiconductors, optics, macromolecular and food chemistry, and food products and beverages. In the thematic area of food, agriculture and fisheries, the Netherlands had the highest share in the world of scientific publications in the top 10% most cited scientific publications with a score of 17.8% (2000-2009). In the field of nanosciences, the Netherlands had the second highest score in the world (behind Israel) in terms of scientific publications produced between 2000 and 2009.

A quantitative analysis of the number of EPO patents (2000-2010) by applicant classified by FP7 thematic priorities show that the Netherlands has higher shares of total patenting activity than the EU average in some fields including food and agriculture (6.31% vs. 4.07%), information and communication technologies (37.7% vs. 21.4%) and security (3.16% vs. 2.94%).

Policies and reforms for research and innovation

Although the Netherlands traditionally has a good organisational capacity that translates into productivity performance, its relative underinvestment in R&D is not without consequences. For instance, the productivity gains in the Netherlands tend to stagnate albeit at a high level. This may weaken the capacity of the Netherlands to position itself internationally in sectors where it could build comparative advantage over time. These challenges are addressed by a specialisation strategy, but it remains to be seen whether sufficient public resources can be concentrated in the selected domains.

The national innovation strategy ("Naar de top") relies indeed on the new top sectors approach which is characterised by increased focus on demand-driven policies, fewer direct subsidies, more generic indirect support (e.g. tax incentives, deregulation) and more emphasis on entrepreneurship, in particular for innovative SMEs. A significant share of the public R&D budget is to be mobilised in favour of the top sectors. The aim is to reduce the administrative burden and to create additional tools for innovation funding via a revolving Innovation Fund. The shift from grants to tax incentives is based on three main instruments: WBSO scheme for wage subsidies, the RDA for complementary types of cost other than wages, and the Innovation Box.

That strategy identifies nine "top sectors" to stimulate more cooperation between government, business and knowledge institutes through a series of public-private partnerships: chemistry, creative industry, energy, high-tech systems and materials, life sciences and health, agro and food, logistics, horticulture and propagating stock, and water. Each of these sectors is characterised by a strong market and export position with a very good knowledge base and high potential for public-private collaborations. Top sectors are often geographically concentrated in innovation hotspots, such as the Brainport region (Eindhoven area) or Food Valley (Wageningen area). Each top sector will consider how to attract foreign business and top talents to the Netherlands. This approach aims to bring research closer to business and to foster valorisation and product innovation activities. It was presented in 'To the Top: Towards a new enterprise policy' (February 2011) and 'Enterprise policy in action' (September 2011).

So-called 'top teams' involving various stakeholders from these sectors have developed sector policy agendas which will be evaluated regularly. These agendas have been translated in so called innovation contracts per top sector. Innovation contracts are a balanced mix of fundamental research, applied research and valorisation, tailored to the needs of the market and consistent with the European agenda. The societal knowledge needs and overarching topics are also addressed in the contracts. The government puts the responsibility for this on the field by bringing relevant parties to the table under the direction of the leading players. This gives the parties a common goal: each sector will want to present the best plan possible that is supported by their grass roots and organisations. Drafting contracts is an open process with room for all, including the SME sector.

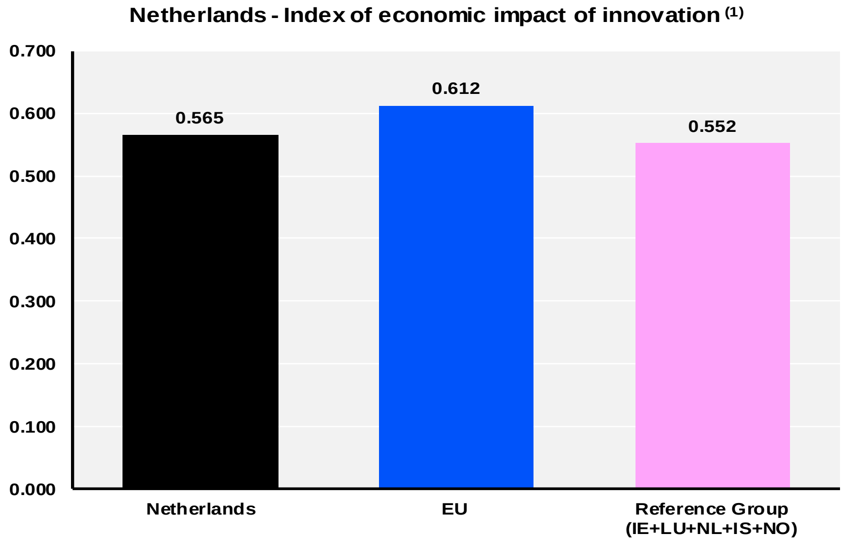
As part of the top sector approach, 19 Top consortia for Knowledge and Innovation (TKI) are put into action as of September 2012. TKIs are designed as public private partnerships, bundling excellence (in terms of research and business) in promising fields of technology. Driven and supervised by the top teams, they will play an important role in the prioritisation and guiding of public spending and in demand-side management.

An important aspect of the new business policy is to target support for the promotion and creation of fast growing new science-based companies spinning-off from business, universities and research laboratories. In parallel, continued public efforts are envisaged to support non-targeted academic research and to attract and train a larger number of students in science and engineering.

The Strategic Agenda for Higher Education, Research and Science (published on 1 July 2011) complements the "top sectors" approach by encouraging universities and universities of applied sciences to adapt and improve academic curricula, to regroup into knowledge clusters and to strengthen their 'valorisation' mission. Addressing the challenge of a relatively low number of graduates, in particular in science and engineering, the strategic agenda emphasizes the need to focus on research, to foster specialisation in higher education institutions and to reward quality when funding applied science in universities. The government has also reserved funding for new and updated research infrastructures and has put in place a national roadmap for research infrastructures.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[37].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The share of employment in knowledge-intensive activities is in the Netherlands clearly above the EU average. The overall good patenting performance in the Netherlands reflects primarily the patenting behaviour of a small group of MNEs based in the Netherlands while Dutch young firms (less than five years old) have noticeably less PCT patent applications than their equivalents in other R&I intensive Member States. The low score of the Netherlands on the indicator "*Share of knowledge-intensive exports in services exports*" is largely explained by high volumes of activities in some logistics, transport and trade related services which are linked to the geographical intermediation role of the Netherlands and which are classified as non-knowledge-intensive.

Building on its excellent science base, the Netherlands has the capacity to build up internationally attractive innovation environments for innovative SMEs and to retain and attract R&I activities of MNEs. The existing technology supply of innovative firms in the Netherlands would benefit from closer links with the technology demand from larger MNEs, thus enhancing fast-growing innovative firms. In the medium term, the Netherlands needs to respond to internationalisation by upgrading the structure of its economy and injecting knowledge in key growth sectors. Since 1995, there have been few changes in the economic structure in the Netherlands towards higher knowledge intensity in the manufacturing sector. The service sector is growing and would, if oriented towards knowledge-intensive services, have the potential for linking up to the internationalisation of research and innovation.

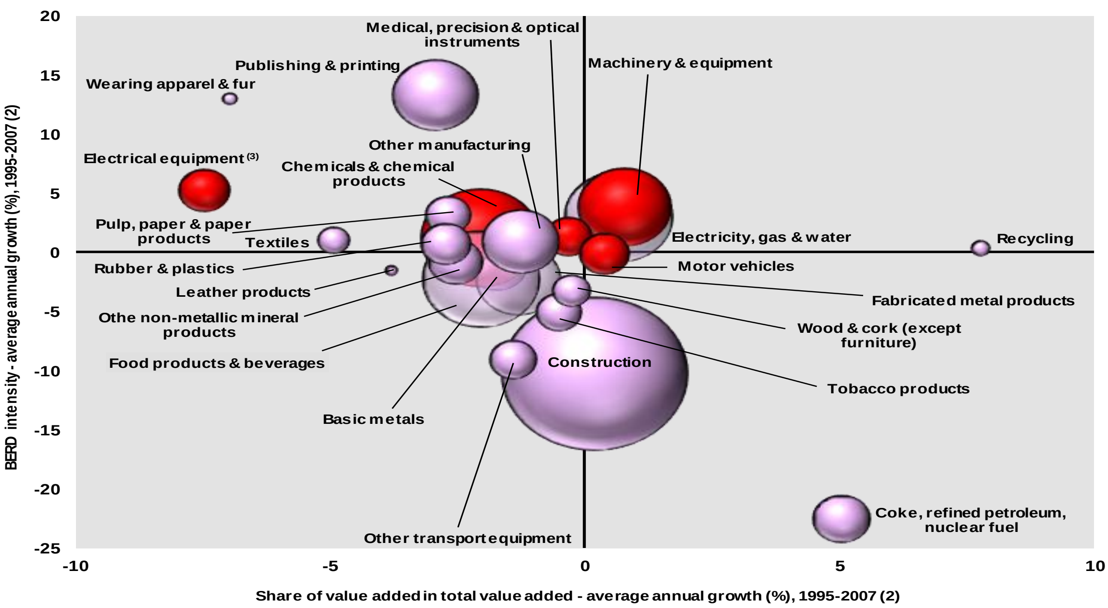
Finally, the Netherlands is fairly advanced in implementing demand-side policy measures, such as the SBIR (Small Business Innovation Research) programme which stimulates the creation or expansion of innovation markets by supporting SMEs in developing innovative products through several stages of procurement contracts. This scheme can be considered as pilot in Europe (a similar scheme exists in South Korea). As a first step, companies submit their proposals for product development. Several companies are funded for half a year to perform feasibility studies. In the light of these studies, three companies are asked to develop their ideas into a marketable product and are subsidised for 18 months with up to € 450 000 each. After that, the procuring authority is free to buy ownership of one of these three products.

[37] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Netherlands - Share of value added versus BERD intensity - average annual growth, 1995-2007



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Other manufacturing': 1995-2006; 'Recycling': 1996-2006; 'Leather products', 'Wearing apparel and fur': 1996-2007. to 2003-2009.
(3) 'Electrical equipment' includes: 'Office, accounting and computing machinery', 'Electrical machinery and apparatus', and 'Radio, TV and communication equipment'.

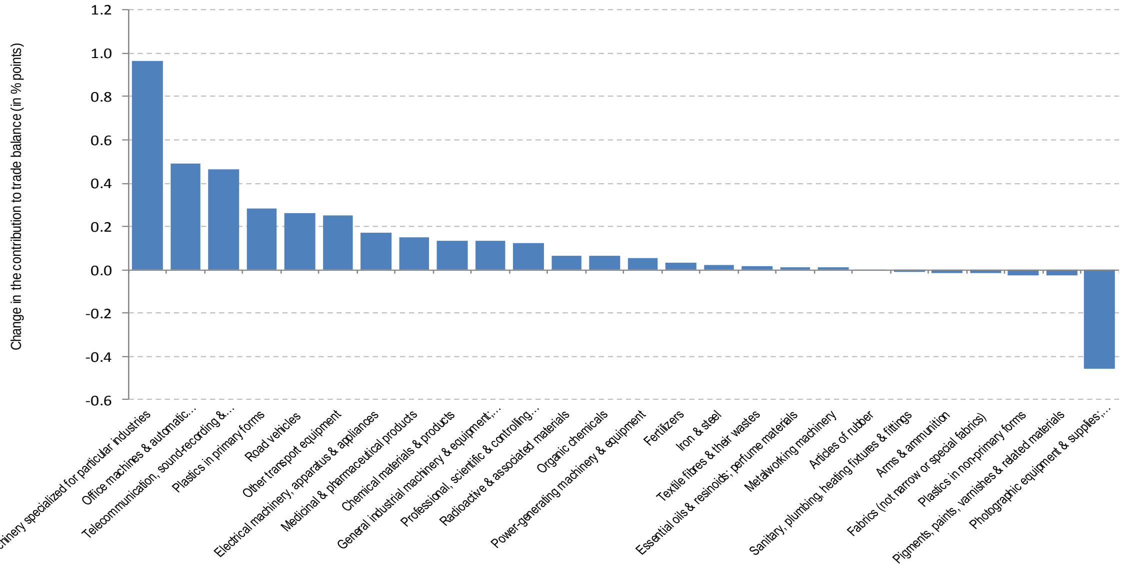
Since the mid-nineties, there have been only few changes in the economic structure. Most manufacturing sectors have had stable or declining R&D intensities. However, positive trends are visible in high-tech and medium-high-tech sectors such as machinery, chemicals, and also in some larger medium-tech sectors such as publishing and printing. In general, the Dutch economic structure is oriented towards the services sector while the manufacturing sector is largely focused on medium-tech and medium-high-tech sectors such as food processing, chemicals, electrical machinery and petroleum refining. In terms of weight in the economy (horizontal axis), the graph above illustrates the decreasing contribution of manufacturing industry to value added in the Netherlands, with many sectors losing relative weight (left-hand side of graph).

The crisis package put forward by the Dutch government with regard to R&D and innovation included measures for leveraging private sector investments. From 2000, private R&D intensity declined in the Netherlands, indicating a shift towards less research-oriented activities. Some medium-high-tech and high-tech sectors have lost importance in the overall Dutch economic structure despite the fact that research investment in various industrial sectors has remained largely stable. The structural development of the Dutch economy is certainly a major concern of the government. One of the main rationales behind top sectors approach is to stimulate knowledge intensive sectors in the economy with a strong competitive position. In the long run this should strengthen the structural composition of the economy.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for The Netherlands between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

In the period 2000-2011 many Dutch industry sectors increased their contribution to the trade balance confirming the important role of the Netherlands in the global markets and its strong export capacities. The most significant improvements took place in various sectors of the machinery industries (i.e. specialised and general industrial, power-generating, electrical, data processing) and in the telecommunication, sound-recording and reproducing apparatus sector led by Phillips. In contrast, the photographic apparatus sector suffered a sharp deterioration of its relative contribution to the trade balance.

Also in real terms, the trade balance of HT and MT products have been growing strongly, although affected by the economic crisis after 2008. The continuing competitiveness of high-tech and medium-tech industries can be explained by the stability of Dutch total factor productivity growth since 2005. The key indicators (table next page) also confirm the excellent S&T results of the Netherlands in international cooperation, in particular in terms of scientific co-publications and license and patent revenues from abroad.

The Dutch economy was deeply affected by the financial and economic crises and underwent a severe contraction in 2009 but the employment rate remains. In total, the progress towards the other Europe 2020 objectives is positive with falling greenhouse gas emissions, a larger share of electricity from renewable energy, a decrease of the population at risk of poverty and a growing share of population having completed tertiary education. As regards technologies contributing directly to societal challenges, the Netherlands patented more environment-related technologies, which is consistent with its progress on environmental objectives. The evolution of health-related technologies fell slightly, but from a high-performance level.

Key indicators for the Netherlands

NETHERLANDS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	1.00	1.04	1.07	1.11	1.18	1.32	1.41	1.54	1.60	1.65	1.87	:	:	6.5	*1.69*	8
Business enterprise expenditure on R&D (BERD) as % of GDP	1.07	1.05	0.98	1.01	1.03	1.01	1.01	0.96	0.89	0.85	0.89	*1,07* (3)	:	*-1.8*	*1.26*	13
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.85	0.88	0.89	0,91 (4)	0.90	0.90	0.87	0.85	0.88	0.96	0.96	*0.98*	:	*0.9*	*0.74*	4
Venture Capital (5) as % of GDP	0.37	0.23	0.20	0.10	0.08	0.16	0.10	0.61	0.28	0.13	0.22	0.34	:	-0.9	0,35 (6)	5 (6)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	69.0	:	:	:	:	78.9	:	:	2.7	47.9	1
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	13.6	13.3	13.3	13.8	14.0	14.3	14.4	15.0	15.1	:	:	:	:	1.3	10.9	1
International scientific co-publications per million population	507	452	494	713	818	886	968	1030	1083	1180	1271	1330	:	9.2	300	4
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	97	101	106	117	128	:	7.2	53	3
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	7.4	8.6	7.0	7.0	7.1	7.1	7.0	6.6	6.5	6.2	:	:	:	-2.0	3.9	5
License and patent revenues from abroad as % of GDP	:	:	:	:	1.78	1.60	1.52	1.75	2.25	2.61	3.15	3.69	:	11.0	0.58	1
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	8.4	:	10.9	:	8.9	:	10.4	:	:	3.8	14.4	18
Knowledge-intensive services exports as % total service exports	:	:	:	:	36.3	37.3	35.2	33.9	32.4	30.7	26.3	:	:	-5.2	45.1	19
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-1.48	-1.98	-0.92	-1.03	-0.69	-0.04	-0.13	0.30	0.01	0.25	0.49	1.68	:	-	4,20 (7)	16.00
Growth of total factor productivity (total economy) - 2000 = 100	100	100	100	100	102	104	105	107	107	103	105	105	105	5 (8)	103	17
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	53.6	:	:	:	:	56.9	:	:	:	:	56.2	:	:	0.5	48.7	7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	16.5	15.4	15,2 (9)	14.9	:	-1.8	13.6	10
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	31.7	:	32.9	:	31.6	:	46.0	:	:	6.4	38.4	5
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.40	0.36	0.41	0.34	0.35	0.32	0.47	0.46	0.49	:	:	:	:	2.3	0.39	6
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.97	1.04	0.92	0.76	0.80	0.89	1.09	0.83	0.88	:	:	:	:	-1.2	0.52	4
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	74.3	75.4	75.8	75.2	74.9	75.1	76.3	77.8	78.9	78.8	76,8 (10)	77.0	:	0.7	68.6	2
R&D Intensity (GERD as % of GDP)	1.94	1.93	1.88	1.92	1.93	1.90	1.88	1.81	1.77	1.82	*1.85*	*2,04* (11)	:	*-0.5*	*2.03*	10
Greenhouse gas emissions - 1990 = 100	101	101	101	102	102	100	98	97	96	94	99	:	:	-2 (12)	85	18 (13)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	2.7	2.7	2.7	3.1	3.4	4.1	3.8	:	:	8.9	12.4	24
Share of population aged 30-34 who have successfully completed tertiary education (%)	26.5	27.2	28.6	31.7	33.6	34.9	35.8	36.4	40.2	40.5	41,4 (10)	41.1	:	4.8	34.6	11
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	16.7	16.0	15.7	14.9	15.1	15.1	15.7	:	-1.0	*24.2*	2 (13)

Source: DG Research and Innovation - Economic Analysis Unit
Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.
(2) EU average for the latest available year.
(3) Break in series between 2011 and the previous years. Average annual growth refers to 2000-2010.
(4) Break in series between 2003 and the previous years. Average annual growth refers to 2003-2011.
(5) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.
(6) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2000.
(9) Break in series between 2010 and the previous years. Average annual growth refers to 2010-2011.
(10) Break in series between 2010 and the previous years. Average annual growth refers to 2000-2009.
(11) Break in series between 2011 and the previous years. Average annual growth refers to 2000-2010.
(12) The value is the difference between 2010 and 2000. A negative value means lower emissions.
(13) The values for this indicator were ranked from lowest to highest.
(14) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Promote innovation, private R&D investment and closer science-business links, as well as foster industrial renewal by providing suitable incentives in the context of the enterprise policy, while safeguarding accessibility beyond the strict definition of top sectors and preserving fundamental research".

Poland

Improving quality of the science base and fostering innovation in enterprises

Summary: Performance in research, innovation and competitiveness

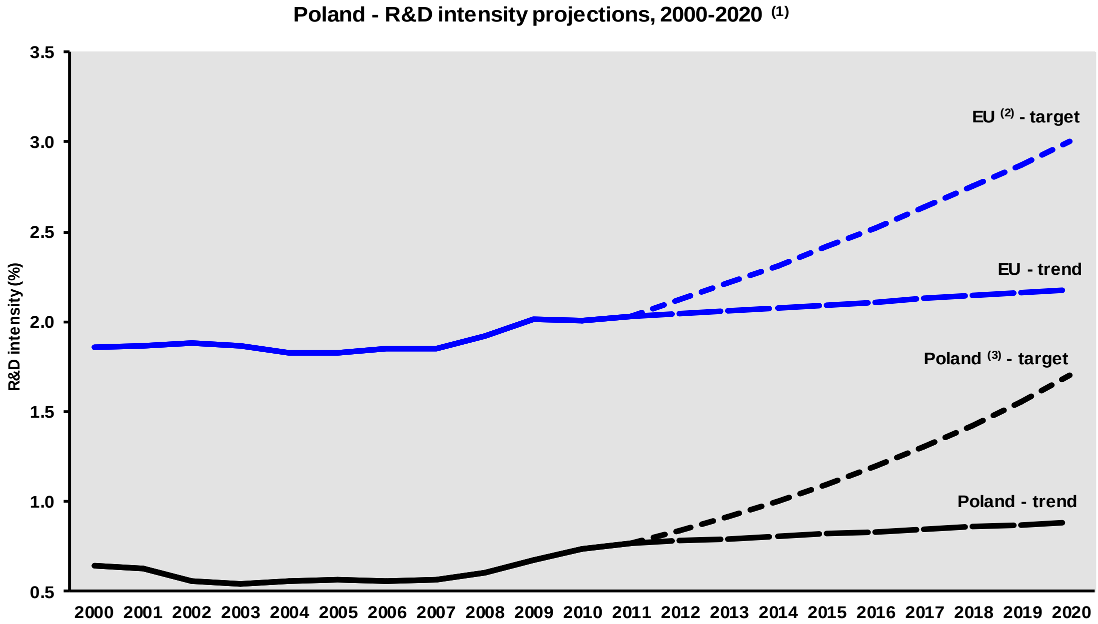
The indicators in the table below present a synthesis of research, innovation and competitiveness in Poland. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.77% (EU: 2.03%; US: 2.75%) 2000-2011: +1.6% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 20.47 (EU:47.86; US: 56.68) 2005-2010: +4.45% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.313 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 31.78 (EU:48.75; US: 56.25) 2000-2010: +1.65% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food, agriculture and fisheries; Energy; Environment; Security; ICT; Materials	*HT + MT contribution to the trade balance* 2011: 0.88% (EU: 4.2%; US: 1.93%) 2000-2011: +37.56% (EU: +4.99%; US:-10.75%)

Since 2000, Poland has increased its investment in R&D and improved its excellence in science and technology (although at a lower rate than EU average), while focusing on key technologies relevant to industry. The economy has been undergoing structural change towards higher knowledge intensity (a 28% improvement since 2000) and Poland's global competitiveness is improving at a higher rate than the EU average. In addition, Polish exports have been growing and Poland has increased its share of high-tech exports by 2% annually over the period 2000-2010. This development seems to reflect the positive effects of large foreign direct investment inflows and the related imports of advanced investment goods that upgraded domestic production structures. Poland scores relatively low on the indicator of contribution of high-tech and medium-tech goods to the trade balance, but the positive value indicates a small comparative advantage and structural surplus in high-tech and medium-tech trade which is growing (0.19 in 2010 and 0.88 in 2011; EU average of 3.54 in 2010 and 4.2 in 2011). However, Poland is still far behind the EU average in terms of investment, excellence and knowledge-intensity in the economy, thus leaving room for further progress, illustrated by the ambitious Polish R&D intensity target for the Europe 2020 strategy.

The Polish R&D system has undergone major restructuring over the last few years. The recent reforms of the science and higher education systems spurred significant changes, including the move towards more competitive funding, the creation of two R&D agencies for applied and basic research and efforts on tackling fragmentation through concentration of funding on the best performing institutions. These changes were dovetailed with the evolution of the governance structure by the establishment of two advisory bodies: the Committee for Science Policy and the Committee for Evaluation of Scientific Institutions. These reforms are bound to bear fruit in the mid to long term. A key challenge for the Polish economy is to maintain high growth and this requires higher innovation and the deployment of new technologies. Measures adopted so far have not led to visible improvement in the innovativeness of Polish companies. Persistently low R&D spending, in particular severe underinvestment in research and innovation in the private sector, and limited cooperation between research and industry call for giving way to a new approach with well-designed incentives and effective support through public funding, including more public-private cooperation.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) PL: This projection is based on a tentative R&D intensity target of 1.7% for 2020.

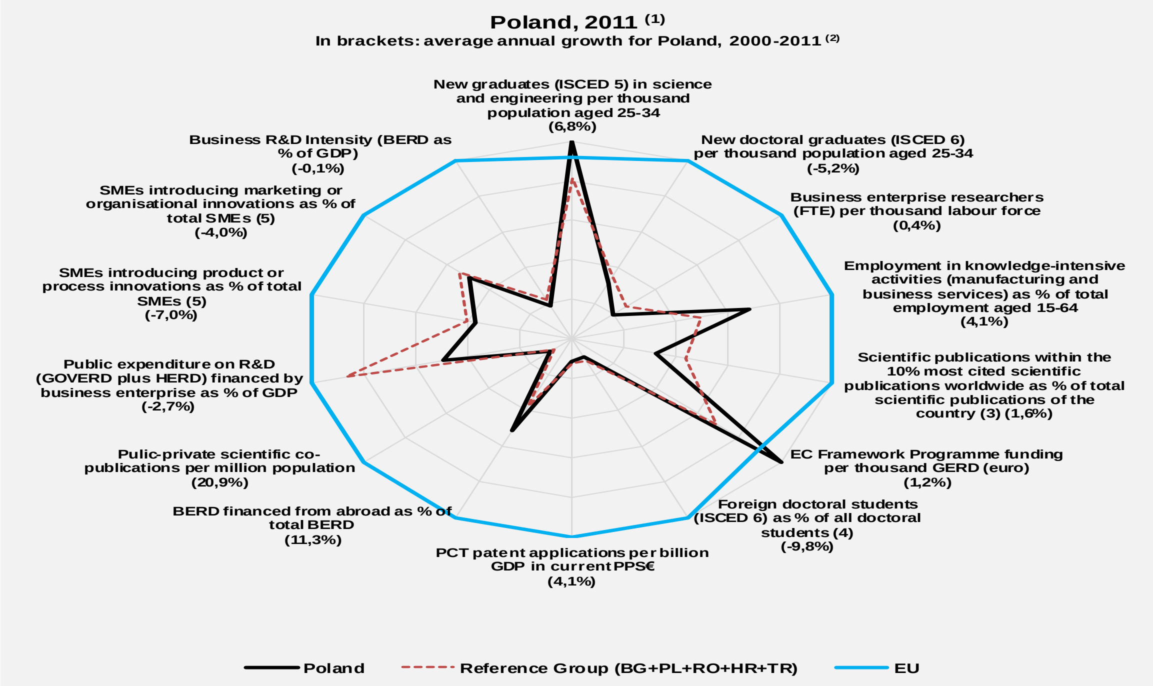
Poland has set an ambitious national R&D intensity target of 1.7% by 2020. Poland's R&D expenditure has grown slowly in recent years and remains low at 0.77 % of GDP in 2011, one of the lowest levels in the EU. Poland's R&D intensity experienced an average annual growth of +1.6% between 2000 and 2011. The average annual increase required to hit the 2020 target is considerably higher at +8.7%. The main weakness remains underinvestment by the private sector. Business R&D expenditure accounts for only 0.2 % of GDP. The breakdown of total R&D expenditure by source of funds and sector of performance illustrate reverse shares in comparison to the EU average. In 2010 the government financed more than 60% of total R&D, while business enterprise financed 24.4% of total R&D and performed 26.6% of total R&D.

Compared to countries with a similar catching-up dynamics as Poland, performance is good. However, the shares of R&D financed by and performed by business enterprise have slightly declined over the 2000-2010 period. In the EU as a whole, business enterprise financed more than 50% of total R&D and performed more than 60% of R&D in 2010. Even if Poland's industrial structure was in line with the average industrial structure for OECD countries, there would only be a slight increase in Polish business R&D intensity. This indicates that Poland's business R&D investment is well below average regardless of sectoral specialisation. These indicators do not reflect yet the efforts undertaken recently to increase public R&D spending and to trigger private sector investment in R&D. The 2012 national research budget grew by around 10% and together with funding provided under the EU structural funds (around 20 % of the overall budget) this makes it Poland's highest R&D budget so far. A further increase of around 3.5% is foreseen in 2013.

Structural funds are an important source of funding for research and innovation activities. Out of the 67 billion euro of structural funds allocated to Poland over the 2007-2013 programming period, around 15 billion euro (22.8% of the total) relate to R&D, ICT, business environment and SMEs. Projects amounting to more than 9 billion euro have been selected up to the end of 2011, representing a commitment rate of 61.2% (the EU average is 46.6%). Polish applicants for funding under the EU's 7th Framework Programme (FP7) have a success rate of 19%. Over 1500 partners from Poland have been participating in FP7 receiving a total EC financial contribution of 286 million euro.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Polish system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) TR is not included in the reference group.

The Polish research and innovation system exhibits a similar performance as comparable countries in the reference group, but in order to progress further towards the EU average Poland should address weaknesses in the innovation cycle - from knowledge production to commercialisation. Poland's relative weaknesses are mostly on the output side and relate to the innovation performance of companies. Its relative strengths are in human resources, where the average annual growth of new graduates in science and engineering exceeds the EU average. However, new doctoral graduates and foreign doctoral students show a decline. Poland has a low intensity of business researchers (less than one per thousand labour force). This reflects the small role that the business sector plays in the national R&D system. On a more positive note, the number of business researchers increased in 2011 and shows a positive average annual growth over the period 2000-2011. Poland is one of the top-20 countries of origin of foreign scholars in the US (2006-08).

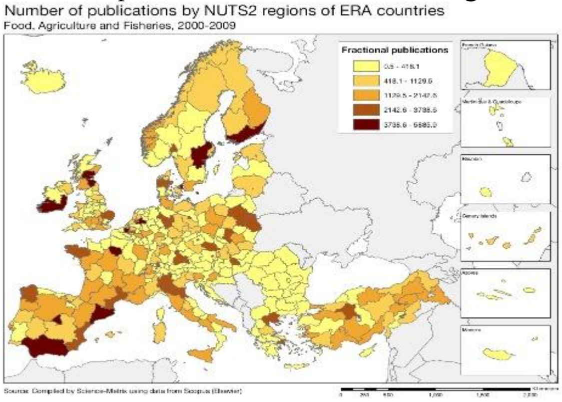
Poland relies on transfer of foreign technology to upgrade its economy. Domestic knowledge production is limited. Poland scores low both in terms of high-impact scientific publications and patent applications, where the gap with the EU average is particularly large. Around 3.7% of Polish scientific publications are in the top 10% most cited scientific publications worldwide. This is the third lowest value among EU countries. The level of public-private co-publications is equally very low highlighting weak linkages and a lack of cooperation culture between science and industry in Poland. While the level of employment in knowledge-intensive activities is one of the lowest in the EU, Poland shows a positive trend with an average annual growth of 4.1 % for this indicator. High growth is observed for the share of knowledge-intensive services exports in total services exports and for BERD and license and patent revenues from abroad (but starting from a very low level). Relatively strong declines are observed for the innovation activities of SMEs. Overall, the low level of R&D expenditure and the low R&D and innovation activity of companies, coupled with insufficiently favourable framework conditions, are reflected in a poor scientific and technological performance.

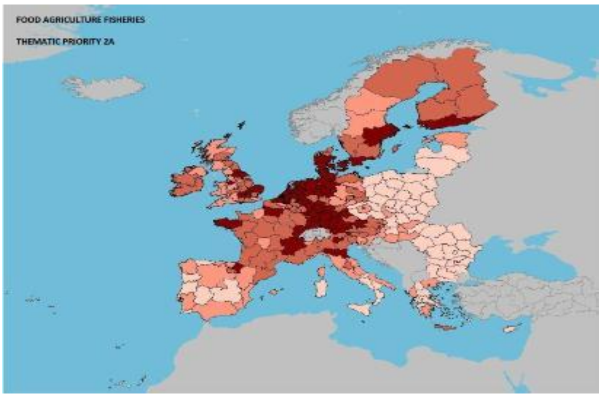
Poland's scientific and technological strengths

The maps below illustrate several key science and technology areas where Polish regions have real strengths in a European context. The maps are based on the numbers of scientific publications and patents produced by authors and inventors based in the regions.

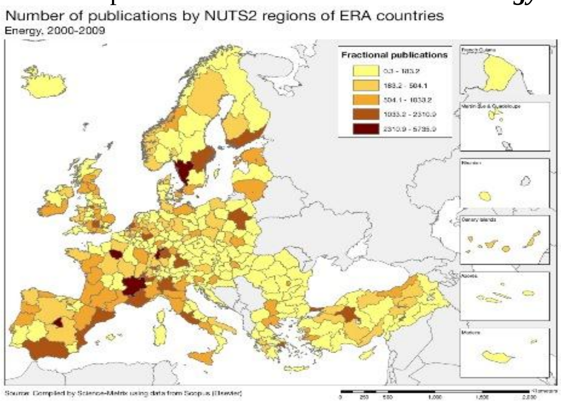
Strengths in science and technology at European level

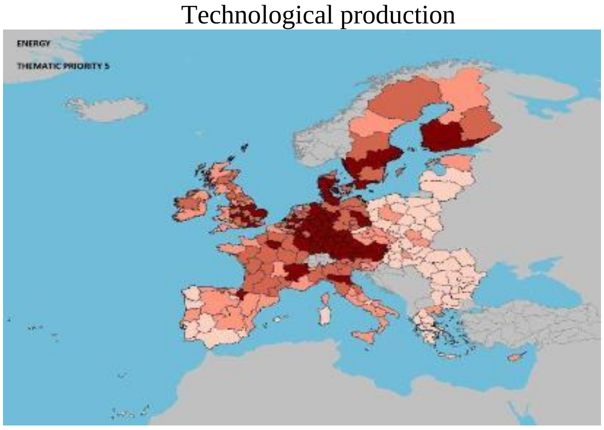
Scientific production **Food, agriculture and fisheries** Technological production



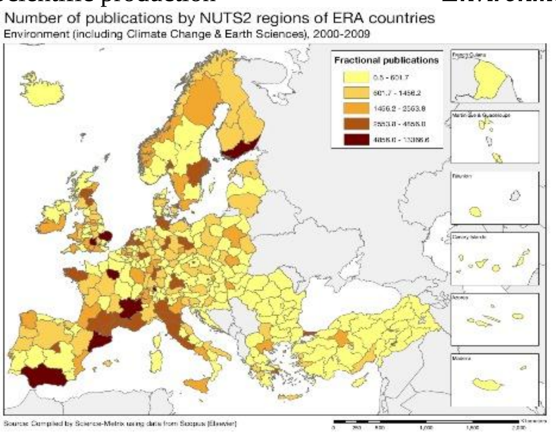


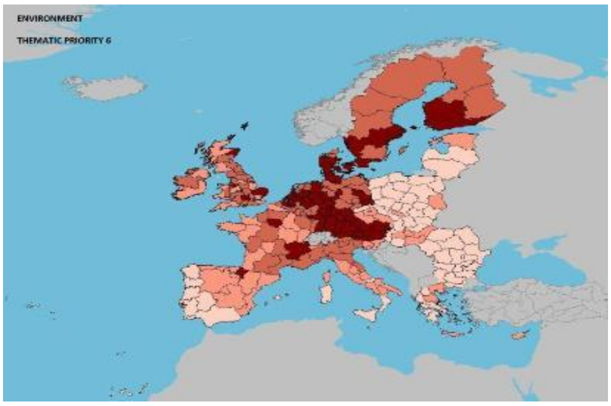
Scientific production ***Energy*** Technological production





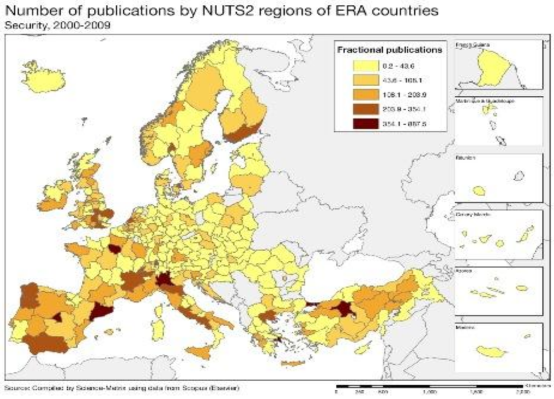
Scientific production ***Environment*** Technological production

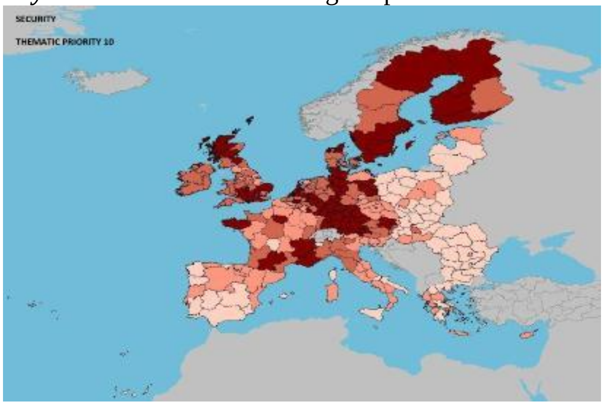




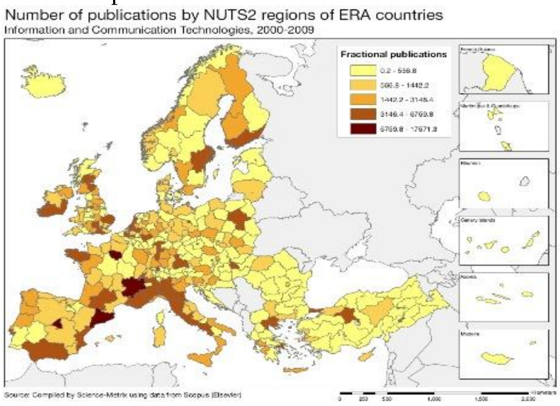
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

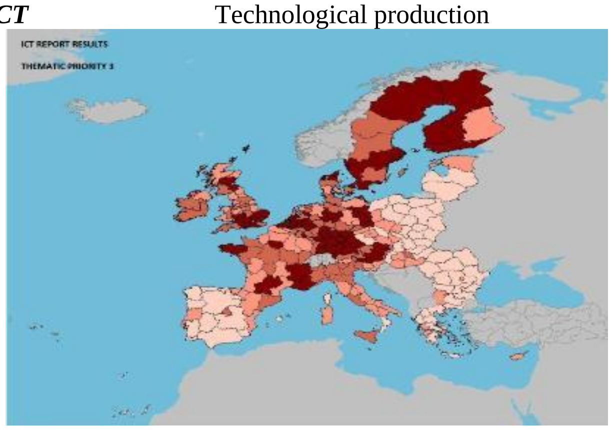
Scientific production **Security** Technological production



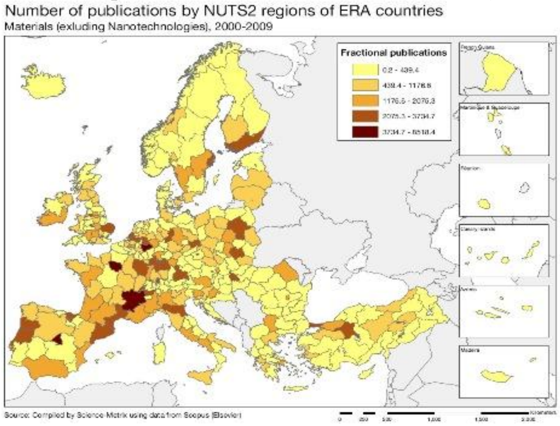


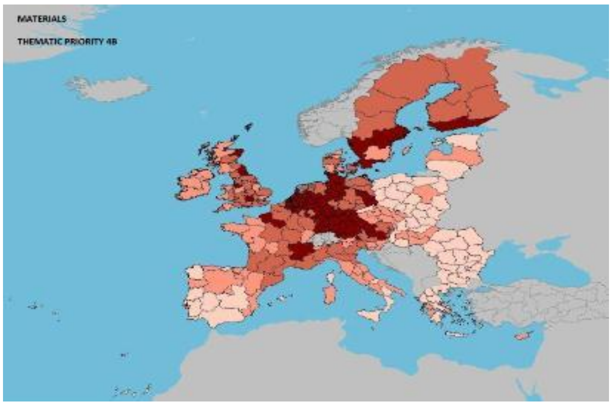
Scientific production **ICT** Technological production





Scientific production ***Materials (excluding nano)*** Technological production





The Polish composite indicator for research excellence is only 35% of the EU average. Performance, of course, varies across sectors. The maps present the sectors in which Poland's scientific and technological production is relatively strong. Interestingly, these sectors largely correspond to the priority areas identified recently in the 2011 National Research Programme (KPB). Poland is therefore focusing its efforts on its strengths. Food, agriculture and fisheries, energy, ICT, and materials are four fields in which Poland's scientific production reaches the highest levels. These strengths are not yet matched on the output side. No Polish region reaches the two highest proxies for technology specialisation in terms of patent applications. This re-affirms the overall finding that Poland has untapped potential in knowledge commercialisation and needs to reinforce its innovation capacity to better translate knowledge into innovative outputs. Poland exhibits low levels of specialisation. The process of consolidating publicly funded research efforts has started only recently.

Policies and reforms for research and innovation

The challenges involved in increasing the quality and effectiveness of the Polish research and innovation system have been addressed by major reforms launched in recent years. The reforms of higher education ("Partnership for knowledge") and science ("Building on knowledge" - package of six reforming acts) entered into force in October 2011 and October 2010 respectively. The reforms spurred significant changes, including a move towards more competitive funding, the creation and reinforcement of two executive agencies for applied research (the National Research and Development Centre - NCBiR) and basic research (the National Science Centre - NCN) and included efforts to tackle fragmentation through concentration of funding on the best performing institutions. These changes were dovetailed with the evolution of the governance structure by the establishment of two advisory bodies: the Committee for Science Policy and the Committee for Evaluation of Scientific Institutions.

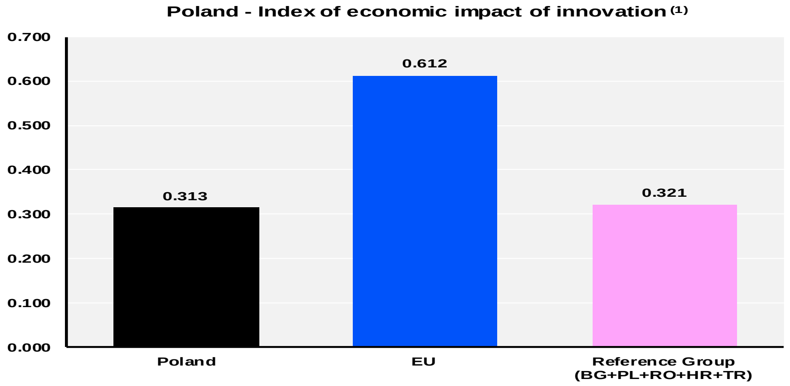
The higher education reform aims to strengthen university-business links and to address the skills and jobs mismatch. The reform aims to make the higher educational system more flexible and better able to respond to the needs of a changing labour market. The first six KNOW (National Leading Scientific Centres) were selected in July 2012. Each of the selected KNOWs will receive up to 50 million PLN additional funding for strengthening research potential and investing in top talent. Good progress has also been made in implementing the science reform six pack. The ministerial decision on the criteria for the evaluation of scientific institutes, after consultations with stakeholders, was adopted in July 2012. Projects run by the applied research agency, NCBiR, focus on stimulating science-industry cooperation, with a cluster initiative in the aviation sector being a good practice example. The Top 500 innovators initiative aims at improving the technology transfer skills of researchers and professionals. It will train up to 500 professionals in the commercialisation of research results and science-industry collaboration. The reforms also included the more effective management and improvement in quality of the Polish Academy of Science (PAN). An example of using the possibilities offered under the new law is the creation of inter-disciplinary centres by research institutes of the PAN.

Poland is also addressing the issue of research fragmentation with initiatives to encourage specialisation outlined in the National Research Programme adopted in August 2011. It identifies seven strategic research and development areas: energy, medicine and pharmaceuticals, IT and advanced technologies, environment and agriculture, socio-economic development, and security and defence. The KPB priorities will be implemented in a series of strategic programmes by the applied research agency. In general, there is a fit between priorities identified in strategic documents and support measures, however further prioritisation and the linking of those priorities with innovation and industrial policies would bring more efficiency, as indicated in the 2012 European Commission assessment of national reform programmes.

The reforms were predominantly designed to correct inherent weaknesses of the Polish R&D system. The new 2020 Innovation and Effectiveness strategy, which will be adopted by the government at the beginning of 2013, aims at an integrated approach to research and innovation embedded in a wider economic context. The strategy builds on previous science and innovation strategies, but is extended to new areas and is rooted in the Europe 2020 strategy and Innovation Union. The strategy is based on a thorough analysis of the strengths and weaknesses of the Polish research and innovation system, including Poland's performance across the Innovation Union Scoreboard's indicators. Given the significant weaknesses in innovative output, the new innovation strategy foresees greater emphasis on financial engineering and demand side measures. Despite various programmes of support, there is still a mismatch between the skills provided by the education system and the needs of industry. A general view voiced by the stakeholders is that the skill shortages relate mainly to innovation, although improving the skills of researchers is also a requirement. This has been a long-standing challenge and different policy responses have been adopted over recent years. The way forward would be to promote new forms of support as a means of fostering closer co-operation between the business sector and HEIs, to improve the mobility and career development of researchers, and to nurture the development of entrepreneurship skills.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[1].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The main challenge for the Polish economy continues to be to enhance investment and innovativeness of Polish businesses, improving the economic impact of innovation. The bar chart above indicates a room for progress for Poland in reaching the EU average, in particular in raising the knowledge and technology intensity of the economy. Poland's main strengths is in the manufacturing trade, where export in high-tech and medium-tech goods give a relatively good contribution to the trade balance. A way forward is to address the dynamics of innovation and growth of firms. In the EU, more than half of the enterprises in the industry and services sectors reported innovation activity between 2006 and 2008. The second lowest rate was observed for Poland which at 27.9% was little over half of the EU average. There is strong awareness of this challenge at national level and support mechanisms have been launched to encourage science-industry cooperation. However, there are persistent structural problems which have resulted in a failure to drive sufficiently private-public collaboration and to stimulate the growth of innovative companies. Structural funds support for R&D&I have been skewed towards absorption of new technologies, and have been less successful in undertaking indigenous research and innovation projects which are inherently more risky. The new innovation strategy identifies these bottlenecks and sets as priorities the stimulation of demand-side measures for innovative products and services and the facilitation of access to finance.

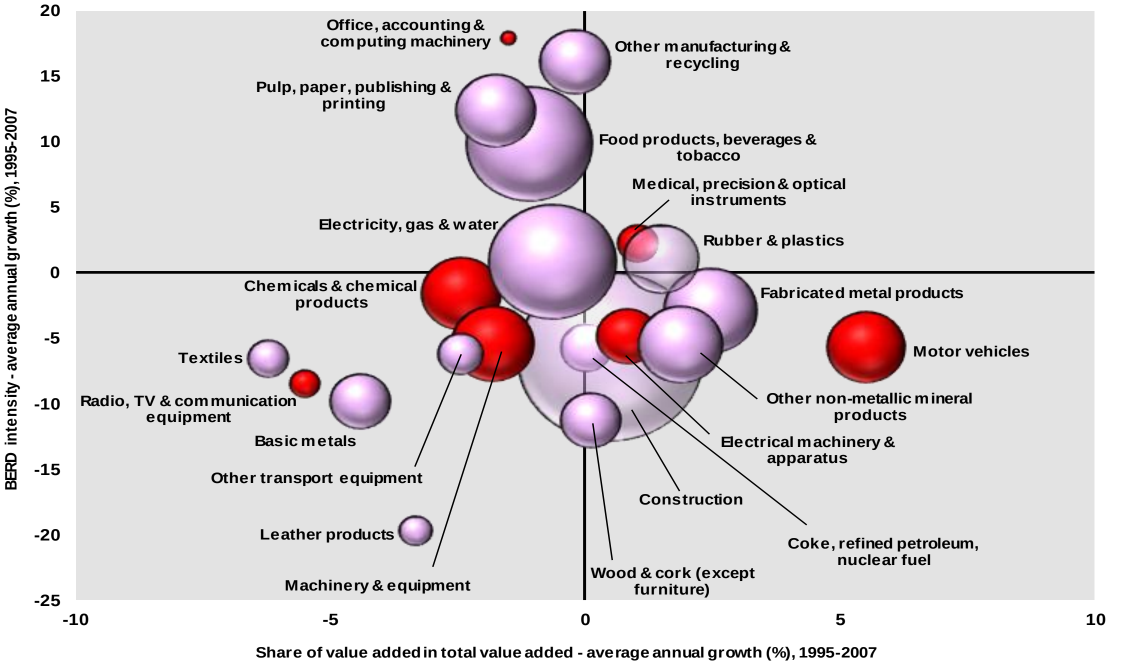
In the CIS 2010 survey, the surveyed Polish companies reported high costs and weak access to finance as the main factors hampering innovation investment. The sectors in Poland with the highest shares of innovative companies are pharmaceuticals (industry sector) and insurance (services sector). Improving the business environment is one of the Polish government's priorities, with two deregulation acts and the entrepreneurship act entering into force in 2012, but the pace of reform is rather moderate. Poland is close to the EU average in terms of access to finance. With the economic crisis spreading in Europe, a decline in the demand for and the number of loans made to SMEs has followed. However, the latest ECB lending survey shows that in 2011 the willingness of banks to provide loans improved in Poland in contrast to the majority of the other Member States. As the venture capital market is still not very developed, the availability of risk capital for innovative companies at early stages of development is limited. The first Polish 'funds of funds', National Capital Fund (KFK), did not become operational until 2010 and it is too early to assess its impact on the development of start-ups and seed capital funds. It is expected that by the end of 2012, the KFK will invest in 22 venture capital funds which in turn will support up to 200 innovative SMEs by 2016. The Polish growth stock market, New Connect, continues to be a best practice example at the European level. It is focused on SMEs with high growth potential, including those investing in new technologies.

[1] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Poland - Share of value added versus BERD intensity - average annual growth, 1995-2007



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Note: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.

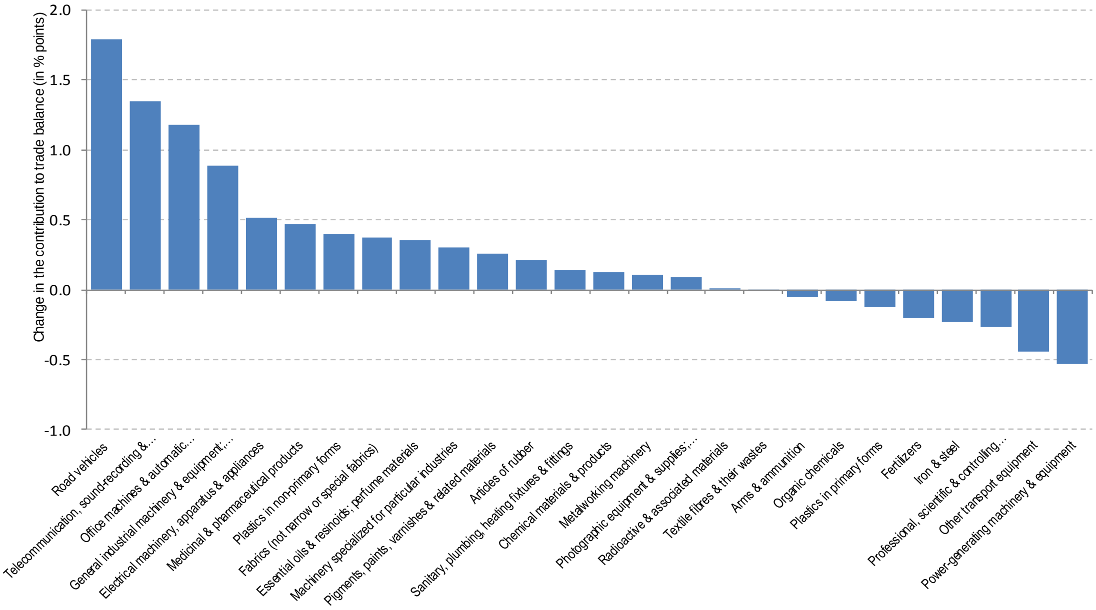
The slight decline of business R&D intensity in Poland in the last decade is mainly due to stagnation of the relative research intensity in high technology sectors and the shift of the economic structure towards less research intensive activities. An exception is the motor vehicles sector, which has gained relative importance in total Polish production in the last decade. Four of the most research intensive sectors, i.e. the machinery and equipment sector, the radio TV and communication equipment sector, the chemicals sector, and the motor vehicles sector suffered from a drop in their relative R&D investments over the value of their production.

This finding suggests that Poland is not moving towards more research intensive, higher value added products in these industries. The two other research intensive sectors: office, accounting and computing machinery and medical, precision and optical instruments, show an increase in their R&D intensities while the medical, precision and optical instruments sector has improved its relative importance in total value added. The above economic structure is reflected in the sectors of activity of the top Polish corporate R&D investors. Poland has seven companies in the 2011 EU Industrial R&D Scoreboard, with companies coming from the fields of telecommunications, banking, computer services and pharmaceuticals. Overall, the relatively stable sectoral composition of Polish industry around low research-intensive sectors reflects Poland's comparative weaknesses in terms of research and innovation performance.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Poland between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Poland's total export of high-tech (HT) and medium-tech (MT) goods grew up to 2008, although the trade balance for HT and MT goods has stayed negative. With a slowdown of imports since 2008, the gap in the HT and MT trade balance remained. However, as overall trade balance in the economy presents a bigger gap which has slightly expanded, the contribution of HT and MT goods to the trade balance has increased for many products.

Overall, Poland has achieved an increasing weight of HT and MT goods in its trade balance, which is noticeable and a potential for structural change. Road vehicles, telecommunications, office machines and industry machinery registered the highest growth in the contribution to the trade balance. The evolution of these goods in the trade balance, confirms the specialisation pattern revealed by their corresponding industry sectors in the bubble graph presented on the previous page. If Poland is to achieve a positive trade balance in HT and MT goods, a more determined knowledge upgrading of a larger span of sectors is needed.

Over the last decade, total factor productivity has grown constantly in Poland. The employment rate has also increased and the share of population at risk of poverty or social exclusion is shrinking. Poland has also made good progress towards the other Europe 2020 targets in environment and education. There are an increasing number of patents in environmental- and health-related technologies.

Key indicators for Poland

POLAND	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	:	0.85	0.83	1.00	0.98	1.00	1.01	1.02	0.92	0.82	0.53	:	:	-5.2	*1.69*	24
Business enterprise expenditure on R&D (BERD) as % of GDP	0.23	0.22	0.11	0.15	0.16	0.18	0.18	0.17	0.19	0.19	0.20	0.23	:	-0.1	*1.26*	23
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.41	0.40	0.44	0.39	0.40	0.39	0.38	0.39	0.42	0.48	0.54	0.53	:	2.4	*0.74*	17
Venture Capital [3] as % of GDP	0.11	0.07	0.05	0.04	0.05	0.04	0.01	0.25	0.20	0.15	0.14	0.19	:	5.0	0,35 [4]	9 [4]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	16.5	:	:	:	:	20.5	:	:	4.4	47.9	21
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	3.1	3.3	3.1	3.1	3.5	3.6	3.5	3.6	3.5	:	:	:	:	1.6	10.9	25
International scientific co-publications per million population	103	99	100	145	166	177	187	190	191	202	203	213	:	6.8	300	24
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	2	3	3	4	5	:	20.9	53	25
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.3	0.3	0.4	0.3	0.3	0.2	0.3	0.3	0.4	0.5	:	:	:	4.1	3.9	21
License and patent revenues from abroad as % of GDP	:	:	:	:	0.01	0.02	0.01	0.02	0.04	0.02	0.05	0.05	:	23.9	0.58	19
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	13.5	:	10.1	:	9.8	:	8.0	:	:	-8.3	14.4	22
Knowledge-intensive services exports as % total service exports	:	:	:	:	21.5	22.6	23.2	22.2	24.5	26.1	26.1	:	:	3.3	45.1	20
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.74	-5.04	-4.64	-4.46	-3.88	-1.99	-0.93	-0.39	0.34	0.45	0.37	0.88	:	-	4,20 [5]	18
Growth of total factor productivity (total economy) - 2000 = 100	100	101	102	106	110	111	114	116	116	114	116	117	117	17 [6]	103	5
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	27.0	:	:	:	:	29.7	:	:	:	:	31.8	:	:	1.6	48.7	24
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	8.2	8.9	9.1	9.3	:	4.1	13.6	22
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	22.2	:	20.4	:	17.5	:	14.4	:	:	-7.0	38.4	26
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.00	0.03	0.02	0.02	0.04	0.03	0.01	0.03	0.06	:	:	:	:	41.0	0.39	19
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.03	0.03	0.03	0.03	0.06	0.05	0.04	0.06	0.06	:	:	:	:	10.3	0.52	20
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	61.0	59.4	57.4	57.1	57.3	58.3	60.1	62.7	65.0	64.9	64.6	64.8	:	0.6	68.6	19
R&D Intensity (GERD as % of GDP)	0.64	0.62	0.56	0.54	0.56	0.57	0.56	0.57	0.60	0.67	0.74	0.77	:	1.6	*2.03*	20
Greenhouse gas emissions - 1990 = 100	84	83	80	83	84	85	88	89	88	83	88	:	:	4 [7]	85	11 [8]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	7.0	7.0	7.0	7.0	7.9	8.9	9.4	:	:	5.0	12.5	17
Share of population aged 30-34 who have successfully completed tertiary education (%)	12.5	13.2	14.4	17.2	20.4	22.7	24.7	27.0	29.7	32.8	35.3	36.9	:	10.3	34.6	15
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	45.3	39.5	34.4	30,5 [9]	27.8	27.8	27.2	:	-3.7	*24.2*	19

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(8) The values for this indicator were ranked from lowest to highest.

(9) Break in series between 2008 and the previous years. Average annual growth refers to 2008-2011.

(10) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:

"Take additional measures to ensure an innovation-friendly business environment, by ensuring better links between research, innovation and industry, and by establishing common priority areas and instruments supporting the whole innovation cycle; improve access to finance for research and innovation activities through guarantees and bridge financing"

Portugal
The challenge of a recovery

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Portugal. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

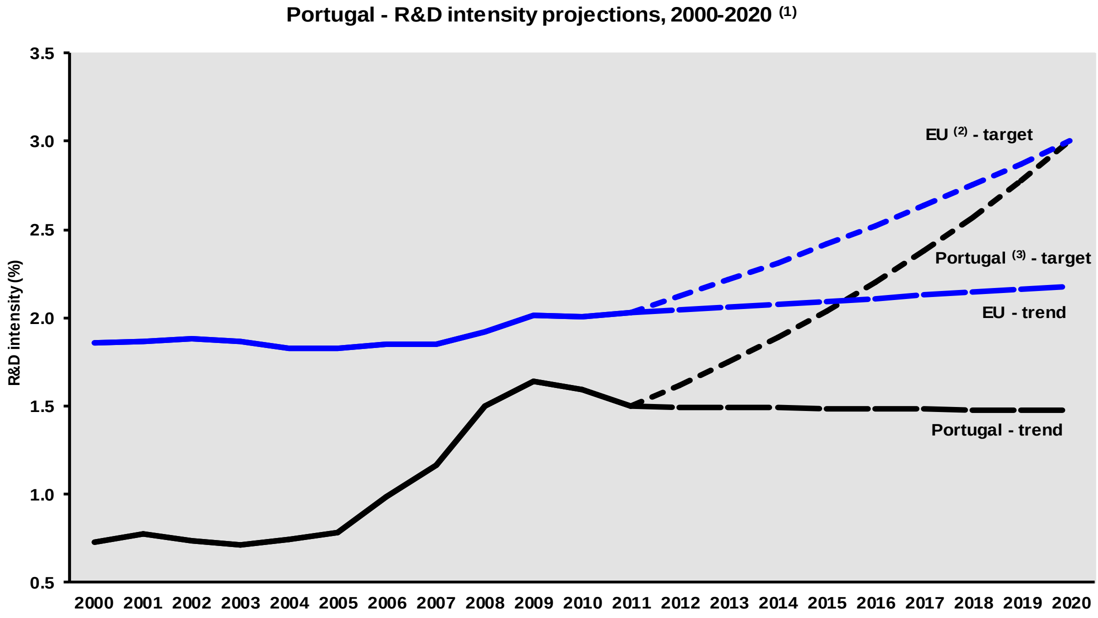
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 1.50% (EU: 2.03%; US: 2.75%) 2000-2011: -0.16% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 26.45 (EU:47.86; US: 56.68) 2005-2010: +4.23% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.387 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 41.04 (EU:48.75; US: 56.25) 2000-2010: +3.18% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food, agriculture, fisheries, Biotechnology, Materials, Environment, ICT	*HT + MT contribution to the trade balance* 2011: -1.2% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

Portugal has expanded its research and innovation system over the last decade, increasing its investment in research at a remarkable average annual real growth rate of 7% between 2000 and 2007. However, R&D intensity in Portugal has decreased by an average of 0.16 % from 2008 to 2011. Public expenditure on R&D was maintained at a level of 0.69% of GDP in 2011, despite the economic crisis. Portugal has also shown notable progress in the number of new doctoral graduates per thousand population aged 25-34 and in the share of researchers in the labour force. Business enterprise investment in R&D grew dramatically, with Portugal nearly quadrupling the intensity of business R&D in its economy between 2000 and 2011. Business enterprise also increased its share as source of funding of GERD from 27% in 2000 to 44% in 2009. These evolutions had a positive impact on scientific production and excellence as well as on innovation, including in SMEs. The knowledge-intensity of the economy has increased by well over the EU average in the period 2000-2010.

However, despite the progress observed on R&D expenditure in the business sector and the large increase in the total number of researchers in recent years, Portugal remains below the EU average in terms of S&T excellence, business enterprise research intensity and business enterprise researchers. Other challenges are the level of education attainment (both secondary and tertiary education), as well as the lower amount of public-private scientific co-publications, PCT patent applications, licence and patent revenues from abroad and knowledge-intensive activities. Some 'traditional' manufacturing sectors like 'leather and footwear' and 'textiles and textile products' lost competitiveness over the last decade and reduced their share in total national added value.

Portuguese policies for research and innovation support adequately the structural change needed by the country to improve productivity and competitiveness and resume growth. The new Strategic Programme for Entrepreneurship and Innovation articulates policies like education, training and employment with the aim of stimulating R&D and Innovation in the scientific system and the business enterprises. New initiatives for research excellence were launched to promote scientific employment of talents and excellent research centres. The Competitiveness Clusters are being rationalised and redirected towards strategic objectives of more competitiveness and an increase in exports and employment. At the same time the programme for applied research and technology transfer to enterprises is being reinforced.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2008-2011 in the case of Portugal.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) PT: This projection is based on a tentative R&D intensity target of 3.0% for 2020.
(4) PT: There is a break in series between 2008 and the previous years.

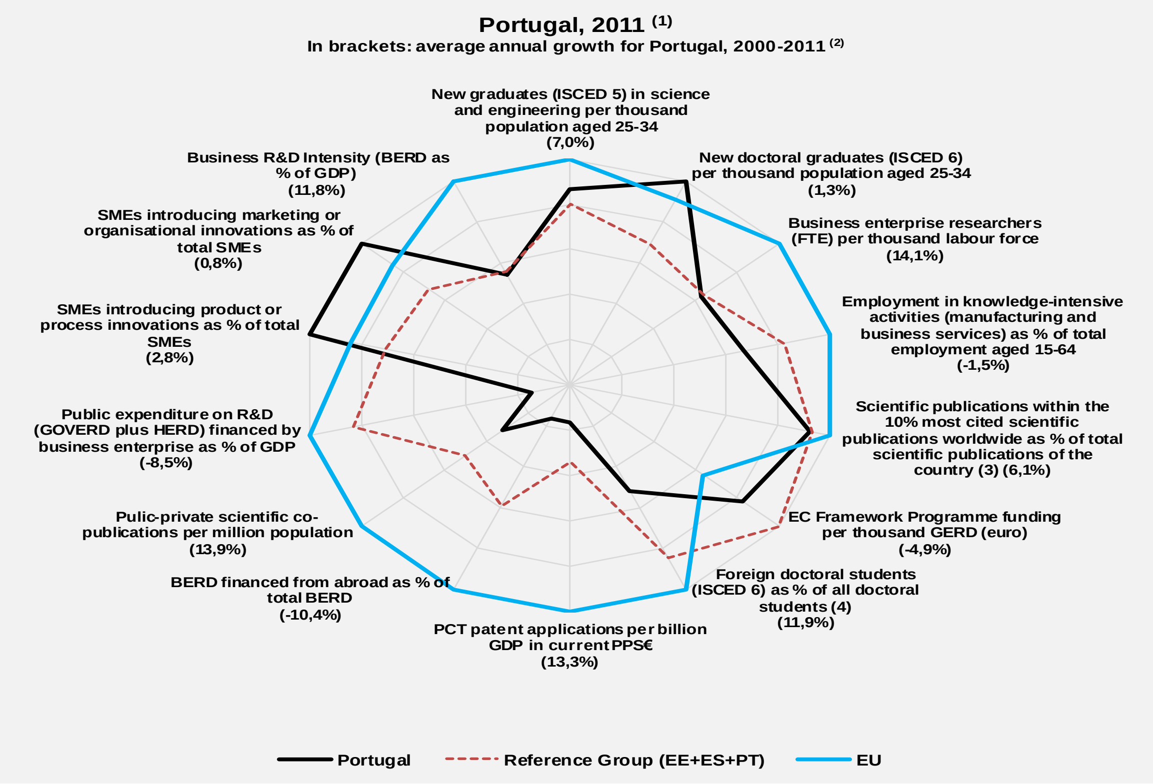
Portugal has set a national R&D intensity target for 2020 of 3%, where public sector R&D intensity would reach 1% and business R&D intensity 2%. From 2005 and up to the crisis, Portugal made a very significant progress towards the R&D intensity target. However, from 2009 onwards, the trend is negative and in 2011, Portuguese R&D intensity had fallen back to 1.50%, with a public sector R&D intensity of 0.69% and a business R&D intensity of 0.69%.

The main challenge for Portuguese R&D, therefore, is to increase the share of business R&D investment in total national R&D investment and to attract foreign business R&D investment. R&D investment has slightly decreased, affected by the economic crisis. Business R&D investment reached its highest level in 2009 in absolute terms and in relative terms after some years of notable growth. The difficult national business environment and the contraction of domestic demand places enterprises in the position of having to find external markets while facing challenges in terms of efficiency (productivity and competitiveness) and financing. The efforts of investing in innovation and research, increasing productivity and competitiveness, point in the good direction. Public funding of R&D has been sustained, despite the pressures created by public expenditure reduction.

Private and public R&D investment also receives support by co-funding from the European budget, in particular through the Structural Funds and from successful applications to the Seventh Framework Program for research. For the FEDER programming period 2007-2013, Portugal benefits from funding of € 5729 million (26.8% of the total allocated to Portugal) for research, innovation and entrepreneurship in the Portuguese regions. In 2010, Portugal had already absorbed 62.5% of these EU funds (the average in the EU was a 46.6% commitment rate). Portugal also has scope to increase its funding of R&D from the 7th Framework Programme. The success rate of Portuguese applicants is 19.1%, lower than the EU average success rate of 21.6%. By early 2012, slightly over 1300 Portuguese participants had been partners in an FP7 project, with a total EC financial contribution nearing € 283 million. Two Portuguese SMEs are among the top twenty SMEs having the highest numbers of FP7 signed grant agreements for the period 2007-2010.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Portugal's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The graph shows in broad terms that the big increase in R&D investment over the period 2000-2011 has triggered a stronger human resources component, higher scientific quality and some innovation but with less progress on technology valorisation. All in all, while good progress is made on human resources, science and business innovation, Portugal remains below the EU average on technology development, business R&D and the knowledge-intensity of the economy.

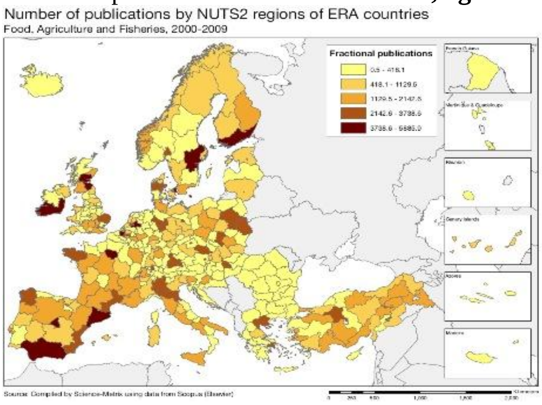
In the field of human resources for research and innovation, Portugal is achieving notable progress on numbers of new doctoral graduates and on researchers employed by business. This is the consequence of strong public incentives. However, the share of employment in knowledge-intensive activities has not followed the same trend, reflecting a weakness as regards its capacity to move towards more knowledge-intensive domains. The quality of scientific production improved significantly as reflected by an average annual growth rate of 6.1% in the share of national scientific publications in the 10% most cited scientific publications worldwide. As seen in the graph above, overall technology development is well below the EU average, although the level of PCT patent applications per billion GDP shows remarkable progress for the period 2000-2009. Product or process innovations in SMEs are at a good level, having increased substantially over the last decade.

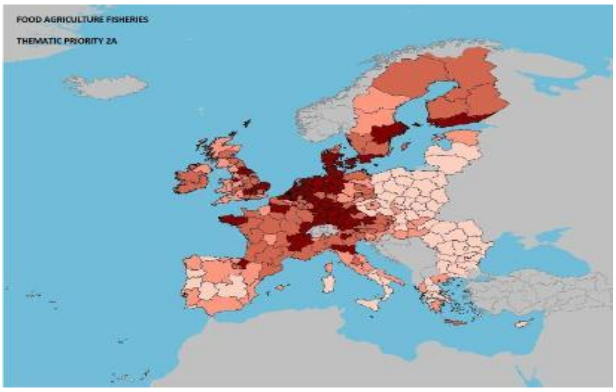
Portugal's scientific and technological strengths

The maps below illustrate several key science and technology areas where Portuguese regions have real strengths in a European perspective. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

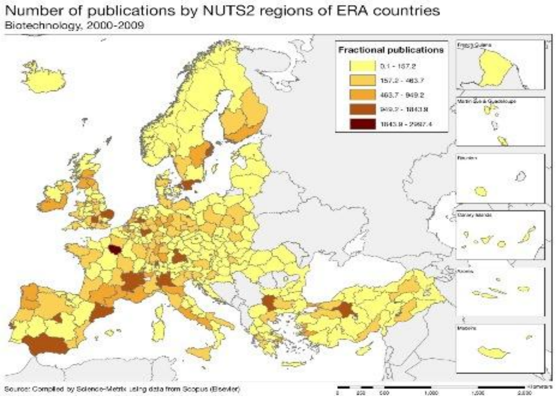
Strengths in science and technology at European level

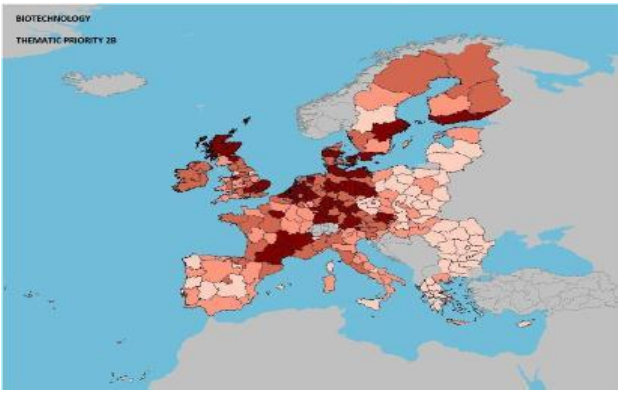
Scientific production **Food, agriculture and fisheries** Technological production



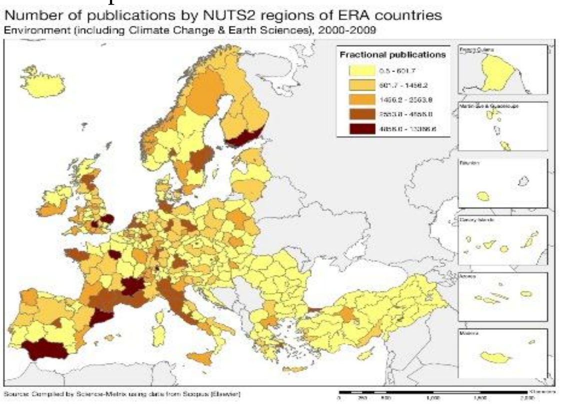


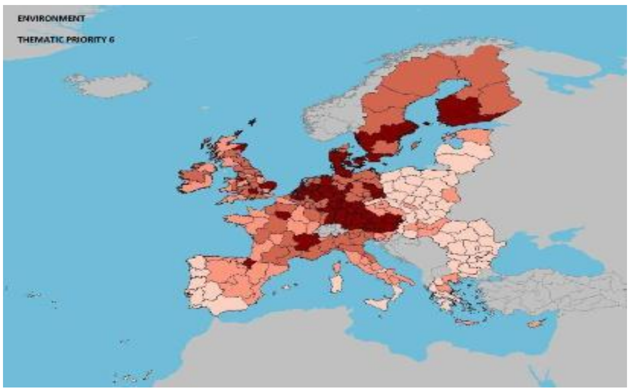
Scientific production **Biotechnology** Technological production





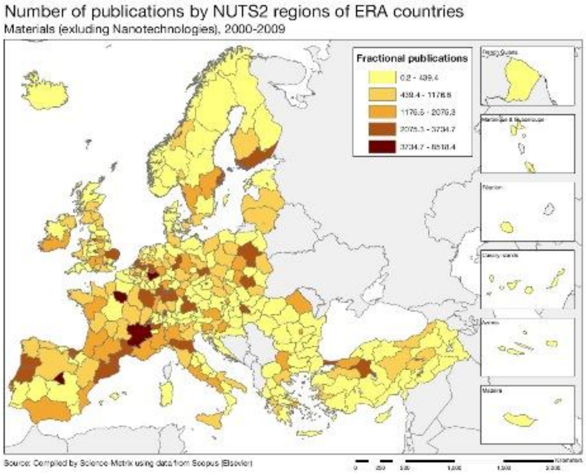
Scientific production **Environment** Technological production

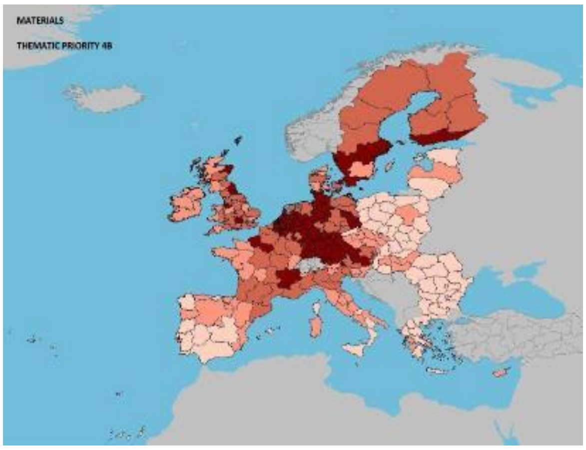




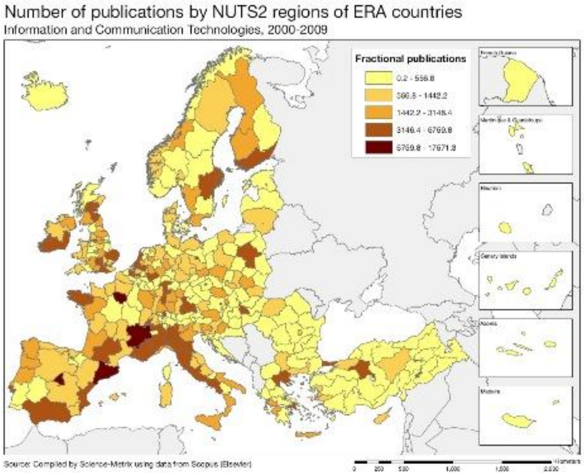
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

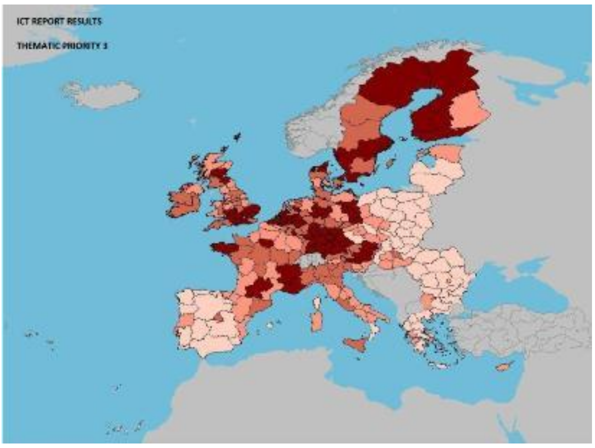
Scientific production **Materials** Technological production





Scientific production **Information and Communication Technologies** Technological production





Portugal, in terms of scientific production, has stronger capacity in the fields of health, food, agriculture and fisheries, ICT, materials, biotech, production and transport. The scientific specialisation index, covering the period 2000-2009, shows higher values in the fields of food, agriculture and fisheries, ICT, materials, production, construction, transport, biotech and security.

Regional diversity in scientific production and excellence is a reality, particularly for health, biotech, ICT and materials with the region of Lisboa taking the lead, followed by Norte and Centro. However, in areas such as food, agriculture and fisheries and environment participation from other regions is more evident. Scientific excellence, as shown by the impact of scientific publications in terms of citations, is shown to be particularly high for food, agriculture and fisheries, materials, energy, environment and transport.

Notwithstanding the diversification of S&T, as shown by the indicators above, the innovation base could be further strengthened by focusing more on some scientific areas that would improve the quality of technological output, such as biotech, food, agriculture and fisheries, materials, environment and ICT.

Policies and reforms for research and innovation

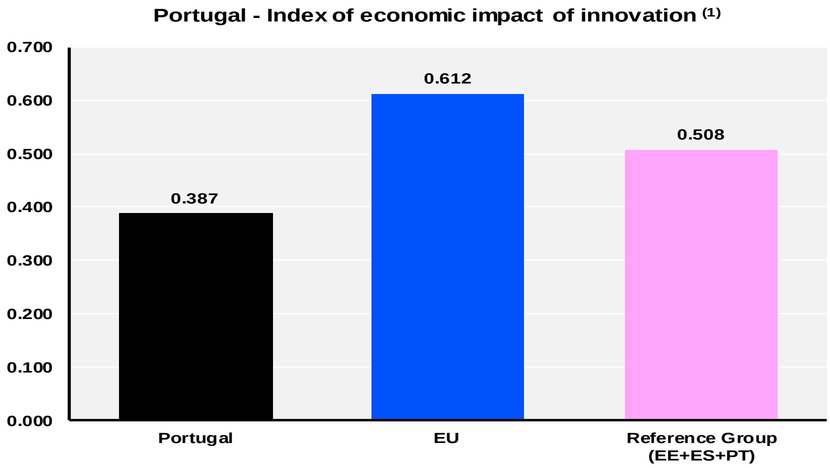
R&I policy is characterised by a large political consensus and continuity over time that allowed for significant progress from a relatively low base. Long term consistency has proved to be a positive determinant in ensuring the consolidation of the research system. However, the need to pursue a very tight budgetary policy has caused some changes. In 2012, for the first time since the economic crisis, the government budget for R&D has decreased. The budget for the Science and Technology Foundation (FCT) decreased by € 42 million between 2011 and 2012, but from a rather high level. In 2012, the FCT launched a call for proposals for 80 scientists, both Portuguese and foreign nationals, to carry out research in Portugal. New calls will be announced to the coming years. This initiative aims to consolidate the pool of high level scientists working in Portugal. A call for research projects in all scientific domains was also launched following a very similar line to those launched by previous governments. Initiatives have also been launched on doctoral and post-doctoral grants. Financing and evaluation of R&D institutions have been made in different scientific areas on a competitive basis and using new excellence-based demand criteria.

Over recent decades, Portuguese research policy has been horizontal in nature and has covered a broad spectrum. Despite the implementation of a number of recent initiatives addressing more targeted objectives and industry-academia interaction, the fact remains that part of the research carried out in the higher education, government and private non-profit sectors is still essentially organized according to academic criteria and responds to academic incentives. There are, however, signs that ‘targeted and thematic funding’ has been increasing in recent years. Examples are the ‘International partnerships’, addressing well defined areas, such as energy, advanced computation, security and health, the creation of the Iberian Nanotechnologies Laboratory, and the ‘Commitment to Science’ initiative that had identified some specific areas that research should address. Some initiatives are indicative of the future R&I policies of Portugal, e.g. the greater emphasis on competition for funding beyond Portuguese strategic funds, or the renewal of the Carnegie Mellon-Portugal programme to a second phase with a change of the main focus from education and training to entrepreneurship and innovation.

The new Strategic Programme for Entrepreneurship and Innovation (E+I+) includes several measures which are aiming to improve the connections between the two areas of "innovation" and "research". These include: (1) promoting experimentation in basic and secondary education; (2) education for entrepreneurship; (3) promoting the transition of PhD holders to non-academic careers, (4) improving the "articulation" of technology transfer units; (5) encouraging the economic exploitation of scientific knowledge; (6) launching of scientific thematic/priority programmes; (7) support for patent registration and licensing; and (8) a host of initiatives to encourage entrepreneurship. The programme of the new government specifies the "encouragement of the integration of Portugal's scientific system in the European Research Area". This will be achieved through an increased participation of Portuguese companies and research organisations in EU Framework Programmes and by supporting industrial research through public-private collaborations. The Strategic Programme for Entrepreneurship and Innovation (E+ I+) also includes a measure aimed at supporting the participation of Portuguese companies in international R&D programmes.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[2].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The index of economic impact of innovation shows that Portugal is lagging slightly behind in terms of orienting its economy towards innovative and knowledge-intensive sectors. This is of course partly attributable to the severe economic crisis. However, the scale of the gap also points at more structural problems.

Portugal's overall performance in innovation is moderate also according to the IUS report. Although there is a high share of SMEs introducing innovations, exports and employment in high-tech sectors and knowledge-intensive services are particularly weak, showing the difficulty for innovative firms to positioning themselves in markets with high potential for growth. This weakness is recognised and a strategic programme to promote entrepreneurship and innovation, 'E+I+', was introduced at the end of 2011, leading to the creation of a National Council for Entrepreneurship and Innovation and the launch of competitions for innovation and R&D projects to be implemented by micro and SMEs in cooperation with universities and research institutes. Standards on innovation management and guidelines for the valorisation and protection of IPR are being developed. Various measures were adopted to reduce the constraints on credit conditions and to promote the internationalisation and exports of SMEs. The on-going "Digital Agenda 2015" is progressing well, leaving Portugal with one of the most advanced broadband networks in the EU.

If the analysis is not limited to innovative enterprises but refers to all fast-growing firms, it reveals that Portugal's share of high growth[3] enterprises (in terms of employment) in the total of active enterprises was 2.70% for micro enterprises and 3.26% for somewhat larger enterprises (10 employees or more) in 2009. These values are lower than the 2008 values, at a similar level to Spain but lower than Estonia and the Czech Republic. If fast-growing firms are measured in terms of turnover, the values for Portugal for 2009 are higher (4.45% and 6.38%, respectively) which seems to indicate that a critical size (in terms of employment and/or turnover), let alone other important factors, is an important factor in the growth of enterprises. The share of fast-growing enterprises by sector is much higher when measured in terms of turnover than in terms of employment. In 2009 the shares of high growth enterprises in the construction sector, in terms of turnover, were 8.27% (5 to 9 employees) and 11.95% (10 employees or more), whereas in terms of employment the corresponding shares were much more modest at 2.90% and 3.35%, respectively.

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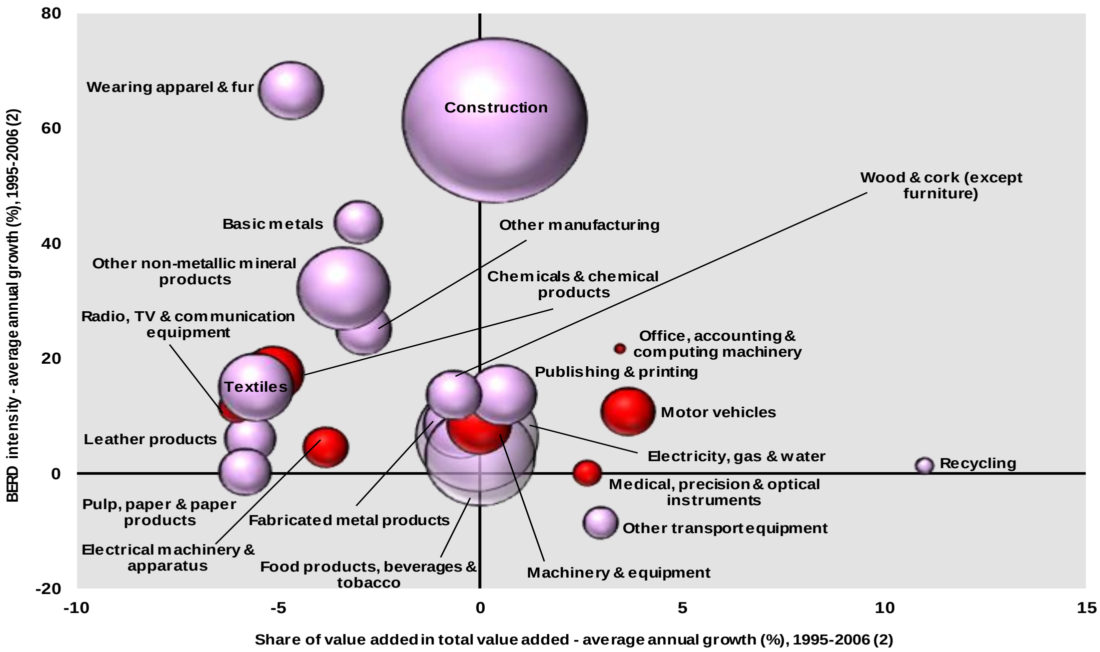
[2] See Methodological note for the composition of this index.
[3] Enterprises with average annualised growth greater than 20% per annum over a three year period.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Portugal - Share of value added versus BERD intensity - average annual growth, 1995-2006



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Food products, beverages and tobacco': 1995-2005; 'Wearing apparel and fur': 1996-2006.

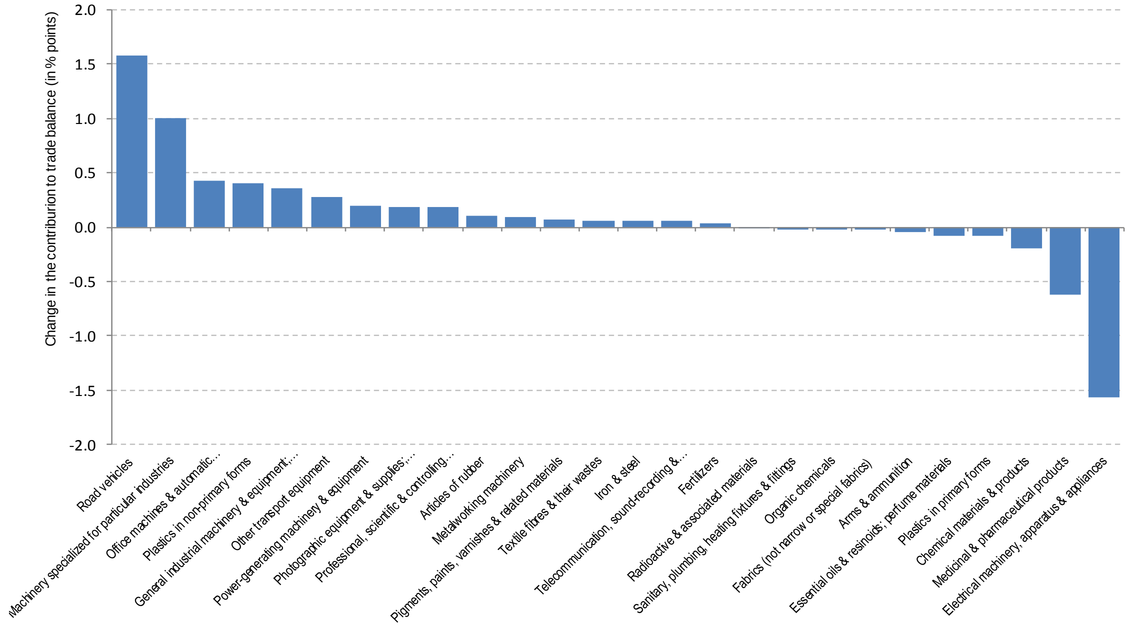
For a small country like Portugal, the road to growth leads to an extended market beyond the national boundaries, where competition must be confronted with high quality actors in sectors providing more value added. This requires reinforcing the capacity of enterprises to move into more high-tech and medium-high-tech sectors. Portugal has scope to upgrade the knowledge intensity in new areas of industry and in 'traditional' sectors by integrating more R&D with creativity, design, etc. The graph above shows a general picture of manufacturing sectors over the pre-crisis period 1995-2006, showing reduced shares of value added but increased BERD intensities for most of the sectors. In particular, textiles, leather products and other non-metallic mineral products, lost important positions. Wearing apparel and fur, despite a growth in R&D intensity over the period, lost an important share of value added, which can be explained by factors such as aggravated price competitiveness loss. Construction (a non-exposed sector) continues to play an important role in manufacturing value added with a very high growth rate of R&D intensity. The growth in the shares of value added for motor vehicles, and medical, precision and optical instruments is encouraging.

The 2011 EU industrial R&D scoreboard, ranking the top 1000 companies investing in R&D, shows that the top Portuguese companies are in the telecommunications, banking and electricity sectors. Just a year earlier pharmaceuticals and construction were also among the top sectors.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Portugal between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Over the last decade, Portugal has had large current account and trade balance deficits, reflecting the overall weak competitiveness of the majority of enterprises. The graph above shows the changes, from 2000 to 2011, of the contributions of various industries to the national trade balance. The highest positive variation occurred in machinery specialized for particular industries. The second highest positive variation is in road vehicles (including air-cushion vehicles), which passed from a negative contribution in 2000 to a positive contribution in 2011. The next positive variation is in plastics in non-primary forms (this industry had a positive trade balance since 2007). On the negative variations, the highest occurred for electrical machinery, apparatus and appliances, and electrical parts. Medicinal and pharmaceutical products and other transport equipment also had negative variations. Industries that contributed positively to the trade balance throughout the decade are: sanitary, plumbing and heating fixtures and fittings and fabrics, woven, of man-made textile materials.

Total factor productivity is lower than a decade ago (see Table below) and the share of employment in knowledge-intensive activities is also relatively low. Labour productivity increased over the same period, but only slightly. Enterprises need to further integrate new technologies and strive to develop new products, processes and services that may provide higher added value for their activities.

Concerning the other EU 2020 objectives, Portugal is progressing well in particular in relation to increasing the share of renewable energy in total energy consumption and the share of population having completed tertiary education.

Key indicators for Portugal

PORTUGAL	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	1.62	1.79	1.88	2.30	2.43	2.53	3.25	3.68	2.99	2.72	1.85	:	:	1.3	*1.69*	9
Business enterprise expenditure on R&D (BERD) as % of GDP	*0.20*	0.25	*0.24*	0.24	*0.27*	0.30	*0.46*	0.60	0.75	0.78	0.73	*0.69*	:	*11.8*	*1.26*	17
Public expenditure on R&D (GOVERD + HERD) as % of GDP	*0.45*	0.44	*0.41*	0.39	*0.39*	0.39	*0.43*	0.46	0,63 [3]	0.72	0.70	*0.69*	:	*3.0*	*0.74*	10
Venture Capital [4] as % of GDP	0.11	0.06	0.04	0.08	0.10	0.14	0.05	0.12	0.23	0.14	0.12	0.21	:	6.3	0,35 [5]	6 [5]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	21.5	:	:	:	:	26.5	:	:	4.2	47.9	18
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	6.2	7.3	7.3	7.2	8.0	9.2	8.9	9.3	10.0	:	:	:	:	6.1	10.9	14
International scientific co-publications per million population	150	148	176	250	299	331	402	423	498	532	600	678	:	14.7	300	15
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	10	11	12	14	17	:	13.9	53	19
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.2	0.2	0.2	0.3	0.3	0.5	0.5	0.5	0.6	0.6	:	:	:	13.3	3.9	19
License and patent revenues from abroad as % of GDP	:	:	:	:	0.01	0.02	0.04	0.04	0.03	0.06	0.02	0.03	:	8.2	0.58	23
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	10.0	:	13.3	:	15.6	:	14.3	:	:	6.1	14.4	11
Knowledge-intensive services exports as % total service exports	:	:	:	:	21.1	22.8	26.5	28.5	28.7	28.9	29.0	:	:	5.4	45.1	14
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-3.61	-3.12	-2.74	-2.28	-2.28	-2.36	-1.47	-1.66	-1.30	-2.98	-3.50	-1.20	:	-	4,20 [6]	20
Growth of total factor productivity (total economy) - 2000 = 100	100	99	98	97	98	98	98	100	99	97	99	99	99	-1 [7]	103	24
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	30.0	:	:	:	:	35.4	:	:	:	:	41.0	:	:	3.2	48.7	17
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	8.8	8.8	8.6	9,1 [8]	:	-1.5	13.6	23
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	38.6	:	38.7	:	47.7	:	45.6	:	:	2.8	38.4	6
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.02	0.01	0.00	0.01	0.01	0.06	0.05	0.05	0.05	:	:	:	:	10.0	0.39	20
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.05	0.06	0.08	0.06	0.04	0.09	0.08	0.09	0.10	:	:	:	:	8.2	0.52	19
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	73.5	73.9	73.6	72.9	72.6	72.3	72.7	72.6	73.1	71.2	70.5	69,1 [9]	:	-0.4	68.6	13
R&D Intensity (GERD as % of GDP)	*0.73*	0.77	*0.73*	0.71	*0.74*	0.78	*0.99*	1.17	1,50 [3]	1.64	1.59	*1.50*	:	*-0.2*	*2.03*	14
Greenhouse gas emissions - 1990 = 100	137	139	146	137	141	144	136	132	130	124	118	:	:	-19 [10]	85	24 [11]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	19.2	19.6	20.8	22.0	23.0	24.6	24.6	:	:	4.2	12.5	5
Share of population aged 30-34 who have successfully completed tertiary education (%)	11.3	11.7	13.0	14.9	16.5	17.7	18.4	19.8	21.6	21.1	23.5	26.1	:	7.9	34.6	21
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	27.5	26.1	25.0	25.0	26.0	24.9	25.3	25.3	:	-1.4	*23.4*	17 [11]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2008 and the previous years. Average annual growth refers to 2008-2011.

(4) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(5) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(6) EU is the weighted average of the values for the Member States.

(7) The value is the difference between 2012 and 2000.

(8) Break in series between 2011 and the previous years. Average annual growth refers to 2008-2010.

(9) Break in series between 2011 and the previous years. Average annual growth refers to 2000-2010.

(10) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(11) The values for this indicator were ranked from lowest to highest.

(12) Values in italics are estimated or provisional.

Romania

The challenge of improving policy coordination of R&I and upgrading the economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Romania. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

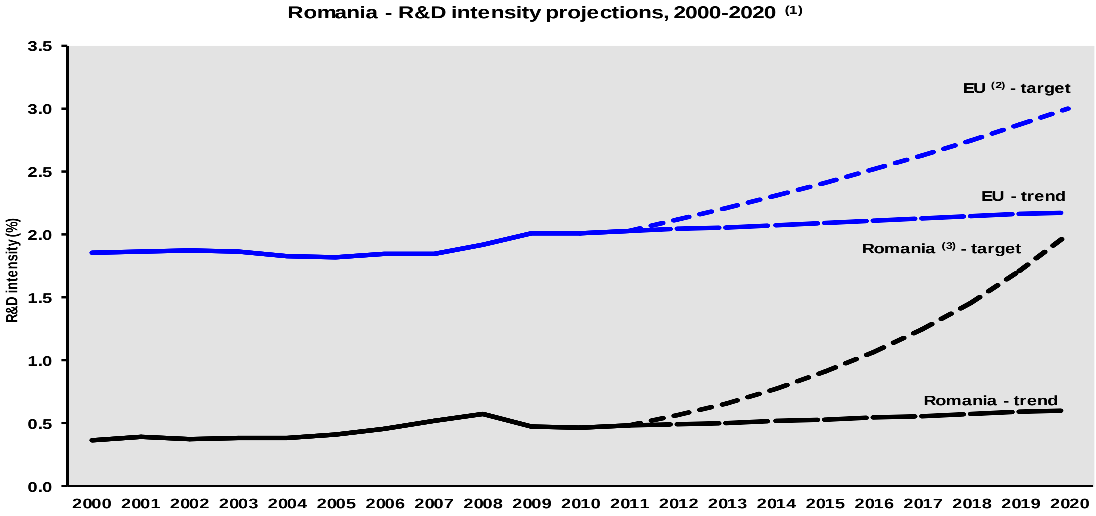
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.48% (EU: 2.03%; US: 2.75%) 2000-2011: +2.53% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 17.84 (EU:47.86; US: 56.68) 2005-2010: +7.81% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.384 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:28.35 (EU:48.75; US: 56.25) 2000-2010: +5.86% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Automobiles, ICT, New production technologies, Nanotechnologies, and Security	*HT + MT contribution to the trade balance* 2011: 0.38% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

The reform of the Romanian R&I system has been under way over the last decade. A National Strategy for Research and Innovation 2007-2013 is in place. However the economic crisis has hampered its full implementation due to massive cuts in the public budget for R&D. It is noteworthy that Romanian authorities decided to support large projects such as the European Light Infrastructure (ELI) in order to make the most of extremely reduced investments in R&D. At the same time, some Romanian scientific journals have acquired an increasing international visibility and Romanian scientific publications have improved in overall quality. Institutional reforms of universities and research institutes are on-going.

The key challenge for Romania is its low level of competitiveness, a challenge which has significant consequences for the R&I system. Romania's economy is characterised by the prevalence of low- and medium-technology sectors, with a weak demand for knowledge and an underdeveloped innovation culture. Romania is ranked as a modest innovator and has the lowest R&D intensity in the EU and a very low level of business R&D activity. To complete the picture of poor innovation, the Global Competitiveness Report 2011 classifies the country as efficiency-driven (together with Bulgaria), all the rest of the EU economies being either in transition to, or already in the innovation-driven stage.

Over the last decade policy makers have made great efforts to reform the R&I system in Romania. However, the adopted measures would benefit from being supported by a long-term vision and are still hampered by the fact that the awareness of the added value of R&I for increasing competitiveness and secure high-quality jobs is not yet central to the political debate. In addition, a lack of continuity in policy decisions from one government to another and a lack of coordination among ministries that have in their portfolio R&I activities are generating "stops and go's" which are particularly detrimental in a domain that requires development of capacities overtime. In order to leverage the importance of R&I in the overall policy-mix of the country, R&I policy measures would indeed justify to be considered in the broader context of the country's economic development and better integrated in the overarching policy objectives of the country. For instance, improving the overall functioning of institutions would result in a better coordination of R&I policies across various ministries, whereas an increased focus on competitiveness at political levels would draw the attention of policy makers to the added value of R&I for growth and jobs.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) RO: This projection is based on a tentative R&D intensity target of 2.0% for 2020.

Over the last decade, R&D intensity in Romania increased from 0.37% in 2000 to 0.58% in 2008, unfortunately only to drop back to 0.48% in 2011. Romania currently has one of the lowest R&D intensity in the European Union, at a value of less than a quarter of its 2% target for 2020.

In absolute terms, public R&D funding reached a peak in 2008, following the adoption of the 2007-2013 Strategy for R&D and Innovation. The Strategy has foreseen a gradual increase of the R&D public budget, but the planned increase of the R&D public budget in 2009 did not take place. In absolute terms, government budget appropriations for R&D decreased by 25.4% in 2009 and by a further 2.6% in 2010 and then increased by 0.5% (provisional value) in 2011. Higher education expenditure on R&D suffered a large decrease of 32.2% in 2009 but increased by 1.4% in 2010. The Government expressed its intention to increase the public budget by 18.6% in 2011 and by an additional 12.7% in 2012 (according to the ERAC Survey, 2012).

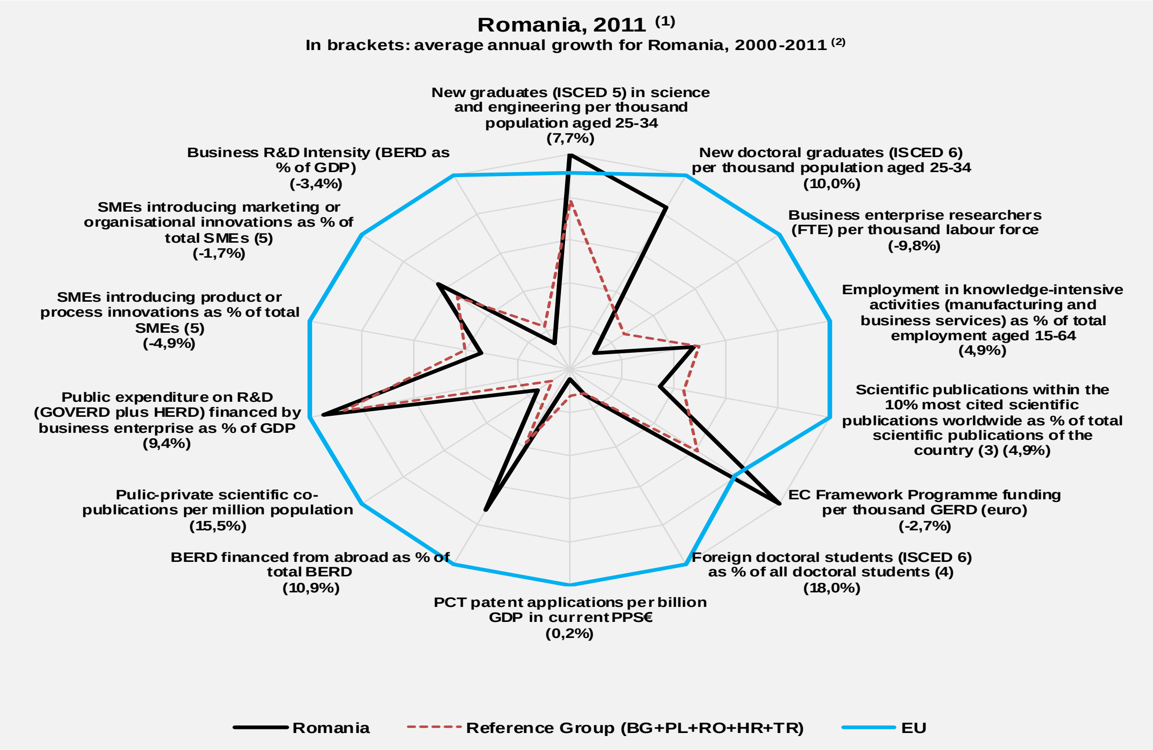
In addition, Romania with a value of 0.17% had one of the lowest business R&D intensities in the EU in 2011 (rank 25 out of 27), with an average annual growth rate of -3.4% between 2000 and 2011. No Romanian firm is among the top-1000 EU R&D investing firms. The recent trends show that the 2% R&D intensity target for 2020 is very ambitious and will be difficult to reach, given both the recent low budgetary commitment and the very low level of business R&D activities. This target could be achieved only if the country prioritises R&I in a context of smart fiscal consolidation, whilst implementing without delay key reforms as outlined in the Action Plan for Research and Innovation adopted by the Government in July 2011.

The total number of Romanian participants in the 7th Framework Programme so far is 704 (out of 4888 applicants); thereby Romania has received € 96 million. The success rate of participants is 14.4%, below the EU average success rate of 21.95%. Romania receives the 19th largest share in the EU of 7th Framework Programme funding and has most collaborative links with Germany, Italy, the United Kingdom, France and Spain.

Private and public R&D investment also receives support by co-funding from the Structural Funds. Currently 13.7% is allocated to research, innovation and entrepreneurship from the total of Structural Funds available to Romania, compared to an overall 25% at the level of EU. A large part of the Structural Funds for R&I has been focussed on programmes for developing R&I infrastructure and human resources which have been developed as complementary to the national R&D programmes. The massive reduction of the R&D budget in 2009 however hampered this complementarity. Whereas the Structural Funds have had an absorption rate of 30% (rate of approved payments) for the R&I sector, the national R&D budget has been indeed severely cut.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Romania's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) TR is not included in the reference group.

The Romanian R&I system is primarily public-based, with only 38.3% of research performed by the business sector (the EU average is 61.5%). Another structural feature is the fragmentation of the public R&D system which has a large number of research performers and a lack of critical mass of research results. Romania scores well regarding the numbers of new S&T and PhD graduates. However, the overall underfinancing of R&I since the 1990s created a brain drain, which left the country with a pool of researchers with high average age and limited career prospects. Romania is suffering a net outflow of researchers (it is estimated that 15000 researchers are currently working abroad).
In terms of research excellence, Romanian universities are underperforming in all major international rankings and their scientific production and staff composition is less internationalized compared to other Member States. An increase in international scientific co-publications and in the share of national scientific publications in the top 10% most cited publications worldwide are nevertheless noticeable over the last 10 years.

Overall the number of international co-publications with other European countries is one of the lowest in Europe, suggesting that the Romania does not sufficiently benefit from the international knowledge flows favoured by the ERA architecture. However, Romanian scientific and technological cooperation is well distributed across Europe, with France, Germany, Italy, the United Kingdom, and Spain as main co-publication partners and Germany and Ireland as co-patenting partners.

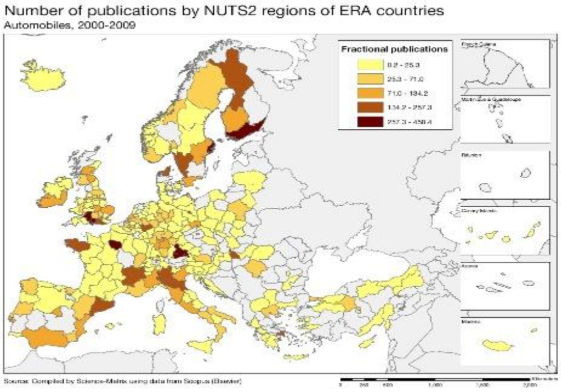
The relative weaknesses of Romanian business sector R&I are striking: very low numbers of PCT patent applications and of business enterprise researchers, and a very low level of business R&D intensity, on a decreasing trend. The business sector is not fuelled by collaborative links between public and private sectors (as reflected by the low number of public-private co-publications).

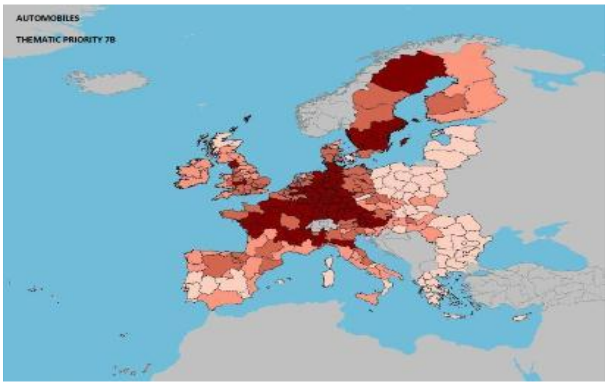
Romania's scientific and technological strengths

The maps below illustrate six key science and technology areas where Romania has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

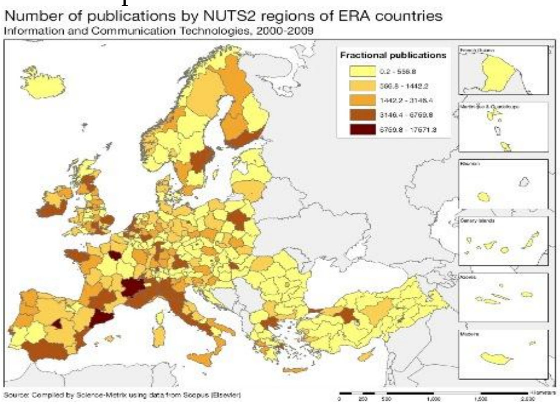
Strengths in science and technology at European level

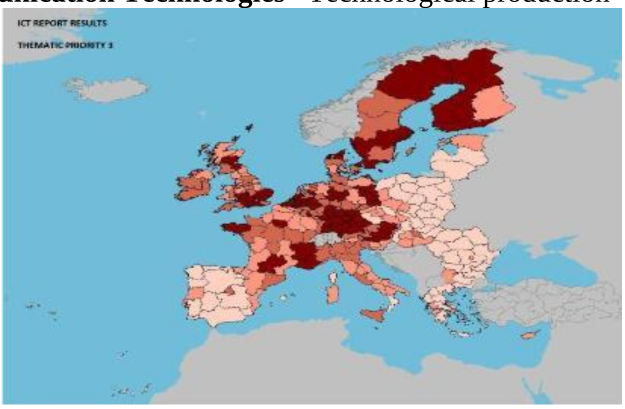
Scientific production **Automobiles** Technological production



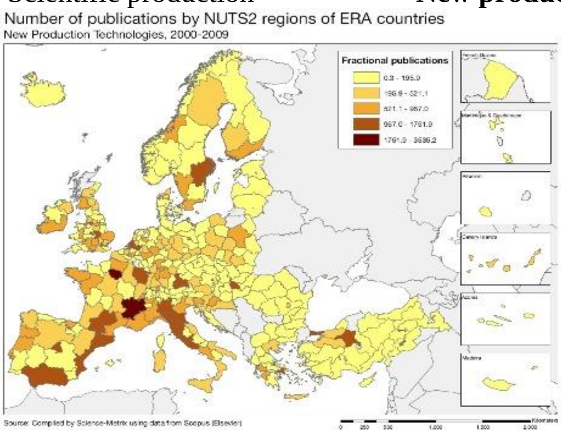


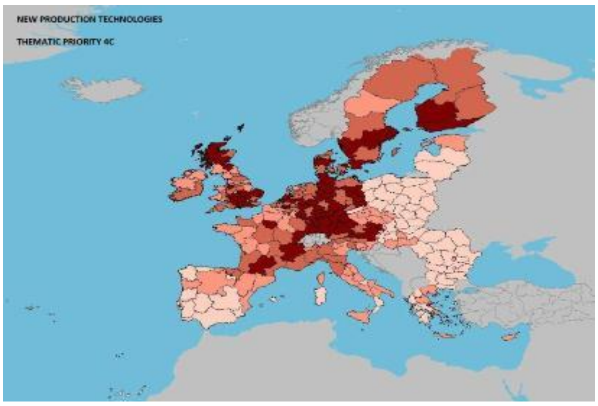
Scientific production **Information and Communication Technologies** Technological production





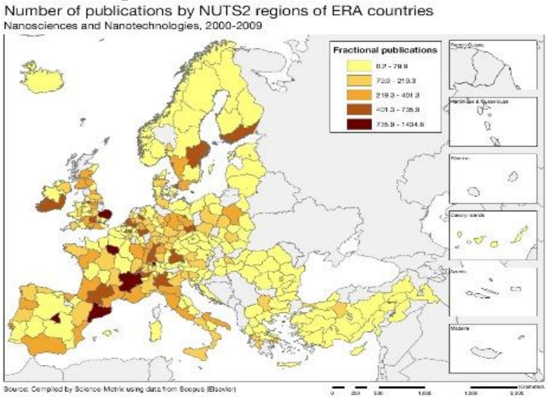
Scientific production **New production technologies** Technological production

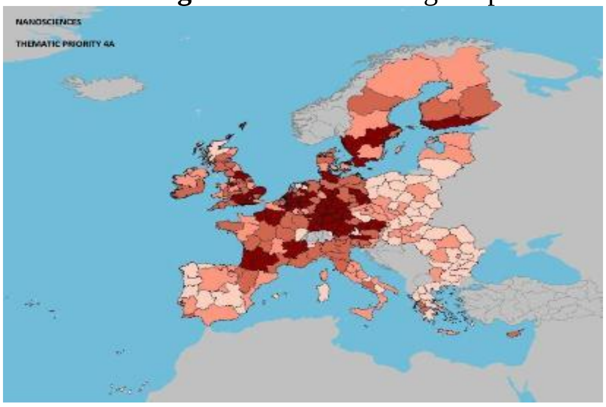




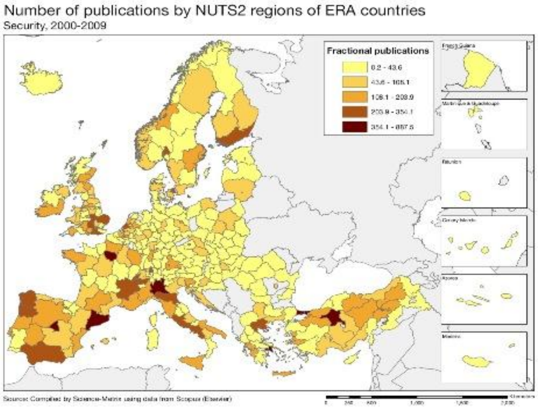
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

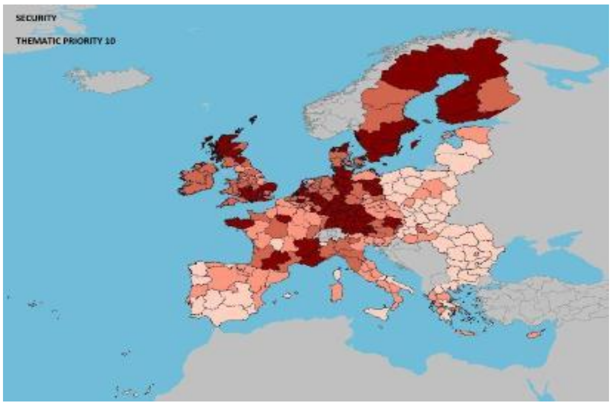
Scientific production **Nanosciences and nanotechnologies** Technological production





Scientific production **Security** Technological production





As illustrated by the maps above, in terms of scientific and technological capacity, Romania has potential for regional clusters in the fields of ICT, nano-sciences and nanotechnologies, automobiles, security and new production technologies.

Romania's scientific specialisation index, citations and impact of scientific publications, not visible in the maps above, reveals that the main scientific fields are mathematics and statistics, physics and astronomy, enabling and strategic technologies, engineering, and information and computer technologies. Chemistry has an interesting evolution, being a field with a rather strong specialisation in Romania, but with an overall impact of scientific publications that is low compared to the world average. In addition, it is striking that the field of agriculture, fisheries and forestry which has a lot of potential in Romania for economic growth given the existing raw materials, is not supported by a comparable scientific specialisation. The potential that exists in the field of agriculture is additionally confirmed by the fact that the low number of scientific publications are of very good quality, as reflected by their relative impact which is comparable to the world average.

Patenting activity in Romania is extremely low and does not demonstrate much statistically significant technological specialisation other than what can be seen in the maps above. In addition, based on data of the mid-2000s, no particular specialised established employment or technology cluster could be identified in Romania. The cluster policy put in place around the European Light Infrastructure project funded from the Structural Funds is expected to lead to the emergence of a specialised cluster in Romania around scientific capabilities in the field of physics. Danube-Danube Delta-Black Sea is another large project with cluster potential around it.

Policies and reforms for research and innovation

The country has undertaken a wide range of measures in the R&I field over the last 10 years: the current National R&I Strategy for 2007-2013 was based on a broad consultation (Foresight) exercise; Romanian scientific journals have been promoted on the international circuit; the share of competition-based funding has surpassed the share of institutional funding for research; measures have been taken to improve science-industry links by grants for projects with industrial partners; innovation vouchers and tax incentives have been introduced. In addition, in August 2011, the Romanian Government adopted a Reform Action Plan for R&I in the context of the loan received from the EU. The Action Plan is built around three pillars: governance of the system, management of public research institutes and increase of private sector R&I. Romanian authorities reported on a number of measures related to the Action Plan, either adopted or already implemented. A process of certification of national R&D institutes is ongoing and the legal framework regarding the funding of these institutes has been amended; ambitious reform of universities has been conducted, paving the way towards more autonomy and differentiation between research universities and those more oriented towards teaching and local needs.

However, the measures would have a greater impact if supported by a long-term vision. The adopted/planned measures would indeed need to be better related to each other within an overarching reform, in order to improve the overall efficiency of the R&I system. The setting up of an inter-ministerial Council for R&I could be of great help in terms of governance. The creation of this Council has been announced in 2002 but it has not really started its activities. It has the potential to steer action both for addressing the lack of coordination of research activities undertaken under the authority of various ministries and for promoting innovation across the economy. It can be expected to raise awareness at the highest political levels on the added value of innovation in various sectors (i.e. innovation in fields such as agriculture, transport, services, etc.), notably if its competencies cover both R&D and innovation activities and if its articulation with other similar councils is clarified.

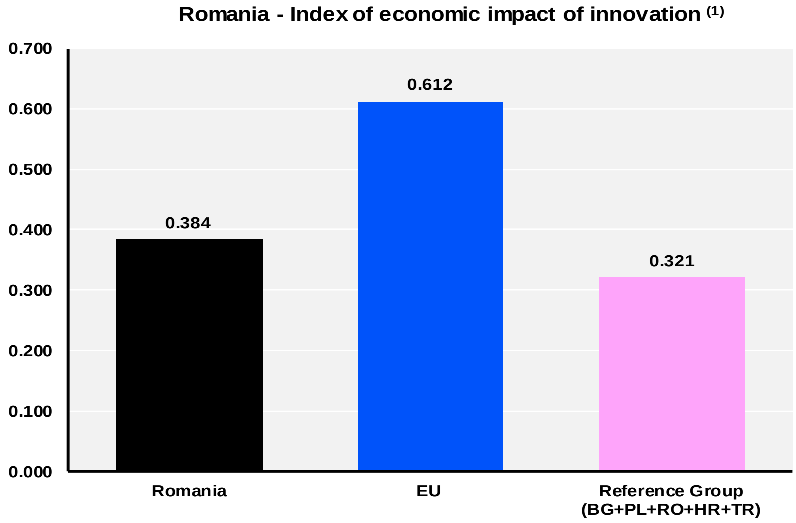
The development, together with the main stakeholders, of a common vision for the progress towards a more knowledge-and innovation-based economy would indeed greatly help in increasing synergies and consistency between the various policies having an impact on business innovation. For instance, there are two different strategies on SMEs and on business environment, with similar objectives but without clear links between them. In this context, it is somewhat worrying that while a strategy for Competitiveness has been developed it is not yet adopted and it is not clear whether or when it will be.

As a matter of fact, private sector R&I remains underdeveloped and has been in continuous decline since 2000 and the existing measures to promote private R&I are not fully commensurable with the challenges faced by local innovative enterprises, multinationals and start-ups. It might be worth considering whether the system could not benefit from replacing the current interventions of a “one size fits all” type by targeted interventions for innovative enterprises with proven successful track records. In addition, there is an obvious need to address the current mismatch between the skills needed by the knowledge market and the qualifications provided by Academia. Multinationals seem somewhat reluctant about setting up R&I facilities in Romania due to the vulnerabilities of the intellectual property rights (IPR) framework, which gives the ownership of an invention/research result to the employees. In this respect, the finalisation of the national patent law is expected to contribute to an increase in foreign direct investment (FDI) for innovative activities that would ensure an increased level of productivity. A regulation on the 'employee patent' is currently under preparation which may address this issue, while additional fiscal incentives for companies undertaking R&D activities are in place and an innovation voucher has been introduced in 2012.

Finally, there is a slow take-off in “high-tech” student's start-ups that would need to be boosted by measures such as financing and mentoring services vouchers. There is a special open operation for innovative start-ups and spin-offs to support the implementation of R&I results. Seed capital is beginning to become available: the Ministry of Economy encourages a network of business angels (venture connectors) in fields such as ICT. However, high risk business angel investment/venture capital is still at a very low level and could benefit from being more easily matched by funding, for instance from an accelerator/investment fund for medium-high and high-tech ventures.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[4].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Romania's index of economic impact of innovation is lower than the EU average but higher than the level of the reference group of countries with similar economic and research profiles. Even if this value needs to be considered over time and not limited to a single year, it highlights a real economic stress for transforming knowledge and technology into economic competitiveness. A key strategy is facilitate the creation of high-growth innovative enterprises, which demands the following three structural challenges: 1) developing an excellent research base focused on sectors where Romania is performing well in terms of international benchmarks and where it has the potential to attract business investment; 2) nurturing entrepreneurship with the aim of disseminating and fostering research and innovation in the economy; and 3) developing appropriate framework conditions for innovation based on an overarching strategy supported by stakeholders.

The most problematic factors in relation to doing business have been identified as tax rates, inefficient government bureaucracy, policy instability, access to finance, and corruption. As a result, measures aiming to improve competitiveness and foster structural change of the business sector should encompass a broad set of measures, going beyond purely R&I related policies and dealing with the business environment, improving the infrastructure, enhancing administrative capacity, fighting corruption and fraud, etc.

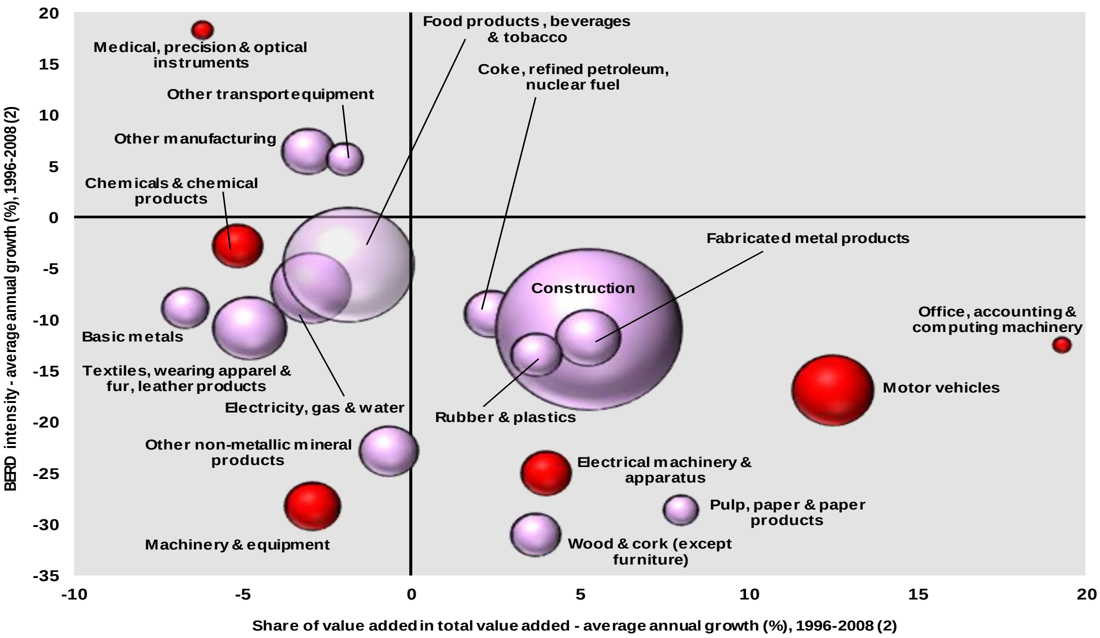
As in most of Eastern Europe, the public support for the development of an informal venture capital market (both early stage capital and expansion and replacement phases) is limited. In addition, access to loans for SMEs undertaking R&I activities is practically non-existent, due both to the perception of banks that R&I activities are risky and to the lack of incentives for banks to grant small loans (the cost of processing a file is similar for a small loan taken out by an SME and for a big loan). Patent costs at EPO and other international patent offices are unaffordable for most potential Romanian applicants.

[4] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Romania - Share of value added versus BERD intensity - average annual growth, 1996-2008



Source: DG Research and Innovation - Economic Analysis unit
Data: Eurostat
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Rubber & plastics': 1996-2007; 'Pulp, paper and paper products': 1997-2001; 'Wood and cork (except furniture)': 1997-2002; 'Fabricated metal products': 2002-2008; Office, accounting and computing machinery': 2003-2007; 'Electrical machinery and apparatus', 'Machinery and equipment', 'Medical, precision and optical instruments', 'Motor vehicles', 'Other transport equipment': 2003-2008.

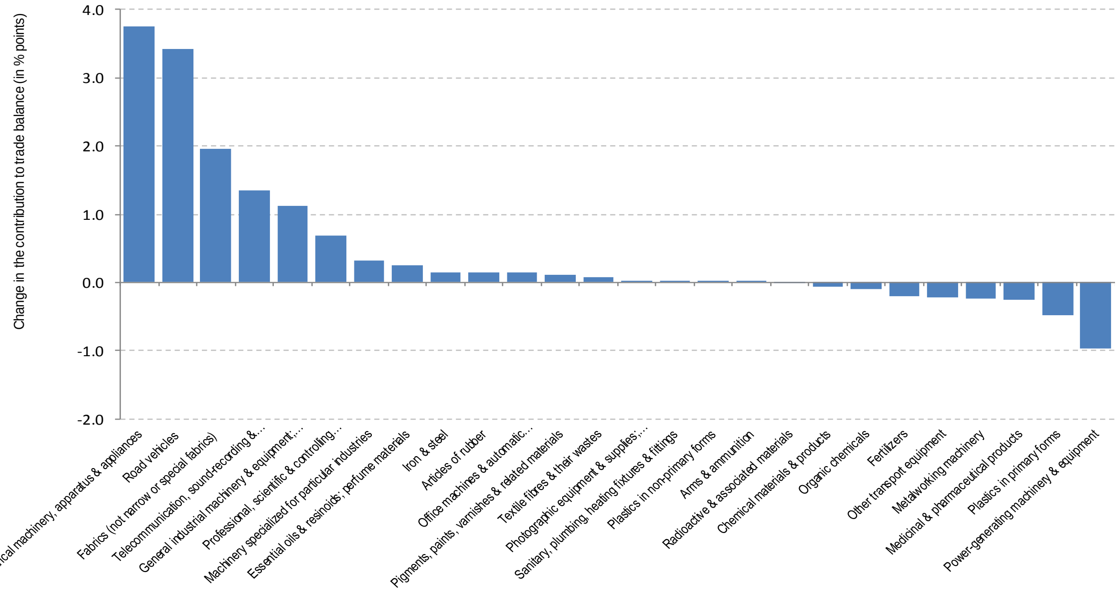
Romania's limited innovation performance is reflected in its economic structure which has a prevalence of low- and medium-technology sectors. Demand for knowledge is weak and there is an underdeveloped innovation culture. In terms of trade and industry specialisation, Romania is part of the group of lower income countries in the EU (together with Bulgaria, Estonia, Latvia and Lithuania), with lower GDP per person than the EU average and specialisation in less technologically advanced sectors. Romania is highly specialised in labour-intensive industries (preparation and spinning of textile fibres, sawmilling, wearing apparel and accessories), in capital-driven industries (cement), and marketing-driven ones (footwear). In terms of innovation, Romania is specialised both in low-innovation sectors (wearing apparel, leather) and in medium-high innovation sectors (textiles, basic metals).

In dynamic terms, a certain degree of structural change is shown in the graph above by the increasing added value in technology-driven and innovation sectors (office, accounting and computing machinery and motor vehicles, as well as to a lesser extent electrical machinery and apparatus). On the other hand, fields with high knowledge intensity such as medical precision and optical instruments and, to a certain extent, chemical and chemical products have decreasing shares of value added. However, whereas the quality of labour-intensive industries has improved, this is not yet the case for technology-driven ones.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Romania between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: The data for "Arms & ammunition" refers to the period 2006-2011.
"Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The trade balance in all high-tech (HT) and medium-tech (MT) products combined was negative in Romania up to 2008 and became positive in 2009 and 2010. This contrasts with the total trade balance, where the positive trend up to 2008 was followed by relative stagnation in 2009 and 2010. The data therefore indicate both a progressive and encouraging shift towards HT and MT in the trade balance of Romania over the last few years, and the fact this shift was instrumental to counterbalance the weaknesses in the rest of the economy.

More precisely, the graph above points to the high-tech and medium-tech industries that have improved their contributions to the Romanian trade balance, in particular road vehicles, electrical machinery, and textiles , and to a certain extent for telecommunication, general industrial machinery and machinery specialised for particular industries. In contrast, industries such as power-generating machinery and equipment, plastics, medicinal and pharmaceutical products, fertilizers and metal working machineries are making decreasing contributions to the trade balance, indicating a possible loss in relative world competitiveness.

Over the last 15 years, the Romanian economy has gained in world competitiveness; however structural change is taking place at a very slow pace. Over the last decade, Romania has had the highest growth of total factor productivity in the EU. Taking 2000 as year of reference, total factor productivity had increased by 50% in 2008 and by 35% in 2012. The relative decrease between 2008 and 2012 can be reasonably attributed to the economic and financial crisis. Romania has made good progress on greenhouse emissions which have fallen and has also succeeded in increasing the share of renewable energy in gross final energy consumption. The employment rate has fallen from 69.1 in 2000 to 62.8 in 2011.

Key indicators for Romania

ROMANIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	:	:	:	0.72	0.76	1.11	0.92	0.86	0.95	1.35	1.40	:	:	10.0	*1.69*	15
Business enterprise expenditure on R&D (BERD) as % of GDP	0.25	0.24	0.23	0.22	0.21	0.20	0.22	0.22	0.17	0.19	0.18	0.17	:	-3.4	*1.26*	25
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.11	0.15	0.15	0.16	0.17	0.20	0.23	0.30	0.40	0.28	0.28	0.31	:	9.6	*0.74*	25
Venture Capital [3] as % of GDP	0.04	0.05	0.03	0.11	0.00	0.02	0.07	0.13	0.09	0.07	0.06	0.04	:	-1.8	0,35 [4]	17 [4]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	12.2	:	:	:	:	17.8	:	:	7.8	47.9	23
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	2.6	2.5	3.0	3.1	4.2	3.9	3.9	4.2	3.8	:	:	:	:	4.9	10.9	24
International scientific co-publications per million population	44	39	45	66	76	84	89	111	122	133	144	148	:	11.7	300	27
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	5	5	6	8	8	:	15.5	53	24
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	:	:	:	0.2	3.9	27
License and patent revenues from abroad as % of GDP	:	:	:	:	0.01	0.05	0.03	0.02	0.12	0.12	0.28	0.13	:	41.4	0.58	16
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	16.6	:	18.5	:	14.9	:	14.3	:	:	-2.5	14.4	12
Knowledge-intensive services exports as % total service exports	:	:	:	:	22.3	41.0	44.9	43.8	42.0	44.9	43.0	:	:	11.6	45.1	7
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-10.69	-9.21	-9.61	-9.30	-8.45	-7.26	-6.00	-4.42	-2.33	0.60	0.25	0.38	:	-	4,20 [5]	19
Growth of total factor productivity (total economy) - 2000 = 100	100	105	116	120	130	134	140	144	148	137	133	134	132	32 [6]	103	2
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	16.0	:	:	:	:	19.0	:	:	:	:	28.3	:	:	5.9	48.7	27
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	5.6	5.8	6.0	6.5	:	4.9	13.6	27
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	17.8	:	19.4	:	18.0	:	13.2	:	:	-4.9	38.4	27
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	:	:	:	:	-1.2	0.39	24
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.01	0.02	0.00	0.01	0.03	0.03	0.02	0.01	0.01	:	:	:	:	-4.2	0.52	25
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	69.1	68.3	63,3 [7]	63.7	63.5	63.6	64.8	64.4	64.4	63.5	63.3	62.8	:	-0.1	68.6	22
R&D Intensity (GERD as % of GDP)	0.37	0.39	0.38	0.39	0.39	0.41	0.45	0.52	0.58	0.47	0.46	0.48	:	2.5	*2.03*	26
Greenhouse gas emissions - 1990 = 100	55	56	58	60	59	59	60	59	58	49	48	:	:	-7 [8]	85	3 [9]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	16.8	17.6	17.1	18.3	20.3	22.4	23.4	:	:	5.7	12.5	7
Share of population aged 30-34 who have successfully completed tertiary education (%)	8.9	8.8	9.1	8.9	10.3	11.4	12.4	13.9	16.0	16.8	18.1	20.4	:	7.8	34.6	26
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	:	45.9	44.2	43.1	41.4	40.3	:	-3.2	*24.2*	26 [9]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) Break in series between 2002 and the previous years. Average annual growth refers to 2002-2011.

(8) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(9) The values for this indicator were ranked from lowest to highest.

(10) Values in italics are estimated or provisional.

Slovakia

The challenge of structural change to upgrade knowledge in the context of industrial globalisation

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Slovakia. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

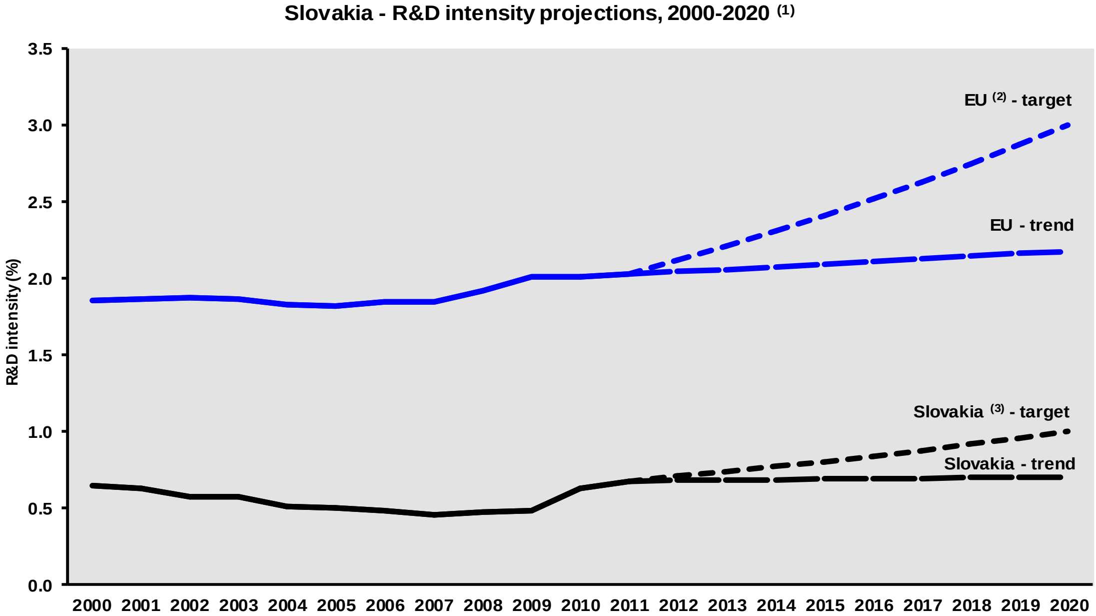
	Investment and Input	**Performance/economic output**
Research	*R&D intensity* 2011: 0.68% (EU: 2.03%; US: 2.75%) 2000-2011: +0.41% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:17.73 (EU:47.86; US: 56.68) 2005-2010: +3.85% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.479 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:31.64 (EU:48.75; US: 56.25) 2000-2010: +0.07% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food and agriculture, Energy, ICT, Materials	*HT + MT contribution to the trade balance* 2011: 4.35% (EU: 4.2%; US: 1.93%) 2000-2011: +32.26% (EU: +4.99%; US:-10.75%)

The Slovak Republic is a small country, dynamic and logistically well positioned between Eastern and Western European countries. Since 2000, the country has improved the quality performance of its science and technology base, slightly changed the structure of its economy towards a higher knowledge-intensity and the weight of high-tech and medium-high-tech products in the trade balance. Slovak Republic faces the challenge of further developing its research and innovation system. Currently, the country is catching-up with respect to competitiveness.

In the Slovak Republic, over the last decade, R&D intensity has steadily declined from a peak of 3.88% in 1989 to 0.68 in 2011, one of the lowest within the EU. The rise of a dual economy limited the indigenous R&D capacity: on the one hand a predominance of foreign multinational companies with high productivity and on the other, 60,000 domestic SMEs and a few large companies typically with low productivity levels. Thus, the main challenge for the Slovak Republic consists in raising the knowledge intensity in Slovak firms through investments and spill overs. Moreover, existing public financing suffers from inefficiency, significant administrative burden and a lack of transparency of the procedures used – including those supporting regional innovation. The Slovak Republic has margins to improve its thematic concentration, including a stronger coordination between responsible public authorities, the links between business and science, and the connexion with international S&T networks

In spite of the current economic and financial difficulties, Slovak authorities drafted and partly implemented comprehensive R&I strategies. Since April 2012, the new government has reaffirmed the country's commitment to the EU2020 targets, even if the challenges remain substantial, especially in the case of R&D intensity. Its policies include in particular, the updated "Minerva 2.0" strategy, which identifies problems, constraints and priorities, and focuses on the speedy implementation of a critical mass of measures to stimulate innovation and private R&D investment including structural reforms and the reform of funding.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) SK: This projection is based on a tentative R&D intensity target of 1.0% for 2020.

The Slovak Republic has set a national R&D intensity target of 1%. In 2011, the Slovak R&D intensity was 0.68% of GDP, where public sector R&D intensity amounted to 0.36% and business R&D intensity 0.27%. The Slovak Republic belongs to the group of Member States which are not on track to reach their Europe 2020 target (1% of GDP of R&D intensity) and there is a need to raise its annual rate of increase in total (public + private) R&D investment. Under these circumstances, in order to reach its national target by 2020, the Slovak Republic would need an annual growth rate of 4.7% over the decade 2010-2020, slightly higher of the EU average of 4.1%. This is possible to achieve provided the right policies are implemented.

Overall, the research & innovation system in the Slovak Republic is characterized by a very low R&D intensity in both the public & private sectors The Slovak R&D intensity is one of the lowest in Europe and also very low compared to the reference group countries CZ, IT, HU, SI (average of 1.27%).

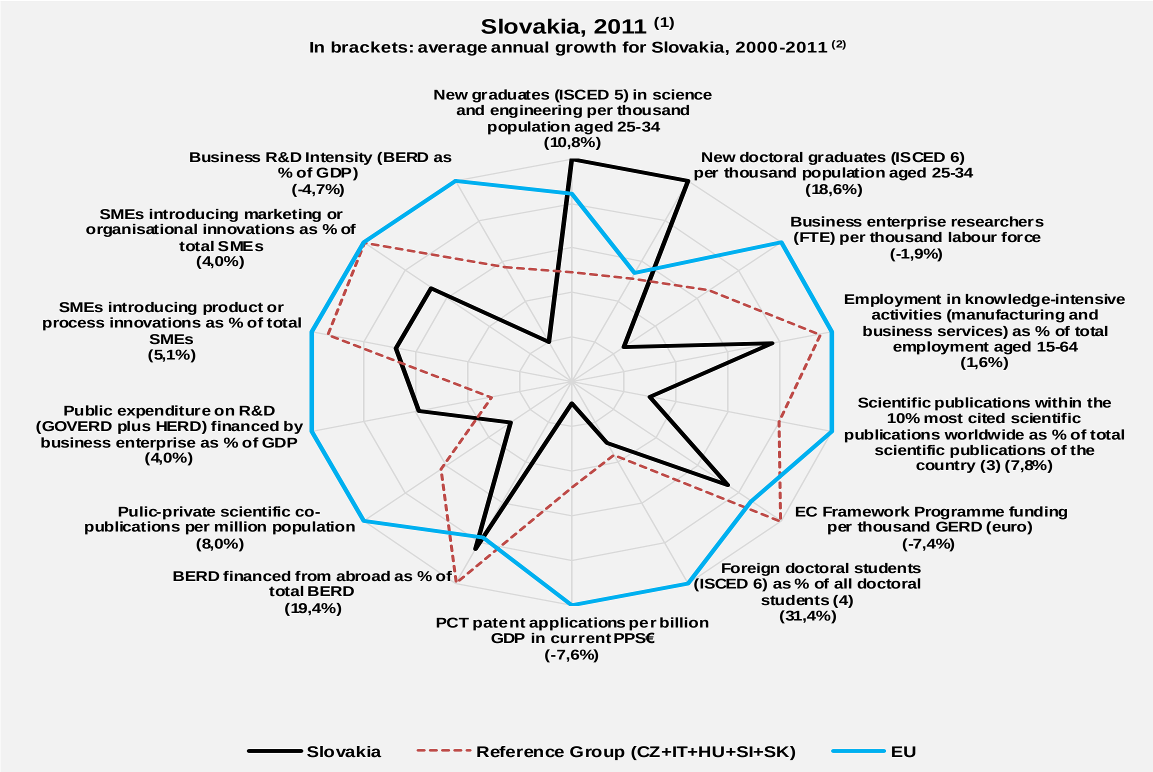
However and in spite the overall decrease of the R&D intensity in the Slovak Republic over the last decade, public support to R&D has increased significantly (€86m in 2000 to €219m in 2010), notably due to the financing from EU resources (mainly through Structural Funds). Between the two programming periods of 2000-2006 and 2007-2013, the Slovak Republic increased the allocations to research and innovation (RTDI) by 19%. In total, over the period 2007-2013, the country received €1.103 million of the EU Structural Funds (a ratio of 81.2% of the total GBAORD), to research, innovation and entrepreneurship. For the 2011 and 2012 public state budget allocated to R&D, there was a further increase of 9% and 18% respectively, but a decrease is foreseen for the 2013 budget due mainly to measures to reduce public deficit.

In the private sector, domestic firms, including a great number of SMEs and a few large companies, are characterised by low R&D expenditure and productivity levels. As a result, the production system is dominated by technology imports. Therefore, a major challenge for Slovakia remains to raise the R&D intensity in Slovak firms.

The FP7 success rate of the Slovak Republic in terms of EU contribution of 12.3% is lower than the average EU-27 of 20.4%. In terms of applicants, the Slovak success rate of 19.2% is close to the EU-27 average of 21.2%. Among the FP7 research priority areas, Slovakia is most active in "Marie-Curie Actions", in "information and communication technologies" and in "research for the benefit of SMEs".

An effective research and innovation system building on the European Research Area

The spider graph below provides a synthetic picture of strengths and weaknesses in the Slovak R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The strengths in Slovakia's R&I system are found in human resources for research and innovation and in attracting business R&D investments from abroad. There is also a positive innovation dynamics in Small and Medium-Sized firms and in attracting foreign doctoral students. By contrast, the country's main weaknesses lay in business research activities, including low patenting, business researchers and R&D investments. In the public sector, the main challenges consist in pursuing the improvement in scientific quality and in public-private cooperation in R&D activities.

There is need to enhance quality of the higher education system and increase excellence and internationalization of its universities, as the latter one are not visible in major international rankings. The overall efficiency of the public science sector can be improved, given the low number of scientific outputs. Meanwhile, the Slovak Republic relative strengths are in Human Resources and Outputs, with a strong increase of the new graduates in science and engineering and at PhD level, although a shrinking number are employed in the business sector.

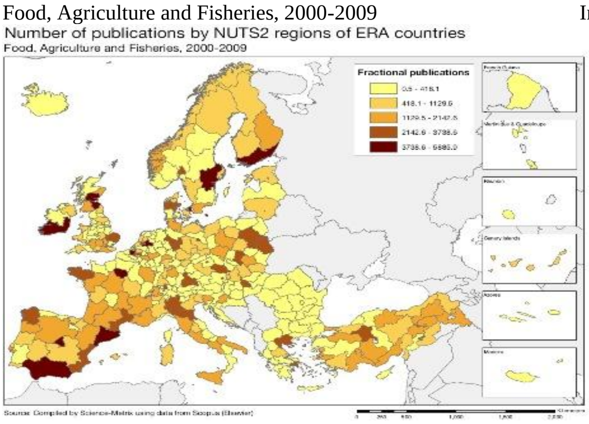
As the country has been able to attract a large volume of Foreign Direct Investment (FDI) in the recent years, this would create the appropriate conditions for a progressive improvement of the knowledge-intensity of the local production, which would benefit the whole economy of the country, creating better paid and qualified jobs. For all the aforementioned, the Slovak Republic is facing a challenging set of reforms in the R&I fields.

Slovakia's scientific and technological strengths

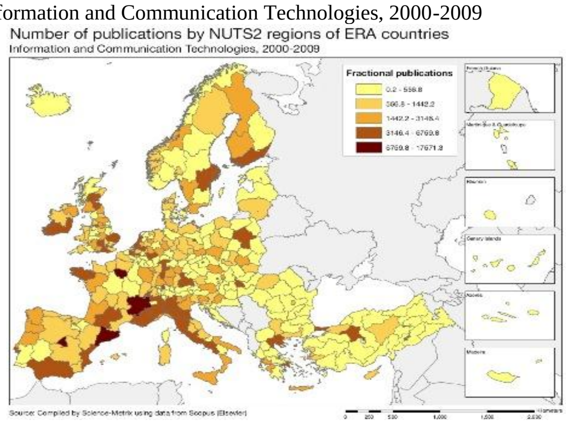
The maps below illustrate several key science and technology areas where Slovak regions have real strengths in a European perspective. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

Strengths in science and technology at European level

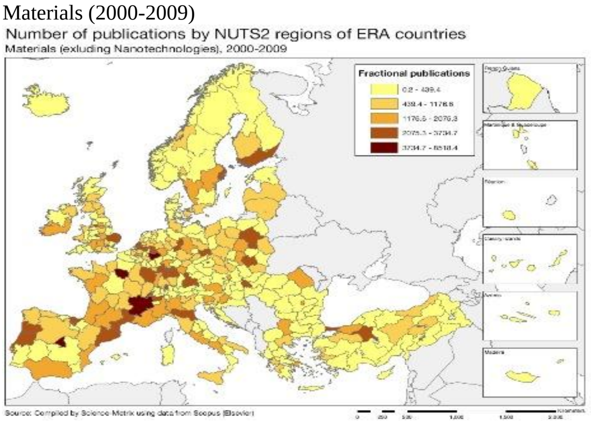
Scientific production
Food, Agriculture and Fisheries, 2000-2009



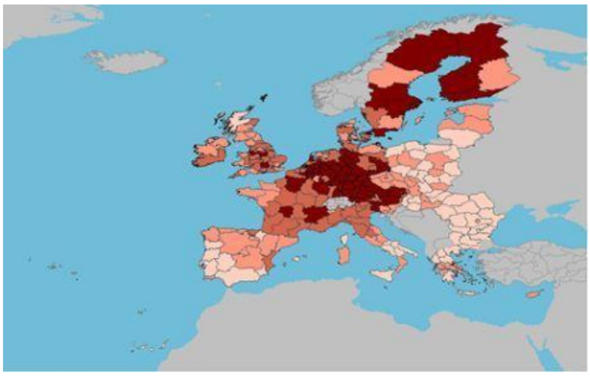
Scientific production
Information and Communication Technologies, 2000-2009



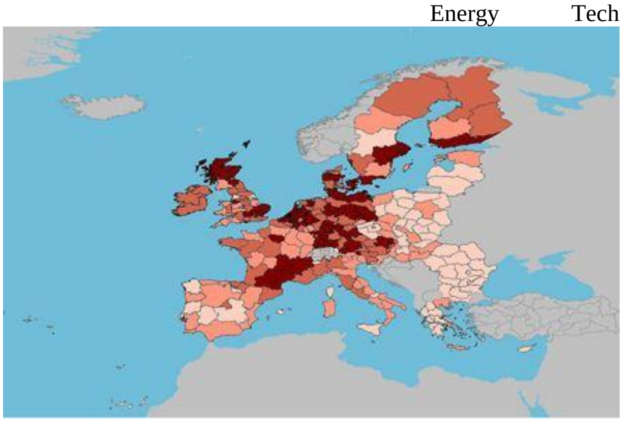
Scientific production
Materials (2000-2009)

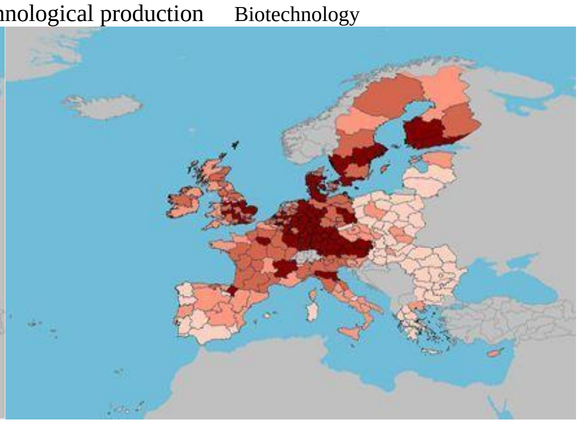


Technological production
Materials, Metallurgy



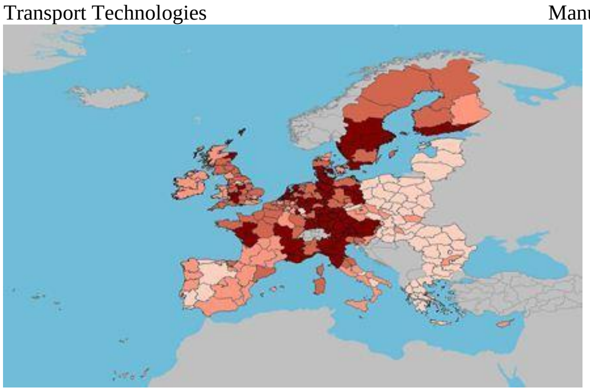
Energy Technological production Biotechnology



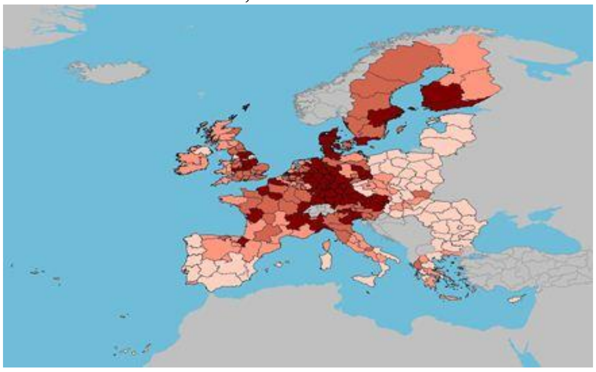


Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

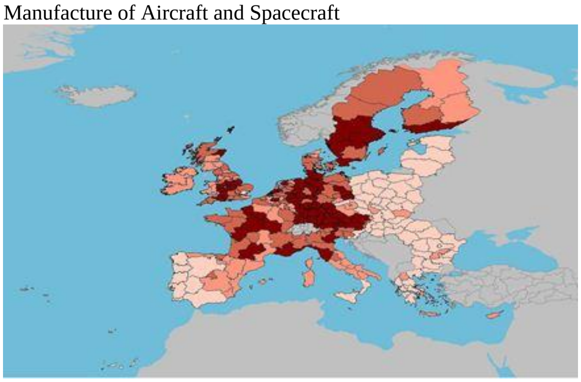
Transport Technologies



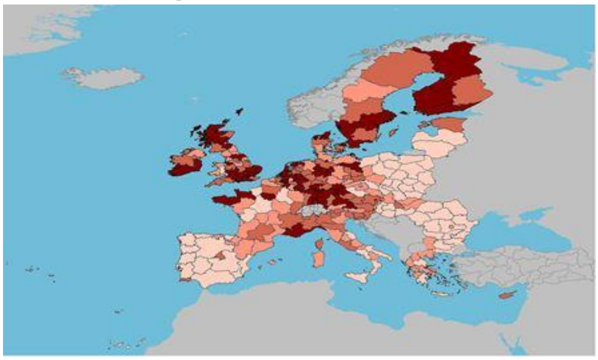
Manufacture of Electrical Motors, Generators and transformers



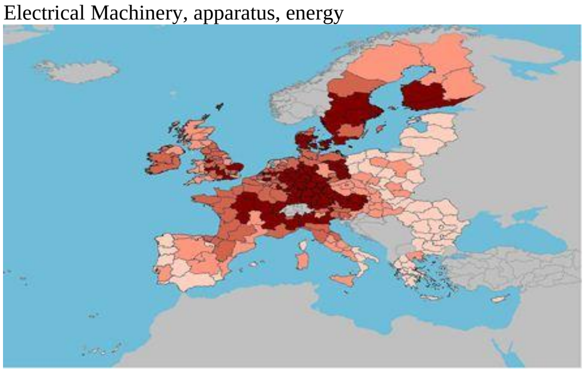
Manufacture of Aircraft and Spacecraft



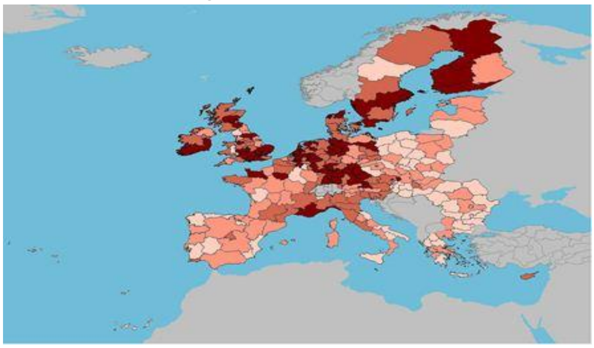
Services for Computer and related activities



Electrical Machinery, apparatus, energy



IT Methods for management



As illustrated in the maps above, in terms of scientific capacity, the Slovak Republic has relative strong regional clusters in the fields of food, agriculture and fisheries, information & communication technologies and materials. Considering the scientific specialisation index, over the period 2000-2009, Slovakia has not significantly improved its rate in new production technologies, energy and transport, with an average below the EU27 average.

In comparison the Slovak regions are less prominent in technology patenting than the Bratislava region, where relative strengths in patenting are quite visible. Overall, significant disparities exist between the capital region and the rest of the country in terms of R&D expenditure and intensity. The main technology sectors are materials, metallurgy, biotechnology, energy, other transport technologies, manufacture of electrical motors. In terms of technological specialisation, considering patenting in industrial sectors within Europe, the Slovak Republic shows particular strengths in the automotive sector.

In terms of importance for economic growth, the plastic product sector is highly relevant for the Slovak Republic, as well as for Poland, Slovenia and Bulgaria in the EU-27 area and worldwide. Additionally, the second largest and the quickest growing industrial sector of the country is electro-technics and electronics. Moreover, as part of global value chains, the Slovak Republic is one of the world leaders in LCD production – a high-tech manufacturing sector. The above referred sectors are for Slovakia the sectors with great potential for doing business in R&D.

Policies and reforms for research and innovation

The last National Reform Programme 2012 (NRP) was drafted by the previous government whose mandate ended on 4 April 2012. The new government set out its policy statement which identifies the objectives of the NRP 2012 but proposes fundamentally different tools. However, the challenges that the Slovak Republic faces today remain the same. Thus, the new Slovak government commits to supplement its policy statement, in the shortest possible time, with measures that will be in line with its own policy conception. At national level, coordinators of the Europe 2020 strategy are the Prime Minister, and the Deputy Prime Minister and Minister of Finance. Furthermore, coordination of the agenda and policies at the inter-ministerial level, of paramount importance for the efficient spending of funds in the years to come, will be the responsibility of the Slovak Government's Council for Science, Technology and Innovation.

The overall government budget for the 2012-2014 period aims to protect expenditures which promote economic growth, such as state budget allocation and Structural Funds. Thus, two priorities stand out in the 2012 budget. The first one is the transport infrastructure and the second priority area is education where the volume of funds at regional level per student has increased by 4.7% in the tertiary school sector. The new Slovak Government considers important to ensure that expenditures on productive areas, such as education, remain among its long-term political priorities in the subsequent years too, and will take steps to improve the quality of higher education and its relevance to market needs. It will focus on measures that will ensure smart, sustainable and inclusive growth as well.

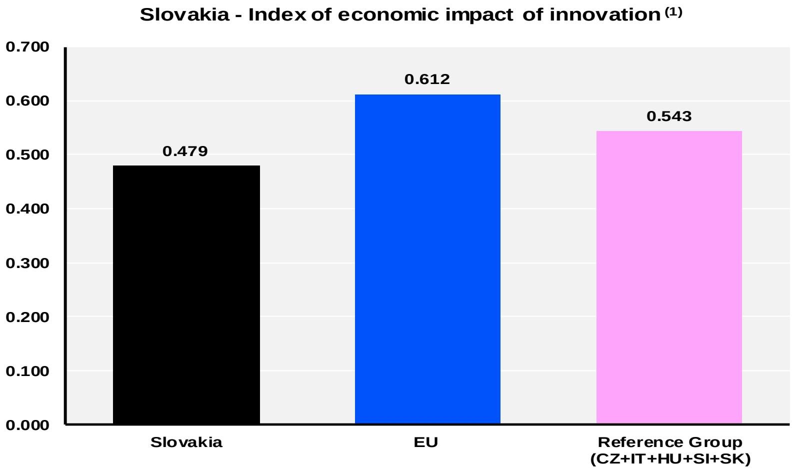
The new strategic policies intend to streamline national objectives to the new EU policies in Europe 2020 and Horizon 2020. In this context, the new government announced further measures to improve collaboration between the public and private sector in terms of financial and organisational arrangements and human capital through partnerships, joint ventures and long term contracts. It plans to set up a new instrument to support young Slovak researchers and to attract the top Slovak scientists working abroad to come back to the country. People should be encouraged to run innovative businesses. This will be promoted by systematically including entrepreneurship teaching (including lessons on tax compliance) in the curricula of primary, secondary and tertiary education establishments. Further, it will develop an adaption of the internationally successful Small Business Innovation Research programme.

In 2011, the Slovak Republic adopted two strategy documents: "Fenix" and the "Minerva 2.0", both aiming at science, technology and knowledge-based economy. They proposed a range of measures for increasing the quality of higher education and research systems, and connecting them to a knowledge-based economy. The "Fenix" strategy also proposed replacing current research and innovation priorities by a demand-driven bottom-up approach, which might indeed reduce the current low share of industry-science cooperation. The strategies identified the main problems in the knowledge triangle policies, and also addressed interaction between the key actors. Further, they defined the reform of research funding and aimed to improve the transparency of the system and to speed up the consumption of resources from Structural Funds. Their coordinated implementation could improve the innovation capacity of the country.

Furthermore, the Innovation Strategy for 2007-2013 sets the general framework for policy intervention, while the Innovation Policy 2011-2013 specifies actions in three areas (infrastructures, quality of human resources, and support for innovation) in order to boost the country's competitive position in Europe. The priority "Infrastructures" includes support to industrial clusters for which the first calls were planned by the end of 2012. Funded mainly by the Operational Programme Competitiveness and Growth, the innovation support for industry is the biggest priority in financial terms. The innovation vouchers are yet to be launched. The Slovak government will concentrate its efforts primarily on social cohesion in regions and notably on science, research and innovation, with a focus on green growth (using cleaner sources of growth and developing green industries, services, technologies and jobs). There is also scope for improving the Slovak innovation capacity and business environment, in particular through more efficient public administration. Finally, a closer integration of the Slovak research and innovation system in the European Research Area is an explicit objective of the national policy.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[5].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

According to this index, the Slovak Republic underperforms its reference group and is clearly below the EU average. The country ranks 18th due in particular to its poor performance in "patent applications per GDP", "share of the employment in knowledge-intensive activities" and "share of knowledge intensive services in total export of services". In all three areas, the Slovak Republic scores the lowest amongst its reference group. The only area where it performs extremely well is in the "sales of new to market and new to firm innovations as % of turnover of firms" where it tops the EU ranking.

In July 2011, the previous government adopted the strategy "Singapore" aimed at improving the business environment. This strategy contains 94 short and mid-term measures for the period 2011-2015. The international "Small Business Innovation Research (SBIR)" programme will facilitate experimental development and implementation of innovative solutions. For the Slovak Republic, improvement of the environment for establishing new start-ups and spin-offs by providing administrative support to the technology transfer from public R&D institutions, and by establishing a link between universities, the Slovak Academy of Sciences and technology incubators is strongly needed.

Access to finance has also been difficult since the start of the economic crisis. The rate of rejected loan applications went up, while the number of SMEs using debt financing increased from 61% to 74%. With an underdeveloped stock exchange and venture capital market, equity financing remained very limited. On the other hand, Foreign Direct Investments (FDI) and technology transfer feature strongly, with the Slovak Republic ranking 9th out of a panel of 142 countries. FDI might offer a good opportunity for developing business R&D projects. The country presents sufficient comparative advantages to attract foreign as well as domestic investors. Development of human resources and talents, competitive R&D costs, presence of foreign investors and availability of highly-qualified human resources are valuable competitive indicators for doing business in this country.

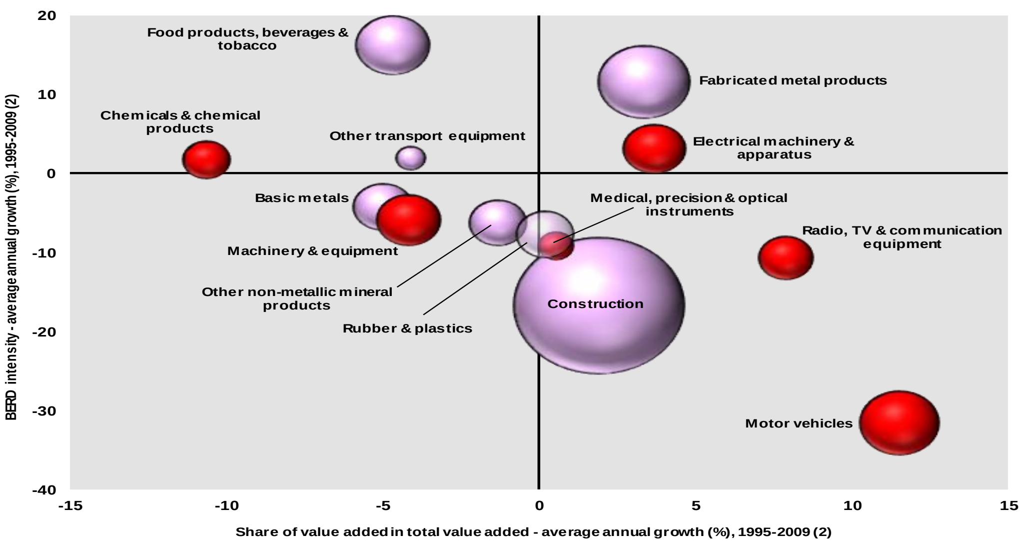
In 2011, the innovation environment reform plan was approved. Since April 2012, the new Slovak government intends to revise its measures in order to include other actions aiming at boosting innovation capacity. For example, the Slovak government intends to enhance the innovation potential of the national economy by increasing the share of high–tech exports to 14% by 2020. The Slovak Republic is challenged to offer favourable framework conditions to remain competitive with regard to other Member States and ensure long term growth, productivity gains and improved living standards.

5 See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates with four variables the upgrading of knowledge in different manufacturing industries. First, position on the horizontal axe illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-aces are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (all sectors presented in the graph), and the red-coloured sectors are those which are already high-tech or medium-high-tech.

Slovakia - Share of value added versus BERD intensity - average annual growth, 1995-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Motor vehicles': 1995-2005; 'Construction': 1996-2009.

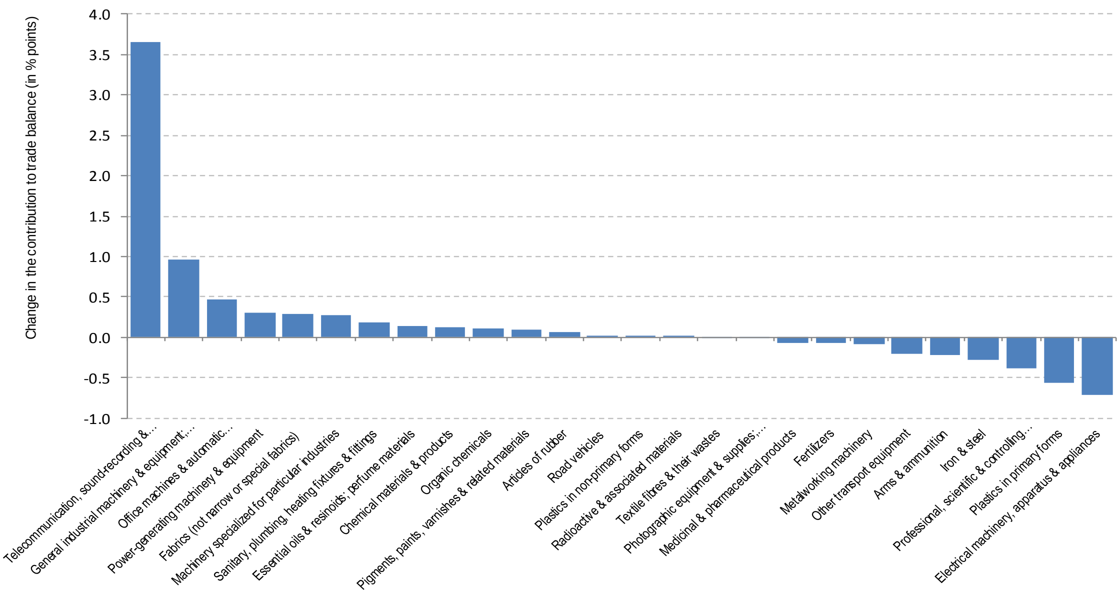
Across the EU, as the industrial structures vary considerably, the Member States have been following different paths toward a more knowledge-intensive economy. In the aftermath of the crisis, Slovakia ranks among the fastest growing economies of the entire European Union. The Slovak economy continues successfully recovering, mainly due to external demand and strong manufacturing activity, covering almost 23.4% of total value added against the EU average of 13.8%. Productivity in manufacturing sector profited from a sustained increase, indicating a good industry performance. The share of exports of GDP, as indicator of the openness of the economy, is in the Slovak Republic quite well performing, notably in the sector of medium-high and high-tech product exports, with an average clearly above the EU-27 level.

The graph above synthetises the structural change of the Slovak manufacturing sectors over the last decade. It shows that several medium and high-tech sectors (in red) have grown in economic (value added) importance, while large medium- or low-tech sectors, such as fabricated metal products and food and beverages have increased their knowledge-intensity (as measured by R&D investments). Economic expansion has been mainly related to radio, TV & communication equipment sector, Electric machinery and to the traditional sector of motor vehicles, followed by fabricated metal products. The Slovak economy has also been diversifying over the last decade, and its specialization degree has been decreased from 6.06 to 4.42. Moreover, as a traditional manufacturing country, The Slovak Republic has been more resilient to the economic crisis. However, many of the Slovak manufacturing industries have not upgraded its knowledge intensity over the period 1995-2009, which could indicate a medium-term threat to the sector in the context of increasing globalisation.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants for a country's competitiveness in global export markets. A higher contribution of high-tech and medium-high-tech industries to the trade balance is an indication of competitiveness in more sophisticated products and services.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Slovakia between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Over the last decade, the trade balance in high-tech (HT) and medium-tech (MT) goods of the Slovak economy showed a high increase, strongly above the EU average, with a high total productivity factor, notably of its labour level, in particular when compared to its catching–up peers. As shows the graph above, the "telecommunication and sound-recording apparatus" was one of the main sources of this improvement of the trade balance. It yielded a quite remarkable progress. The "general industrial machinery and equipment" and the "office-machines and automatic data-processing machines" sectors also contributed significantly to this improvement, in contrast to the more traditional product sectors of plastics, vehicles, machinery, arms and instruments.

However, this progress has not been well reflected to the research and innovation system of the country. The industries corresponding to these goods have not upgraded their R&D intensity. The Slovak Republic, having a dual economy, where a large part is hold by foreign multinational companies, with high productivity, but transferring technology from abroad where they run their R&D activities and limited liaising activities with Slovak research facilities (i.e. to establish R&D centres in Slovakia). Thus, the strong foreign presence has not yet been translated into significantly higher inward BERD. National companies, including a great number of SMEs and a few large companies, have lower R&D expenditure and productivity levels. As a result, source of major productivity in the past years was mainly the technology imports, but this potential is evaporating due to declining of inflows of FDI. Furthermore, a strong decline is observed in the non-R&D innovation expenditure and in license and patent revenues from abroad. For catching-up Member states, such as the Slovak Republic, price competitiveness and on-going industrial restructuring would help to boost exports. As innovation capacity has improved only modestly, it has yet to move significantly towards more knowledge-intensive economic activities.

Key indicators for Slovakia

SLOVAKIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.57	0.67	0.90	2.54	0.99	1.16	1.35	1.50	1.79	2.09	3.11	:	:	18.6	*1.69*	1
Business enterprise expenditure on R&D (BERD) as % of GDP	0.43	0.43	0.37	0.32	0.25	0.25	0.21	0.18	0.20	0.20	0.27	0.25	:	-4.7	*1.26*	21
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.22	0.21	0.20	0.26	0.26	0.25	0.28	0.28	0.27	0.28	0.36	0.42	:	6.1	*0.74*	22
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	14.7	:	:	:	:	17.7	:	:	3.8	47.9	24
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	1.8	2.5	2.7	2.4	2.5	2.4	3.3	3.7	3.3	:	:	:	:	7.8	10.9	26
International scientific co-publications per million population	160	144	158	222	272	248	289	316	349	349	358	379	:	8.2	300	21
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	11	11	12	15	16	:	8.0	53	21
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.7	0.4	0.7	0.6	0.5	0.5	0.5	0.5	0.3	0.4	:	:	:	-7.6	3.9	23
License and patent revenues from abroad as % of GDP	:	:	:	:	0.14	0.16	0.16	0.20	0.17	0.11	0.05	0.004	:	-39.8	0.58	26
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	19.2	:	16.7	:	15.8	:	23.3	:	:	3.3	14.4	1
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	15.5	19.8	22.1	21.4	22.1	19.6	:	:	4.9	45.1	24
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	0.20	-1.14	-1.36	0.46	0.42	0.32	0.95	2.19	3.18	3.31	3.96	4.35	:	-	4,20 (3)	6
Growth of total factor productivity (total economy) - 2000 = 100	100	101	104	108	112	116	122	130	132	126	131	133	135	35 (4)	103	1
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	31.4	:	:	:	:	31.4	:	:	:	:	31.6	:	:	0.1	48.7	25
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	10.0	10.1	10.1	10.5	:	1.6	13.6	21
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	19.3	:	21.4	:	19.0	:	26.0	:	:	5.1	38.4	20
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.06	0.02	0.00	0.05	0.05	0.03	0.04	0.01	0.02	:	:	:	:	-13.2	0.39	22
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.07	0.05	0.11	0.08	0.05	0.00	0.02	0.04	0.03	:	:	:	:	-9.1	0.52	24
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	63.5	63.5	63.6	64.8	63.7	64.5	66.0	67.2	68.8	66.4	64.6	65.1	:	0.2	68.6	18
R&D Intensity (GERD as % of GDP)	0.65	0.63	0.57	0.57	0.51	0.51	0.49	0.46	0.47	0.48	0.63	0.68	:	*0.4*	*2.03*	23
Greenhouse gas emissions - 1990 = 100	69	73	72	73	72	71	71	68	70	62	64	:	:	-5 (5)	85	6 (6)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	6.1	6.2	6.6	8.2	8.4	10.4	9.8	:	:	8.2	12.5	16
Share of population aged 30-34 who have successfully completed tertiary education (%)	10.6	10.7	10.5	11.5	12.9	14.3	14.4	14.8	15.8	17.6	22.1	23.4	:	7.5	34.6	24
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	32.0	26.7	21.3	20.6	19.6	20.6	20.6	:	-7.1	*24.2*	11 (6)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) EU is the weighted average of the values for the Member States.

(4) The value is the difference between 2012 and 2000.

(5) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(6) The values for this indicator were ranked from lowest to highest.

(7) Values in italics are estimated or provisional.

Slenia

Towards a knowledge-intensive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Slovenia. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

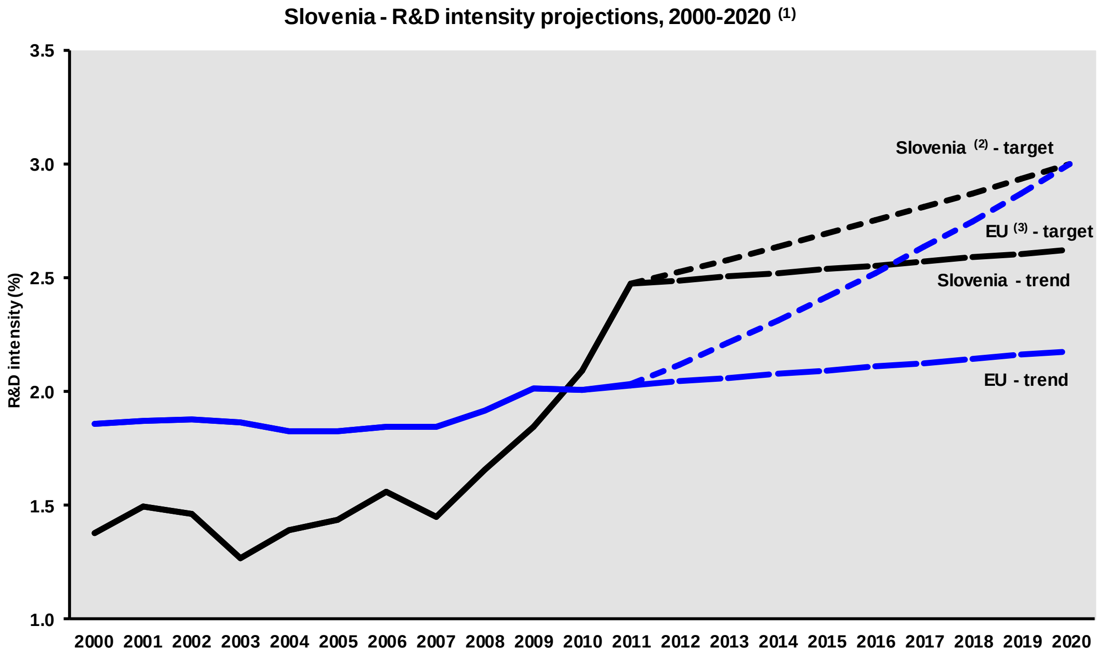
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 2.47% (EU: 2.03%; US: 2.75%) 2000-2011: +12.46% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 27.47 (EU:47.86; US: 56.68) 2005-2010: +3.99% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011:0.521 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:45.9 (EU:48.75; US: 56.25) 2000-2010: +4.25% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Health, Food and agriculture, ICT, Materials, New production technologies, Environment	*HT + MT contribution to the trade balance* 2011: 6.05% (EU: 4.2%; US: 1.93%) 2000-2011: +14.72% (EU: +4.99%; US:-10.75%)

Slovenia has significantly increased its R&D intensity over the last decade, with some fluctuations. It increased from 1.38% in 2000 to 2.11 % in 2010 and reached 2.47 % in 2011, a value which is higher than the EU average of 2.3%. The fluctuations over that period are mirrored by fluctuations in the R&D intensities of both the private and public sectors. In 2011, business enterprise expenditure on R&D as a percentage of GDP was 1.83% compared to an EU average of 1.26% and public sector expenditure on R&D as a percentage of GDP was 0.64% compared to an EU average of 0.74%. In the last decade both business expenditure on R&D and government funding of R&D increased.

This is a clear signal that Slovenia regards investment in R&D as a priority for the development of medium-high and high-tech and competitive enterprises and for increased and sustainable economic growth. Slovenia is meeting the challenge of reaching its 2020 R&D intensity target of 3% by mobilising incentives and resources from public and private sources (human, financial, infrastructural) and providing smooth paths for more technological innovation. At the same time the effectiveness and efficiency of the R&I system needs to be upgraded, notably through improved governance and higher dynamics in the knowledge triangle.

In order to tackle these challenges a new National Research and Innovation Strategy 2011-2020 was prepared and approved in 2011. It aims to better integrate research and innovation, to enhance cooperation between PROs and the business sector, to better contribute to economic and social restructuring and to increase scientific excellence. The National Programme 2011-2010 for Higher Education points to improved efficiency of the system and better articulation with needed skills, notably in science and engineering.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2000-2007 in the case of Slovenia.
(2) SI: This projection is based on a tentative R&D intensity target of 3.0% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(4) SI: There are breaks in series between 2008 and the previous years and between 2011 and the previous years.

R&D intensity in Slovenia increased from 1.66 % in 2008 to 2.47 % in 2011. Slovenia's R&D intensity target of 3% for 2020 is ambitious but achievable despite the economic crisis, provided that there is an effective and efficient increase of resources devoted to research and innovation.

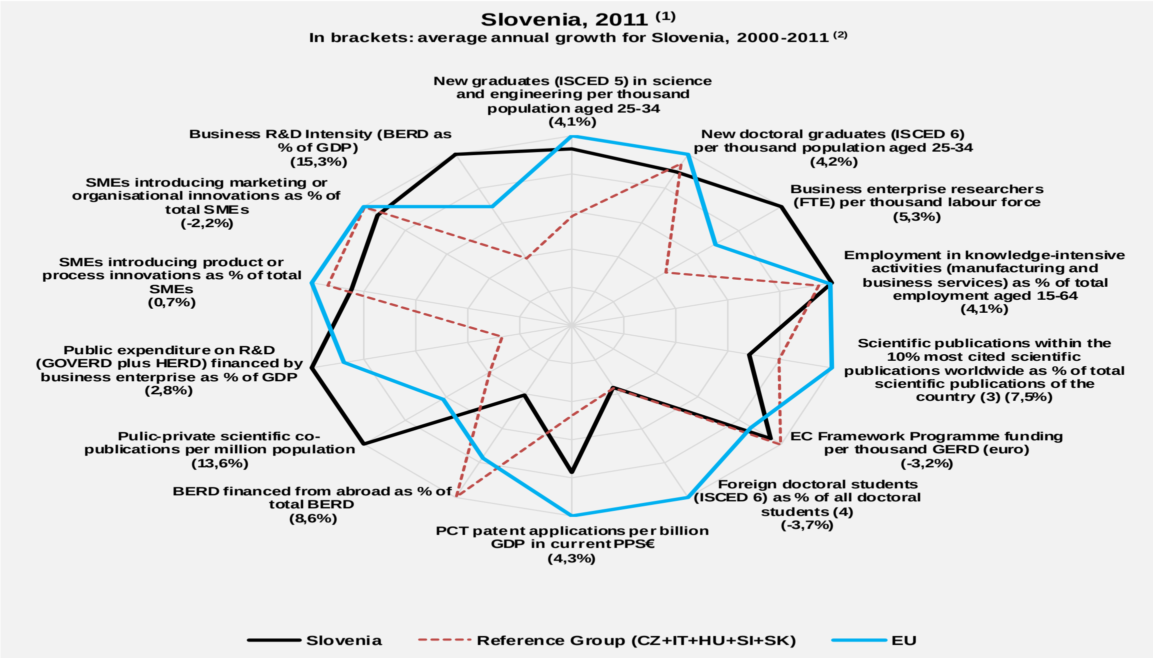
In spite of the economic crisis, the share of R&D financed by business enterprise has been indeed higher than the EU average since 2007. In fact, in 2011 business enterprise expenditure on R&D as a percentage of GDP reached 1.83%, making Slovenia one of the top performers in the EU in terms of business R&D. Notwithstanding, budgetary constraints, public sector expenditure on R&D n 2011 was equal to 0.64%, of GDP, slightly below the EU average but above those of countries with similar research and knowledge structures. Between 2008 and 2010 business expenditure on R&D has increased in real terms at an average annual growth rate of 15,3% while government funding of R&D has increased in real terms over the same period at an average annual growth rate of 1.4%.

Slovenian research and innovation also receives support from the EU budget through two main instruments: the Structural Funds and the 7th Framework Programme. Over the ERDF programme period 2007-2013, a total of €1 207 million has been allocated to activities related to research, innovation and entrepreneurship (29.4% of the total of Structural Funds available for the Slovenian regions). A total of 509 participants from Slovenia benefited by around € 99.4 million from the EU 7th Framework Programme. The participant success rate of participants is 16.12%, was below the EU average success rate of 21.95%.

Slovenia is one of the countries where R&D expenditure has increased steadily both before and after 2008. As a result Slovenia had the sixth highest R&D intensity in the EU in 2011, a development which reflects the Slovenian counter-cyclic commitment to ensure increased and sustainable economic growth.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Slovenia's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The graph above shows that Slovenia's research and innovation system is performing well, with several indicators close to or above the EU average and with positive trends. These include human resources, innovation in business, and R&D expenditure. Nevertheless, there are some weaknesses in the domains of knowledge commercialization, private and public sector internationalisation, and research quality.

Regarding human resources, Slovenia already has a high level of new doctoral graduates, above the EU average, but is still catching up in terms of new graduates in science and engineering. Employment of researchers by business enterprises and in knowledge-intensive activities is also at a high level. In this regard it seems that highly skilled graduates are readily absorbed into the Slovenian economy. However, despite its good performance in human resources, Slovenia is still not attractive enough for foreign doctoral students.

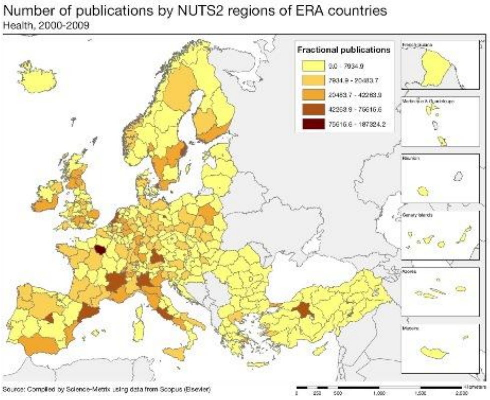
Regarding scientific production, Slovenia has high levels of international scientific co-publications and public-private scientific co-publications but needs to improve their quality in order to perform better in terms of scientific publications within the 10% most cited scientific publications worldwide. In terms of knowledge commercialization Slovenia has an increasing number of PCT patent applications and has a high level of patent applications to the EPO in the field of health-related technologies. However, the levels of both total PCT and total EPO patent applications are below the EU average. Slovenian SMEs perform well in terms of (non-technological) marketing and organisational innovations and fairly well in introducing product or process innovations. However, Slovenia needs to improve its attractiveness for R&D investment by foreign firms as is illustrated by the fact that the share of business R&D expenditure financed from abroad is much lower than the EU average.

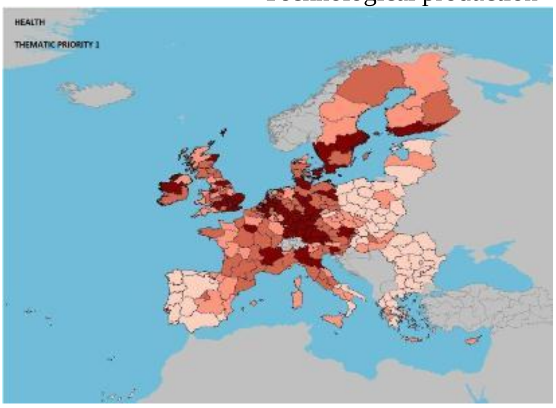
Slovenia's scientific and technological strengths

The maps below illustrate six key science and technology areas where Slovenia has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

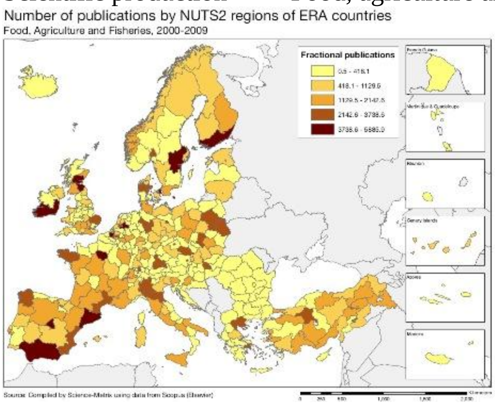
Strengths in science and technology at European level

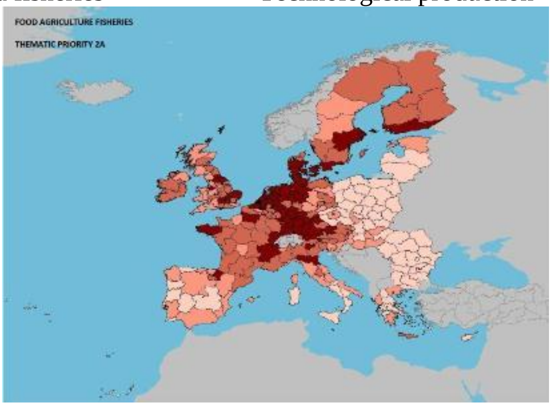
Scientific production Health Technological production



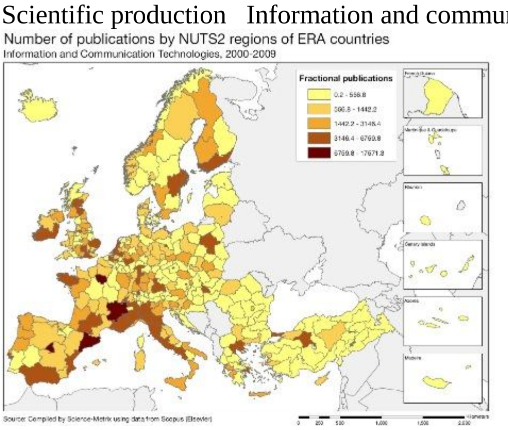


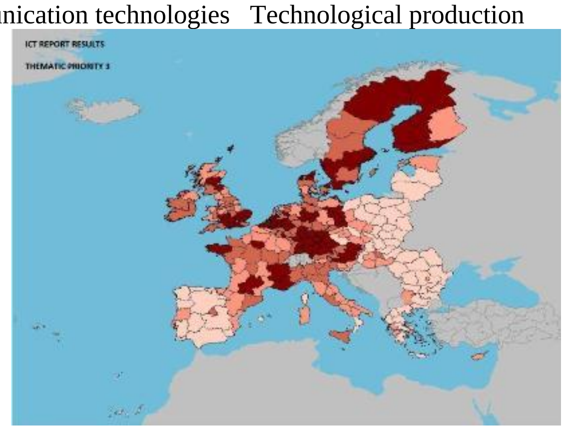
Scientific production Food, agriculture and fisheries Technological production





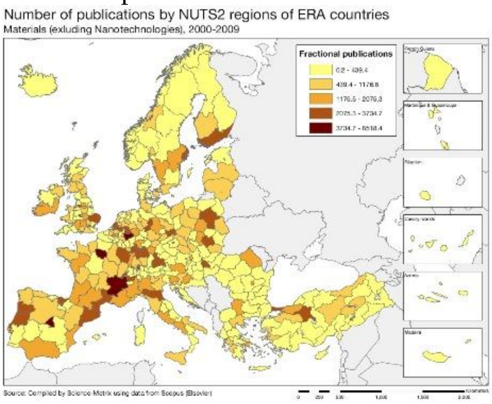
Scientific production Information and communication technologies Technological production

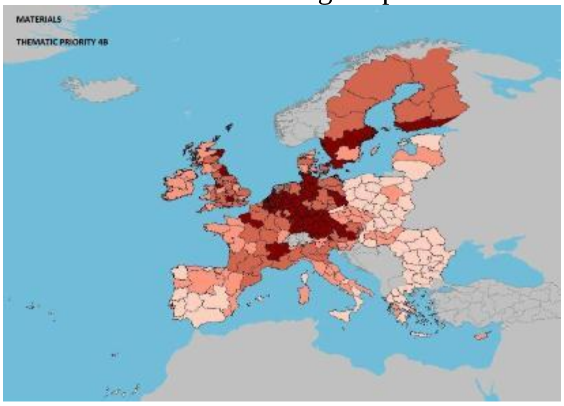




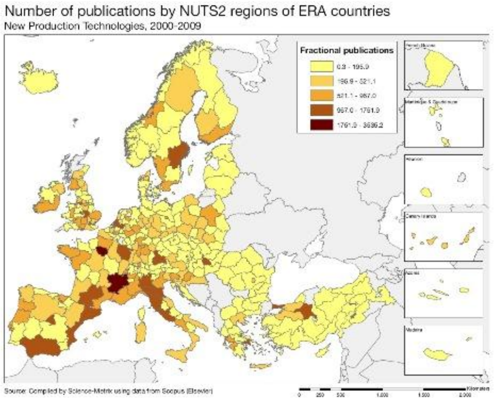
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

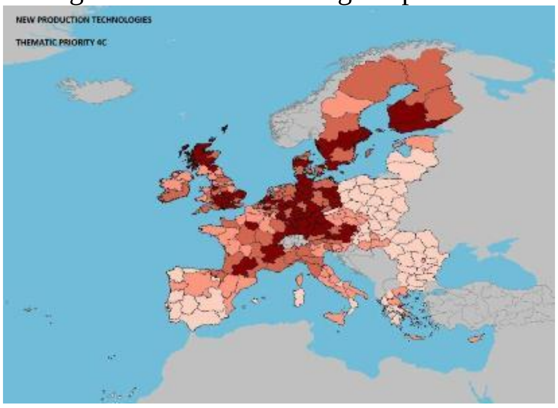
Scientific production Materials Technological production



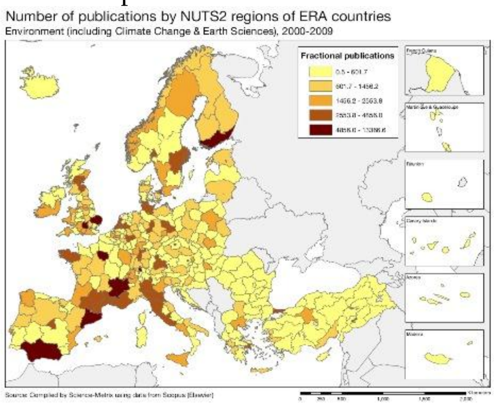


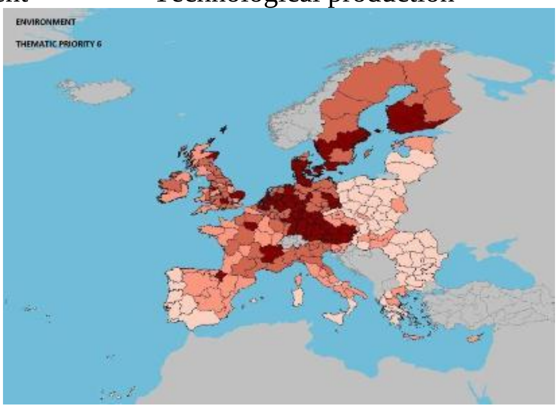
Scientific production New production technologies Technological production





Scientific production Environment Technological production





The maps above illustrate the strengths of Slovenian science and technology production in absolute numbers. Slovenia, in terms of scientific production, using the FP7 thematic priorities, has strong capacity in the fields of health, food, agriculture and fisheries, ICT, materials, production, environment, and socio-economics. In terms of specialisation the 'scientific specialisation index', covering the period 2000-2009, shows high values in the fields of food, agriculture and fisheries, ICT, materials, production, construction, energy, transport, socio-economics, and humanities.

Slovenian scientific excellence, as measured by the impact of citations and the share of its total scientific publications in the top 10% cited publications in each respective field, is particularly high for energy, transport, and security. The 'revealed technological advantage' index, also covering the same period, on the basis of the location of inventor of EPO patents, shows particular strength in health, biotechnology, construction, and transport.

Policies and reforms for research and innovation

Research and innovation is a priority in Slovenia. Slovenia's R&D intensity target for 2020 of 3%, therefore, seems to be achievable. One of the main challenges is the structuring of policies that provide support for research and, in particular, that stimulate innovation. In 2011, the Slovenian authorities approved two important long term strategic documents: The Research and Innovation Strategy of Slovenia 2011-2020 (RISS) and the National Higher Education Programme 2011-2020 (NHEP).

The Research and Innovation Strategy of Slovenia (RISS) defines the R&D priorities for the next decade (2011-2012) and aims to create a high performance research and innovation system which will improve the quality of life. It sets out the following main priorities: (1) better integration of research and innovation; (2) increasing scientific excellence, partly by increasing competitiveness within S&T stakeholders and partly by providing necessary resources, both human as well finance; (3) promoting closer cooperation between universities, research institutions and the business sector; (4) strengthened capacity of research to contribute to economic and social development. The National Higher Education Programme (NHEP) aims at upgrading the Slovenian Higher Education system to a level which is more consistent with education and skills needs in general and in science and engineering in particular. The measures outlined in 2011 in both the RISS and NHEP have yet to materialise. Several legal enactments, in particular, a revamped Law on Research and Development are required for their implementation.

Within the RISS a special section is devoted to the issue of research infrastructure, stipulating the need for a special Slovenian Research Infrastructure Roadmap (2011-2020) to deal with two problems related to the current state of Slovenian research infrastructure. These problems are: a lack of cooperation between research institutes, and the fragmentation and sub-optimisation of R&I utilisation. In this regard, the key objectives of the Research Infrastructure Roadmap are: better exploitation of the existing national research infrastructure; upgrade and construction of new research infrastructure in priority areas, and international integration based on access to large research infrastructures.

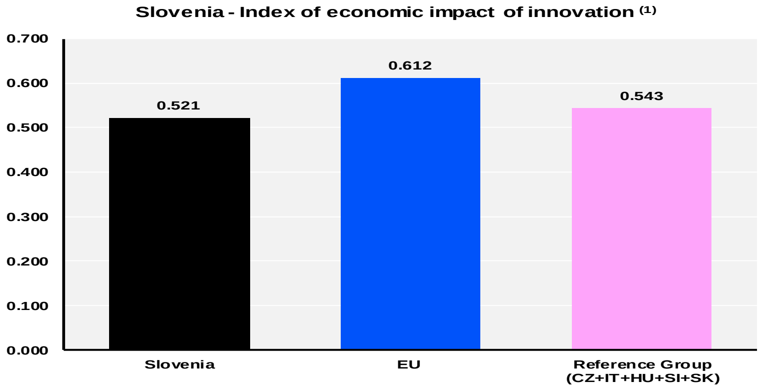
The new government, which was formed after the elections of December 2011, reallocated the competences for Research and Innovation between the Ministry of Education, Science, Culture and Sports, the Ministry of Economic Development and Technology and the Ministry of Infrastructure and Spatial Planning.

In 2010, different stakeholders in innovation policy introduced several new policy measures. The Competence Centres are led by businesses combining basic and applied research with a view to creating future market opportunities, and to some extent complement the Centres of Excellence, introduced in 2009. The latter are focused on basic research made by PROs, in cooperation with those business R&D units active in the same area. And finally the Development Centres (consortia of business firms) support "close to the market" research projects with a view to developing new products, processes and services. It is also noteworthy that tax allowances for research and innovation were increased in April, 2012.

Slovenia has several programmes and instruments to support Research and Innovation, such as the innovation voucher, the mentorship voucher, the mentorship of young researchers, calls for basic and applied projects, financial assistance to institutions that support innovation, the strengthening of development units in the business sector and the transfer of technologies from the public sector. In the aftermath of the economic crisis Slovenia will focus on cutting its annual budget deficit from 6% to 3% by 2013. This will lead to difficult decisions about priorities for the public sector. It remains to be seen if support for R&I will be affected. The new government announced several policy changes in both strategic documents in order to preserve research and innovation capabilities of Slovenia against reduction of government budget on R&D.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[6].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

According to this index, Slovenia underperforms its reference group and is clearly below the EU average. While the country only ranks 16th in the EU, Slovenia displays a contrasted pattern of marked strengths and weaknesses. Slovenia is the best performer amongst its reference group for "patent applications per GDP", "share of the employment in knowledge-intensive activities" and "contribution of medium and high-tech product exports to the trade balance". In all three areas, Slovenia ranks rather well amongst EU Member States, in particular regarding its medium and high-tech trade specialisation where it is second only to Germany. However, these strengths are counterbalanced by equally marked weaknesses in the "share of knowledge intensive services in total export of services" and "sales of new to market and new to firm innovations as % of turnover of firms".

Therefore, it seems that Slovenia may not have fully developed its innovative potential. One of the reasons is that some components of the business and competitive framework have changed very little: links between public sector and private sector are still weak and some structural aspects of the business environment hinder foreign direct investment. In order to improve competitiveness, there would be benefits to consider developing a new industrial policy including a strategy for attracting foreign capital, notably linked to R&I.

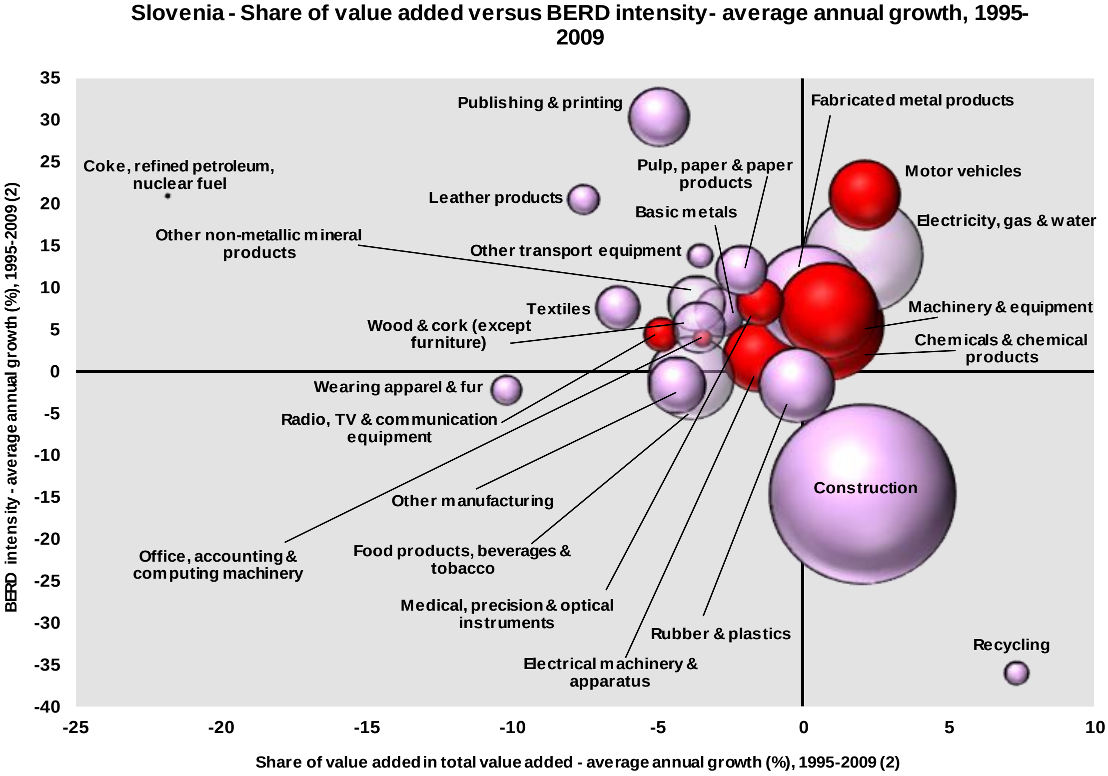
The approach to attracting investment outlined in the National Reform Programme seems to rely mainly on financial incentives rather than on making also other improvements to the business environment, while the latter could contribute to maximise the impact of these incentives. Progress has been made through changes in tax legislation: the R&D tax allowance was increased to 100% of the amount invested.

The background of economic crisis and fiscal austerity implies a lower availability of resources, and companies, especially SMEs, struggle to obtain funding not only for projects but also for operational capital. In this regard the government is planning to increase funds for guarantees and credits for R&D and new technologies through the Slovenian Enterprise Funds (SPD) and the Slovene Development and Export Bank (SID) rather than providing direct subsidies to the business sector. The question remains whether credit is a suitable instrument for SMEs with little experience of research and innovation. The Slovene Enterprise Fund also supports start–up companies in the first three years of their life. The results show that this instrument should be reinforced. Most of the stronger financial measures currently being implemented are co-financed from the Structural Funds. Overall the main challenge remains the efficient and effective use of available resources. Slovenia has room to better address funding priorities. There is a need for more focus on and critical mass in sectors related to the existing R&D strengths and economic strengths of Slovenia.

6 See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Wearing apparel and fur': 1995-2008; 'Electricity, gas and water': 1996-2009; 'Other non-metallic mineral products', 'Publishing and printing', 'Pulp, paper and paper products', 'Wood and cork (except furniture)': 1997-2009; 'Coke, refined petroleum, nuclear fuel': 1998-2007; 'Recycling': 2003-2007.

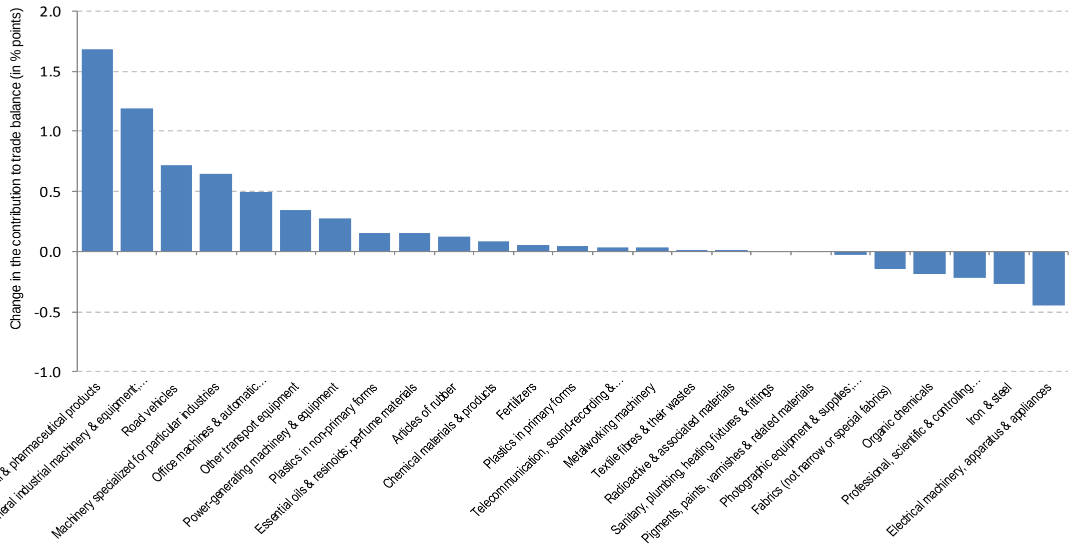
The Slovenian economy is characterised by a relatively strong manufacturing industry. Manufacturing makes a higher contribution to total value added than the EU average. Nevertheless, as in many other countries, the share of manufacturing value added is tending to decrease (as shown by the position of most of the sectors on the left side of the graph), due to a corresponding increase in services value added.

Although some industry sectors have achieved slight increases in their shares of the economy, specialization in labour intensive industries has decreased considerably over the last decades. As the graph illustrates, Slovenia's manufacturing industries are moving towards higher research intensity in almost all sectors. Highly innovation-intensive sectors are: electrical machinery and apparatus, chemical products, machinery and equipment, motor vehicles, medical precision and optical instruments, and radio, TV and communication equipment. Slovenia has two companies in the 2011 EU Industrial R&D Scoreboard in the fields of pharmaceuticals, and construction and materials.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Slovenia between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The Slovenian trade balance for high-tech (HT) and medium-tech (MT) products has grown progressively since 2000. The contribution of the basket of the above products to the Slovenian trade balance grew at an average rate of over 12% per annum during the last decade. Medicinal and pharmaceutical products, road vehicles, and general industrial machinery and equipment and machine parts increased their contributions whereas iron and steel, professional, scientific and controlling instruments and apparatus, and electrical machinery, apparatus and appliances, and electrical parts have lower contributions.

It should be noted, however, that some commodities, such as the last two referred to above, contribute positively to the national trade balance, whereas others, such as office machines and automatic data-processing machines have reduced their negative contribution over the period. It is also worth noting that medicinal and pharmaceutical products, road vehicles, and general industrial machinery and equipment and machine parts which make a strong positive contribution to the trade balance are produced in sectors with high positive variations in added value and R&D intensity (see previous graph).

Slovenia is investing and catching-up. Total Factor Productivity increased from 2000 to 2011 at a higher rate than the EU average. Gross Fixed Capital Formation grew in real terms from 2000 to 2008 at an average rate of 5.9% per annum but has declined since then. R&D intensity grew at an average annual rate of 12.5% between 2008 and 2010. Labour productivity grew at an average annual rate of more than 3% up to 2010. Slovenian employment in knowledge-intensive activities (manufacturing and services) is at the level of the EU average and EPO patent applications per billion GDP in the domain of health-related technologies are the second highest in the EU.

Key indicators for Slovenia

SLOVENIA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [(1)] (%)	EU average [(2)]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	1.00	1.02	1.08	1.25	1.20	1.24	1.31	1.37	1.34	1.52	1.51	:	:	4.2	*1.69*	13
Business enterprise expenditure on R&D (BERD) as % of GDP	0.78	0.86	0.87	0.81	0.93	0.85	0.94	0.87	1,07 [(3)]	1.19	1.42	*1,83* [(4)]	:	*15.3*	*1.26*	6
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.59	0.61	0.57	0.45	0.46	0.59	0.62	0.58	0.59	0.65	0.67	*0,64* [(5)]	:	*1.4*	*0.74*	13
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	22.6	:	:	:	:	27.5	:	:	4.0	47.9	17
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	4.2	4.6	4.4	4.8	5.8	6.5	6.6	7.6	7.4	:	:	:	:	7.5	10.9	18
International scientific co-publications per million population	286	240	292	449	459	578	570	689	783 [(6)]	817	857	955	:	13.4	300	11
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	51	54	61	70	85	:	13.6	53	7
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	2.1	1.6	2.5	2.2	2.3	2.7	2.5	2.7	3.1	3.0	:	:	:	4.3	3.9	10
License and patent revenues from abroad as % of GDP	:	:	:	:	0.03	0.05	0.04	0.04	0.09	0.11	0.15	0.17	:	25.9	0.58	14
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	14.3	:	13.3	:	16.3	:	10.6	:	:	-4.8	14.4	17
Knowledge-intensive services exports as % total service exports	:	:	:	:	18.4	18.6	17.7	18.9	23.8	21.7	20.9	:	:	2.2	45.1	23
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	1.34	1.71	1.90	2.16	2.62	3.74	3.96	4.16	4.77	5.79	6.06	6.05	:	-	4,20 [(7)]	2
Growth of total factor productivity (total economy) - 2000 = 100	100	101	103	104	107	109	112	115	114	105	107	109	107	7 [(8)]	103	9
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	30.3	:	:	:	:	37.4	:	:	:	:	45.9	:	:	4.2	48.7	13
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	12.2	13.0	13.4	13.8	:	4.1	13.6	14
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	31.7	:	31.0	:	32.6	:	:	0.7	38.4	17
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.10	0.10	0.06	0.10	0.03	0.08	0.08	0.03	0.07	:	:	:	:	-5.0	0.39	18
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.26	0.46	0.61	0.48	1.03	0.81	1.19	1.19	1.15	:	:	:	:	20.5	0.52	2
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	68.5	69.4	69.0	68.1	70.4	71.1	71.5	72.4	73.0	71.9	70.3	68.4	:	0.0	68.6	14
R&D Intensity (GERD as % of GDP)	1.38	1.49	1.47	1.27	1.39	1.44	1.56	1.45	1,66 [(3)]	1.85	2.09	*2,47* [(4)]	:	*12.5*	*2.03*	6
Greenhouse gas emissions - 1990 = 100	102	107	108	107	108	110	111	112	116	105	106	:	:	4 [(9)]	85	19 [(10)]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	16.2	16.0	15.5	15.6	15.1	18.9	19.8	:	:	3.4	12.5	9
Share of population aged 30-34 who have successfully completed tertiary education (%)	18.5	18.1	20.7	23.6	25.1	24.6	28.1	31.0	30.9	31.6	34.8	37.9	:	6.7	34.6	14
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	18.5	17.1	17.1	18.5	17.1	18.3	19.3	:	0.7	*24.2*	9 [(10)]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2008 and the previous years.

(4) Break in series between 2011 and the previous years. Average annual growth refers to 2008-2010.

(5) Break in series between 2011 and the previous years. Average annual growth refers to 2000-2010.

(6) Break in series between 2008 and the previous years. Average annual growth refers to 2000-2007.

(7) EU is the weighted average of the values for the Member States.

(8) The value is the difference between 2012 and 2000.

(9) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(10) The values for this indicator were ranked from lowest to highest.

(11) Values in italics are estimated or provisional.

Spain

The challenge of structural change for a more knowledge-intensive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Spain. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 1.33% (EU: 2.03%; US: 2.75%) 2000-2011: +3.56% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:36.63 (EU:47.86; US: 56.68) 2005-2010: +3.66% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.53 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:36.76 (EU:48.75; US: 56.25) 2000-2010: +2.65% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Food and agriculture, Energy, ICT, Security, Biotechnology, Environment	*HT + MT contribution to the trade balance* 2011: 3.05% (EU: 4.2%; US: 1.93%) 2000-2011: +23.73% (EU: +4.99%; US:-10.75%)

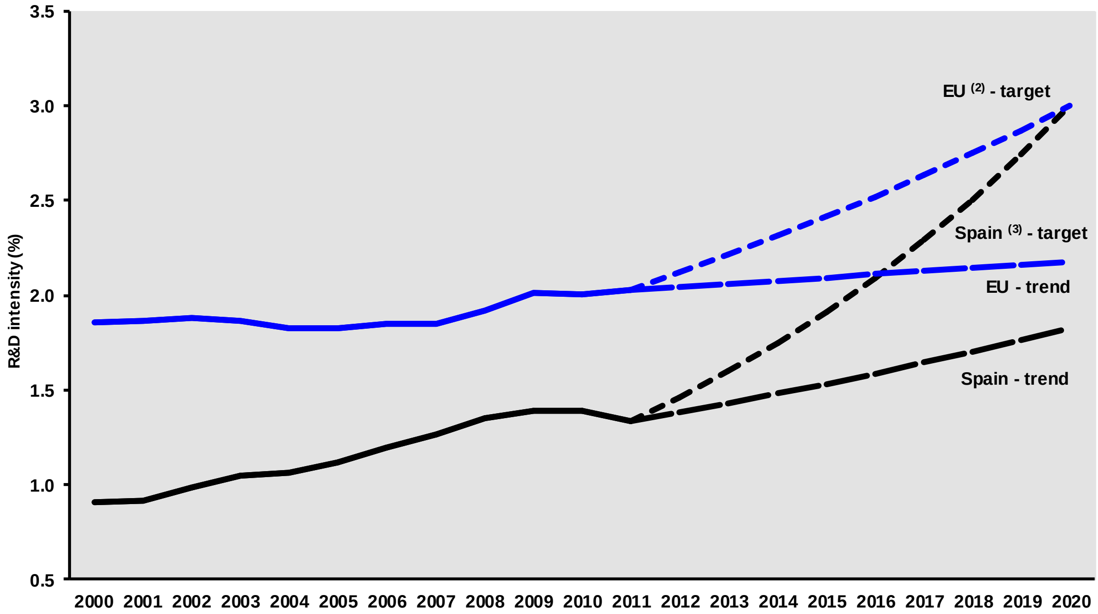
Investment in research and innovation (R&I) has grown substantially in Spain over the last decade. Public investment in R&D grew even beyond the economic crisis, in a counter-cyclic effort. Business investment in R&D also grew over the period 2000-2008. As a result, excellence in science and technology has substantially improved and Spain demonstrated a fair degree of structural change towards a more knowledge-intensive economy and a slight upgrading of the R&D intensity in most manufacturing industries. Another positive sign is the rising contribution of high-tech and medium high-tech goods to the trade balance.

However, despite this positive evolution, the Spanish economy remains less knowledge-intensive than the EU economy as a whole. Investment levels are still low, excellence in science and technology lags behind the EU average, and growth in innovative firms must be boosted. The economic crisis has hit Spain hard, partly because international competition and the globalisation of production has had a particularly harsh impact on several industries and services in which Spain is specialised. In particular, the low scale of hot spots in key technologies and the lack of innovation for societal challenges contrast with the expanding potential for these products and services in global markets and value chains. The main challenges for Spain remain, therefore, to invest in knowledge and to better ensure the effectiveness of this investment in creating a more knowledge-intensive economy.

A new law for Science, Technology and Innovation was adopted in 2011. It strengthens the governance system, simplifies the allocation of competitive funding creating a new national research agency, and stimulates researcher mobility between the public and private sectors. However, with the economic crisis, the government has recently reduced public funding in R&D and in education. Consequently, as part of the Europe 2020 process, it was recommended that Spain should review spending priorities and reallocate funds to support small and medium-sized enterprises (SMEs), research, innovation and employment opportunities for young people. In order to meet with this recommendation, the government has included in its National Reform Programme 2012 a package of structural reforms especially devoted to boosting SMEs, research, innovation and employment opportunities for young people.

Investing in knowledge

Spain - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) ES: This projection is based on a tentative R&D intensity target of 3.0% for 2020.

Spain has set a national R&D intensity target of 3%, within which public sector R&D investment would reach 1% and business R&D investment 2% of GDP by 2020. In 2011, Spanish R&D intensity was 1.33%. Public sector R&D intensity amounted to 0.64% and business R&D intensity 0.70%. Both values have fallen slightly in 2011 compared to 2010.

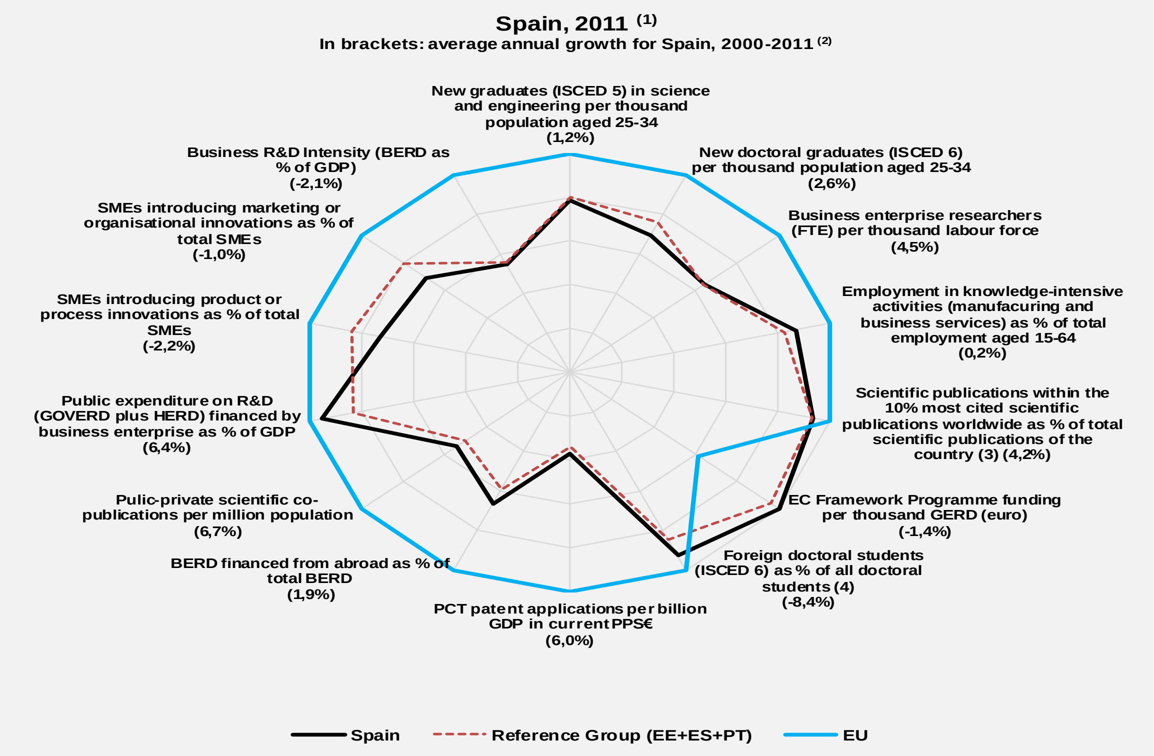
Over the period 2000-2009, the Spanish R&D intensity increased with an annual average growth of 4.3%, well above the EU average. In absolute terms, public R&D funding reached a peak in 2009, which means that the Spanish government continued to increase its R&D budget up to two years after the start of the financial crisis in 2008. However, since then, the government R&D budget has been reduced by 4.12% in 2010 and by 7.38% in 2011. The 2012 budget foresees a more drastic decrease of 25.57%.

Private R&D expenditure has also been seriously affected by the economic crisis. Business R&D expenditure in real terms reached a peak in 2008. Spanish firms more than doubled their R&D expenditure in real terms over the period 2000-2008. However, following the economic crisis and liquidity constraints, business R&D investment fell by 6.27% in 2009 and by another 0.81% in 2010. Firms in food, automobiles, and construction, have undertaken the strongest cuts.

A total of € 7.8 billion from the EU FEDER Structural Funds has been allocated to research, innovation and entrepreneurship in the Spanish regions for the period 2007-2013. This represents 22.6% of the total FEDER fund for Spain. By 2010, Spain had committed 38.4% of these EU funds (the average in the EU was a 46.6% commitment rate). Spain also has the scope to increase its funding of R&D from the EU 7th Framework Programme. It will adopt a national strategy to foster the participation of national R&I teams in European projects and programmes. The success rate of Spanish applicants is 19.99%. This is lower than the EU average success rate of 21.95%. Up to mid-2012, over 6400 Spanish participants had been partners in an FP7 project, with a total EC financial contribution of € 1.8 billion (representing 6.88% of total EC funding contribution at that stage in FP7).

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Spanish R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

The graph above indicates that the increase in public funding for R&D (2000-2011 average annual growth) has triggered a stronger scientific excellence but without clear progress in business innovation. Spain faces a negative trend in business R&D investments and is still below the EU average on technology development and innovation. Its performance is however similar to the reference group of countries. In the field of human resources, 40.6% of the population aged 25-34 completed tertiary education, although with lower share of new graduates (ISCED 6) in science and engineering than the EU average. While Spain is below the EU average in highly-cited scientific publications, Spanish researchers are successful in international scientific co-publications.

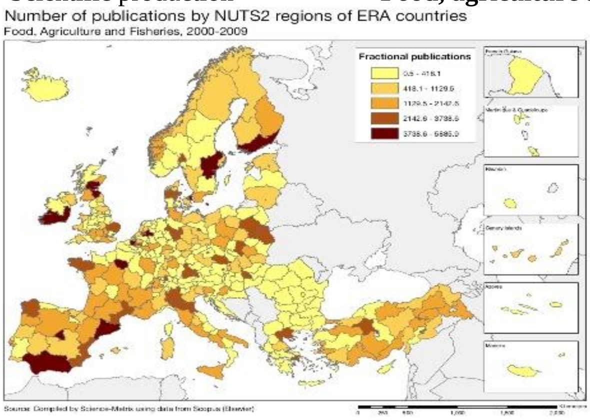
The number of business researchers in Spain has grown between 1999 and 2010, but Spain has still a lower level than the EU average. These numbers point at the need to enhance the quality of the higher education system and to address the non absorption of highly-skilled graduates in firms. Spain has improved its scientific quality and production but still faces the challenge of increasing the excellence and internationalization of its universities and PROs. The universities are not visible in major international rankings and their scientific production and staff composition is less international than is the case in several other Member States. And despite an improvement, Spain still performs well below the EU average for public-private cooperation in science. Spain also faces challenges in relation to business R&D. As shown on the graph above, overall technology development is low – but increasing. Product and process innovations in SMEs have decreased over the last decade.

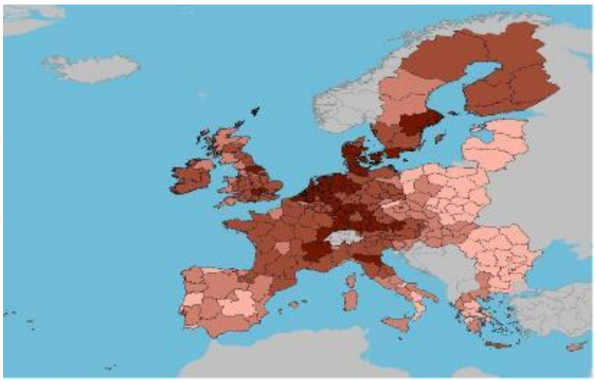
Spain's scientific and technological strengths

The maps below illustrate six key science and technology areas where Spain has real strengths in a European context. The maps are based on the numbers of scientific publications and patents produced by authors and inventors based in the regions.

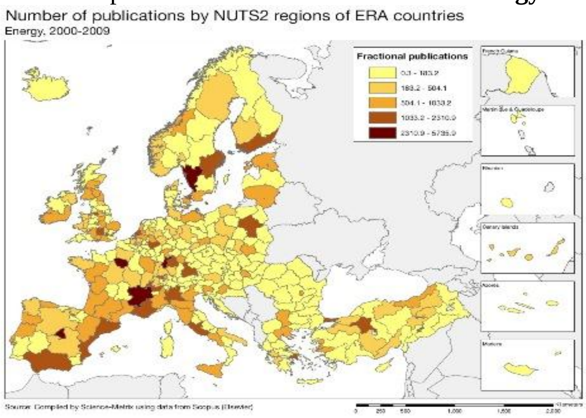
Strengths in science and technology at European level

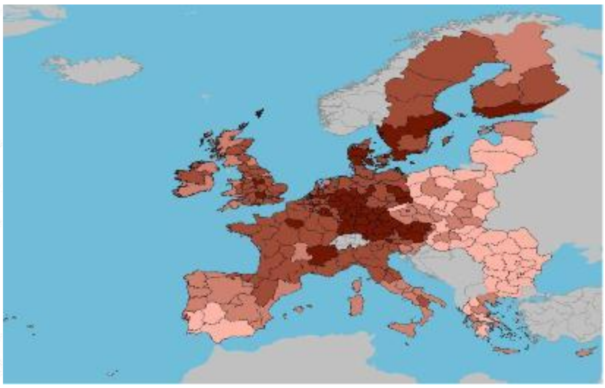
Scientific production **Food, agriculture and fisheries** Technological production



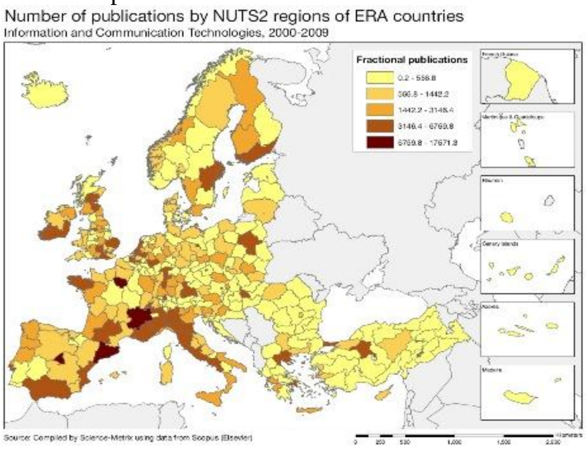


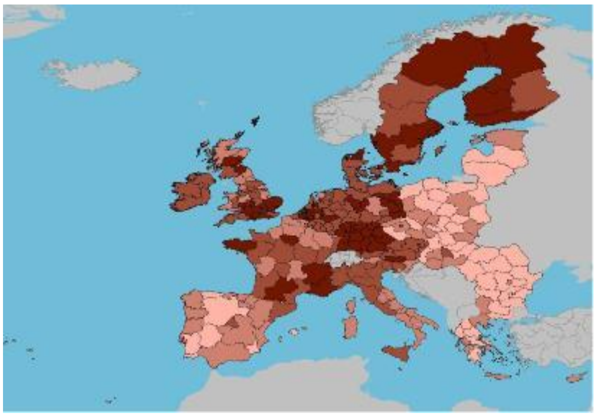
Scientific production **Energy** Technological production





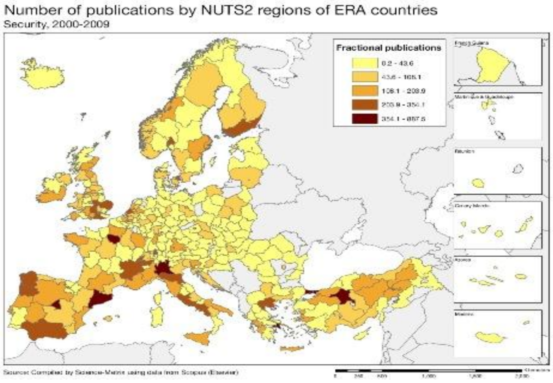
Scientific production **Information and Communication Technologies** Technological production

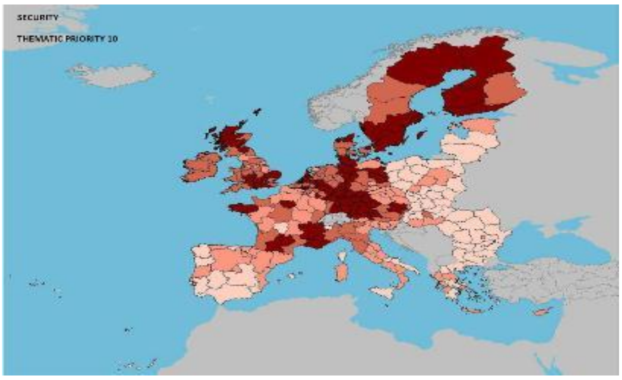




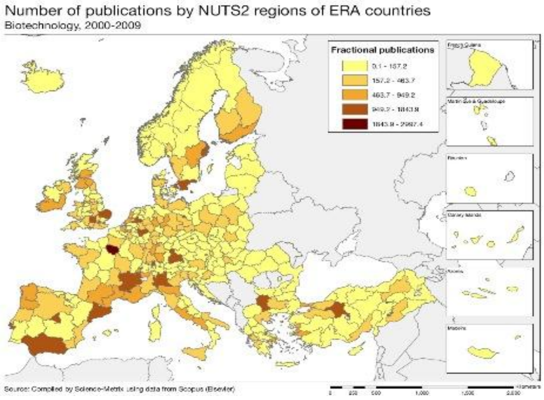
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

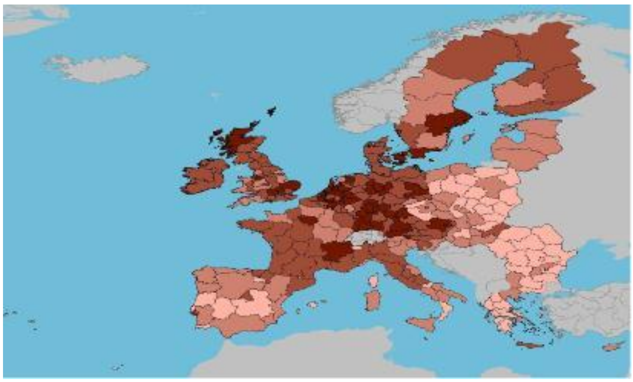
Scientific production **Security** Technological production



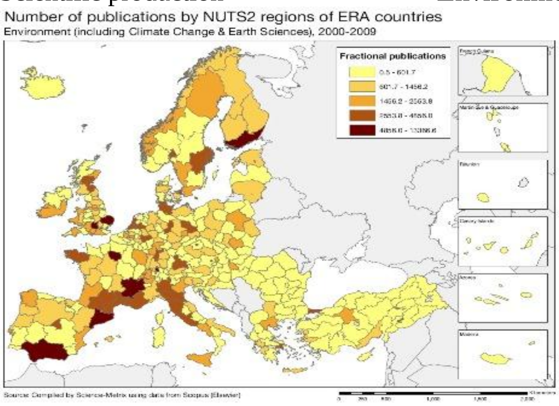


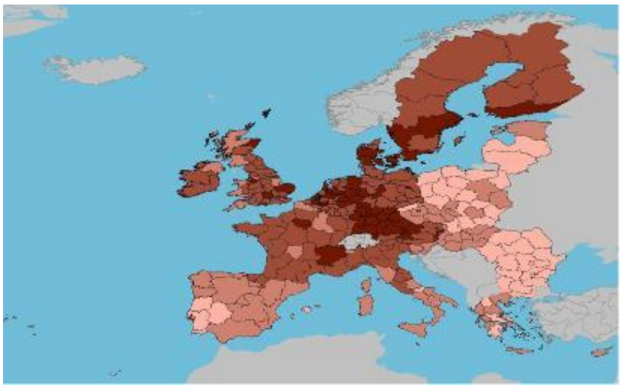
Scientific production **Biotechnology** Technological production





Scientific production **Environment** Technological production





As illustrated by the maps above, in terms of scientific production, Spain has strong regional capacity in the fields of food, agriculture and fisheries, energy, ICT, security, biotechnology and environmental science and technologies (including the important water sector). In terms of scientific quality, the most prominent scientific work in Spain is in energy, security, transport and materials. Spain's scientific specialisation index (not shown on the maps above) shows that the main scientific fields are food, agriculture and fisheries, ICT, security, but also construction technologies and humanities.

The relative strengths in patenting are visible in Catalonia, Madrid and the Basque country, although Aragon and Cantabria are also present in energy patenting. The main technology sectors are food and agriculture, biotechnology, ICT and energy although the core technology development in Europe in these sectors takes place in regions outside Spain. The data on patenting in industrial sectors (not included on the maps above), show that Catalonia has particular strengths (within the highest 25th percentile) in organic fine chemistry, pharmaceuticals, food chemistry, while the Basque country has similar technology strengths in engines, pumps and turbines, thermal process and apparatus, furniture, games, other consumer goods, machine tools, electrical motors and green energy.

Policies and reforms for research and innovation

The Spanish authorities are addressing these challenges in a new Law for Science, Technology and Innovation adopted with broad political support in 2011, as well as in new Spanish Strategy for Science, Technology and Innovation and in the State Plan for Scientific and Technical Research and Innovation adopted in February 2013. The new innovation strategy is very relevant and needed. Reform proposals cover the governance system, the quality of human resources, the funding allocation system and knowledge transfer between actors. The strategy for the Spanish research and innovation system now need to be implemented effectively and swiftly. Stronger coordination between national and regional R&I policies and instruments is a crucial element for improved system efficiency. Objectives and priorities are well aligned with the objectives of Europe 2020, the Innovation Union and Horizon 2020. The law of 2011 also simplifies the allocation of competitive funding for research and innovation by giving responsibility for the allocation of funds to two main bodies, the new national research agency (AEI) and the existing agency for innovation (CDTI). Public-private cooperation will be reinforced by the introduction of legal changes to researchers' contracts, thereby stimulating mobility between the public and the private sector. Legal reforms related to the recruitment and careers of researchers will encourage international outward mobility as well as inward mobility of foreign researchers of high levels of excellence. In addition to these legal reforms, agreed among all parties, a strong policy focus is placed on technology transfer to the market and on instruments to stimulate private R&D.

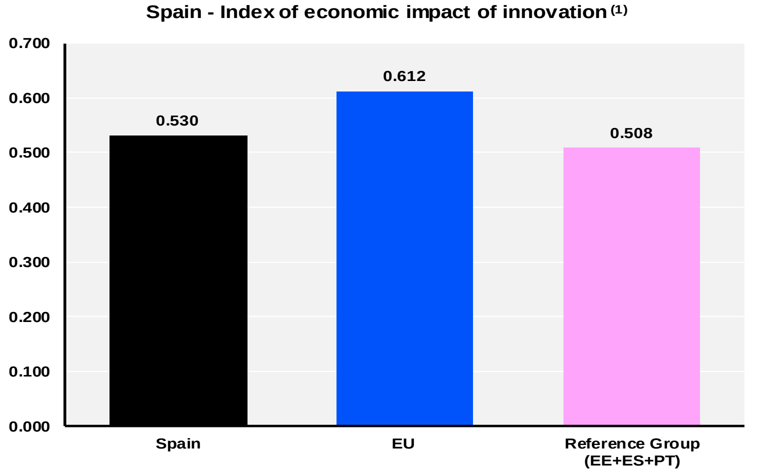
Key areas for action are a better matching between supply and demand for innovation, a favourable financial framework for innovation, high quality human capital and its engagement in R&I activities of Spanish industry, boosting risk capital activities and instruments alongside a reorientation of part of the public procurement towards innovative products and services, and increasing the participation of Spanish teams in EU research and innovation programmes. The Government has created a trading platform, a user guide and special programs aimed at making easier for firms to bid in innovative and pre-commercial public procurement calls.

The reforms in the Law for Science, Technology and the Spanish Strategy for Science, Technology and Innovation as well as the 2015 University strategy for excellence would need to be implemented fully in 2013. The falling public funding in R&D and education is a worrying trend. An enhanced focus on innovation and competitiveness in the EU Structural Funds for the 2014-2020 period would also contribute to this objective. At present, Spanish regions are designing their new innovation strategies aligned with smart specialization, under close monitoring by the central administration. Building on the positive experiences of other Member States in boosting the efficiency of the public R&I system, Spain could also improve institutional funding, introduce a performance-based financing system for universities and public research institutions, link a proportion of institutional funding to progress in scientific excellence, and increase the levels of internationalization and public-private cooperation.

Since early 2012, a package of reforms has been implemented, while ensuring the execution of some of the initiatives launched previously. Among the new reforms there are comprehensive laws to foster entrepreneurship, reform the labour market, and enhance a more unified domestic market. On-going reforms cover the execution of the Small Business Act for SMEs, simplification of the regulations, modernisation of public administration, boosting the internationalization of firms, and addressing the crucial challenge of access to funding. As part of the future Spanish Entrepreneurship Act, the government has announced the creation of the Spain Co-investment Start-up Fund, allocating a budget of 20 million euros to enhance venture capital on early-stage investments. The "AVANZA ICT plan will finish in 2015. The ministry of industry will also revise the existing industrial policy (PIN 2020) which was approved in 2010. Instead of focusing on an identified number of strategic sectors and building on Spain's strengths, the new government wishes to adopt a more horizontal approach where no specific sector is highlighted. There is however scope for further synergies between the industrial policy and the more strategic focus of innovation policies at national and regional level.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[7].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Economic impact of innovation in Spain is clearly above that of the reference group of countries with similar industrial and knowledge structure. However, there is room for further progress in reaching the EU average performance. One of the relevant policy areas is cluster support. Industrial clusters in Spain have been dominated by low-tech and medium-tech sectors such as food, textiles, tourism, leather, and the furniture industry. In order to foster innovation in these clusters as well as the emergence of new sectors, over 80 science and technology parks were established in the last decade where SMEs and larger firms work with research institutions. In terms of employment, these knowledge clusters are focused on transport, ICT and media, tourism, water and energy, health, optics, as well as agro-business, machinery, and wood. Science and technology parks can be found in all of the Spanish regions. Technology platforms are also very active in setting priorities in key sectors and boosting public-private cooperation.

The challenge ahead is to focus on real innovation-based clusters in sectors where Spain or a Spanish region has comparative advantage to address regional or global societal challenges. Strategies must be coordinated in a consistent national policy, including building networks between regions. Incentive-structures are needed to stimulate larger firms to develop smaller technology-based firms in a more sustainable eco-system; in parallel research institutions and researchers must be more incentivized to engage in innovation activity with surrounding firms. Economic impact of innovation is further enhanced by a better matching between science and technology and the regional or national industrial structure.

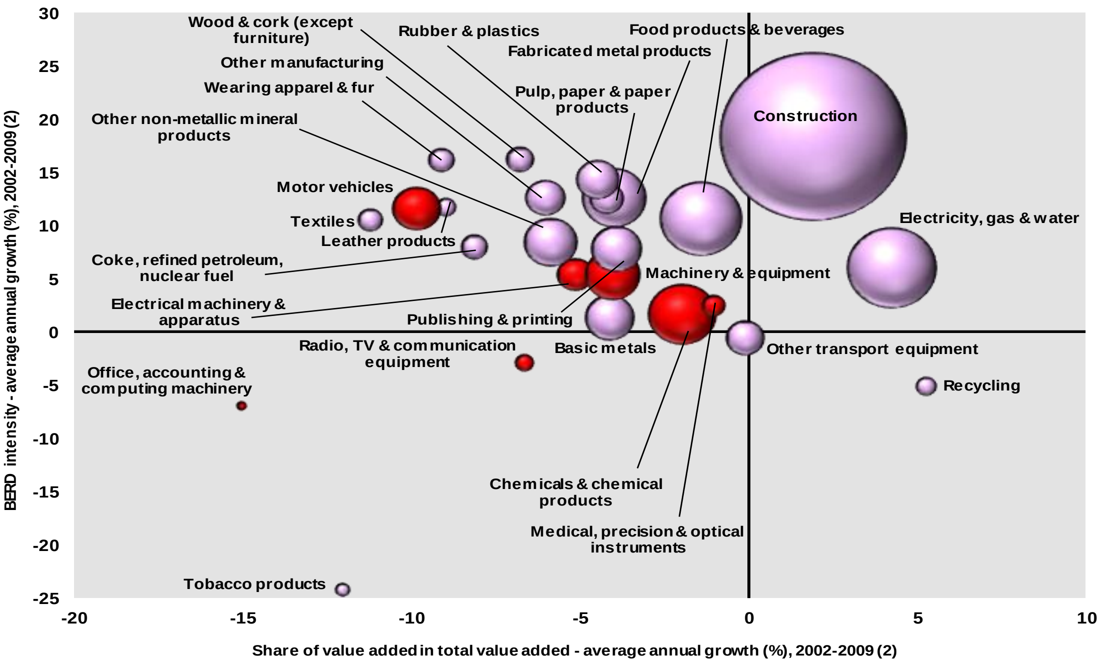
Spain has had to face the challenge of less favourable framework conditions for innovation, in particular following the economic crisis. In 2011, the ease of access to loans in Spain was among the lowest in the EU and this indicator had fallen sharply compared to 2007-2008 when the economic crisis broke out. Venture capital as % of GDP is also well below most EU Member States, in particular seed and start-up capital. However, in absolute terms, Spain is above the EU average in venture capital investment. Over the last decade, barriers to entrepreneurship have been lowered, but Spain's internal market has been more fragmented with a rapid increase in regional regulations.

[7] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Spain - Share of value added versus BERD intensity - average annual growth, 2002-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Food products and beverages', 'Tobacco products': 2002-2007.

As recognised by Spanish economic and industrial policy, the medium-term avenue for a more sustainable economy is to upgrade and to move up on the value chain and to internationalise its outreach. Compared to other countries, Spain has the scope to both increase the share of value added of high-tech and medium-high-tech sectors and to increase knowledge intensity in more traditional sectors of the economy.

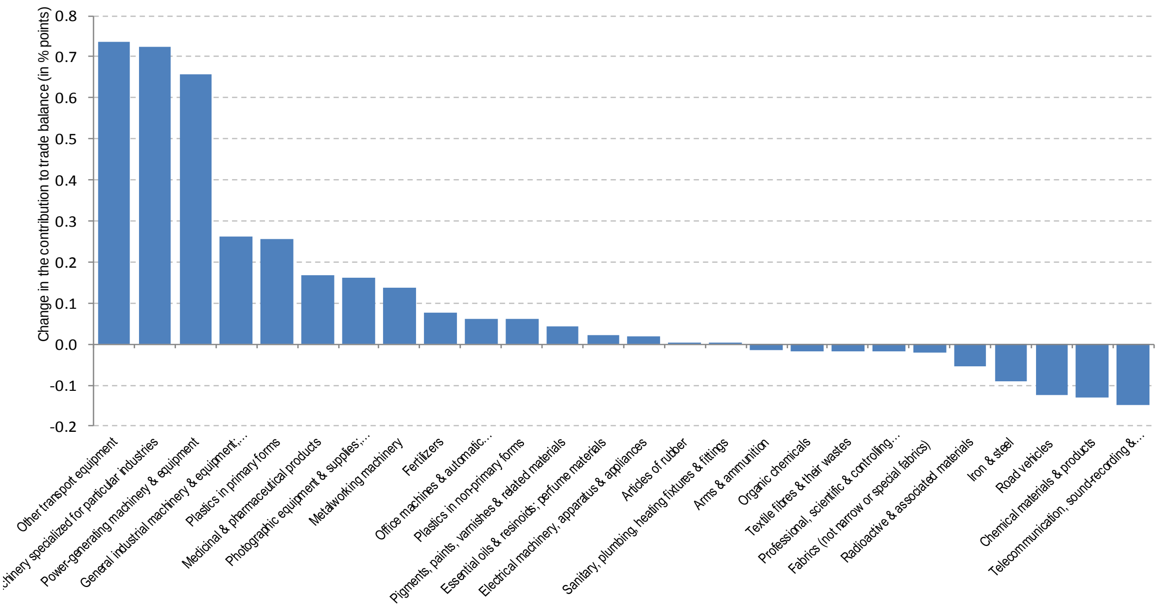
The graph above synthesises the structural change of the Spanish manufacturing sector over the last decade. It shows that the Spanish manufacturing has been dominated by low-tech sectors or large consumer goods and services. However, there has been an increase in R&I investment and in skilled human resources in most industrial sectors of the Spanish economy, and in particular in the low-tech and traditional sectors. But this knowledge injection has not been directly translated into an increasing share of the value added in the overall economy, except for the construction sector, which dominates the Spanish economy, and for the electricity, gas and water sector.

Firm-level data in the EU Industrial Scoreboard reveals that since the crisis started in 2008, firms active in computer services, telecommunications and banking have in general increased their annual R&D investments until 2010, while firms in pharmaceuticals, biotechnology and food production have decreased their investments in R&D, in some cases considerably. Firms in the electricity sector show a mixed performance.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Spain between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The contribution of high-tech (HT) and medium-tech (MT) products to the trade balance has grown over the period 2000-2011. The graph above shows that most high-tech and medium-tech industries have improved their contribution to the Spanish trade balance. This is particularly true for machinery sectors, transport equipment, plastics, medical and pharmaceutical products, photographic equipment and fertilizers, indicating an increasing specialisation of the country in these products in international trade. In absolute numbers, trade balance is particularly positive for metalworking machinery.

However, in absolute numbers the Spanish trade balance in almost all high-tech and medium-tech products is negative and has continuously decreased up to 2008 (after which the gap diminished due to a drop in imports). The overall Spanish trade balance has also become increasingly negative over the decade, falling at an even higher degree. Because the erosion of the trade balance in HT and MT products has been slower than the deterioration of the overall trade balance, the positive contribution of these products has increased over the decade.

Over the last decade, Spanish total factor productivity has remained stagnant. The employment rate has fallen dramatically with the economic crisis. However, Spain has made good progress on the other Europe 2020 target indicators, addressing both societal needs and future economic growth sectors. Greenhouse emissions have fallen, supported by progress in the deployment of renewable energy sources and progress in environmental technologies. Progress has also been made in health-related technologies, relevant for economic growth and an ageing population.

Key indicators for Spain

SPAIN	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.91	0.96	1.00	1.06	1.13	0.93	0.95	0.94	0.95	1.04	1.17	:	:	2.6	*1.69*	17
Business enterprise expenditure on R&D (BERD) as % of GDP	0.49	0.48	0,54 [3]	0.57	0.58	0.60	0.67	0.71	0,74 [4]	0.72	0.72	0.70	:	*-2.1*	*1.26*	16
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.41	*0.43*	0.45	0.48	0.48	0.52	0.53	0.56	0.61	0.67	0.67	*0.64*	:	*4.0*	*0.74*	15
Venture Capital [5] as % of GDP	0.13	0.15	0.10	0.12	0.15	0.09	0.13	0.26	0.15	0.09	0.24	0.21	:	4.6	0,35 [6]	7 [6]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	30.6	:	:	:	:	36.6	:	:	3.7	47.9	12
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	7.4	7.5	7.4	7.6	8.6	9.2	9.5	9.6	10.2	:	:	:	:	4.2	10.9	11
International scientific co-publications per million population	184	168	192	271	307	348	390	422	454	493	546	599	:	11.3	300	16
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	22	22	24	26	29	:	6.7	53	16
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	0.9	1.0	1.0	1.0	1.2	1.3	1.3	1.3	1.4	1.4	:	:	:	6.0	3.9	16
License and patent revenues from abroad as % of GDP	:	:	:	:	:	:	0.08	0.04	0.05	0.05	0.06	0.07	:	-1.1	0.58	18
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	13.8	:	15.9	:	15.9	:	19.0	:	:	5.4	14.4	2
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	:	:	24.0	22.7	22.5	21.6	:	:	-3.4	45.1	22
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	0.29	0.22	0.49	0.60	0.60	1.35	1.75	1.58	1.97	1.92	2.56	3.05	:	-	4,20 [7]	10
Growth of total factor productivity (total economy) - 2000 = 100	100	100	99	99	99	99	99	98	98	97	98	99	100	0 [8]	103	20
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	28.3	:	:	:	:	30.6	:	:	:	:	36.8	:	:	2.7	48.7	19
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	11.8	11.8	11.5	11.8	:	0.2	13.6	18
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	32.1	:	29.5	:	27.5	:	28.1	:	:	-2.2	38.4	19
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.05	0.05	0.04	0.05	0.06	0.09	0.10	0.10	0.09	:	:	:	:	8.2	0.39	16
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.16	0.17	0.14	0.18	0.26	0.27	0.23	0.22	0.22	:	:	:	:	4.0	0.52	14
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	60.7	62.1	62.7	64.0	65.2	67.2	68.7	69.5	68.3	63.7	62.5	61.6	:	-1.4	68.6	23
R&D Intensity (GERD as % of GDP)	0.91	0.92	0.99	1.05	1.06	1.12	1.20	1.27	1.35	1.39	1.39	*1.33*	:	*3.6*	*2.03*	16
Greenhouse gas emissions - 1990 = 100	135	135	141	143	149	154	151	154	143	130	126	:	:	-9 [9]	85	25 [10]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	8.2	8.3	9.0	9.5	10.6	12.8	13.8	:	:	9.1	12.5	12
Share of population aged 30-34 who have successfully completed tertiary education (%)	29.2	31.3	33.3	34.0	35.9	38.6	38.1	39.5	39.8	39.4	40.6	40.6	:	3.0	34.6	12
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	24.4	23.4	23.3	23.1	22.9	23.4	25.5	27.0	:	1.5	*24.2*	18 [10]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2002 and the previous years.

(4) Break in series between 2008 and the previous years. Average annual growth refers to 2008-2011.

(5) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(6) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(7) EU is the weighted average of the values for the Member States.

(8) The value is the difference between 2012 and 2000.

(9) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(10) The values for this indicator were ranked from lowest to highest.

(11) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Review spending priorities and reallocate funds to support access to finance for SMEs, research, innovation and young people."

Sweden

World positioning in challenge-driven innovation

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Sweden. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

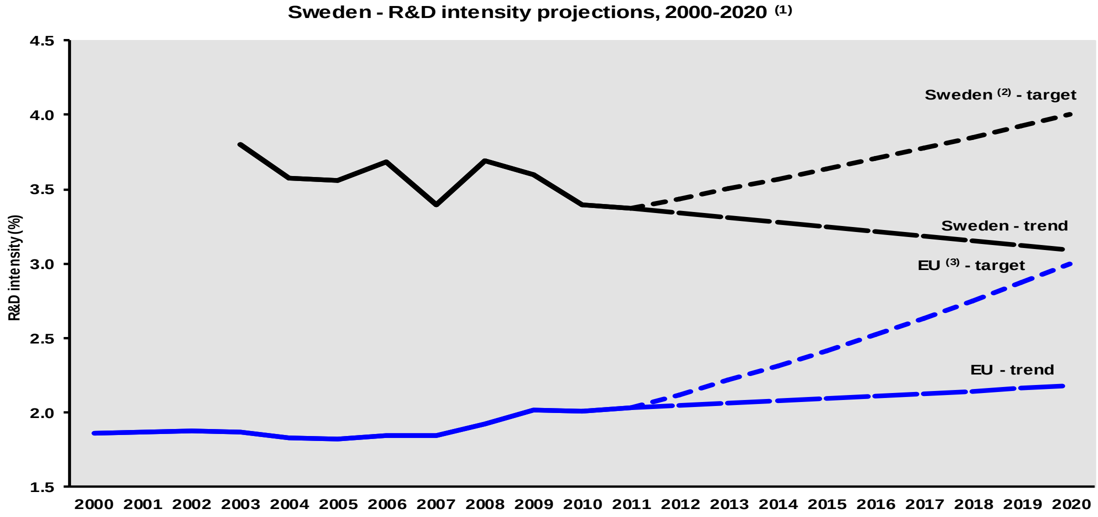
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 3.37% (EU: 2.03%; US: 2.75%) 2000-2011: -0.96% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 77.2 (EU:47.86; US: 56.68) 2005-2010: +3.58% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.652 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:64.6 (EU:48.75; US: 56.25) 2000-2010: +1.41% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Health, Environment, Energy, ICT, Materials, Security	*HT + MT contribution to the trade balance* 2011: 2.02% (EU: 4.2%; US: 1.93%) 2000-2011: -1.97% (EU: +4.99%; US:-10.75%)

Sweden has one of the world's highest R&D intensities. The country also performs very well in terms of scientific and technological excellence, with a very positive evolution. The Swedish economy is very knowledge-intensive, and has achieved a continuous development towards a stronger high-tech and medium-high-tech composition and specialisation. The country has several hot-spot clusters in key technologies at European and world scale, in particular in energy and environmental technologies, health and medical technologies, biotechnologies, ICT, materials and new production technologies, machine tools as well as transport technologies and motor vehicles.

However, Sweden's competitive position is facing challenges. While world competitors in the knowledge-intensive global markets are stepping up their R&D investments, Sweden is losing ground due to an increasing delocalisation of private R&D investment to firms outside the country. Since 2002 the outflow of R&D business investment has exceeded the inflow. Sweden's good R&D position is vulnerable due to its strong dependence on a few large multinational companies, which increasingly orient themselves towards the global innovation system. At the same time, SMEs, which were responsible for the growth in employment in recent years, are not growing fast.

To address these challenges a new bill on research and research-based innovation as well as a new innovation strategy were launched in Autumn 2012 increasing public funding for R&D and fostering the growth of firms in innovative sectors. By orienting innovation more closely towards global societal challenges it aims at enhancing service and product innovation. Supply-side policies will be matched more closely with policies enhancing the demand for innovation, both from private actors and from public procurement and regulation. As part of the Europe 2020 process, it was recommended that Sweden fosters cooperation between the technology and innovation demands of larger multinational companies with the innovative products and services produced by local firms. The new EU Structural Funds for 2014-2020 also provides an opportunity to enhance clusters and infrastructures for the testing and demonstration of new technology-based innovation.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2005-2010 in the case of Sweden.
(2) SE: This projection is based on a tentative R&D Intensity target of 4.0% for 2020.
(3) EU: This projection is based on the R&D Intensity target of 3.0% for 2020.
(4) SE: There are breaks in series between 2005 and the previous years and between 2011 and the previous years.

Based on recent trends, Swedish progress towards the national R&D target of 4% of GDP has indeed come to a halt in recent years, with R&D intensity declining from a peak of 4.13% in 2001 to 3.56% in 2005 and to 3.37% in 2011. This is the result of a significant drop in business R&D intensity. Business R&D intensity fell from 3.20% in 2001 to 2.59% in 2005 and to 2.34% in 2011.[8] This will make it a challenge to meet the Swedish target of reaching 4% R&D intensity by 2020. Within the business sector, R&D investment is highly concentrated in large, often foreign-owned, companies, which makes the Swedish prima-facie good position vulnerable to change of firm strategies. At the same time, R&D investment in SMEs has fallen almost 30% between 2005 and 2009.

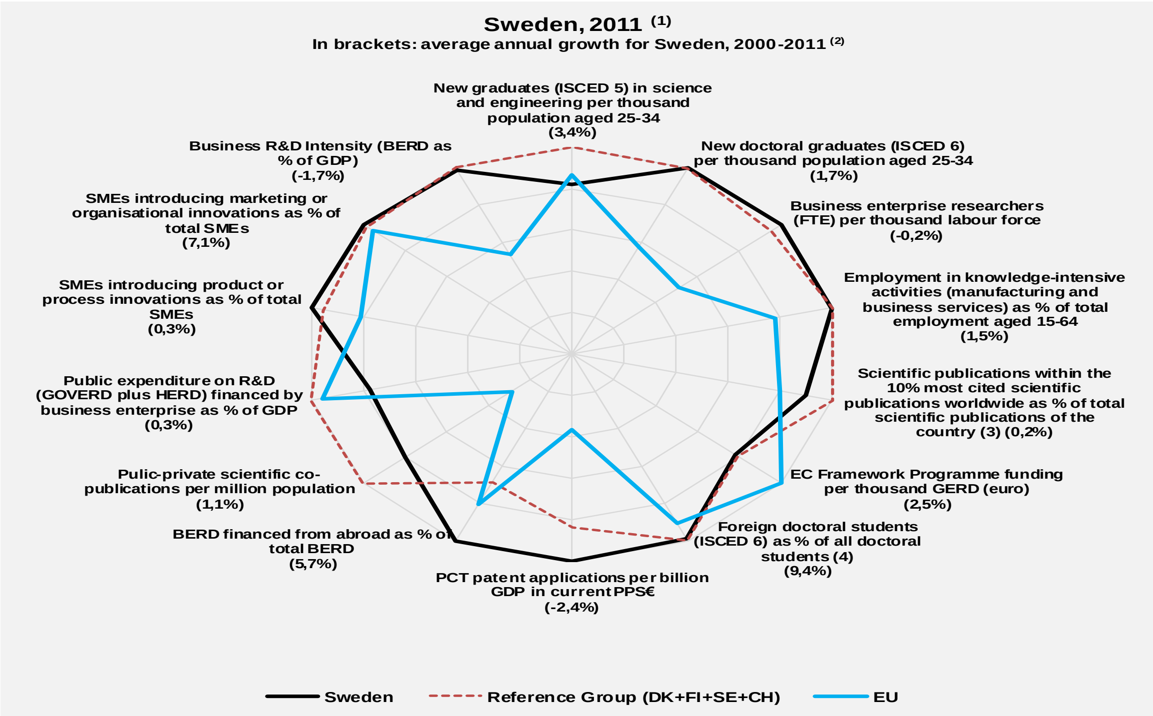
Public funding of R&D has increased since the research bill of 2008, and this trend is planned to continue up to 2012 with a total increase of around € 500 million for 2008-2012. Sweden raised its public R&D budget by 3.2% in 2011 and another 4.5% in 2012. A new research bill covering 2013-2016 budget, plans an additional SEK 4000 million for R&D. Sweden has received € 741 million of EU ERDF Structural Funds allocated to research, innovation and entrepreneurship over the period 2007-2013, with a high execution level (65.8%). In addition, up to early 2012, 2782 Swedish research teams have been successful in the EU FP7 programme, receiving a total of € 1.0 billion (representing 3.83% of all EU funding from FP7). The success rate of applicants was 23.78% (above the EU average of 21.95%).

This public funding effort seems having a counter-cyclic effect on business R&D investment. All major R&D-intensive firms in Sweden increased their R&D investments between 2009 and 2011. More broadly, total R&D investment (GERD) in Sweden in current Euro increased by 13% in 2010, partly recovering from a 15% decrease between 2008 and 2009. The long-term trend of decreasing business R&D investment is partly linked to a reallocation of investment to countries outside of Sweden. The R&D investment flows are depending on the general globalisation of research and innovation. The outflow of R&D investment from Sweden increased between 2002 and 2007 to € 3000 million. Inward R&D investment grew as well, but for Sweden the outflow of R&D business investment exceeded the inflow.

[8] There is a break in series between 2005 and the previous years for both R&D intensity and business R&D intensity in Sweden.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Sweden's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) CH is not included in the reference group.

Sweden performs above the EU average in all R&I dimensions except for new graduates in science and engineering, EC framework programme funding, and public expenditure on R&D financed by business. A similar picture emerges when Sweden is compared to the reference group, pointing up Sweden's relative weakness in public-private R&D cooperation, in new graduates for science and engineering and in scientific excellence.

Higher education institutions perform over 26% of R&D in Sweden. More than half of the funding for higher education institutions is competitive funding and part of their institutional funding is now subject to performance-based criteria. Given the small size of Sweden, optimisation of research and innovation also depends on integration into the expanding European research and innovation system. Currently, only the most research-intensive universities in Sweden cooperate extensively with international partners. In contrast, the business sector has developed strong co-patenting activity with firms in Germany, France and the United Kingdom.

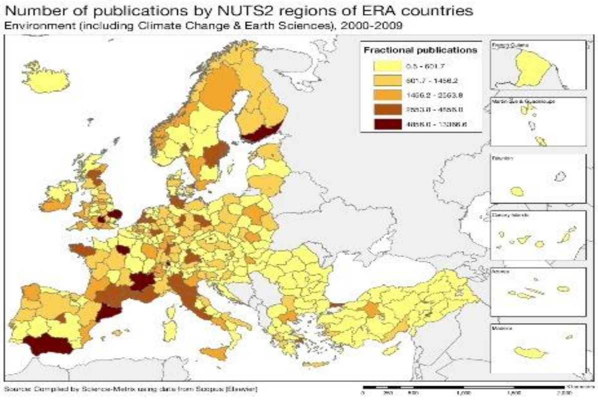
However, firm knowledge dynamics are less intensive than could be expected from the high level of research performance and favourable framework conditions. Overall business R&D investment and patent applications are slightly declining. Many of the reference countries, as well as the United States, have higher private R&I investment growth and more dynamic patenting activity, both for PCT patents and for SME patenting. The patenting activity of young firms (less than five years old) in Sweden is clearly lower than that of young firms in the United States and other Nordic countries.

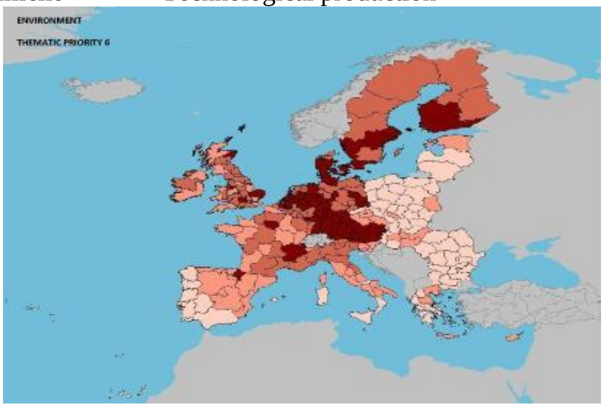
Sweden's scientific and technological strengths

The maps below illustrate six key science and technology areas where Sweden has real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

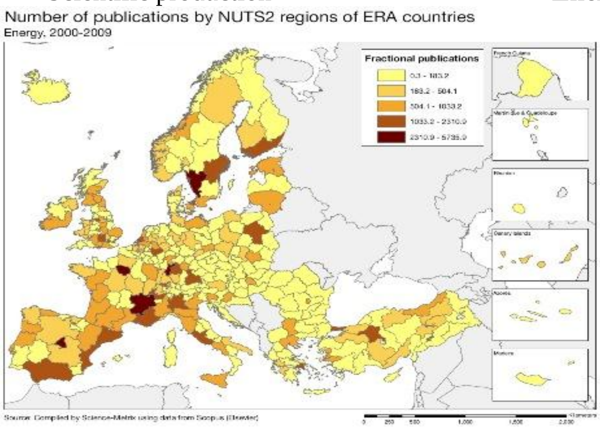
Strengths in science and technology at European level

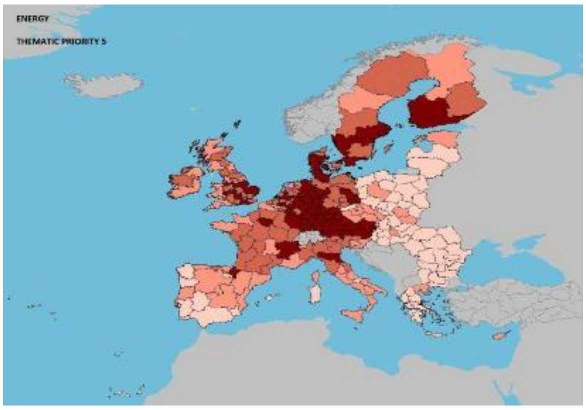
Scientific production **Environment** Technological production



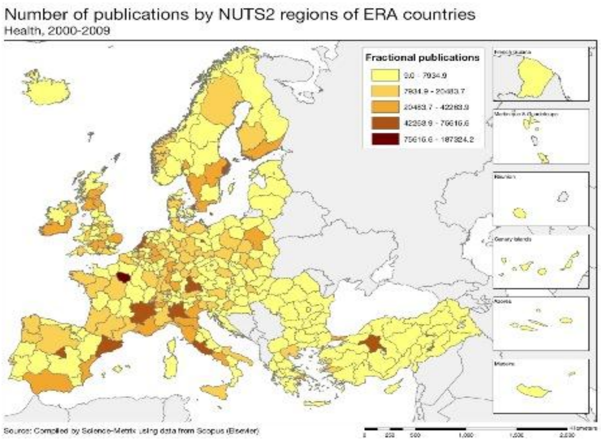


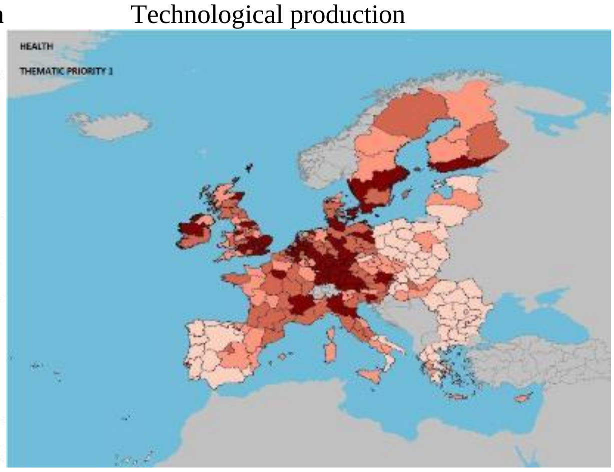
Scientific production **Energy** Technological production





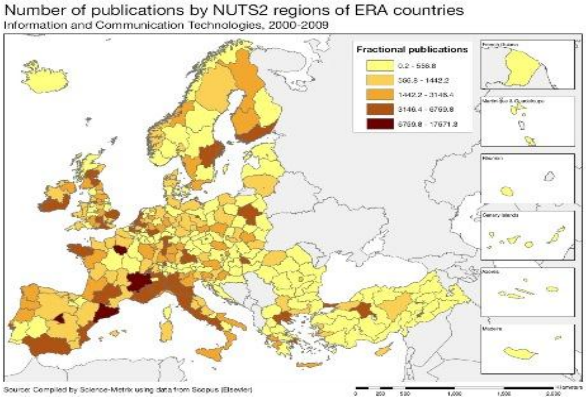
Scientific production **Health** Technological production

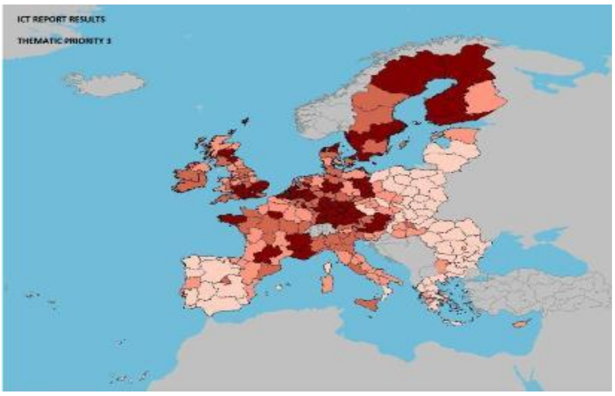




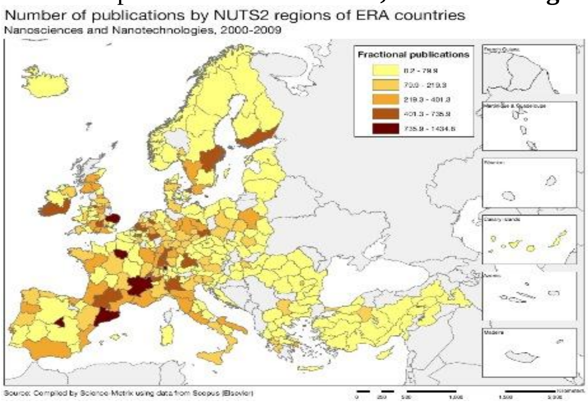
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

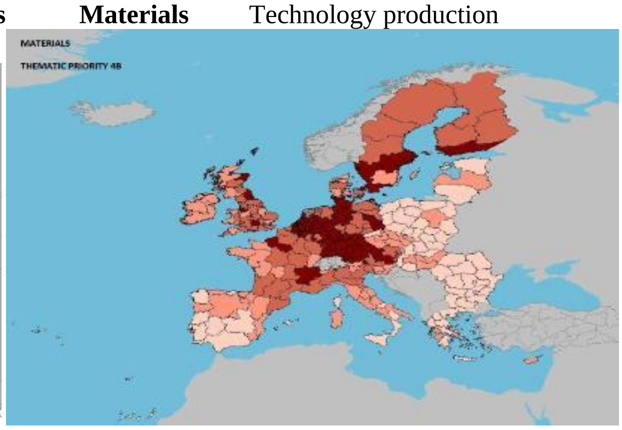
Scientific production **Information and Communication Technologies** Technological production



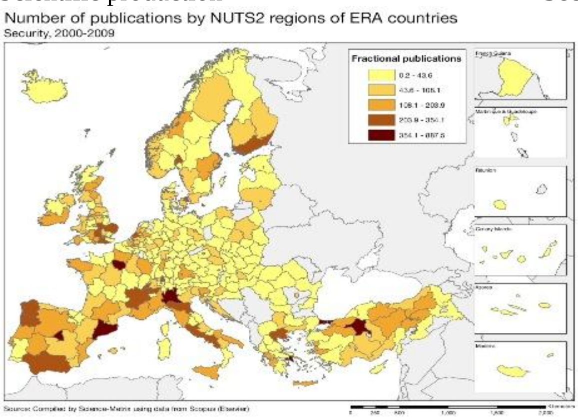


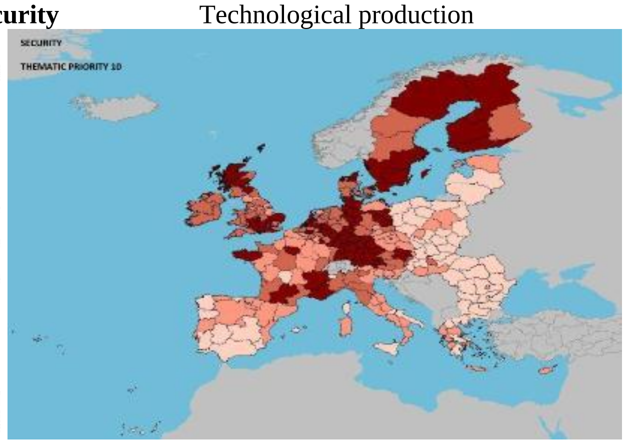
Scientific production **Nanoscience, nanotechnologies** **Materials** Technology production





Scientific production **Security** Technological production





Sweden performs well in most areas of technology production. Apart from the sectors illustrated in the maps above, Sweden has intensive patenting in transport technologies, motor vehicles, machine tools, new production technologies, and biotechnologies, among other sectors. In terms of technological specialisation world-wide, Sweden stands out in digital and basic communication processes, and transport patents.

However, the maps do not always show corresponding scientific strengths in these sectors. These findings are confirmed by the data on shares of the 10 % most cited scientific publications, which show that Sweden is lagging behind the world scientific leaders in future strategic areas such as health, energy, and environment as well as security and automobiles. There is thus room for enhancing scientific excellence in the fields where Swedish industry has European level technology strengths. Being a small country with a large dependency on private multinational research performers, Swedish institutions and clusters need high quality, critical mass and a relevant focus.

Policies and reforms for research and innovation

The current Swedish policy follows the research and innovation bill of 2008, which stresses the links between research and innovation. In the broad sense of innovation policy, governance issues are crucial to actively enhancing innovation in several policy areas and reinforcing comprehensive framework conditions for business innovation. In a more narrow sense, the bill reinforced the funding and strategic focus of research and innovation. Public funding was boosted both for the new performance-based grant funding of universities and for strategic programmes in 24 research areas important to the Swedish business sector and society, including cancer, diabetes, epidemiology, e-science, molecular bioscience, nanoscience and nanotechnologies, neuroscience, stem cell and regenerative medicine, nursing research, eco-systems and natural resources, oceanic environment, climate modelling, sustainable use of natural resources, material science, production technologies, security and crisis, transport, IT mobile communication, and energy. In view of the 2013-2016 budget, a new research and research-based innovation bill gives a strong emphasis to R&D in strategic innovation and in core areas for the Swedish industry, such as mining, steel, wood products and the construction of a sustainable society. Public funding to R&D will be progressively increased and funding allocation systems to universities progressively reformed to enhance scientific excellence

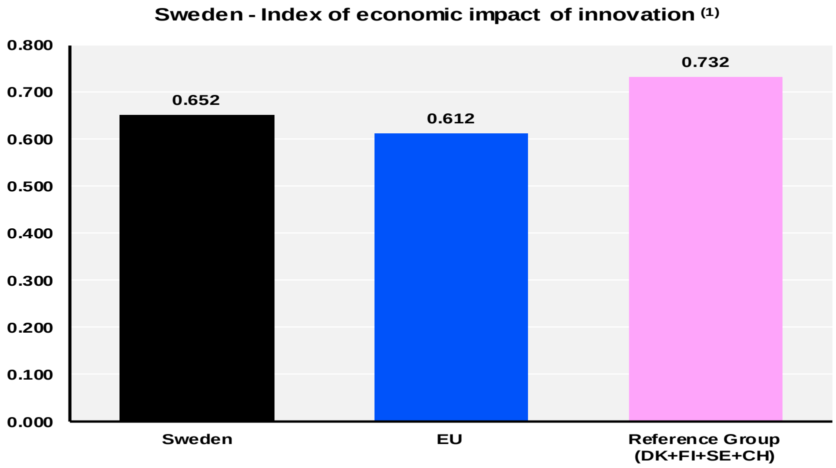
Over the last five years, several initiatives have been launched to enhance the effectiveness of the Swedish R&I system, with a focus on innovation in SMEs through reinforced public-private cooperation with universities and better access to seed funding and venture capital. Industrial Research Institutes have been created to be specific innovation intermediates and to act as an interface between academic research and product development in the business sector. The model is that the private business sector buys R&D services from the Institutes, while the state funds their facilities and skills development. In addition, the bill established innovation offices to foster the commercialisation of research results. The commercialisation of research in seven universities was encouraged by additional state funding (SEK 150m per year). Access to funding, in particular early stage seed financing, for innovative SMEs is enhanced through business incubators and venture funds i.e. *Innovationsbron*, *Industrifonden*, *Almi* and more than 30 incubators, often located in Technology parks. The Swedish innovation agency, Vinnova, also funds programmes to enhance research in SMEs, *Forska och Väx*, as well as cluster building. However, the overall budget for these programmes is relatively small.

The new national innovation strategy, adopted at the end of 2012, comprises a holistic approach to innovation policy aiming at the year 2020. Interesting proposals have been made for both demand-side measures (i.e. introducing a new procurement law fostering innovation-friendly procurement) and supply-side measures (in particular to fund testing, demonstration infrastructure and reinforce incubators of new research-based products). The role of the public sector as driver of innovation is stressed. The 2011 innovation procurement inquiry proposed the introduction of a new law on pre-commercial procurement. An increasing importance is given to innovation in services, mobilising knowledge in a broad sense and enhancing societal challenge-driven innovation, new business models and design-based thinking.

Additional value is drawn from linking supply-side and demand-side measures more closely to each other. Compared to other EU Member States, Sweden has margins for increasing its state aid to R&I. Direct funding to larger firms could be linked to conditions to buy products and services from Swedish SMEs with the aim of fostering innovative eco-systems in strategic sectors for Sweden. A strategic harnessing of EU Structural Funds for challenge-driven innovation would enable the expansion of infrastructures for testing and demonstration of new technology-based innovation and boost the world-class Swedish innovation clusters, thus better linking demand for innovation by large multinational enterprises with supply of technologies and services from SMEs and enterprises of intermediate size. The building in Lund of a world-class neutron source laboratory in the field of new materials, namely the European ESFRI infrastructure *European Spalling Source*, and the determined funding to Life science in the region of Uppsala and Stockholm, *SciLifeLab*, constitute opportunities both for frontier research and for business applications.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[9].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

In a Schumpeterian perspective, Sweden offers good framework conditions for innovation in business activities, in particular for the creation of new firms. In general, barriers to entrepreneurship are lower than in most OECD countries. The time involved and the cost of starting up a business are below the EU average. The share of doctoral graduates is high (although less focused on science and technology). Clusters in some sectors (i.e. ICT, power generation, biotechnology) have grown around some of the larger research-intensive firms. Early stage funding as a share of GDP was the highest among the EU Member States. Also venture capital investment as a share of GDP is among the highest in the OECD. However, the share of early stage funding in total risk capital is lower than in other EU Member States, and following the financial crisis, there has been a sharp decline in risk finance.

The innovation challenges for Sweden lay elsewhere. Even if Sweden scores much higher than the EU average in the index above on economic impact of innovation, it performs below its reference group. Despite its very knowledge-intensive labour force and high patenting intensity, the relative weakness of the Swedish economy is rooted in the commercialisation and trade of innovative and knowledge-intensive products. Sales of new to market and new to firm innovations and trade in knowledge-intensive services in total services export are particularly lower than in its reference countries. The challenge of Sweden is not in technology production or firm creation, but in the sustainability of knowledge-intensive firms for medium-term growth and market presence. The survival rate (after two years) of new firms is relatively high, but many innovative start-ups are bought up by larger and often foreign firms. This dynamics is aggravated by the Swedish firm structure, still dominated by a small number of old, large and globalized companies. With an outsourcing of employment, and more recently of research and innovation (visible in the falling business R&D intensity), these larger firms no longer support the sustainability of new Swedish knowledge-intensive firms.

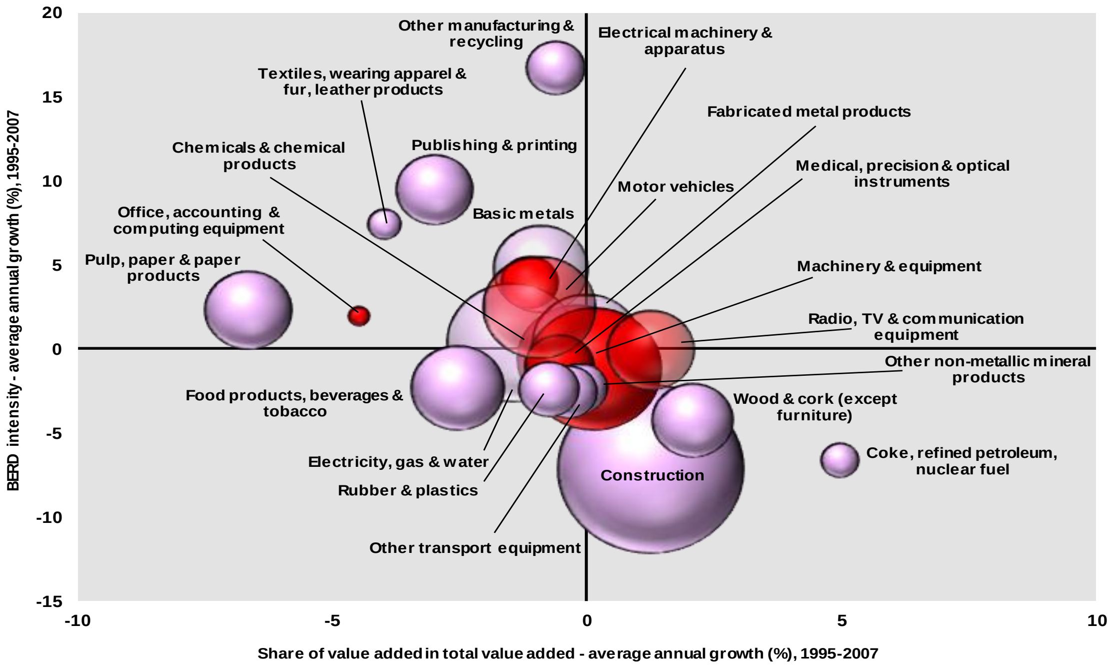
There are positive signs of change. The proportion of high-growth enterprises (measured by revenues or by employment) is higher in Sweden than in other Nordic countries, and is only slightly behind the United States. Among the existing firms, the innovation activity in SMEs as measured by the Eurostat Community Innovation Survey (CIS) is comparable to other knowledge-intensive Member States, although on average is clearly below the innovation activity in German enterprises.

[9] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Sweden - Share of value added versus BERD intensity - average annual growth, 1995-2007



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Note: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.

The Swedish economy has managed to maintain an important manufacturing industry since the mid 90s. In most other EU Member States, the share of value added of manufacturing industry in total value added has decreased (illustrated by a leftward shift in the graph above), linked to the expanding services sectors. In general, countries with a strong manufacturing sector have been more resilient to the economic crisis.

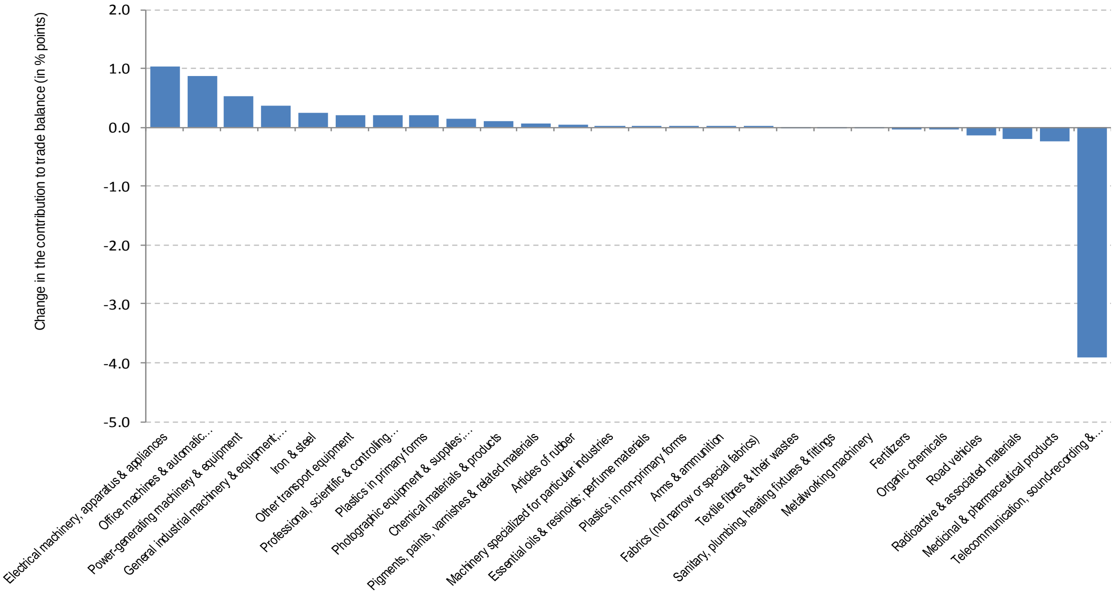
However, compared to other EU Member States, Swedish manufacturing industry presents a lower dynamic in terms of upgrading knowledge, in particular R&D. This is particularly true of the larger manufacturing sectors, such as the electricity, gas and water industries, fabricated metal products, basic metals, and motor vehicles, all key sectors in the Swedish economy both currently and historically. There are some promising exceptions, such as recycling, publishing and printing, textiles and apparel, but these sectors have a smaller size in the economy.

Considering R&D investment at firm level, as illustrated in the EU Industrial Scoreboard, the large Swedish R&D-intensive enterprises (Ericsson, Volvo, Sandvik, Electrolux, Vattenfall, Atlas Copco, SKF, etc.) broadly maintained or even increased their global R&D intensities in 2010 as compared to 2009. Swedish firms have on average increased their R&D investment over the last three years (2007-2010) by 3.4%, although there are exceptions - firms in the motor vehicle sector, software, biotechnology and pharmaceutical sectors. Many of the Swedish firms operate on a global base with the result that increased R&D investment may not necessarily be made in Sweden.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Sweden between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

In real terms, the Swedish trade balance for high-tech (HT) and medium-tech (MT) products grew substantially up to 2006, and thereafter it fell and counted almost half the size in 2010. It was mainly exports in HT and MT products which dropped in the economic crisis in 2009. The graph above shows that most high-tech and medium-tech products and in particular electrical machinery, office machinery, power-generating machinery and general industrial machinery have slightly increased their contribution to the Swedish trade balance over the period 2000-2011. This constitutes a good performance in increasingly competitive markets. However, a serious concern is the falling weight of telecommunications in the Swedish trade balance (and to a less extent other high-tech product sectors such as medical products, vehicles and organic chemistry), possibly a sign of a weaker world competitiveness of Sweden regarding these products. Looking at the data in relation to the previous graph, it is clear that since 1995 these sectors have not substantially upgraded their knowledge intensities in terms of average annual growth of business R&D. On the other hand, the lower dynamics of R&D upgrading is found in most manufacturing sectors, including the machinery and electricity sectors; although these products have expanded their position in the overall trade balance, their exports in real terms have dropped with the economic crisis after 2008.

Total factor productivity grew continuously in Sweden between 2001 and 2007, but since then it has stagnated. The employment rate shows a similar evolution, with an overall level of 80% (the highest in the EU). Apart from falling R&D intensity, Sweden is making good progress on all other Europe 2020 targets. Greenhouse gas emissions have decreased considerably while the share of renewable energy in final energy consumption has grown. In line with this progress, the number of patents in environment-related technologies per billion GDP has increased to the third highest level in the EU. However, the number of patents in health-related technologies (another major societal challenge) has fallen when measured as ratio of GDP. Despite this, Sweden is among the top three EU Member States in both these technology areas.

Key indicators for Sweden

SWEDEN	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	2.47	2.78	2.93	3.01	3.29	2.40	3.28	3.40	3.16	3.10	2.93	:	:	1.7	*1.69*	2
Business enterprise expenditure on R&D (BERD) as % of GDP	:	3.20	:	2.83	2.63	2,59 (3)	*2.75*	2.47	*2.74*	2.53	*2.33*	*2.34*		*-1.7*	*1.26*	2
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.93	:	0.96	0.93	0,96 (3)	*0.92*	0.92	*0.95*	1.06	*1.06*	*1.02*	:	*1.1*	*0.74*	2
Venture Capital (4) as % of GDP	0.21	0.40	0.25	0.15	0.23	0.29	0.29	0.75	0.98	0.42	0.89	0.56	:	9.3	0,35 (5)	2 (5)
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	64.8	:	:	:	:	77.2	:	:	3.6	47.9	3
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	12.1	12.1	12.6	11.6	12.0	12.2	12.5	12.2	12.3	:	:	:	:	0.2	10.9	5
International scientific co-publications per million population	723	675	702	966	1056	1153	1209	1317	1321	1428	1513	1604	:	7.5	300	2
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	140	139	140	144	147	:	1.1	53	2
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	13.3	11.6	9.9	9.1	9.0	10.1	10.7	11.1	10.5	10.7	:	:	:	-2.4	3.9	1
License and patent revenues from abroad as % of GDP	:	:	:	:	0.95	0.94	1.00	1.02	0.96	1.13	1.26	1.16	:	2.8	0.58	4
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	13.4	:	:	:	9.2	:	8.4	:	:	-7.5	14.4	20
Knowledge-intensive services exports as % total service exports	:	:	:	:	42.0	41.2	40.5	40.7	40.5	40.9	38.7	:	:	-1.4	45.1	9
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	2.51	1.79	1.91	1.95	1.82	1.89	2.41	1.76	1.97	2.30	1.83	2.02	:	-	4,20 (6)	13
Growth of total factor productivity (total economy) - 2000 = 100	100	99	101	104	108	110	113	114	111	107	112	114	114	14 (7)	103	6
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	56.2	:	:	:	:	56.7	:	:	:	:	64.6	:	:	1.4	48.7	3
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	16.6	16.8	17.1	17.4	:	1.5	13.6	4
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	46.5	:	40.7	:	40.6	:	47.4	:	:	0.3	38.4	4
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.56	0.54	0.57	0.60	0.63	0.53	0.63	0.65	0.64	:	:	:	:	1.7	0.39	3
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	1.94	2.09	2.02	1.62	1.48	1.74	1.69	1.47	1.02	:	:	:	:	-7.7	0.52	3
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	77.7	78.7	78.5	77.9	77.4	78,1 (8)	78.8	80.1	80.4	78.3	78.7	80.0	:	0.4	68.6	1
R&D Intensity (GERD as % of GDP)	:	4.13	:	3.80	3.58	3.56	*3.68*	3.40	*3.70*	3.60	*3.39*	*3.37*	:	*-1.0*	*2.03*	2
Greenhouse gas emissions - 1990 = 100	95	96	97	97	96	93	92	90	87	82	91	:	:	-4 (11)	85	13 (12)
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	38.7	40.6	42.7	44.2	45.2	48.1	47.9	:	:	3.6	12.5	1
Share of population aged 30-34 who have successfully completed tertiary education (%)	31.8	26,6 (13)	28.3	31.0	33.9	*37.6*	*39.5*	*41.0*	*42.0*	*43.9*	*45.8*	*47.5*	:	*6.0*	34.6	3
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	16.9	14.4	16.3	13.9	14.9	15.9	15.0	16.1	:	-0.7	*24.2*	3 (12)

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012,
(2) EU average for the latest available year.
(3) Break in series between 2005 and the previous years. Average annual growth refers to 2005-2011.
(4) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.
(5) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2000.
(8) Break in series between 2005 and the previous years. Average annual growth refers to 2005-2011.
(9) Break in series between 2005 and the previous years.
(10) Break in series between 2011 and the previous years. Average annual growth refers to 2005-2010.
(11) The value is the difference between 2010 and 2000. A negative value means lower emissions.
(12) The values for this indicator were ranked from lowest to highest.
(13) Break in series between 2001 and the previous years. Average annual growth refers to 2001-2011.
(12) Values in italics are estimated or provisional.

Country-specific recommendation in R&I adopted by the Council in July 2012:
"Take further measures in the upcoming research and innovation bill to continue improving the excellence in research and to focus on improving the commercialisation of innovative products and the development of new technologies"

United Kingdom

Delivering a better environment for commercialising research

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in the United Kingdom. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

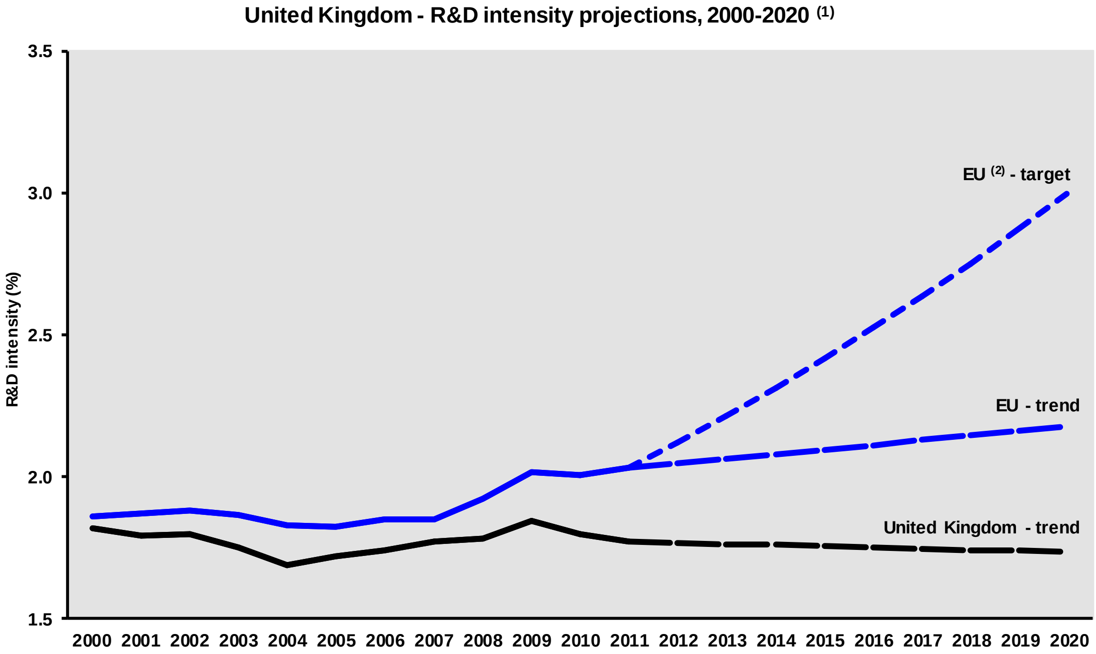
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 1.77% (EU: 2.03%; US: 2.75%) 2000-2011: -0.23% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:56.08 (EU:47.86; US: 56.68) 2005-2010: +2.27% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.621 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:59.24 (EU:48.75; US: 56.25) 2000-2010: +1.2% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Organic chemistry, Biotechnology, Pharmaceuticals, Medical technology, High-value manufacturing, Nanotechnology, Digital technologies	*HT + MT contribution to the trade balance* 2011: 3.13% (EU: 4.2%; US: 1.93%) 2000-2011: +4.83% (EU: +4.99%; US:-10.75%)

The UK shows overall innovation performance above the EU average. There are particular strengths in human resources, venture capital, international and public-private co-publications, and entrepreneurship. The number of collaborations by innovative SMEs with other entities is increasing rapidly, while rates of improvement in human resources and international co-publications are well above average. The presence of several world-class universities, a significant proportion of young doctoral graduates, and competitive strengths in sectors such as pharmaceuticals and digital technologies have helped achieve this strong performance. However, there are relative weaknesses in RDI investments by firms, the creation of intellectual assets, and SMEs introducing innovations.

The UK economy has several distinctive characteristics that represent actual or potential sources of competitive advantage in the innovation sphere: a world-leading science base and information infrastructure; a prominent financial sector (although this could be better incentivised to support the creation and growth of firms); a rich supply of high-level skills plus a proven attractiveness to globally mobile talents; strong performance by business in creating intangible assets; and a relatively large role of the service sector for industry and export performance. These characteristics, highlighted by the UK Government in its new strategy for innovation published at the end of 2011, underpin the four priority areas identified for policy development: strengthening the sharing and dissemination of knowledge within the innovation system; fostering the development and use of a more coherent innovation infrastructure; driving business innovation in all sectors of the economy — high-tech, medium-tech and low-tech, and in the services sector; and transforming the public sector into a major driver of innovation.

Apart from the recent abolition of regional development agencies, which represents a significant change in the innovation policy delivery infrastructure, the UK continues to benefit from a key strength of its innovation policy governance system: a long-term, strategic view of innovation policy informed by an extensive process of review and evaluation and benefiting from a relative absence of dramatic shifts in priorities, instruments or structures.

Investing in knowledge



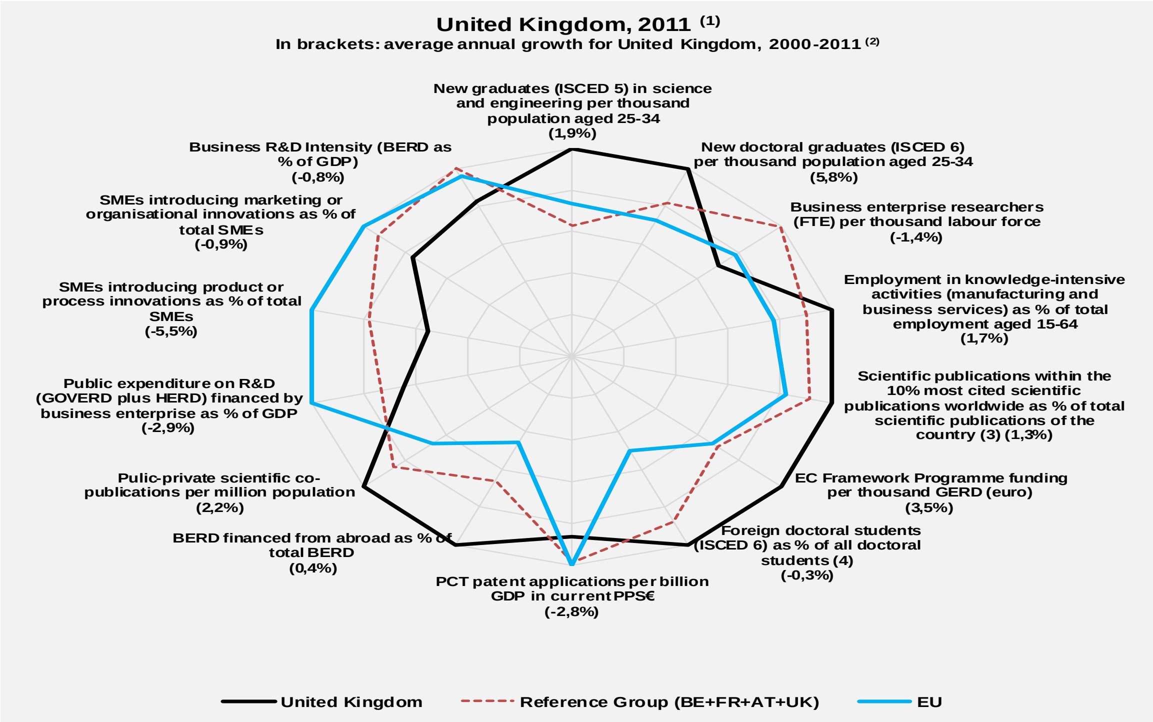
Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) UK: An R&D intensity target for 2020 is not available.

The higher education sector was responsible in 2010 for €8.19 billion of R&D activities, representing 27.2% of total R&D performed. This share increased from 20.6% in 2000 at an average annual growth rate of 3.2%. Business enterprise finances 45% of R&D and performs around 61% of R&D. R&D expenditure by business enterprise amounted to €18.3 billion in 2010, close to the level of 2003. Government finances around 32% of R&D. An important characteristic of the UK research system is the significant R&D investment financed from abroad — some 17% (8% EU average) — and from the non-profit sector — about 5%. In 2010, the UK's gross domestic expenditure on R&D was some €33 billion and had decreased by 0.8% in real terms, from 2009. UK institutions also benefitted from € 3.9 billion from FP7 (14.9% of the total, which is the second-highest share among Member States). The success rate of UK applicants in FP7 is 23.62%, well above the average EU rate of 21.5%. For 2007-2013, the UK has been allocated around €10.6 billion in Cohesion Policy funding. The UK plans to invest €4.5 billion of this in RDI.

R&D intensity (2011) was 1.77% of GDP, down from 1.86% and lower than the EU average of 2%. The trend since 2000 shows an initial fall, a mild recovery from 2005 (peaking in 2009), and a recent decline. Public spending accounted for about one-third of the total. Albeit with ups and downs, growth has been negative overall for the past decade (averaging out at -0.3% per year); Business R&D intensity has fell from 1.17% in 2001 to 1.08% in 2010. As part of the government's 2010 fiscal consolidation strategy, the budget for science was frozen in cash terms at just over £4.6 billion (€5.4 billion) for the next four years. This amounts to a cut of some 10% in real terms over the period. The capital expenditure budget for science was not protected and is expected to be cut by some 44% over the same period. In spite of this negative trend, the UK has not set a national R&D intensity target corresponding to the request of the European Council regarding Europe 2020 headline targets. The current Government has stated that it does not believe that Lisbon targets have proved effective in the past. However, it indicated that the level of R&D investment will be monitored on an annual basis, although data will be available with an 18-month time-lag. In the last decade, R&D intensity has averaged around 1.8%. Reinforced fiscal incentives, the new "patent box" and an ambitious public procurement policy may yet succeed in progressively reversing the negative trend in business R&D.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the UK R&I system. Clockwise, it gives information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.

As a whole, the UK R&I system performs above the EU average, with strengths in the quality of research, but weaknesses in the introduction of innovations to the market. The proportion of human resources in science and technology as a share of the UK labour-force is above the EU average, and has risen since 2006. High numbers of highly qualified UK-educated researchers are resident in other OECD countries, associated with the circulation of high-level human resources. On research infrastructures, the UK recognises that investment in world-class infrastructure is a prerequisite for world-class research: it hosts a large number of national and international facilities and is involved in many facilities in Europe and the rest of the world. Regarding universities, greater emphasis has been placed recently on stimulating their engagement with businesses and local communities, with a Higher Education Investment Fund as the main policy stimulus. Knowledge transfer from the research base to business is a UK policy priority, with several initiatives providing funding to stimulate collaborative research and inter-sectorial mobility or supporting the creation of university and public-sector spin-outs.

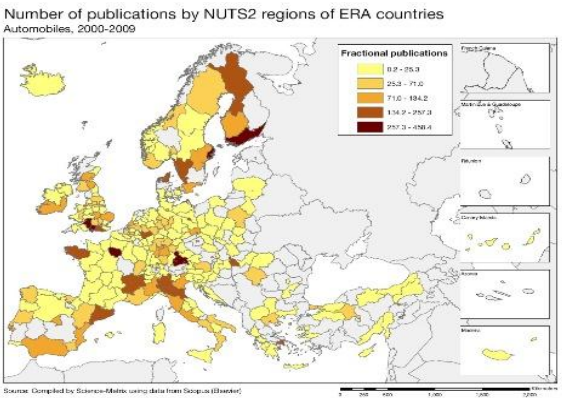
Sectorial support is strongly focused on advanced manufacturing, covering vocational skills education, apprenticeships, high-value manufacturing technology innovation accelerators ("Catapults"), incentive prizes, fellowships and advisory services. Life sciences also attract particular support via a Biomedical Catalyst Fund. Overall, public-private partnerships are becoming more significant, particularly in the mobilisation of risk and venture financing, growth capital and other forms of support. Many support measures engage industry in co-funding initiatives, especially in programmes addressing major socio-economic challenges ("research & technology clubs") and cross-cutting technology sectors. 58% of businesses were innovation-active between 2006 and 2008 (*UK Innovation Survey, 2009*).

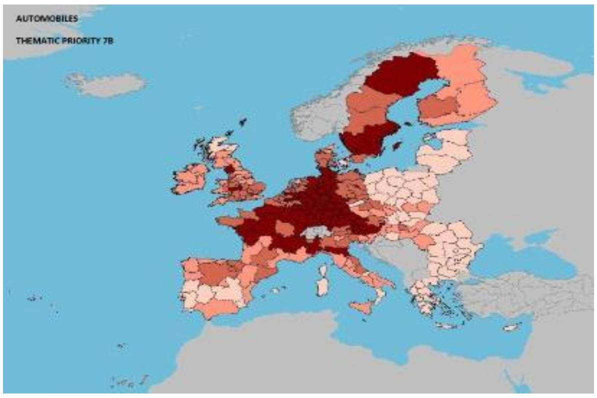
UK's scientific and technological strengths

The maps below illustrate six key science and technology areas where the UK has real strengths in a European context. These maps are based on the numbers of scientific publications and patents produced by authors and inventors based in the regions. Caution should be exercised, however, as not all industries either find patents the most useful means of protecting intellectual property or are accustomed to publicising research results in the scientific press.

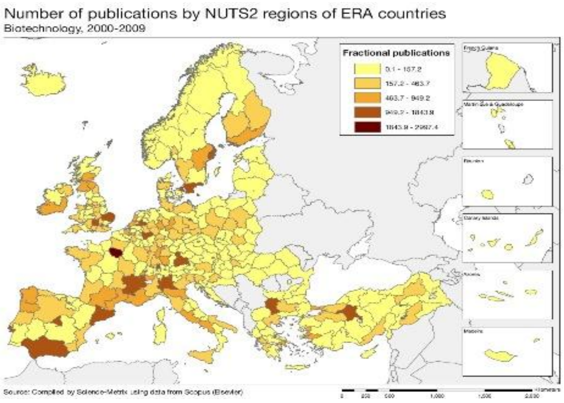
Strengths in science and technology at European level

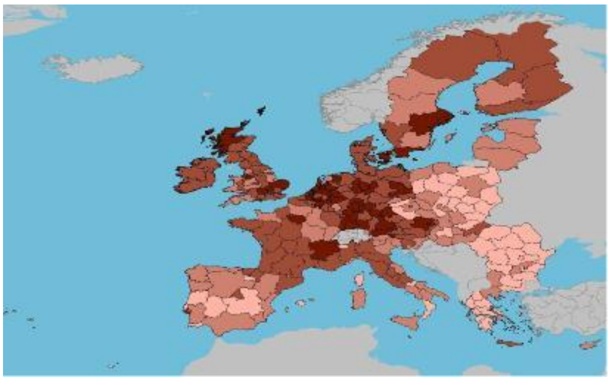
Scientific production **Automobiles** Technological production



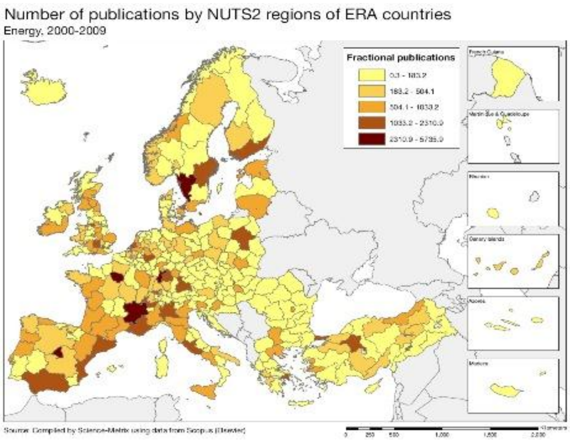


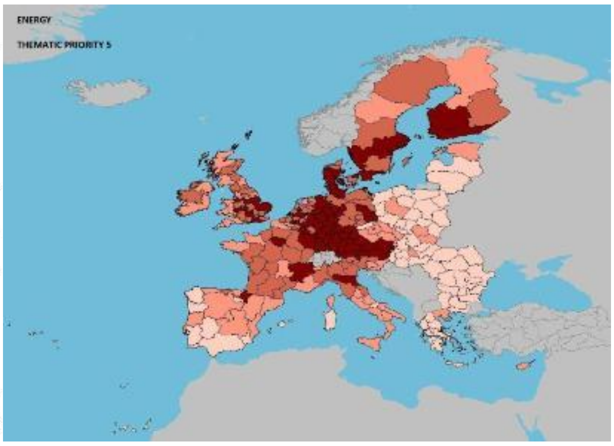
Scientific production **Biotechnology** Technological production





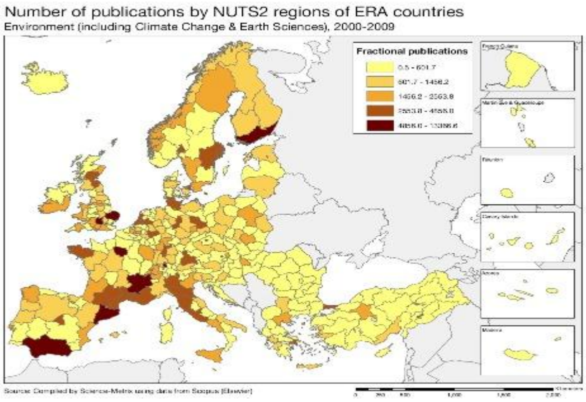
Scientific production **Energy** Technological production

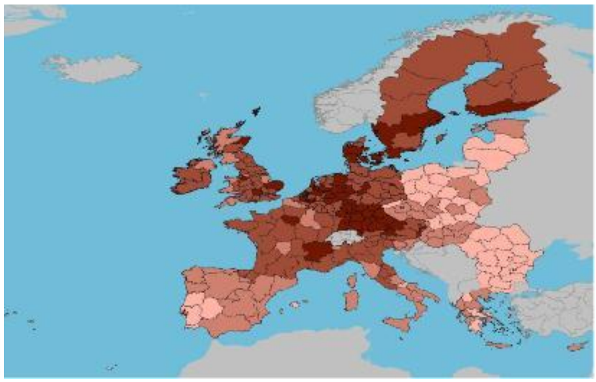




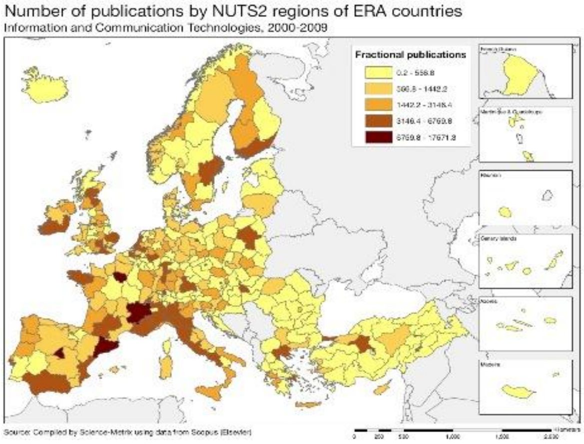
Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010

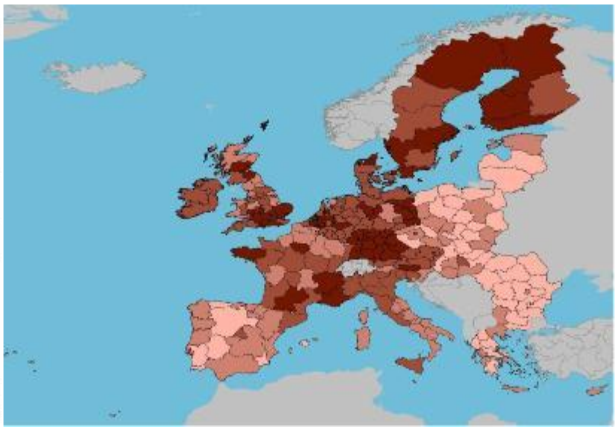
Scientific production **Environment** Technological production



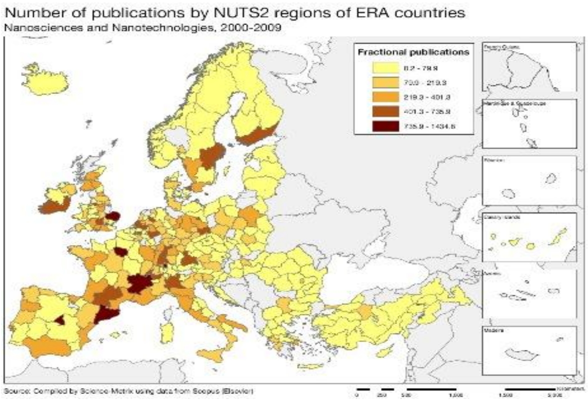


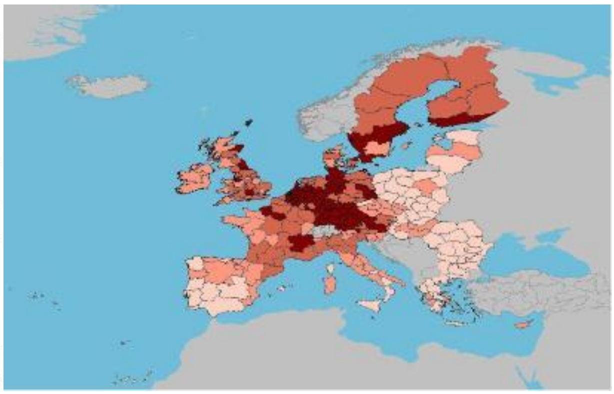
Scientific production **Information and Communication Technologies** Technological production





Scientific production **Nanoscience and Nanotechnologies** Technology production





The UK performs well in most areas of technology production. Apart from the sectors highlighted in the maps above, current patent activity suggests that the UK is also relatively strong in the areas of organic chemistry, pharmaceuticals and medical technology. It has a world-class reputation in aerospace and nanotechnology research, and particularly significant R&D capabilities in renewables, especially offshore wind power and marine energy. However, compared to its competitors, UK R&D is concentrated in a relatively small number of sectors and is carried out by relatively few businesses. Greater business investment in R&D would be helpful across all sectors of the UK economy.

In terms of scientific production, the UK research-base is the most productive in the G8, generating more papers and citations per unit of investment than any other large country (*International Comparative Performance of the UK Research Base, Elsevier, 2011*).

Policies and reforms for research and innovation

The UK Government stated its commitment to prioritising, to a certain extent, spending on science and innovation while pursuing fiscal consolidation. It reiterated its continuing support for RDI in the document "The Innovation and Research Strategy for Growth" published in December 2011, which states that RDI policy, overall, is focused on increasing the UK's ability to innovate and commercialise new technologies as a means for driving economic growth and creating jobs. The aim is to encourage greater levels of innovation in all sectors of the economy, supported by a better-integrated and more cohesive innovation system. The Strategy made a number of specific announcements of additional investments planned in RDI, including additional capital investments in research infrastructure, the creation of a Graphene Global Research & Technology Hub, a large-scale demonstrator in the area of "future cities", and investment to support technology-based SMEs.

RDI policies are managed at national level by the Department for Business, Innovation and Skills, which sponsors the seven UK Research Councils, the Higher Education Funding Council for England (HEFCE), and the Technology Strategy Board (TSB). The TSB is responsible for funding innovation and technology development within business and acts as the national innovation agency for the UK. The devolved administrations of Northern Ireland, Scotland and Wales are responsible for certain elements of funding, specifically for higher education research and for enterprise agencies.

The Government has decided that all programmes for and funding linked to R&I should be delivered by national organisations. Consequently, regional development agencies, which had previously played a role in innovation funding, were dissolved in mid-2012. New "Local Enterprise Partnerships" are being introduced at sub-national level, though without dedicated budgets for research and innovation, and with no a role in delivering innovation support programmes.

Funding for research in the UK is provided in two ways: competitive, project-based funding delivered through the Research Councils, for which researchers in UK universities or public sector research can apply, with each Research Council allocating resources within its field between institutes, facilities, research studentships and projects; and via HEFCE in England and its counterparts in Northern Ireland, Scotland and Wales, covering research, knowledge transfer and infrastructure.

The TSB is the UK’s prime channel for supporting business-led technology innovation. It is responsible for a range of innovation programmes, including knowledge transfer partnerships, which embed new graduates in, mostly, SMEs; knowledge transfer networks, to help industry access knowledge and information; collaborative R&D, which supports the business and research communities working together on projects; funding for proof of concept, market validation studies and the development of prototypes (the "Smart" initiative); and the new network of "Catapult" innovation accelerators.

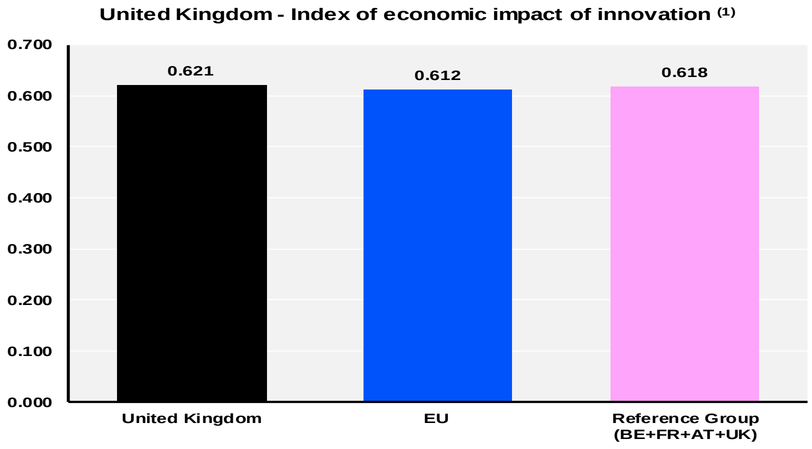
Tax credits are the biggest single funding mechanism provided by the UK Government for incentivising investment in business R&D. The SME scheme gives companies a deduction from corporate tax of 125% of qualifying expenditure and the possibility of a payable credit. The large-company scheme offers a deduction of 30%.

The Government has also put considerable emphasis on using public procurement to stimulate innovation capacity: the Small Business Research Initiative encourages innovative firms to tackle RDI challenges facing government departments, while the Forward Commitment Procurement programme helps public-sector organisations to develop new products and services to meet demand.

A "Patent Box" scheme, to be launched in 2013, will apply a reduced rate of tax to profits from patents and some other types of intellectual property. The hypothesis is that this will encourage firms to retain existing patents, develop new, innovative technologies and patent them, and to locate jobs and activities associated with patentable activities in the UK.

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[10].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The rather good performance of the UK on this index as well as its score on each of its components reflect the specificities of its economic structure, which an overall orientation towards the service economy and a specifically strong specialisation in financial intermediation, a knowledge-intensive sector. The share of the UK's employment in knowledge-intensive activities (17.6 %) is the third highest of all EU Member States, while the share of knowledge-intensive services in services export is the fourth highest.

High-growth firms play a central role in the economic impact of innovation in the UK. Research shows that the 6% of UK businesses with the highest growth-rates generated half the new jobs created by existing businesses between 2002 and 2008 (*The vital 6 per cent, NESTA, 2009*). Although young firms are more likely to be high-growth, the majority are at least five years old. Furthermore, high-growth firms are found across the UK and across sectors, and are almost equally present in the high-tech and low-tech sectors. Innovation drives firm growth, with innovative companies growing twice as fast (in both employment and sales) in the period studied compared to firms that failed to innovate. In addition, high-growth firms generate spillovers in other regions. Although the analysis covers the period before the current recessionary environment developed, the limited evidence available suggests that high-growth businesses are resilient to downturns, continuing to grow despite worsening economic conditions.

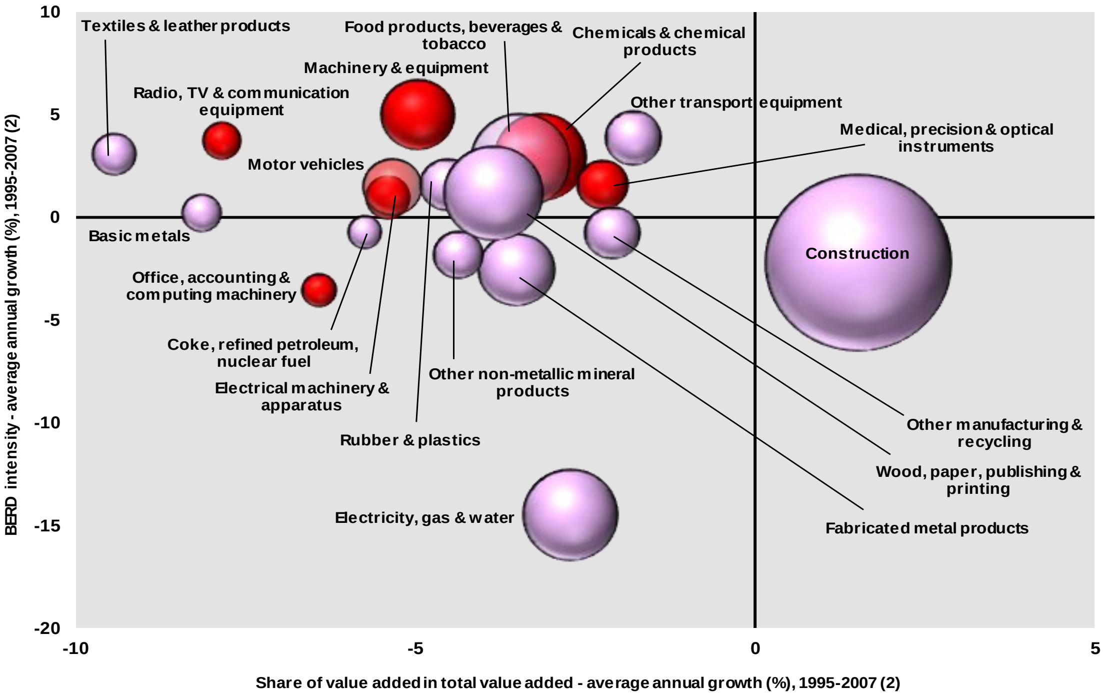
Although the sectoral dynamics of the UK economy will undoubtedly change as the financial and economic crisis continues to unfold, the contribution that high-growth firms make to that economy in both times of growth and times of contraction has been acknowledged by the Government as a valid basis for policy-making. In that light, the Government is committed to providing support via tax incentives, as described above, and to enabling such businesses to access more diverse sources of finance, including debt and equity. Regarding access to finance, the Government has increased the amount committed to an existing enterprise capital funds programme, backed business angels with a co-investment fund, reinforced an investor tax-relief scheme, spurred banks to set up a business growth fund targeting firms with high-growth trajectories, and encouraged investment into new, early-stage companies through an income tax relief and capital gains tax-exemption scheme. Furthermore, research has consistently shown a link in the UK between the use of design and improved business performance across a range of measures, including turnover, profit and market share. The Government continues to support a programme, Design on Demand, to build greater design capability and understanding among SMEs.

10 See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis shows the changing weight of each industry sector in value-added over the period 1995-2007. The general trend of moving to the left-hand side reflects the decreasing share of manufacturing in the overall economy. The sectors above the horizontal axis are those whose research intensity has increased over time. The size of a bubble represents the share of a sector (in value-added) in manufacturing (all sectors shown). Red sectors are those that are already high-tech or medium-to-high-tech.

United Kingdom - Share of value added versus BERD intensity - average annual growth, 1995-2007



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Other transport equipment' includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
(2) 'Construction': 1995-2008.

Manufacturing is the third largest sector of the UK economy in terms of share of GDP, after business services and the wholesale and retail sectors. In common with other leading manufacturing countries, the UK has increasingly specialised in higher-technology manufacturing industries such as medical or chemical products and precision machinery and equipment.

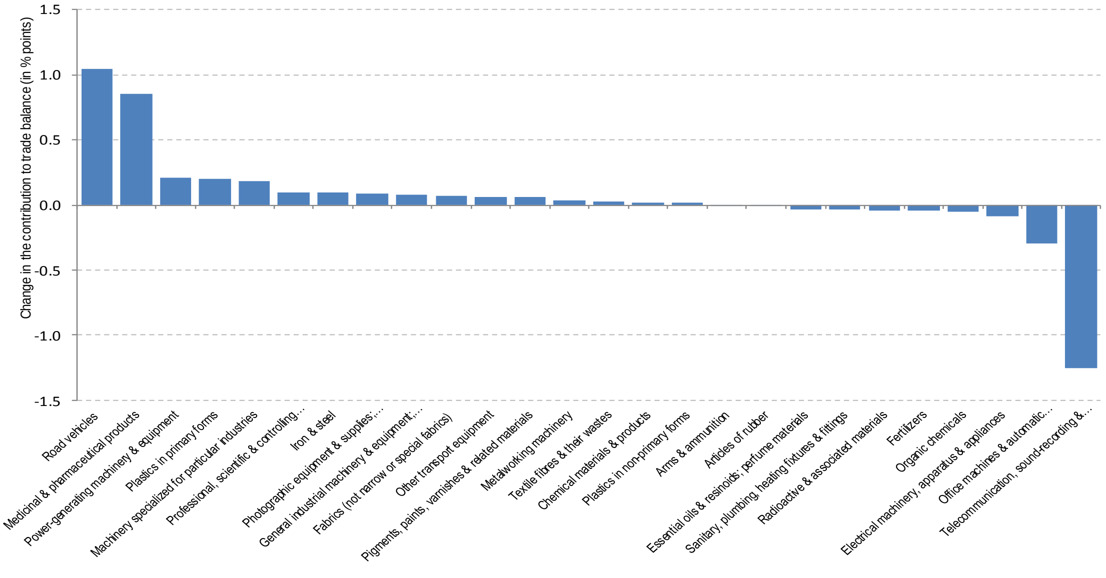
Furthermore, there has been a shift in employment in manufacturing away from production and towards support services, logistics and distribution, sales and marketing, and R&D activities. Current patent activity suggests that the UK is presently relatively strong in the areas of organic chemistry, biotechnology, pharmaceuticals and medical technology, while relatively weak in the areas of electronics, optics, nanotechnology and information technology. In addition, the proportion of firms that are exporting is increasing in many manufacturing industries.

The graph demonstrates that a significant proportion of medium-tech and high-tech sectors have increased their research intensity, but not their share of value-added. However, the research intensity of some sectors has stagnated, or in several cases fallen, which could endanger their long-term competitiveness.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of manufacturing are determinants of a country's competitiveness in global export markets. A higher contribution of high-tech (HT) and medium-tech (MT) industries to the trade balance indicates specialisation and competitiveness in more sophisticated products and services.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for United Kingdom between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Overall, the UK's trade balance in HT and MT firms is negative, with an increasing gap over the last decade. The total trade balance demonstrates an even larger gap, in particular in the period 1997-2005 (the negative trend has been halted since 2005 and is improving since 2008). Nevertheless, the graph above shows that several HT and MT industries have improved their contribution to the UK's trade balance, since the erosion of the trade balance in HT and MT has been slower than the deterioration of the overall UK trade balance. While the medical and pharmaceutical products, road vehicles, plastics, and machinery sectors maintain their competitiveness, the telecommunications (especially) and office machines/data-processing industries have markedly diminished their contributions to the trade balance, suggesting a possible loss in relative competitiveness worldwide.

Alongside established enabling technologies such as ICT, new general-purpose technologies are emerging in areas such as materials, tools, transportation and power. These technologies include low-carbon and environmental technology, advanced materials (such as composites), nanomaterials and nanotechnology, photonics, and biotechnology. Official trade data show that the value of UK manufactured exports to emerging markets has risen in recent years. This can be attributed to a rise in the number of exporting firms and an increase in the average value of their exports. Some of the highest rates of growth in the value of exports have been in higher technology products to emerging markets such as Brazil, Mexico and the Middle East (*Manufacturing in the UK: an economic analysis of the sector, Department for Business, Innovation & Skills, 2010*).

Over the past 12 years, the UK's total factor productivity (see table below) has grown on average by 5% a year, though the financial and economic crisis has knocked back values from a peak in 2007 to 2003's level. Looking at the Europe 2020 targets, the employment rate has fallen slightly, while R&D intensity has recently declined from its 2009 high, averaging around 1.8% over the past decade.

Key indicators for the United Kingdom

UNITED KINGDOM	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]	Rank within EU
ENABLERS																
Investment in knowledge																
New doctoral graduates (ISCED 6) per thousand population aged 25-34	1.33	1.65	1.70	1.83	1.90	1.99	2.08	2.23	2.11	2.22	2.32	:	:	5.8	*1.69*	5
Business enterprise expenditure on R&D (BERD) as % of GDP	1.18	1,17 [3]	1.17	1.12	1.06	1.05	1.07	1.11	1.10	1.11	1.10	*1.09*		*-0.8*	*1.26*	12
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.60	0,59 [3]	0.60	0.60	0.60	0.62	0.63	0.62	0.63	0.68	0.66	*0.64*	:	*0.9*	*0.74*	14
Venture Capital [4] as % of GDP	0.39	0.18	0.17	0.25	0.22	0.35	0.61	1.67	1.25	0.55	1.13	1.10	:	10.0	0,35 [5]	1 [5]
S&T excellence and cooperation																
Composite indicator of research excellence	:	:	:	:	:	50.1	:	:	:	:	56.1	:	:	2.3	47.9	7
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	12.0	12.3	12.4	12.4	12.6	12.8	12.9	12.8	13.3	:	:	:	:	1.3	10.9	4
International scientific co-publications per million population	409	365	394	564	650	712	761	819	857	905	949	989	:	8.4	300	10
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	73	70	70	76	79	:	2.2	53	8
FIRM ACTIVITIES AND IMPACT																
Innovation contributing to international competitiveness																
PCT patent applications per billion GDP in current PPS€	4.4	4.2	4.1	3.9	3.7	3.6	3.8	3.6	3.5	3.4	:	:	:	-2.8	3.9	9
License and patent revenues from abroad as % of GDP	:	:	:	:	0.54	0.58	0.59	0.58	0.55	0.63	0.63	0.58	:	1.2	0.58	8
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	13.9	:	8.5	:	7.3	:	:	:	:	-14.9	14.4	25
Knowledge-intensive services exports as % total service exports	:	:	:	:	58.3	57.7	58.6	60.5	62.5	60.7	57.6	:	:	-0.2	45.1	4
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	1.86	3.57	4.57	3.09	2.67	4.46	6.86	2.74	3.12	3.82	3.05	3.13	:	-	4,20 [6]	9
Growth of total factor productivity (total economy) - 2000 = 100	100	102	103	105	106	108	109	111	109	105	106	106	105	5 [7]	103	16
Factors for structural change and addressing societal challenges																
Composite indicator of structural change	52.6	:	:	:	:	53.5	:	:	:	:	59.2	:	:	1.2	48.7	4
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	16.8	17.5	17.0	17.6	:	1.7	13.6	3
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	29.8	:	25.1	:	27.0	:	21.3	:	:	-5.5	38.4	22
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.21	0.22	0.18	0.19	0.17	0.18	0.21	0.19	0.21	:	:	:	:	0.0	0.39	12
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.95	0.89	0.84	0.78	0.68	0.68	0.60	0.53	0.51	:	:	:	:	-7.5	0.52	11
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES																
Employment rate of the population aged 20-64 (%)	74.0	74.4	74.5	74.7	75.0	75.2	75.2	75.2	75.2	73.9	73.6	73.6	:	0.0	68.6	8
R&D Intensity (GERD as % of GDP)	1.82	1.79	1.80	1.75	1.69	1.72	1.74	1.77	*1.78*	*1.84*	*1.80*	*1.77*	:	*-0.2*	*2.03*	12
Greenhouse gas emissions - 1990 = 100	88	88	86	86	86	86	85	84	82	75	77	:	:	-11 [8]	85	10 [9]
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	1.1	1.3	1.5	1.8	2.3	2.9	3.2	:	:	19.5	12.5	25
Share of population aged 30-34 who have successfully completed tertiary education (%)	29.0	29.9	31.5	31.5	33.6	34.6	36.5	38.5	39.7	41.5	43.0	45.8	:	4.2	34.6	6
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	24.8	23.7	22.6	23.2	22.0	23.1	22.7	:	-1.5	*24.2*	14 [9]

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2001 and the previous years. Average annual growth refers to 2001-2011.

(4) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(5) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK, These Member States were not included in the EU ranking.

(6) EU is the weighted average of the values for the Member States.

(7) The value is the difference between 2012 and 2000.

(8) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(9) The values for this indicator were ranked from lowest to highest.

(10) Values in italics are estimated or provisional.

Iceland

More innovation for a more competitive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Iceland. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2009: 3.11% (EU: 2.03%; US: 2.75%) 2000-2011: +1.7% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 38.8 (EU:47.86; US: 56.68) 2005-2010: +9.22% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0. 485 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: n.a (EU:48.75; US: 56.25) 2000-2010: n.a. (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Fishing industries, Industrial machinery, Geothermal energy	*HT + MT contribution to the trade balance* 2011: -13.57% (EU: 4.2%; US: 1.93%) 2000-2011: n.a. (EU: +4.99%; US:-10.75%)

Iceland has one of the highest R&D intensities in Europe and has an excellent science base. However, a main challenge for Iceland is to transform this into economic competitiveness. Evidence shows that Iceland's competitiveness in high-tech and medium-tech products and services is low, with a negative trade balance for high-tech and medium-tech products since 2000. Research and innovation are part of Iceland's recovery package for economic growth. Although there has been less emphasis on major societal challenges following the economic crisis, lifelong learning and the development of adequate skills for the future are two areas that are receiving political attention. A new strategy for R&I for 2010-2012 was presented by the Science and Technology Policy Council (STPC) and a tax reduction scheme was created in 2009 for business R&D projects. Iceland is numbered among the high income countries and has one of the highest levels of early stage entrepreneurial activity.

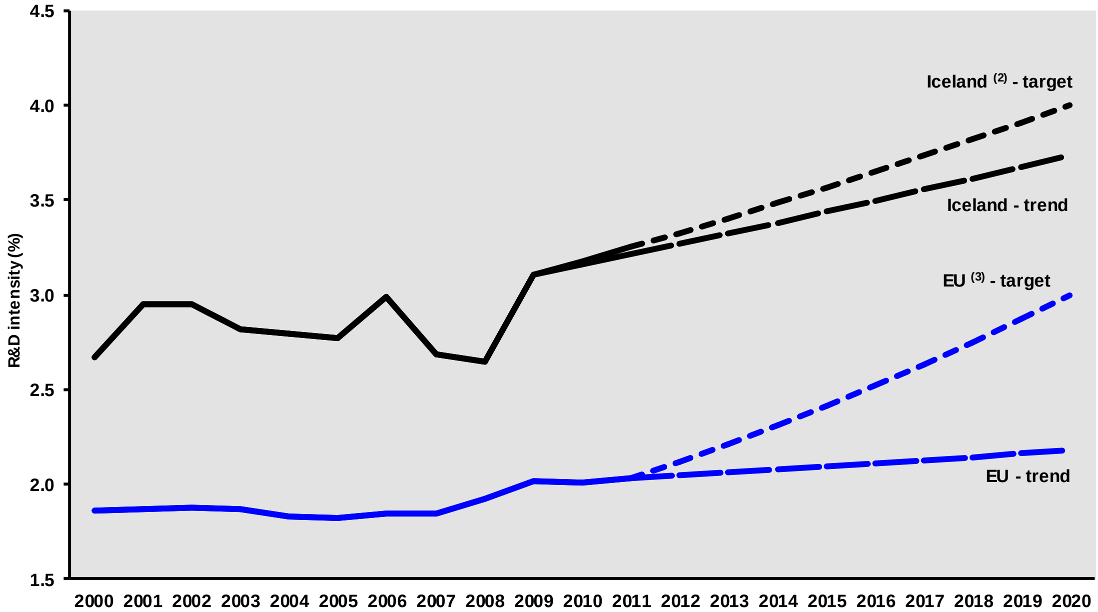
Current research and innovation policy priorities in Iceland match the structural challenges that the country is facing. The current strategy of the STPC, entitled *Building on Solid Foundations. Science and Technology Policy for Iceland 2010-2012* highlights the following priorities:

- increased focus on innovation and close industry support, on creative industries, and on user-driven innovation;
- more cooperation and synergy among the various universities, research institutions and other actors in the system;
- evaluation and quality control;
- international cooperation and participation in international programmes; and funding on the basis of excellence and thus competition.

This strategy will also address two major weaknesses of the R&I system: the first is the need for increased thematic-oriented funding taking into consideration issues related to the size of the country and critical mass; the second is weaknesses related to governance with an increased emphasis on evaluation as outlined in the STPC strategy for the period 2010-2012.

Investing in knowledge

Iceland - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2000-2009 in the case of Iceland.
(2) IS: This projection is based on a tentative R&D intensity target of 4.0% for 2020.
(3) EU: This projection is based on the R&D intensity target of 3.0% for 2020.

Iceland had an R&D intensity of 3.11% in 2009, a relatively high level compared to the EU average of 2.03% (2011). Iceland had already achieved an R&D intensity of 2.95% in 2001. In January 2011, Iceland set an R&D intensity target of 4%, to be reached by 2020, with the private sector contributing 70% of the total and the public sector contributing 30%.

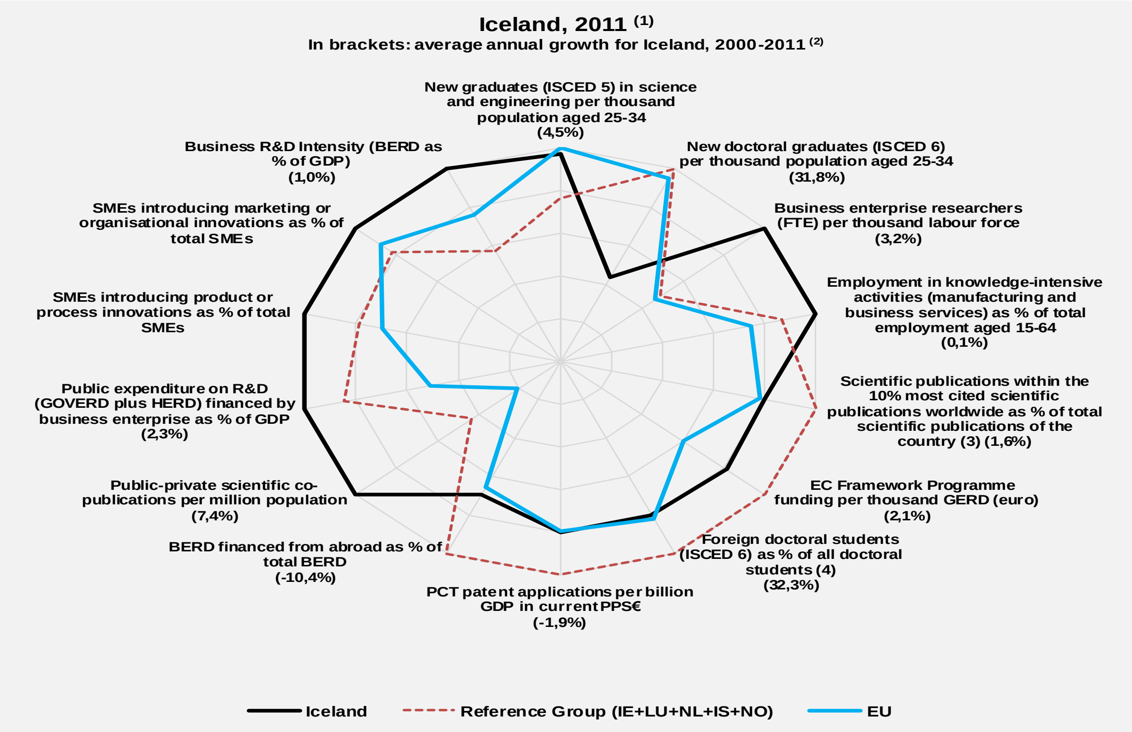
A significant share of total R&D investment in Iceland comes from the public sector. In 2009, the public sector accounted for 44.9% of total R&D investment. The business sector accounted for 52.9%, which shows a decline from 2007 when the share was 54.6%. Insufficient business enterprise expenditure on R&D is one of the key weaknesses of the Icelandic research and innovation system.

In spite of the economic crisis, the government budget for R&D increased by 6.6% between 2011 and 2012. It will be a challenge to maintain this level of increase in public funding for research and development. Mobilising private R&D funding in times of economic crisis is another challenge: the level of private sector funding of R&D in Iceland is considered to be low and has declined since 2007. The government is planning an extra investment of 6,000 billion euros for research and innovation for the period 2013-2015 in the context of the recovery plan.[11]

[11] Investment Plan for Iceland 2013-2015

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Iceland's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.; Reference group does not include IE, LU, NL

The main pillar on which political and economic relations between Iceland and the European Union rests, is the European Economic Area (EEA) agreement signed in 1994 which gives Iceland the right to participate in a range of EU programmes in areas such as research and education. The Icelandic Centre for Research (RANNIS) coordinates and promotes Icelandic participation in collaborative international projects in science and technology inside the European Research area. In particular, Iceland places great emphasis on integration in Nordic R&D co-operation programmes, including the Nordic Research and Innovation Area.

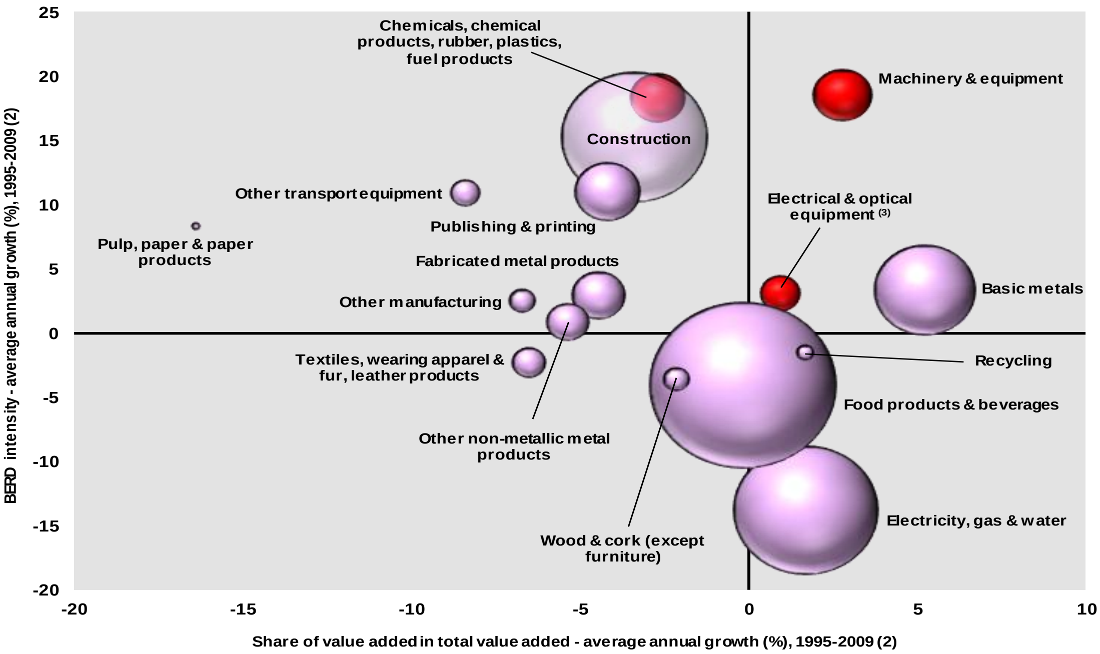
The graph above illustrates that Iceland's strong investment in R&D has triggered high scientific production and very good results in terms of participation in the EC Framework programmes. The economy is very knowledge-intensive as illustrated both by the level of employment in knowledge-intensive activities and the high number of business researchers per thousand labour force. A challenge for Iceland is to increase the numbers of students participating in science, engineering and doctoral studies. There is limited expertise in technology transfer in Iceland. However, recently, there has been an increase in expertise within the field of technology transfer through successful research and development active companies.

The Innovation Centre Iceland (ICI), a government agency, is responsible for delivering support services and providing subsidies for innovation and entrepreneurship related activities. It has the central role of disseminating technology to SMEs and of valorising public investments.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Iceland - Share of value added versus BERD intensity - average annual growth, 1995-2009



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Chemicals, chemical products, rubber, plastics, fuel products' and 'Other transport equipment' include High-Tech, Medium-High-Tech and Medium-Low-Tech,
(2) 'Electrical and optical equipment': 1997-2009; 'Fabricated metal products': 1998-2009; 'Publishing and printing': 1999-2009.
(3) 'Electrical and optical equipment' includes: 'Electrical machinery and apparatus', 'Radio, TV and communication equipment' and 'Medical, precision and optical instruments'.

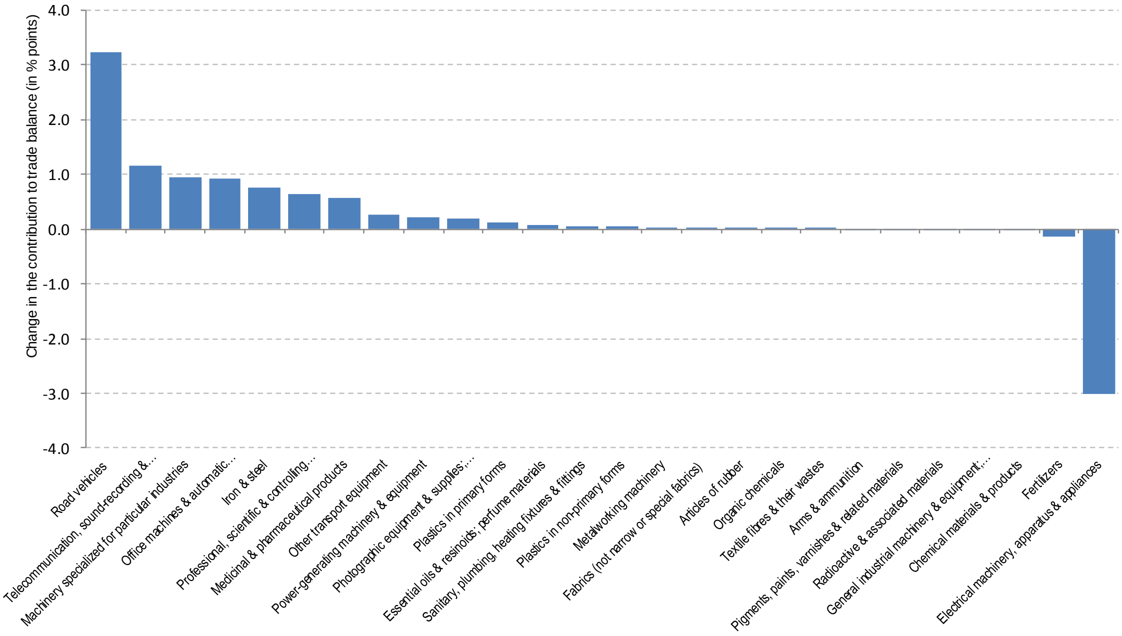
In the last decade, Iceland's economy has been diversifying into manufacturing and service industries, in particular into the fields of software production, biotechnology, and tourism, but the country is still very dependent on the fishing industry (representing 12% of GDP). As a moderate innovator, Iceland has increasing BERD intensities in most of its sectors, as shown on the above graph, with the high-tech and medium-high-tech sectors also gaining in shares of value added.

Iceland has a unique status in terms of energy production: 80% of its electricity needs come from renewable sources, both geothermal and hydropower. This feature has attracted a large amount of foreign investment to the aluminium sector (aluminium production consumes 75% of all electricity generated), and has also attracted the interest of high-tech firms looking to establish data centres using cheap green energy. Pharmaceutical and health industries are considered strategic by the government (even if they only represent 1% of GDP) which wants Iceland to take advantage of its existing knowledge capacity and world level expertise in these domains as reflected by the high number of scientific citations (mostly in molecular biology, genetics, clinical medicine and biology and biochemistry). The Centres of Excellence programme, launched in 2009, aims to stimulate collaboration between industry and academia and is also a means of valorising public R&D investment. Creative industries are an emerging sector, mainly involving SMEs, and are considered to have a very high growth potential.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Iceland between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Between 2000 and 2007, the total trade balance in Iceland deteriorated rapidly mainly due to increasing levels of imports not being covered by a corresponding growth in exports. This trend has since changed, with a substantial reduction in imports leading to a positive trade balance in 2009. The trade balance deficit was also reflected in a negative trade balance for all high-tech (HT) and medium-tech (MT) products. However, some products performed better than others. The graph above shows the increase of the contribution to the trade balance of several HT and MT products, such as road vehicles, machinery specialised for particular industries, telecommunications and sound recording, other transport equipment, office machines and automatic data-processing machines, medical and pharmaceutical products, and iron and steel. A comparison with the previous graph shows that several industry sectors related to these products have upgraded their R&D intensities over the period 1996-2009. However, few of these sectors have increased their value added.

Total factor productivity is higher in 2012 than in 2000. The employment rate of the population aged 20-64 decreased slightly after 2007, but is still well above the EU average (80.6% against 68.6% in 2011). Iceland is also well positioned, compared to the EU average, regarding societal challenges, with a smaller share of population at risk of poverty and a higher share of population aged 30-34 having completed tertiary education. However, there is a rising level of greenhouse gas emissions and a low and falling level of environmental technologies.

Key indicators for Iceland

ICELAND	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]
ENABLERS															
Investment in knowledge															
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.05	0.07	0.12	0.15	0.24	0.34	0.34	0.22	0.48	0.67	0.77	:	:	31.8	*1.69*
Business enterprise expenditure on R&D (BERD) as % of GDP	*1.50*	1.74	*1.69*	1.46	:	1.43	1.59	1.46	1.44	1.64	:	:		*1.0*	*1.26*
Public expenditure on R&D (GOVERD + HERD) as % of GDP	*1.11*	1.15	*1.20*	1.30	:	1.26	1.32	1.15	1.14	1.40	:	:	:	*2.5*	*0.74*
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation															
Composite indicator of research excellence	:	:	:	:	:	25.0	:	:	:	:	38.8	:	:	9.2	47.9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	9.8	10.3	10.9	11.4	10.4	10.3	11.5	11.7	11.2	:	:	:	:	1.6	10.9
International scientific co-publications per million population	624	656	701	1023	1067	1345	1314	1619	1683	2020	2386	2349	:	12.8	300
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	192	200	216	239	255	:	7.4	53
FIRM ACTIVITIES AND IMPACT															
Innovation contributing to international competitiveness															
PCT patent applications per billion GDP in current PPS€	4.7	4.4	6.5	5.7	4.5	4.6	4.3	3.0	2.7	3.9	:	:	:	-1.9	3.9
License and patent revenues from abroad as % of GDP	:	:	:	:	0.01	:	0.00	0.00	0.00	1.80	1.60	:	:	124.0	0.58
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	12.7	:	:	:	:	:	6.1	:	:	-11.6	14.4
Knowledge-intensive services exports as % total service exports	:	:	:	:	26.3	20.7	20.6	19.3	19.1	52.9	50.3	:	:	11.4	45.1
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-19.65	-17.96	-17.02	-18.17	-17.51	-16.81	-17.67	-13.22	-12.93	-11.96	-12.83	-13.57	:	-	4,20 [3]
Growth of total factor productivity (total economy) - 2000 = 100	100	101	101	102	108	109	107	107	106	103	100	103	105	5 [4]	103
Factors for structural change and addressing societal challenges															
Composite indicator of structural change	39.8	:	:	:	:	53.3	:	:	:	:	60.6	:	:	4.3	48.7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	18.2	18.8	18.3	18.2	:	0.1	13.6
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	:	:	:	:	55.1	:	:	:	38.4
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.57	0.00	0.00	0.07	0.12	0.00	0.00	0.00	0.00	:	:	:	:	-32.1	0.39
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	1.65	0.89	2.00	1.21	1.30	2.00	1.62	0.47	0.87	:	:	:	:	-7.7	0.52
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES															
Employment rate of the population aged 20-64 (%)	:	:	:	85.1	84.4	85.5	86.3	86.7	85.3	80.6	80.4	80.6	:	-0.7	68.6
R&D Intensity (GERD as % of GDP)	*2.67*	2.95	*2.95*	2.82	:	2.77	2.99	2.68	2.64	3.11	:	:	:	*1.7*	*2.03*
Greenhouse gas emissions - 1990 = 100	110	109	110	109	111	109	124	131	142	134	130	:	:	20 [5]	85
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 30-34 who have successfully completed tertiary education (%)	32.6	31.0	33.6	38.2	38.8	41.1	36.4	36.3	38.3	41.7	40.9	44.6	:	2.9	34.6
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	13.7	13.3	12.5	13.0	11.8	11.6	13.7	13.7	:	0.0	*24.2*

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) EU is the weighted average of the values for the Member States.

(4) The value is the difference between 2012 and 2000.

(5) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(6) Values in italics are estimated or provisional.

Israel

The challenge of attracting foreign funding for innovation

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Israel. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2010: 4.40% (EU: 2.03%; US: 2.75%) 2000-2011: +0.31% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 77.13 (EU:47.86; US: 56.68) 2005-2010: +2.68% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: n.a. (EU: 0.612)	*Knowledge-intensity of the economy* 2010: n.a (EU:48.75; US: 56.25) 2000-2010: n.a. (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* ICT, Chemicals, Food products and beverages	*HT + MT contribution to the trade balance* 2011: 5.42% (EU[1]: 4.2%; US: 1.93%) 2000-2011[2]: +8.62% (EU[1]: +4.99%; US:-10.75%)

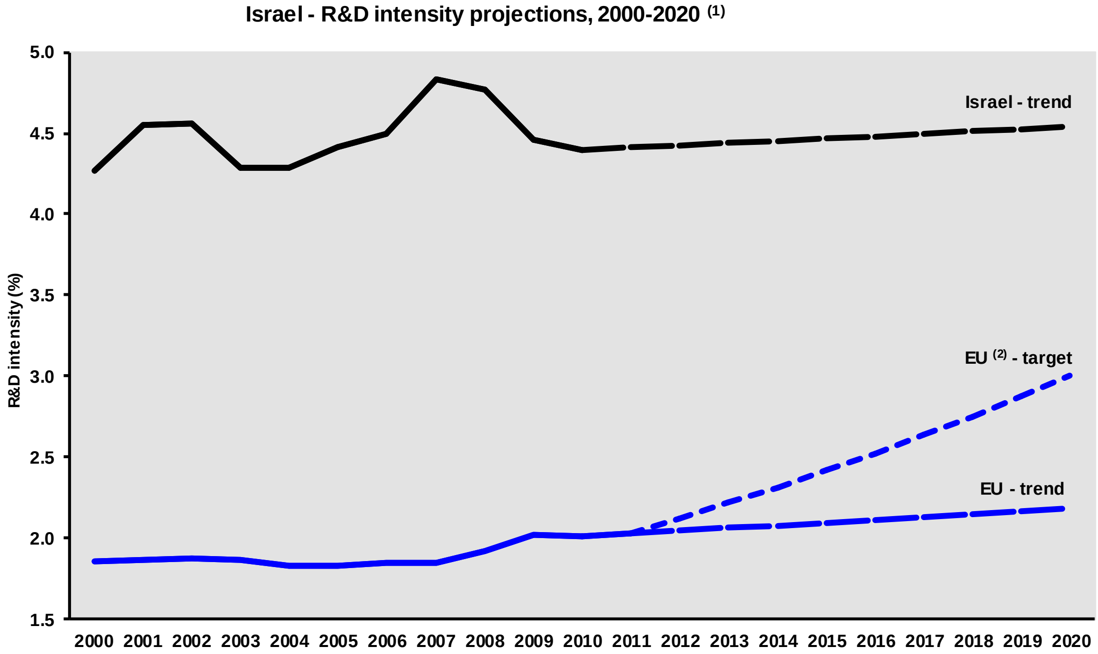
[1]*The EU value is the weighted average of the trade balance of the Member States.*
[2]*The annual growth rate is calculated for the period 2008 - 2010.*

Israel is a very knowledge-intensive country. It has a strong and dynamic business sector and has achieved excellence in scientific and technical education and research. This has led to high levels of technological entrepreneurship and start-ups. The economy is very knowledge-intensive with high-tech and medium-tech products contributing significantly to the trade balance. The main strengths of Israel are its high research intensity, mainly due to a very high business expenditure on R&D, and its patenting activity. The number of business researchers (head count) per thousand labour force is more than four times the EU average (14.8 compared to 3.4, in 2009) and the country has been successful in attracting foreign investment for research and innovation. Israel is ranked second (to the United States) worldwide in terms of venture capital availability, thus ensuring the right conditions for highly innovative small companies across all sectors.

Nevertheless, in spite of this high performance in the field of research and innovation, Israel faces some structural challenges that have created certain stagnation over the last decade. Budgets for Israeli universities have not increased in line with the growth of student numbers resulting in a decline in scientific production and outward mobility of students. Venture Capital (VC) has fallen due to the low returns on VC investments. As a consequence, the total funds available for investment are at a lower level than in previous years. Israeli fund management firms need to raise new funds if they are to continue their important role in supporting Israeli start-ups.

Recently there has been a reform of the governance of the public R&I system, and a six-year plan to revive higher education and university-based research was launched in 2011. The plan calls for a 30% increase in budgets, a doubling of funding for competitive grants, and a 9% increase in the number of researchers. The plan provides for the creation of twenty new CORE centres of research, four of which are already operational.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) IL: An R&D intensity target for 2020 is not available.

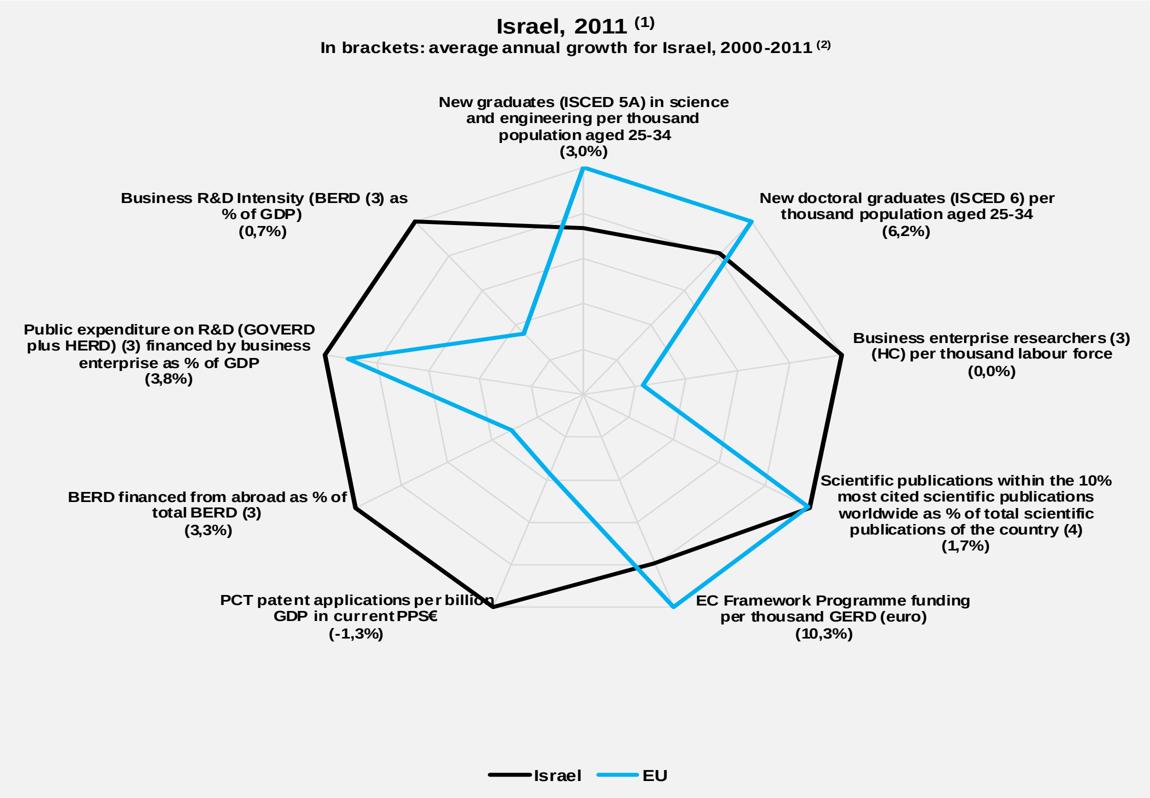
Israel's R&D intensity was already higher than 4% in 2000 and continued to increase until 2007, when it reached 4.84%. It then decreased to 4.40% in 2010 a value which is more than double the EU average. The business sector accounts for around 80% of total R&D expenditure. Although Israel was less affected by the global economic and financial crisis than other countries, business R&D intensity decreased from 3.9% in 2007 to 3.51% in 2010.

Foreign owned firms contribute to increasing the R&D intensity of a country through inward investment in R&D. The level of inward investment in R&D is an indicator both of the degree of internationalisation of business R&D and also of the attractiveness of the country for foreign investors. In 2007 (the latest available year), R&D expenditure of foreign affiliates accounted for 62% of the total R&D expenditure of enterprises. The corresponding shares for Belgium, Austria and Sweden were 59.4%, 53.5% and 33.1%, respectively. In the case of Israel 80% of inward investment in R&D is invested in non-manufacturing sectors.[12]

12 Internationalisation of business investments in R&D and analysis of their economic impact, Final Report, Study financed by the European Commission, DG RTD, April 2012

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Israel's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) IL: Defence is not included.
(4) Fractional counting method.

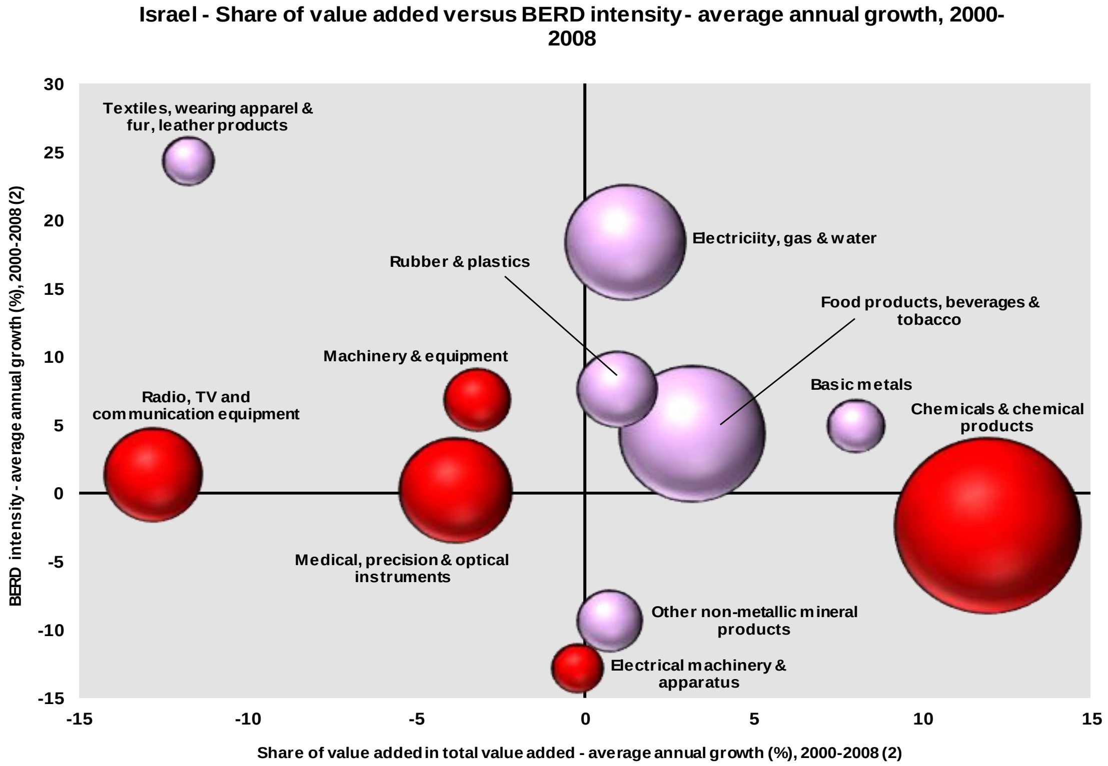
The graph shows that Israel is well above the EU average for the majority of the R&I indicators. Indeed, Israel's overall level of innovation performance places it among the group of European "innovation leaders". Only Sweden, Switzerland and Finland show higher levels of innovation performance. PCT patent applications per billion GDP are three times higher than the EU average, a remarkable difference (even if there has been an average annual decrease of 1.43% over the period 2000-2010).

Although the supply of human resources for science and technology is below the EU average for new science and technology graduates and new doctoral graduates per thousand population aged 25-34, knowledge production as evidenced by highly-cited scientific publications is at the same level as the EU average indicating a good scientific base. This is confirmed by Israel's remarkable level of participation as an associated country in the 7th Framework Programme: Israel has four institutions[13] in the top 50 participant HES organisations in signed grant agreements for the period 2007-2010.

[13] HEBREW UNIVERSITY OF JERUSALEM, WEIZMANN INSTITUTE OF SCIENCE, TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY and TEL AVIV UNIVERSITY.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red.
(2) 'Medical, precision and optical instruments': 2001-2008.

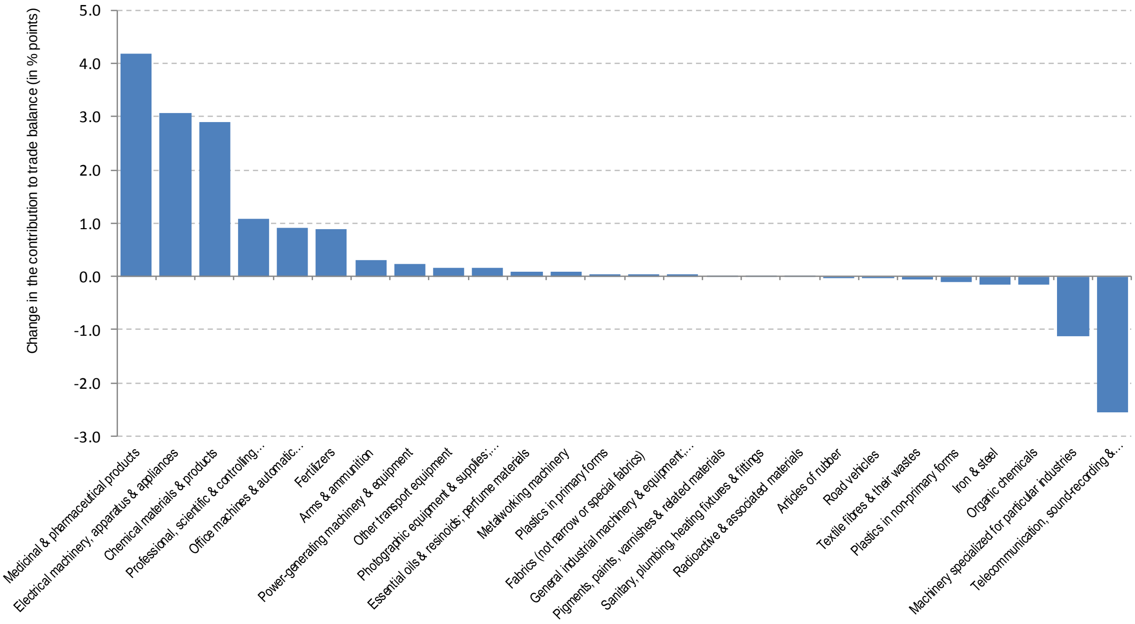
GDP growth is expected to be lower in 2012 than in the previous two years. Industry plays an important role in the Israeli economy and is focused on high technology products. There are a growing number of start-up companies, in particular in the communications, IT and defence sectors. The graph above shows the evolution of value added and business R&D expenditure by manufacturing sectors for the period 2000-2008. While most of the sectors increased their BERD intensities (with the exceptions of other non-metallic mineral products, and electrical machinery and apparatus) a smaller number of sectors reinforced their weights in the economy, by increasing their shares of value-added, most notably in the cases of chemicals and chemical products, basic metals, and food products, beverages and tobacco. On the contrary, high-tech sectors such as machinery and equipment, medical, precision and optical instruments, and radio, TV and communication equipment show declining shares of value added over the same period.

According to the EU Industrial R&D Investment Scoreboard, Israel has been successful in maintaining its position in strategic sectors. In the last five years, the most R&D-intensive Israeli firms have increased their investments in R&D, even during the economic crisis, and have retained their positions among the top R&D investors in sectors such as Pharmaceuticals, Aerospace, Electronics, Semiconductors and Software and General Industrial.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Israel between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Between 2000 and 2008 Israel succeeded in reducing its overall trade balance deficit and in 2009 achieved a positive trade balance. This positive outcome is explained by the growing importance of all high-tech (HT) and medium-tech (MT) products, which since 2008 have registered a positive trade balance. In fact, in 2000 the exports of HT plus MT products only covered 70% of the corresponding imports. However, by 2010 this state of affairs had been reversed with exports of HT plus MT commodities now 30% higher than the corresponding imports. As shown on the graph above, the highest growths at sector level, for HT and MT products were in medical and pharmaceutical products, electrical machinery, chemical materials and products, professional scientific and controlling instruments, fertilizers, and office machines and automatic data processing machines.

Israel is investing strongly in environmental-related technologies as shown by a value of 0.47 (compared to an EU average of 0.39) for patent applications to the EPO per billion GDP in 2008 and an average annual growth rate of 13.7% over the period 2000-2008. On the contrary, patent applications for health-related technologies per billion GDP have decreased at an average annual rate of 1% but in 2008 were still at a very high level of 2.61 compared to an EU average of 0.52. Both indicators are evidence of the dynamism of the business sector. The employment rate increased in 2011 to 60.9% but was lower than the EU average of 68.6%.

Key indicators for Israel

ISRAEL	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)
ENABLERS															
Investment in knowledge															
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.75	0.90	0.87	0.99	1.10	1.15	1.14	1.19	1.31	1.23	1.37	:	:	6.2	*1.69*
Business enterprise expenditure on R&D (BERD) (3) as % of GDP	3.28	3.52	3.47	3.19	3.25	3.43	3.51	3.90	3.80	*3.55*	*3.51*	:	:	*0.7*	*1.26*
Public expenditure on R&D (GOVERD + HERD) (4) as % of GDP	0.87	0.91	0.95	0.96	0.89	0.85	0.83	0.79	0.82	*0.77*	*0.75*	:	:	*-1.5*	*0.74*
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation															
Composite indicator of research excellence	:	:	:	:	:	67.6	:	:	:	:	77.1	:	:	2.7	47.9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	9.6	10.7	10.1	10.4	10.8	11.0	11.0	11.0	11.0	:	:	:	:	1.7	10.9
International scientific co-publications per million population	573	513	522	716	751	774	800	828	836	820	860	897	:	4.2	300
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
FIRM ACTIVITIES AND IMPACT															
Innovation contributing to international competitiveness															
PCT patent applications per billion GDP in current PPS€	11.8	11.1	10.2	11.6	12.2	14.0	14.2	13.7	11.3	10.6	:	:	:	-1.3	3.9
License and patent revenues from abroad as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-4.67	-5.40	-5.06	-3.25	-3.55	-3.08	-2.29	-5.06	4.23	6.86	6.48	5.42	:	-	4,20 (5)
Growth of total factor productivity (total economy) - 2000 = 100	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Factors for structural change and addressing societal challenges															
Composite indicator of structural change	51.1	:	:	:	:	55.4	:	:	:	:	63.2	:	:	2.2	48.7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.17	0.20	0.12	0.23	0.26	0.25	0.32	0.29	0.47	:	:	:	:	13.7	0.39
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	2.83	2.91	2.92	3.39	3.15	3.71	2.98	2.84	2.61	:	:	:	:	-1.0	0.52
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES															
Employment rate of the population aged 15-64 (%)	56.1	55.7	54.8	55.0	55.7	56.7	57.6	58.9	59.8	59.2	60.2	60.9	:	0.7	68.6
R&D Intensity (GERD (3) as % of GDP)	4.27	4.55	4.56	4.28	4.29	4.42	4.50	4.84	4.77	4.46	4.40	:	:	*0.3*	*2.03*
Greenhouse gas emissions - 1990 = 100	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 25-34 who have successfully completed tertiary education (%)	:	:	:	:	:	:	:	:	:	42.9	:	:	:	:	34.6
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Defence is not included,

(4) Defence is not included in GOVERD; Social Sciences and Humanities is not included in HERD.

(5) EU is the weighted average of the values for the Member States.

(6) Values in italics are estimated or provisional.

Norway

The challenge of structural change for a more knowledge-intensive and sustainable economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Norway. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 1.70% (EU: 2.03%; US: 2.75%) 2000-2011*: +0.66% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 51.77 (EU:47.86; US: 56.68) 2005-2010: +11.61% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.433 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 39.99 (EU:48.75; US: 56.25) 2000-2010: +2.22% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Energy, Environment, Food, agriculture and fisheries, Other transport technology	*HT + MT contribution to the trade balance* 2011: -17.38% (EU**: 4.2%; US: 1.93%) 2000-2011***: n.a. (EU**: +4.99%; US:-10.75%)

**The growth rate for Norway refers to the period 2001-2011.*
***The EU value is the weighted average of the trade balance of the Member States.*
****For the period 2000-2011 there are no data available to provide the annual growth rate. The negative values for this period indicates a structural deficit for the industry for the country.*

Norway has the second highest GDP per inhabitant in Europe, with the high GDP partly explaining the low R&D intensity level. The Norwegian economy is mainly based on traditional industrial activities related to the extraction of raw materials and natural resources (petroleum and natural gas, fish) and to their industrial processing into bulk products and semi-finished goods. These industries are less R&D intensive than industries such as pharmaceuticals and ICT, which partly explains why Norway's R&D intensity level was only 1.70% (in 2011), a lower value than the EU average of 2.03% and also lower than the R&D intensity of the United States (2.75% in 2011). Norway's R&D intensity has fluctuated over the period 2001-2011 reaching a high of 1.78% in 2009 and a low of 1.48% in 2006 and with an average annual growth rate of 0.7% (a little lower then EU growth rate). Norway has a higher level of S&T excellence and a higher growth rate for S&T excellence than the EU average.

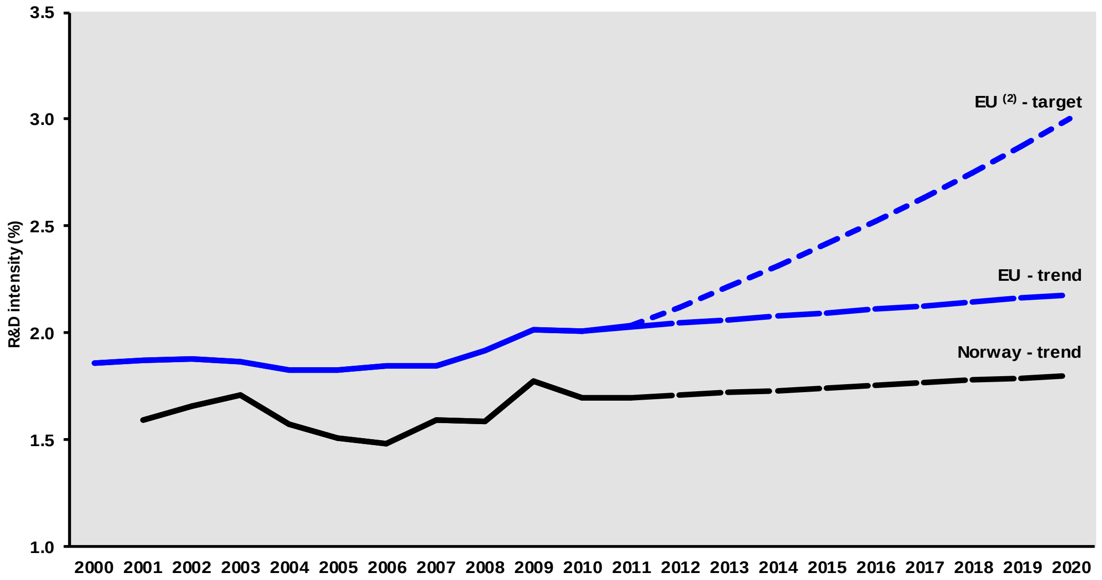
Norway is below the EU average in terms of the knowledge-intensity of its economy. Norway performs moderately on all indicators related to structural change (not visible in the table above). As part of the structural change, internationalization has become an overall priority of the government's R&I policy in the last years and the new internationalization strategy states that all activities of the RCN[14] must include clearly defined objectives and plans for international co-operation. Moreover, in terms of funding, there is a shift from instruments dedicated to internationalization towards including the internationalization dimension in all activities.

The low-tech nature of the Norway's economy is reflected also in the negative contribution to the trade balance of high-tech (HT) and medium-tech (MT) products, with imports much higher than exports for the last 11 years. There are no signs that this characteristic of the Norwegian economy will change in the coming years.

[14] Research Council of Norway

Investing in knowledge

Norway - R&D intensity projections, 2000-2020 (1)



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.in the case of the EU and for 2001-2011 in the case of Norway.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) NO: An R&D intensity target for 2020 is not available.

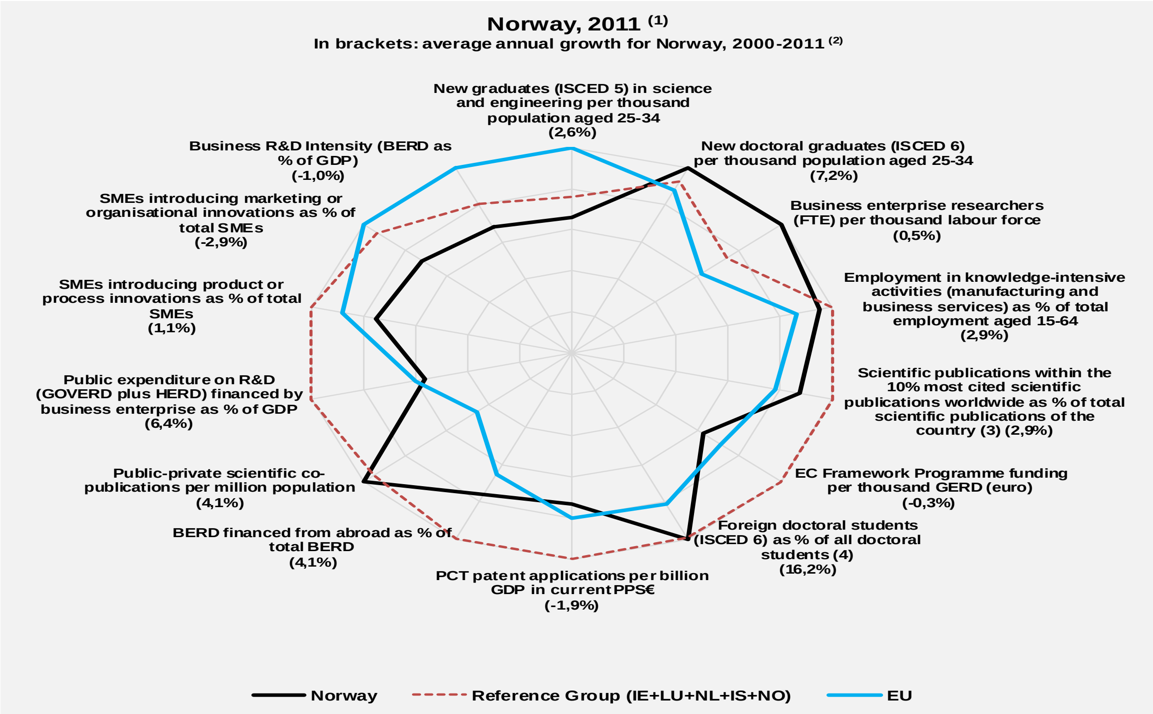
Norway's R&D intensity of 1.70% in 2011 is below the EU average. This is due to the particular nature of Norway's economy which is characterised by traditional industrial activities related to the extraction and processing of natural resources. In recent years, Norwegian policy makers have increasingly recognized that the low level of industrial R&D should be seen against the backdrop of the country's industrial structure. Although Norway's R&D intensity has fluctuated over the last decade, the average annual growth rate of its R&D intensity is close to that of the EU as a whole. If Norway's R&D intensity continues to grow at the same average annual growth rate, the R&D intensity value attained by Norway in 2020 will still be below the EU value and, in fact will be lower than 2%.

Over the last decade, total expenditure on R&D (GERD) in Norway has increased in real terms at an average annual growth rate of 2.1% while the corresponding growth rate for business expenditure on R&D (BERD) was 0.4%. The business enterprise sector accounts for 51% of Norwegian R&D and a large share of it is performed by SMEs. Norway's business R&D intensity of 0.86% in 2011 is much lower than the EU value of 1.26% and is far below the level of the other Nordic countries all of which have values higher than 2%. It is important to mention that the value excludes indirect support for R&D such as R&D tax credits, which is the largest R&D support scheme for business in Norway. The country is therefore an outlier with regard to innovation, with a low-tech but very knowledge-intensive industry sector based on raw materials. This is reflected in the increasing share of SMEs introducing product or process innovations (1.1% growth over the period 2004-2010). On the other hand, the share of knowledge-intensive services exports in total service exports has grown at an average annual rate of 1.6% over the period 2004-2009.

The EU Framework Programmes are the most important international research programmes in which Norway participates. Norwegian researchers have participated in EU FPs since 1987. In FP7, Norway's participant success rate was 24.64%. The successful participants received a total EC financial contribution of € 563 million.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Norwegian innovation system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.; Reference group does not include IE, LU, NL

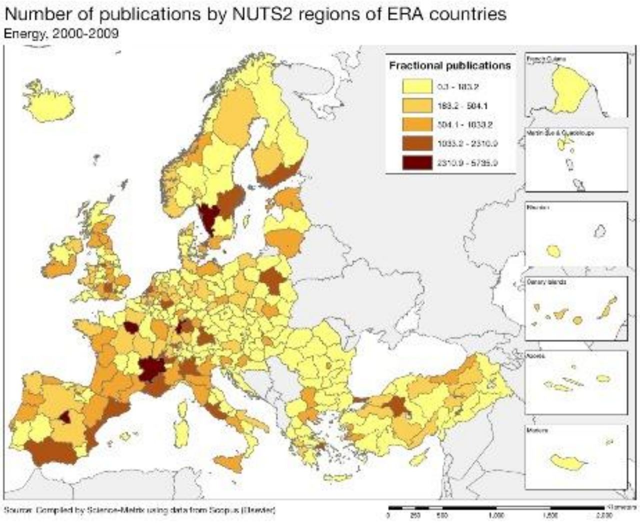
The excellent macroeconomic performance of the Norwegian economy does not yet translate into a high performance level for R&D and innovation. Overall, the Norwegian R&I system's relative strengths are in human resources, public-private cooperation, an attractive research system, financing and entrepreneurship (the latter two dimensions are not shown on the above graph). In the last decade, venture capital, an important financial tool for the business sector, has increased to 0.21% of GDP in 2011, with an average annual growth rate of 2.4%. In particular, the business sector is supported through a number of specific programs for seed venture capital whereby state venture capital is provided as a loan with a risk relief element. Areas of relative weakness are private sector investment, patenting levels and business innovations. The main structural challenges faced by the Norwegian innovation system are a relatively low level of science and engineering graduates, the need to increase industrial R&D and the need to increase innovation in firms. The main program for R&D grants to business is an open research arena for quality projects without thematic restrictions. There has been a shift from indirect to direct support for business R&D and innovation.

The Norwegian innovation system is adapted to knowledge-intensive industry supplemented by a strong service sector. Norway's innovation system is dominated by knowledge-intensive enterprises that rely on collaborative learning. Two other types of enterprise complete the system: enterprises operating with little knowledge accumulation, and small R&D-intensive enterprises that rely on collaborative learning and operate within global innovative networks. Norway's share of employment in knowledge-intensive activities is higher than the EU average but lower than its reference group of countries as shown on the above graph.

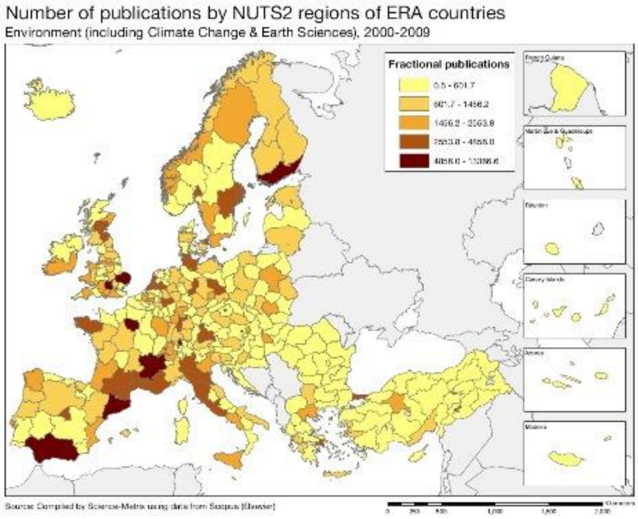
Norway's scientific strengths

The maps below illustrate four key science areas where Norway has real strengths in a European context. The maps are based on the number of scientific publications produced by authors and inventors based in the regions.

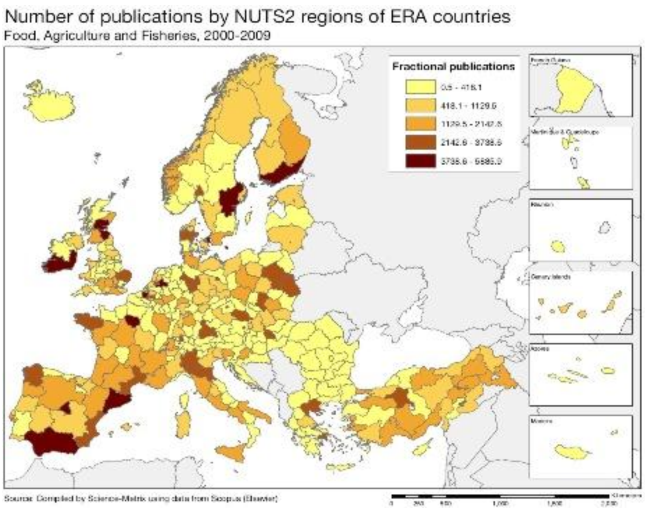
Energy (Scientific production)



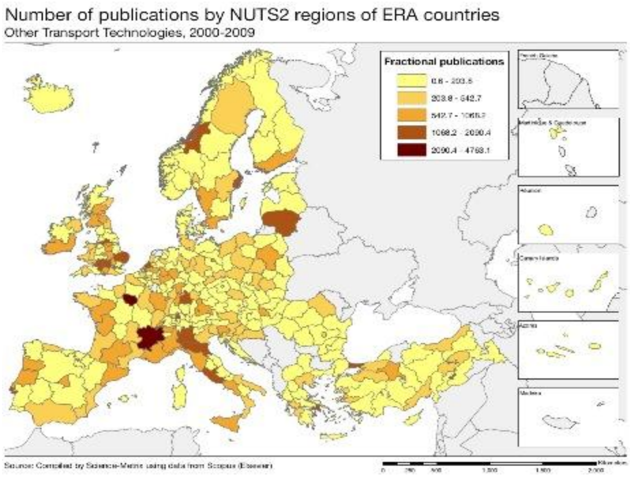
Environment (Scientific production)



Food, Agriculture and Fisheries (Scientific production)



Other Transport Technologies (Scientific production)

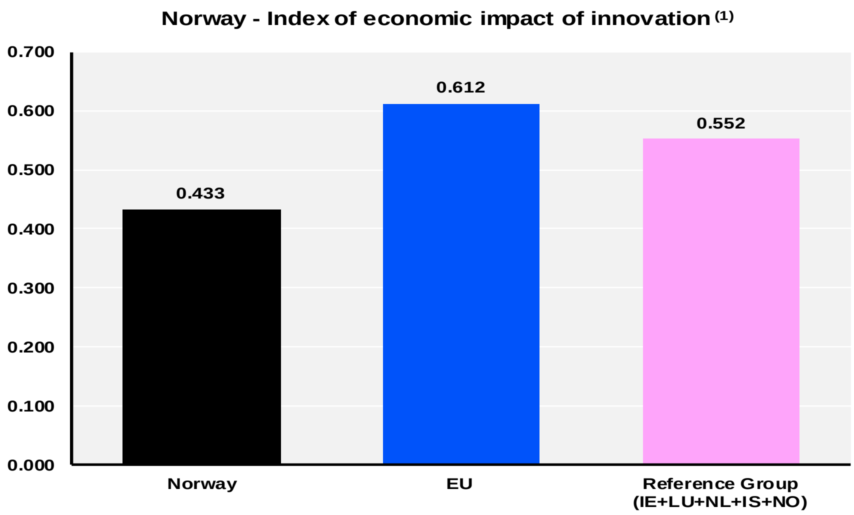


Norway's scientific production shows good results in the fields of energy, environment, food, agriculture and fisheries, and other transport technology[15]. Scientific activity is closely related to Norway’s R&D strategies and takes into account the need to meet global challenges. It focuses particularly on environment, climate change, oceans, food safety and energy research.

[15] Railway vehicles (including hover trains) and associated equipment; aircraft and associated equipment; spacecraft (including satellites) and spacecraft launch vehicles; parts thereof; ships, boats (including hovercraft) and floating structures (SITC Rev.4).

Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators[16].



Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

The situation of Norway's on this index as well as its score on each of its components reflects the specificities of its economic and trade structure. Despites scores higher than EU average on the employment in knowledge-intensive sectors and in the share of knowledge-intensive services export in total services export, the overall result is strongly influenced by the negative contribution of high-tech and medium-tech exports to the trade balance.

Although innovation performance refers to more than technology-driven innovation, it is to be noted that Norway has a number of policy measures the objective of which is to support R&D in companies. Overall public support for industrial R&D is relatively high in Norway, and the mix of instruments has remained largely stable for at least a decade.

The most significant innovation policy developments in Norway since mid- 2009 concern the follow up and implementation of the priorities outlined in the innovation White Paper. The objectives of innovation policy were to foster sustainable value creation, secure future job opportunities and protect welfare in order to respond to increasingly globalised challenges. The competitiveness of trade and industry is dependent on increased research activity in selected service, technology and industrial areas - industrial sectors that could replace the loss in value-creation that will occur when oil and gas production declines. Human resources are an important asset for innovation, value creation and growth and are essential for future growth in new knowledge-intensive sectors.

In order to further improve the quality and capacity of Norway's R&I system, research activity must promote the development of a more knowledge-intensive trade and industrial sector that invests in its own research and development, boosts expertise within the companies and enhances the ability of companies to make use of research conducted by others.

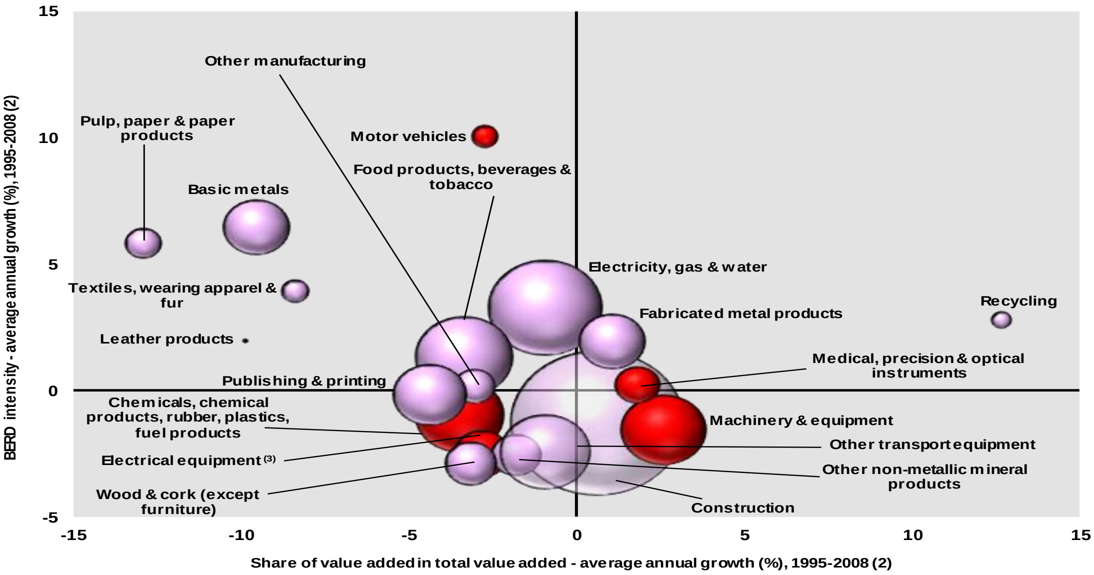
Environmental technologies or eco-innovations are an emerging and important field in Norwegian innovation policy. In June 2011, the government published a strategy for environmental technologies that describes the measures that the government intends to implement in order to create favourable conditions for the development of internationally competitive industries and markets for environmental technologies.

[16] See Methodological note for the composition of this index.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Norway - Share of value added versus BERD intensity - average annual growth, 1995-2008



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Notes: (1) High-Tech and Medium-High-Tech sectors are shown in red. 'Chemicals, chemical products, rubber, plastics, fuel products' and 'Other transport equipment' include High-Tech, Medium-High-Tech and Medium-Low-Tech,
(2) 'Electrical equipment', 'Motor vehicles'', 'Other manufacturing', 'Other transport equipment': 1995-2007; 'Recycling': 1996-2007.
(3) 'Electrical equipment' includes: 'Office, accounting and computing machinery', 'Electrical machinery and apparatus', and 'Radio, TV and communication equipment'.

Norway has a particular industrial structure and as can be seen on the above graph there has been no significant change in R&D investments in the manufacturing sector over the period 1995-2008. Very few sectors have increased their R&D intensities and manufacturing in general has less weight in the overall economy. Most of the sectors are grouped near the axes intersection point, meaning that small variations in levels of R&D intensity are usually accompanied by small or no variations in shares of value added. There are some exceptions. In sectors such as basic metals, motor vehicles and pulp, paper and paper products, business R&D intensity has increased significantly although the share of value added is decreasing. Recycling is the only sector where a small increase in R&D intensity has been accompanied a significant increase in its share of value added, however, this sector is one of the smallest in the economy.

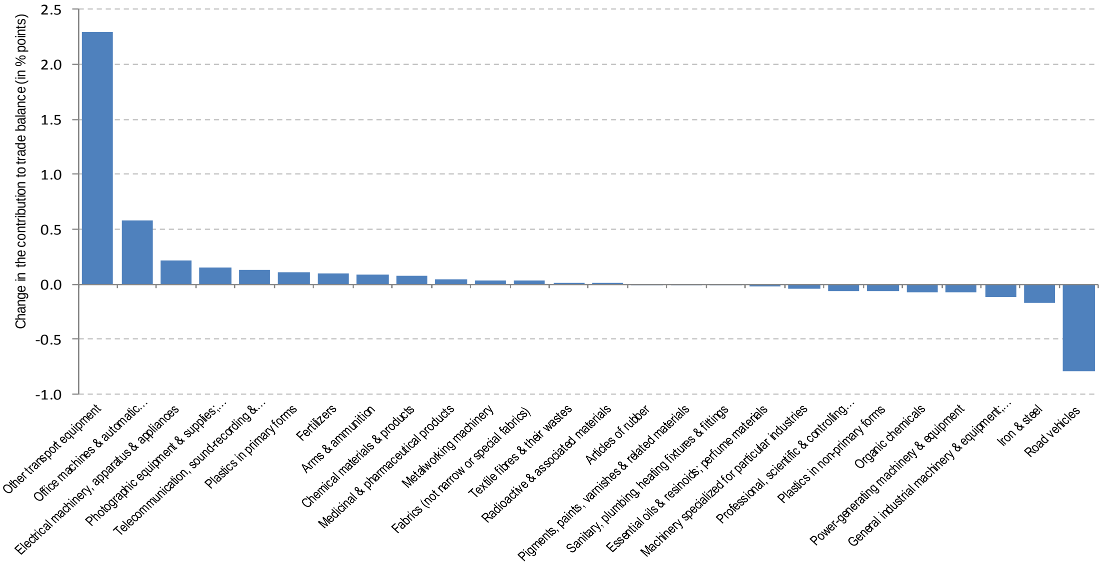
Over recent years, R&D policies and innovation strategies have been developed to focus on specific and representative areas of Norway's economy. These include the strategies for oil and gas, energy, climate, green growth, biotechnologies, nano-technologies and the maritime sector. At national level, there has been a broad political consensus on the need to foster more R&D intensive, knowledge-intensive manufacturing industries and services, exploiting both renewable and non-renewable energy technologies[17]. Therefore, green growth and environmental issues continue to develop as key areas for Science, Technology and Industry (STI), alongside prioritised technology fields such as bio- and nano-technology and ICT.

[17] Report on Science & Technology Indicators for Norway by the Research Council of Norway 2011

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Norway between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Over the period 2000-2011, Norway's trade balance had an upward trend, with an average annual growth of around 10.4%. For each year over the same period imports of high-tech (HT) and medium-tech (MT) products exceeded exports. The share of HT and MT imports in total HT and MT trade was lower in 2011 (70%) than in 2000 (72%). Over the period 2000-2011 some HT and MT products have increased their contributions to the trade balance (left side of the graph). The most significant increases were in other transport equipment[18] and office machines. The product with the biggest decrease in its contribution to the trade balance over 2000-2011 is road vehicles.

Norway's total factor productivity grew between 2000 and 2005 but then declined to reach a level in 2012 that is lower than the level in 2000. This type of evolution is not unusual due to the fact that the petroleum sector, a large part of Norway's economy, depends on physical oil production which is directly related to the characteristics of the actual reservoirs. As a result, production at a new well will rise for several years and then fall for even longer periods affecting the total factor productivity of the country. Norway's employment rate decreased slightly from 80.3% in 2000 to 79.6% in 2011 but remains much higher than the EU average of 68.6%. The share of population at risk of poverty or social exclusion has decreased by 1.1 percentage points between 2004 and 2011 to reach 14.6%.

Norway is the European country with the highest share of renewable energy in gross final energy consumption. Its share of 61.1% in 2010 is five times higher than the EU average. Greenhouse gas emissions in Norway have decreased over the last decade but are still significantly higher than the EU average. It is also noteworthy that in 2008 patents in environment-related technologies were at a considerably lower level than the EU average with only a slight increase since 2000. The level of patent applications in health-related technologies has decreased significantly between 2000 and 2008.

[18] idem 3

Key indicators for Norway

NORWAY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]
ENABLERS															
Investment in knowledge															
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.96	1.13	1.11	1.09	1.17	1.33	1.41	1.59	1.99	1.74	1.92	:	:	7.2	*1.69*
Business enterprise expenditure on R&D (BERD) as % of GDP	:	0.95	0.95	0.98	0.86	0.81	0.79	0.84	0.84	0.92	0.87	*0.86*	:	*-1.0*	*1.26*
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.64	0.71	0.73	0.71	0.70	0.69	0,76 [3]	0.74	0.86	0.83	*0,84 [4]*	:	*3.0*	*0.74*
Venture Capital [5] as % of GDP	0.16	0.14	0.09	0.12	0.10	0.13	0.09	0.26	0.24	0.23	0.31	0.21	:	2.4	0,35 [6]
S&T excellence and cooperation															
Composite indicator of research excellence	:	:	:	:	:	29.9	:	:	:	:	51.8	:	:	11.6	47.9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	9.7	9.8	10.1	10.5	10.7	11.0	11.4	11.1	12.2	:	:	:	:	2.9	10.9
International scientific co-publications per million population	464	450	462	691	813	916	1039	1139	1213	1335	1416	1483	:	11.1	300
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	98	102	114	119	116	:	4.1	53
FIRM ACTIVITIES AND IMPACT															
Innovation contributing to international competitiveness															
PCT patent applications per billion GDP in current PPS€	4.3	3.9	4.0	3.4	3.6	3.5	3.2	3.1	2.9	3.6	:	:	:	-1.9	3.9
License and patent revenues from abroad as % of GDP	:	:	:	:	0.09	0.17	0.20	0.18	0.15	0.17	:	:	:	12.5	0.58
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	7.2	:	4.8	:	3.3	:	6.1	:	:	-2.7	14.4
Knowledge-intensive services exports as % total service exports	:	:	:	:	45.0	47.7	50.1	46.9	48.9	49.4	:	:	:	1.6	45.1
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-19.77	-17.84	-17.42	-16.68	-18.05	-18.39	-18.26	-17.52	-17.73	-16.74	-16.46	-17.38	:	-	4,20 [7]
Growth of total factor productivity (total economy) - 2000 = 100	100	101	102	103	106	106	105	104	101	98	98	97	98	-2 [8]	103
Factors for structural change and addressing societal challenges															
Composite indicator of structural change	32.1	:	:	:	:	33.9	:	:	:	:	40.0	:	:	2.2	48.7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	13.8	14.9	14.2	15.1	:	2.9	13.6
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	30.8	:	29.8	:	28.9	:	32.8	:	:	1.1	38.4
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.22	0.14	0.18	0.20	0.22	0.24	0.21	0.30	0.24	:	:	:	:	1.0	0.39
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.55	0.33	0.45	0.31	0.37	0.29	0.32	0.29	0.23	:	:	:	:	-10.2	0.52
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES															
Employment rate of the population aged 20-64 (%)	80.3	80.1	79.6	78.4	78.2	78.2	79.5	80.9	81.8	80.6	79.6	79.6	:	-0.1	68.6
R&D Intensity (GERD as % of GDP)	:	1.59	1.66	1.71	1.57	1.51	1.48	1.59	1.58	1.78	1.69	*1.70*	:	*0.7*	*2.03*
Greenhouse gas emissions - 1990 = 100	107	110	107	109	110	108	108	111	108	103	108	:	:	1 [9]	85
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	58.4	60.1	60.6	60.5	62.0	65.1	61.1	:	:	0.8	12.5
Share of population aged 30-34 who have successfully completed tertiary education (%)	37.3	42.2	43.4	40.7	39.5	39.4	41,9 [10]	43.7	46.2	47.0	47.3	48.8	:	3.1	34.6
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	15.8	16.2	16.9	16.5	15.0	15.2	14.9	14.6	:	-1.1	*24.2*

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2007 and the previous years.

(4) Break in series between 2011 and the previous years. Average annual growth refers to 2007-2010.

(5) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(6) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK.

(7) EU is the weighted average of the values for the Member States.

(8) The value is the difference between 2012 and 2000.

(9) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(10) Break in series between 2006 and the previous years. Average annual growth refers to 2006-2011.

(11) Values in italics are estimated or provisional.

Switzerland

The challenge of structural change maintaining a leading competitive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Switzerland. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

	Investment and Input	Performance/economic output
Research	*R&D intensity* 2008: 2.87% (EU: 2.03%; US: 2.75%) 2000-2011[1]: +1.9% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010: 97.59 (EU:47.86; US: 56.68) 2005-2010: +3.42% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.837 (EU: 0.612)	*Knowledge-intensity of the economy* 2010: 70.05 (EU:48.75; US: 56.25) 2000-2010: +2.11% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Energy, Environment, ICT, Nanosciences and Nanotechnologies	*HT + MT contribution to the trade balance* 2011: 8.44% (EU[2]: 4.2%; US: 1.93%) 2000-2011: +2.69% (EU[2]: +4.99%; US:-10.75%)

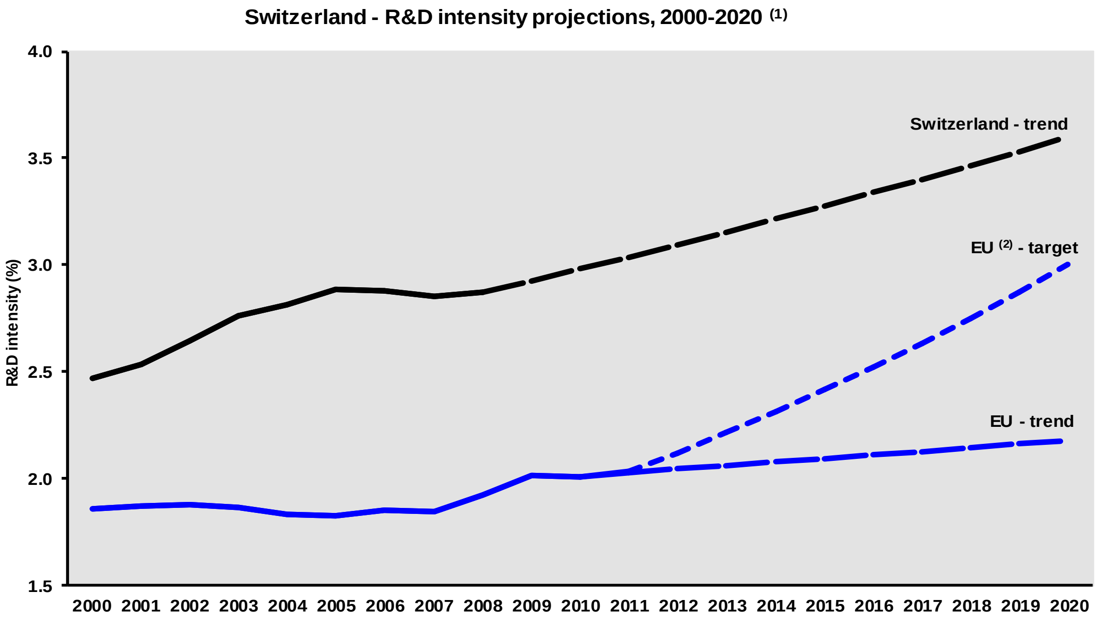
[1]*For Switzerland the growth rate is calculated for the period 2000-2008.*
[2]*The EU value is the weighted average of the trade balance of the Member States.*

Switzerland has a level of economic development that is amongst the highest in Europe. Swiss research policy is characterised by continuity and stability and Switzerland performs better in R&D than the EU (average) and the United States. Switzerland had an R&D intensity of 2.87% in 2008 (the latest available year) with an R&D intensity average annual growth rate of 1.9% over the period 2000-2008 both of which are higher than the corresponding values for EU (2.03% and 0.8%) and United States (2.75% and 0.2%).

The high level of R&D performance is accompanied by a high level of S&T excellence with Switzerland performing at a level that is almost double that of the EU. Switzerland is one of the most advanced countries in terms of the knowledge-intensity of its economy, and has made even further progress over the decade 2000-2010. The country performs well in all indicators that indicate the size of the knowledge economy. There is also a high performance on the cumulative inward and outward FDI stock as a share of GDP, the relative specialization in the exports of medium-high-tech and high-tech products (Revealed Competitive Advantage – RCA) and the share of value added in knowledge-intensive activities within the total value added of the country.

The contribution of high-tech (HT) and medium-tech (MT) products to the country's trade balance is much higher than the corresponding contributions in the EU as a whole and the United States, and is based on a very good performance of the knowledge-intensive sectors of the economy..

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D Intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011 in the the case of the EU and for 2000-2008 in the case of Switzerland.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) CH: An R&D intensity target for 2020 is not available.
(4) CH: The values for 2001, 2002, 2003, 2005, 2006 and 2007 were interpolated by DG Research and Innovation.

The Swiss research system is of very good quality and is based on a clear-cut separation between the public sector, which is centred on very research-intensive universities, and the private sector, which is centred on the large research units of multinational companies. The main priority of Swiss national research and innovation (R&I) policies is to provide excellent framework conditions by fostering basic as well as applied research and technology transfer.

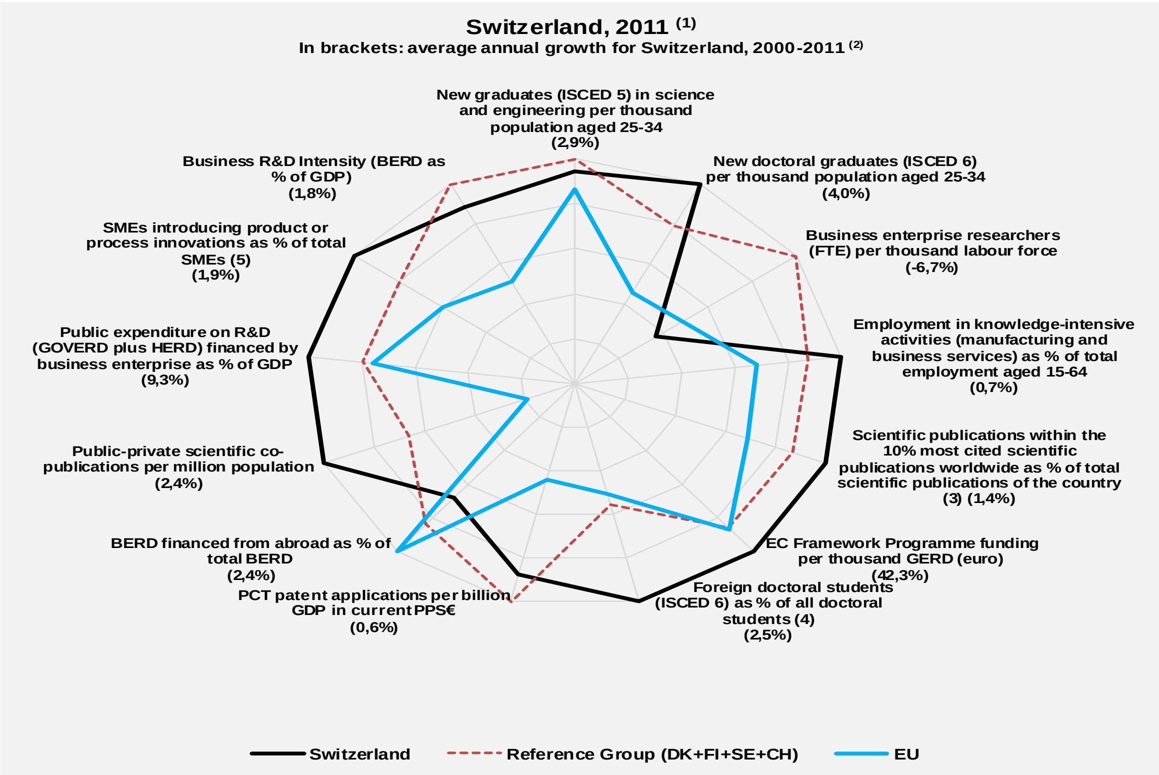
Switzerland has one of the highest R&D intensities both in Europe and in the world with a value of 2.87% in 2008. Over the last decade, R&D intensity grew at an average annual rate of 1.9%, well above the EU rate of 0.8% and if the same trend is continued, will reach 3.60% in 2020. Almost 74% of R&D is performed by the private sector. This is due to the specific structure of the Swiss economy which is dominated by large multinational companies with their own global strategies. Swiss research policy focuses mainly on the quality of the public research sector and on the training of skilled researchers. An important trend in public R&D expenditures is the increasing R&D expenditure for universities. As a result, over the period 2000-2010, total higher education expenditure on R&D increased in real terms at an average annual rate of 5%. In 2008, higher education expenditure on R&D as a percentage of total expenditure on R&D in Switzerland was approximately on the same level as the EU average (CH: 24.2%; EU: 23.0%).

The share of new doctoral graduates per thousand population aged 25-34 has increased from 2.7% in 2002 to 3.6% in 2009, a value which is more than double the EU average. Switzerland's competitive R&I system is maintained by intensive and successful scientific activity as shown by a high share of scientific publications within the 10% most cited scientific publication worldwide (15.8% in 2008), a high number of international scientific co-publications per million population (2505 in 2011), a high level of PCT patent applications per billion GDP (7.8 in 2009) and a high level of licensing and patent revenues from abroad as % of GDP (2.95% in 2011).

Switzerland has a good tradition of participating in international programs at European level. Switzerland's participant success rate in the EC Seventh Framework Programme was 25%. The successful participants received a total EC financial contribution of € 1.3 billion.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Switzerland's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) CH is not included in the reference group.

The Swiss research and innovation system is characterized by a very strong scientific and technological production that outperforms the EU on almost all the indicators analysed in the graph above, making Switzerland an innovation leader.

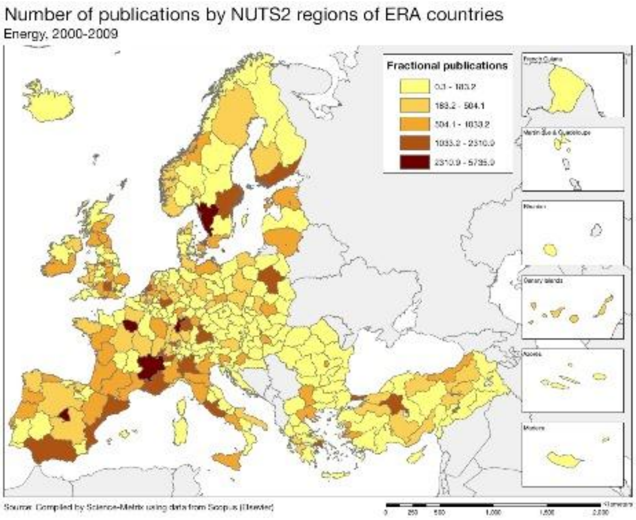
An important weakness in the Swiss R&I system is the relatively low level and the significant decrease in the number of researchers employed by business enterprises. A lack of researchers could become a problem in the future for Switzerland. Although the number of graduates in the fields of science and engineering per thousand population aged 25-34 has increased at an average annual growth rate of 2.9% over the period 2002-2010, there is still an insufficient supply of graduates in these fields. Another challenge facing the Swiss R&I system (not visible in the graph above) is the need to improve education and training curricula in relation to entrepreneurial education and the teaching of intercultural and communications skills.

Although business expenditure on R&D (BERD) as a percentage of total expenditure on R&D is very high in Switzerland (73.5%), the share of business expenditure financed from abroad is lower than both the EU average and Switzerland's reference group of countries. Switzerland outperforms both the EU and its reference group of countries in terms of production of scientific publications, public-private scientific co-publications, share of foreign doctoral students in all doctoral students and share of employment in knowledge-intensive activities in total employment aged 15-64.

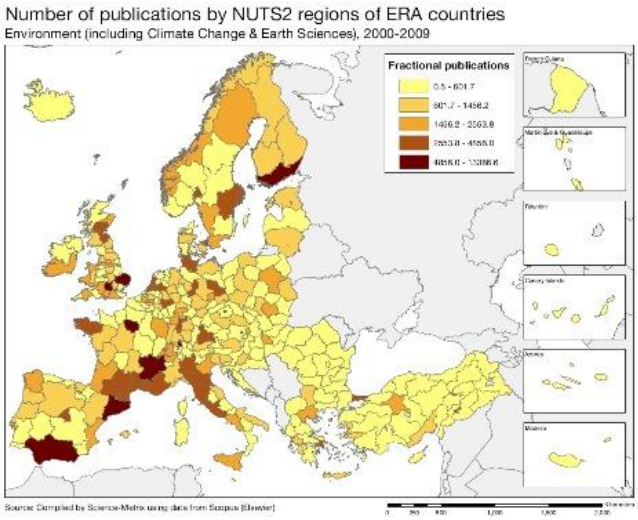
Switzerland's scientific strengths

The maps below illustrate four key science areas where Switzerland has real strengths in a European context. The maps are based on the number of scientific publications produced by authors and inventors based in the regions.

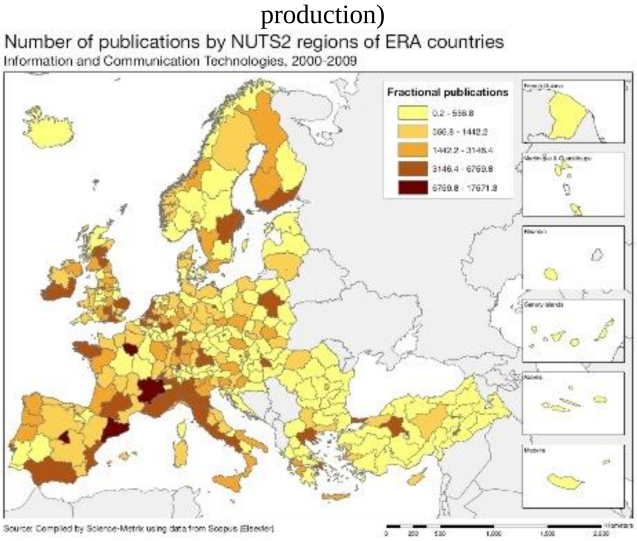
Energy (Scientific production)



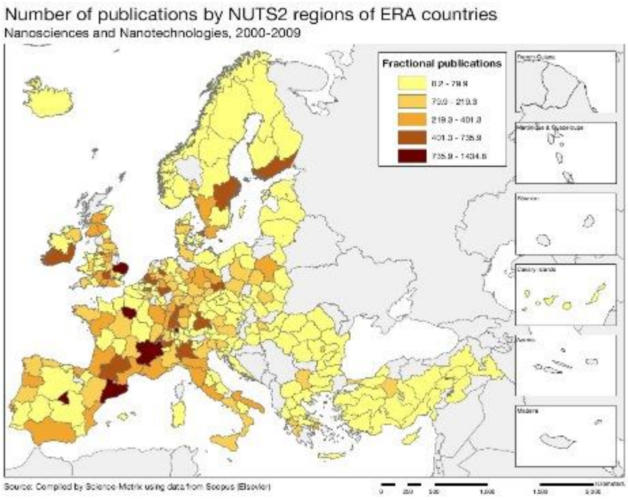
Environment (Scientific production)



Information and Communication Technologies (Scientific production)



Nanosciences and Nanotechnologies (Scientific production)

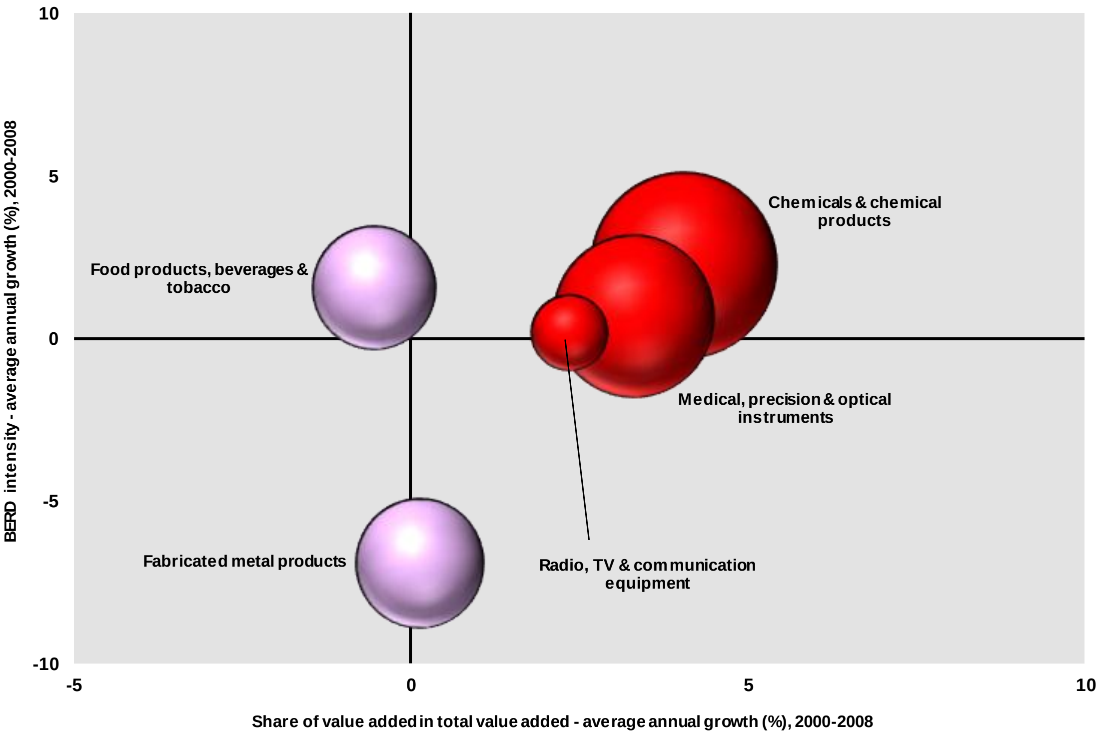


Switzerland's scientific production shows good results in the fields of energy, environment, information and communication technology (ICT), and nano-sciences and nanotechnologies. In Switzerland, almost all public sector research is carried out in higher education institutions and research policy is focused mainly on basic and applied research in universities. Switzerland has taken an important step to improve and strengthen its universities and to allow them to position themselves in the European and international context by adopting a new higher education act that will provide a common regulatory framework for the whole system.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

Switzerland - Share of value added versus BERD intensity - average annual growth, 2000-2008



Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
Note: (1) High-Tech and Medium-High-Tech sectors are shown in red.

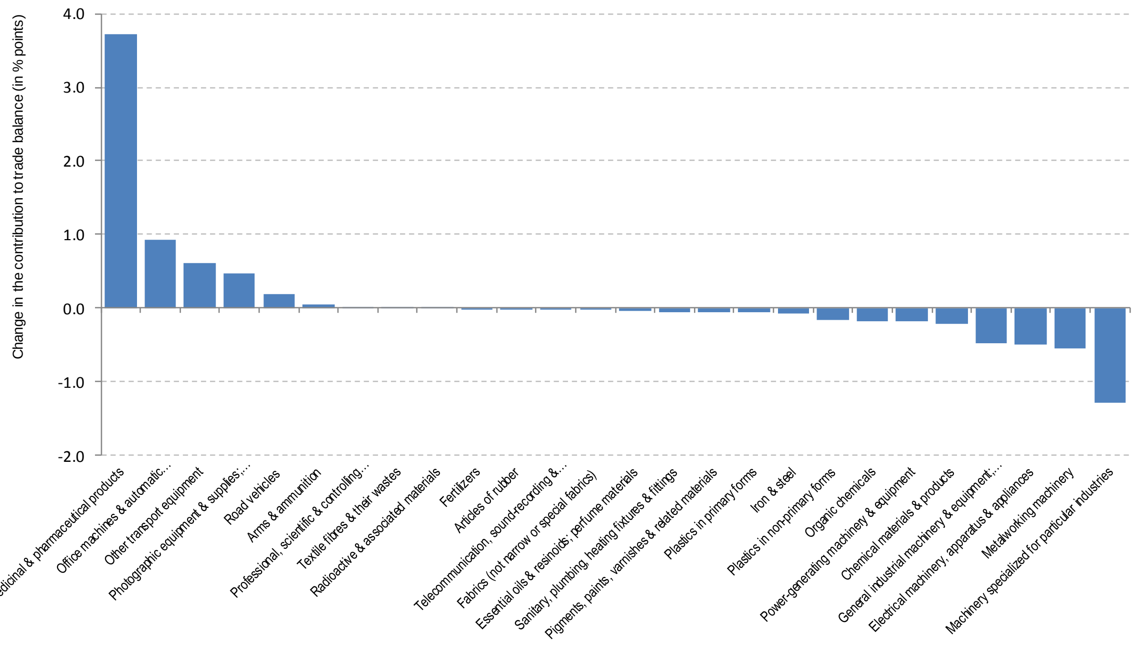
R&I excellence plays an important part in Swiss manufacturing. Switzerland displays a strong specialization in a number of technologically-intensive sectors, including the chemicals, pharmaceuticals, medical, precision and optical instruments industries. High-tech sectors make an important and increasing contribution to the Swiss economy in terms of value added.

Business R&D intensities and shares of value added show average annual increases over the period 2000-2008 for medical, precision and optical instruments, chemicals and chemical products, and Radio, TV and communication equipment. The challenge for Switzerland is to achieve the same competitive advantages in the new emerging sectors in which the country has scientific and technological strengths, in particular energy, environment and nanotechnologies. In this regard, partnerships between higher education institutes, research centres and business are actively promoted. Policies and instruments such as knowledge transfer platforms and voucher systems are in place to encourage cooperation and knowledge sharing and to create a more favourable business environment for SMEs.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Switzerland between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
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"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

Over the period 2000-2011 the characteristics of the Swiss trade balance have not changed significantly. The evolution of the shares of imports and exports of HT and MT products in total imports and exports shows little variation - the HT and MT share of total imports decreased by 2.28% while the HT and MT share of total exports increased by 2.06%. Overall the contribution of HT and MT goods to the trade balance has increased over the period 2000-2011. HT and MT goods represent 56% of total trade. In terms of contribution to the trade balance, the graph above shows that over the period 2000-2011, medical and pharmaceutical products had the highest increase whereas metalworking machinery and machinery specialized for particular industries had the biggest decreases.

In Switzerland total factor productivity has increased by 7% between 2000 and 2012. Switzerland has one of the highest employment rates in the world at 81.8% in 2011, much higher than the EU average of 68.6%. The high rate of employment is associated with an increasing share of population aged 30-34 with tertiary education (44% in 2011) and a decreasing share of the population at risk of poverty or social exclusion (17.3% in 2011).

Switzerland has one of the highest business R&D intensities in Europe, 2.11% in 2008 (the latest available year). This value has been increasing at an average annual rate 1.8% over the period 2000-2008. However, the high level of private sector R&D and the relatively low level of public sector expenditure on R&D could be considered as a challenge for the Swiss R&I system. The bottom-up approach to knowledge demand is characterized by a strong and an extensive involvement of social and economic stakeholders in the design of research policy where decision on research direction is left to researchers and private companies.

Key indicators for Switzerland

SWITZERLAND	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth [1] (%)	EU average [2]
ENABLERS															
Investment in knowledge															
New doctoral graduates (ISCED 6) per thousand population aged 25-34	:	:	2.70	2.68	2.93	3.31	3.42	3.49	3.44	3.58	3.68	:	:	4.0	*1.69*
Business enterprise expenditure on R&D (BERD) as % of GDP	1.82	:	:	:	2.08	:	:	:	2.11	:	:	:	:	1.8	*1.26*
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.60	:	0.65	:	0.67	:	0.66	:	0.71	:	0.79	:	:	2.9	*0.74*
Venture Capital [3] as % of GDP	0.07	0.06	0.09	0.05	0.04	0.11	0.12	0.26	0.35	0.18	0.37	0.14	:	6.6	0,35 [4]
S&T excellence and cooperation															
Composite indicator of research excellence	:	:	:	:	:	82.5	:	:	:	:	97.6	:	:	3.4	47.9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	14.2	14.9	14.3	14.4	15.0	15.4	15.8	15.4	15.8	:	:	:	:	1.4	10.9
International scientific co-publications per million population	992	869	953	1392	1593	1724	1861	2056	2110	2222	2351	2505	:	8.8	300
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	253	254	269	281	278	:	2.4	53
FIRM ACTIVITIES AND IMPACT															
Innovation contributing to international competitiveness															
PCT patent applications per billion GDP in current PPS€	7.4	8.1	7.8	8.1	8.8	9.0	8.6	9.0	7.8	7.8	:	:	:	0.6	3.9
License and patent revenues from abroad as % of GDP	:	:	:	:	1.74	2.24	1.97	2.07	2.17	2.93	3.00	2.95	:	7.8	0.58
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	10.7	:	:	:	24.9	:	:	:	:	23.5	14.4
Knowledge-intensive services exports as % total service exports	:	:	:	:	34.7	37.4	37.3	38.3	34.2	30.3	26.5	:	:	-4.4	45.1
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	6.30	7.56	6.11	6.10	6.32	6.98	7.56	7.58	8.28	8.17	8.02	8.44	:	-	4,20 [5]
Growth of total factor productivity (total economy) - 2000 = 100	100	100	99	99	101	103	105	107	107	105	107	107	107	7 [6]	103
Factors for structural change and addressing societal challenges															
Composite indicator of structural change	56.8	:	:	:	:	64.1	:	:	:	:	70.0	:	:	2.1	48.7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	19.5	19.9	19,8 [7]	20.0	:	0.7	13.6
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	52.9	:	:	:	57.0	:	:	:	:	1.9	38.4
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.42	0.47	0.47	0.42	0.47	0.53	0.49	0.67	0.55	:	:	:	:	3.4	0.39
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	2.28	2.30	2.22	2.56	2.50	2.78	2.62	2.46	2.18	:	:	:	:	-0.6	0.52
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES															
Employment rate of the population aged 20-64 (%)	80.9	81.9	81.2	80.2	80.0	79.9	80.5	81.3	82.3	81.7	81,1 [8]	81.8	:	0.1	68.6
R&D Intensity (GERD as % of GDP)	2.47	:	:	:	2.82	:	:	:	2.87	:	:	:	:	1.9	*2.03*
Greenhouse gas emissions - 1990 = 100	98	100	98	100	101	103	102	98	101	99	102	:	:	4 [9]	85
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 30-34 who have successfully completed tertiary education (%)	27.3	27.3	30.0	32.4	32.8	33.4	35.0	36.5	41.3	43.4	44.2	44.0	:	4.4	34.6
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	:	:	18.6	17.2	17.2	17.3	:	-2.4	*24.2*

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.

(4) Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK.

(5) EU is the weighted average of the values for the Member States.

(6) The value is the difference between 2012 and 2000.

(7) Break in series between 2010 and the previous years. Average annual growth refers to 2010-2011.

(8) Break in series between 2010 and the previous years. Average annual growth refers to 2000-2009.

(9) The value is the difference between 2010 and 2000. A negative value means lower emissions.

(10) Values in italics are estimated or provisional.

Turkey

The challenge of structural change for a more competitive economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Turkey. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

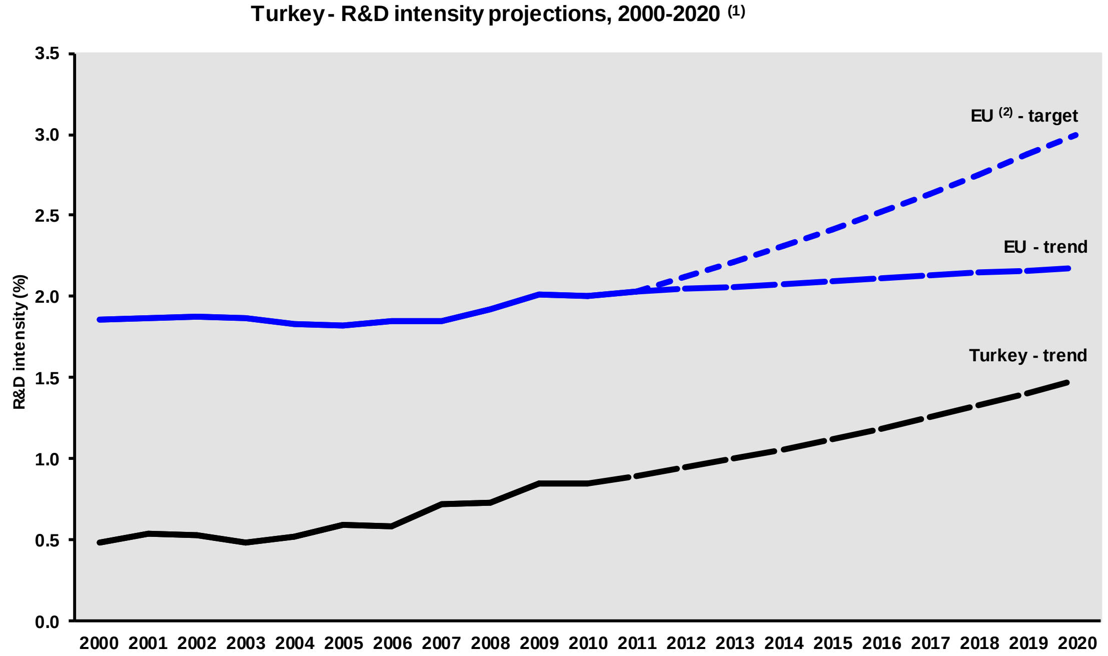
	Investment and Input	Performance/economic output
Research	*R&D intensity* 2011: 0.84% (EU: 2.03%; US: 2.75%) 2000-2011: +5.82% (EU: +0.8%; US: +0.2%)	*Excellence in S&T* 2010:13.79 (EU:47.86; US: 56.68) 2005-2010: +2.52% (EU: +3.09%;US: +0.53)
Innovation and Structural change	*Index of economic impact of innovation* 2010-2011: 0.315 (EU: 0.612)	*Knowledge-intensity of the economy* 2010:18.6 (EU:48.75; US: 56.25) 2000-2010: +0.92% (EU: +0.93%; US: +0.5%)
Competitiveness	*Hot-spots in key technologies* Energy, Water, Food, Space	*HT + MT contribution to the trade balance* 2011: -2.22% (EU[1]: 4.2%; US: 1.93%) 2000-2011[2]: n.a. (EU[1]: +4.99%; US:-10.75%)

[1]*The EU value is the weighted average of the trade balance of the Member States.*
[2]*For the period 2000-2010 there are no data available to provide the annual growth rate. The negative values for this period indicates a structural deficit for the industry for the country.*

Since the early 2000s, Turkey has devoted increasing importance to investment in science, technology and innovation as shown by the continuous increase in Government funding for R&D and innovation activities. The growing political commitment to science, technology and innovation has also been reflected in the Ninth Development Plan (2007–2013), which was issued in 2006. The Plan identifies improving science and technology performance as one of the building blocks for greater competitiveness.

The new science, technology and innovation strategy document, National Science, Technology and Innovation Strategy, covering the period 2011-2016 was approved by the Supreme Council of Science and Technology (BTYK) in December 2010. It aims to create more output from existing research capacity and to enhance needs-oriented research capacity and defines strategic focus areas for increased science, technology and innovation performance. Target-oriented approaches are identified in the areas where Turkey has R&D and innovation capacities, demand-oriented approaches where further R&D and innovation efforts are needed and bottom-up approaches (including basic, applied and frontier research) are also an option.

Investing in knowledge



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2000-2011.
(2) EU: This projection is based on the R&D intensity target of 3.0% for 2020.
(3) TR: An R&D intensity target for 2020 is not available.

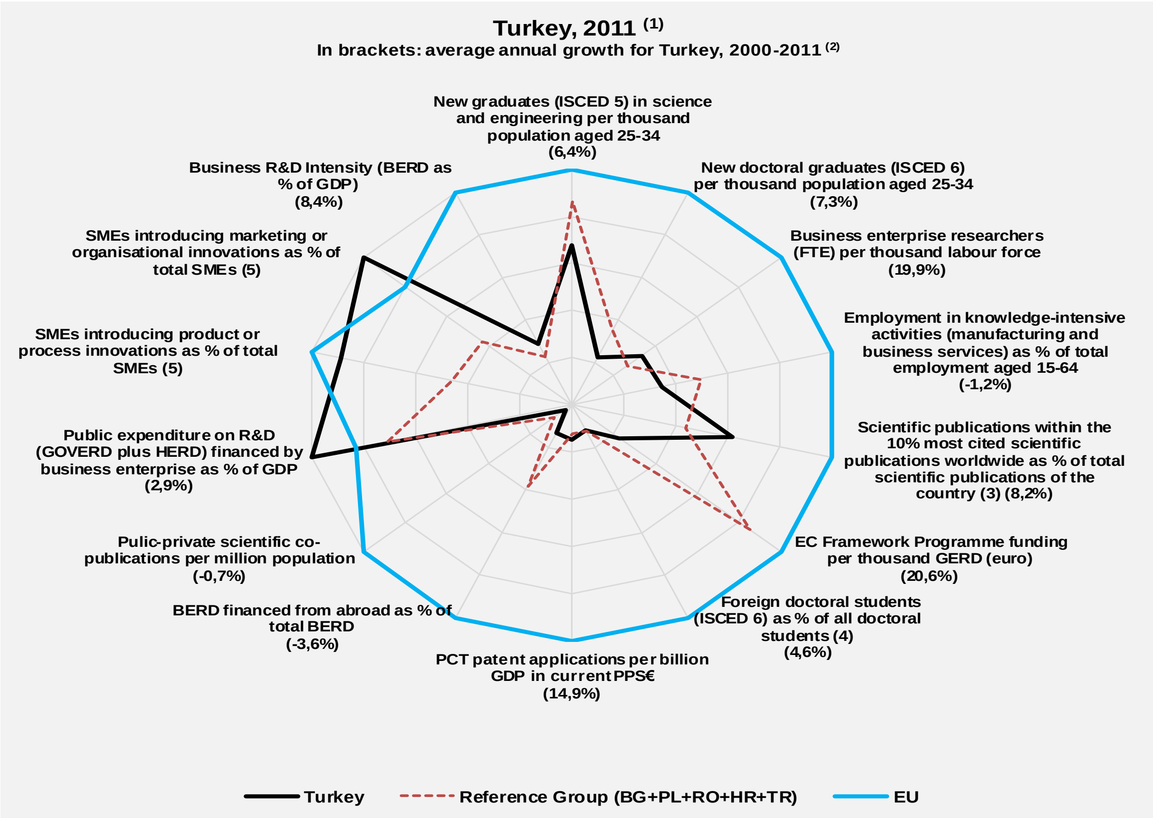
R&D intensity in Turkey has increased progressively from 0.48% in 2000 to 0.84% in 2010. Over this period R&D intensity has experienced an average annual growth rate of 5,8%. If this trend continues Turkey will have an R&D intensity of 1.48% in 2020, a very good achievement although still below the projected European Union average for 2020.

Turkey's R&D intensity decreased from 0.85% in 2009 to 0.84% in 2010 due to a corresponding decrease in public R&D intensity from 0.51% to 0.48%. Despite the decrease in Public R&D intensity and the economic crisis, R&D expenditure in all sectors has increased and business R&D intensity has grown from 0.34% in 2009 to 0.36% in 2010. Although Turkey's business R&D intensity is still well below the EU average of 1.26%, it is involved in a positive catching up process with an average annual growth rate of 8.4%.

Turkish research and innovation are also benefitting from support from the EU budget. The main instrument is the 7th Framework Program for Research and Development. The total number of participants in the 7th Framework Program in Turkey is 879 (out of 5982 applicants), receiving more than € 145,1 million. The success rate of participants of 14,7 % is below the EU average success rate of 21.95 %.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Turkey's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.



Source: DG Research and Innovation - Economic Analysis Unit
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2011 or to the latest available year.
(2) Growth rates which do not refer to 2000-2011 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2000-2011.
(3) Fractional counting method.
(4) EU does not include DE, IE, EL, LU, NL.
(5) TR is not included in the reference group.

The graph above shows that the Turkish research and innovation system is still weaker than the EU average in all areas except innovation in SMEs and public expenditure on R&D financed by business enterprise as a % of GDP. On the other hand, the average annual growth rates for most of the indicators indicate a progressive increase.

Most vulnerable areas include human resources, patents and public-private scientific co- publications. In particular Turkey is behind countries with similar knowledge capacity and economic structure in human resources with new graduates in science and engineering and new doctoral graduates showing especially low averages. Nevertheless, the research and innovation system in Turkey has relative strength in the quality of its scientific production, with an average annual growth of 8,2 % in the share of its scientific publications among the top 10 % most cited worldwide.

Policies and reforms for research and innovation

Eight sectors are identified as priority areas in UBTYS 2011-2016 in Turkey. These include automotive, machinery and manufacturing technologies, ICT, energy, water, food, space and defense. The sector-oriented standpoint adopted within UBTYS 2011-2016 has been promoted by two result driven and targeted call based funding programs which were recently set up by TUBITAK. Accordingly, temporary governance mechanisms have been established by TUBITAK in automotive, machinery and manufacturing technologies, and also in the ICT, energy, water and food areas which are designed to enable a bottom-up approach and an entrepreneurial discovery of the technology needs of each sector. These governance mechanisms are comprised of high level representatives from academia, the private sector, and the public sector. In the high level prioritization meetings of these actors, a consultative and a consensus building process takes place to designate R&D priorities in each sector. Calls through the aforementioned funding programs are opened in each sector in the technology needs/topics that have been previously identified and prioritized at the high-level prioritization meetings

The most recent STI priorities in Turkey include the decrees adopted in the 23rd and 24th meetings of BTYK which have set new targets for the national innovation and entrepreneurship system of Turkey. The main themes of these meetings were "Ecosystem of innovation and entrepreneurship in Turkey" and "Human resources for STI". Regarding these themes, 17 new decrees were adopted which are being implemented in coordination with all relevant ministries and stakeholders.

The national innovation and entrepreneurship system targets have been renewed and targets have been set for the year 2023 with the objective of being one of the top 10 economies in the world by 2023. The 2023 targets for the National Innovation and Entrepreneurship System of Turkey are as follows:

- To increase R&D intensity to 3%
- To increase business R&D intensity to 2%
- To raise the number of full-time equivalent (FTE) researchers to 300,000
- To raise the number of FTE researchers in business to 180,000

The private sector is considered to be the driving force for many improvements and therefore supportive decrees were adopted both for increasing the private sector's activities and fostering collaboration between the private sector and universities. For example, it has been decided to develop policies to provide R&D intensive start-ups with ready access to finance and complementary mentorship support at all stages of the life cycle of start-ups and to adoptembracing a tailor-made approach. It has also been decided to establish an adequate innovation and entrepreneurship ecosystem to increase the number of R&D intensive start-ups in Turkey. Furthermore, governmental organizations will be allowed to participate in venture capital funds in order to increase their effectiveness, especially in the seed funding and start-up capital phases. In this way it is hoped to reinvigorate venture capital funding in Turkey. These measures are expected to activate and enhance the commercialization process of research results.

Another example can be given by the decree aims at developing policy tools to trigger innovation and entrepreneurship in the universities by

- developing proper mechanisms to support technology transfer offices with an aim to trigger the commercialization of research conducted at universities
- developing proper mechanisms to support technology incubators with an aim to provide a gateway between universities and technoparks
- developing an index to measure the entrepreneurship and innovativeness performances of universities with an aim to increase the entrepreneurship and innovation oriented competition between universities
- redesigning academic promotion criteria to foster entrepreneurship and innovative activities by academicians

In line with this decree, in 2012, a university index has been developed to evaluate the entrepreneurship and innovativeness performance of universities based on such criteria as R&D projects, university-industry collaborations, international collaborations, articles, licences and spin-offs. The 50 most entrepreneurial universities in Turkey were listed for the first time, and this list will be renewed and published each year.

A similar approach will probably also be used in relation to university research institutions based on a protocol between the Ministry of Development and TUBITAK. Under this new protocol, a more efficient utilization and sustainability of existing and future Higher Education Research Centers will be ensured by a classification based on the measurement, monitoring and evaluation of their performances.

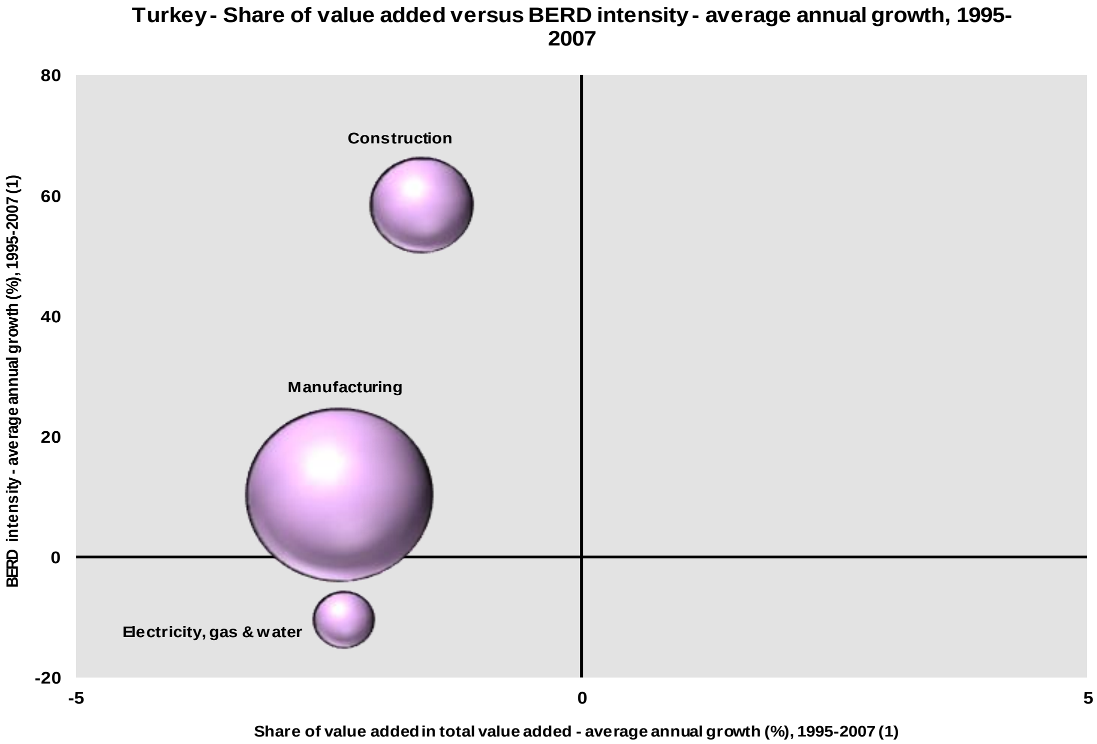
Furthermore, a temporary inter-ministerial coordination board including the participation of related governmental bodies has been set up to review all R&D, innovation and entrepreneurship support mechanisms in Turkey with a view to ensuring a target oriented approach.

Fostering and diffusing S&T awareness in society are among the areas which are under the auspices of the Prime Minister. It has been decided to work in close cooperation with local authorities to establish science centers, featuring interactive exhibits that encourage children and young people to experiment and explore, in each metropolis by the year 2016 and in each city by the year 2023.

The decrees adopted at the 24th meeting of BTYK which are focused on furthering the development of human resources for STI can be considered as complementary initiatives to the National Science and Technology Human Resources and Action Plan (2011-2016). These decrees strengthen the linkage between the Action Plan and education policies, as their main purpose is to improve the quality of the education system in Turkey by conducting educational assessment studies, developing digital course contents for primary-secondary education and also higher education, revising teaching programmes to enable students to acquire core competencies more efficiently, restructuring scholarship programs for graduate students to study abroad, and organizing science fairs for primary and secondary school students.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented on the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.



Source: DG Research and Innovation - Economic Analysis unit
Data: Eurostat
Note: (1) 'Construction': 1997-2007.

The graph above illustrates that in Turkey, as in many other countries, the share of value added of manufacturing industries is tending to decrease due to the increase of services in the overall economy (as illustrated by a leftward shift in the graph above).

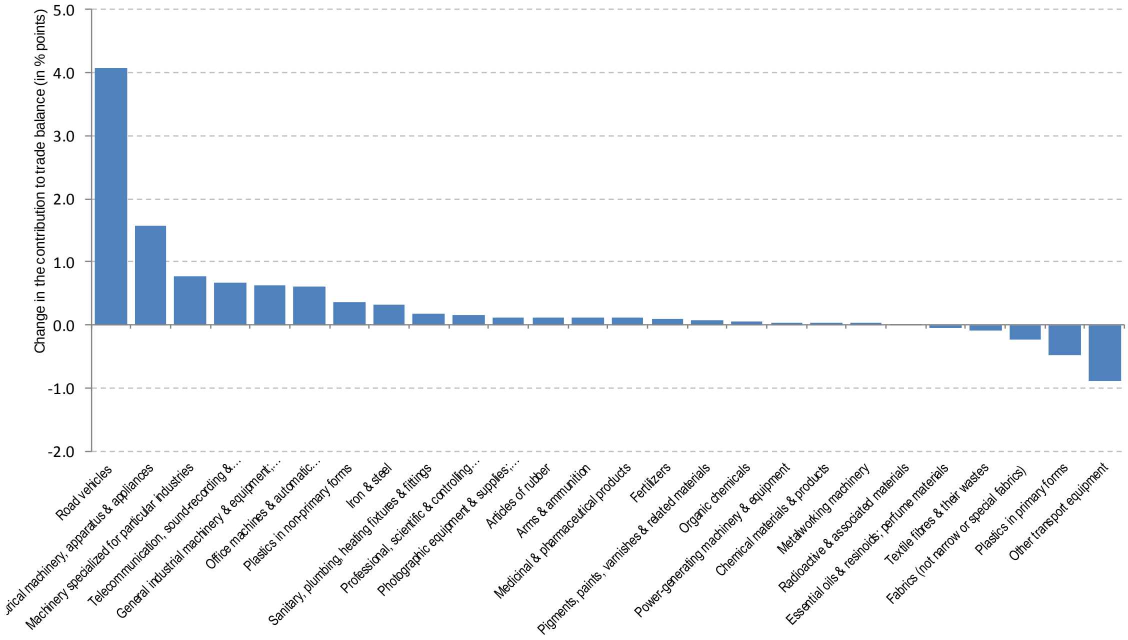
The three major industry sectors have seen their shares in the Turkish economy decrease over the period 1995-2007. However manufacturing and construction are moving towards more research intensive activities as shown by increases in business R&D intensity (business expenditure on R&D as % of value added) for these sectors. Turkey has four companies in the 2011 EU Industrial R&D Scoreboard - companies with a considerable level of R&D expenditure in the fields of general industrials, automobiles and parts, and leisure goods.

Turkey has strengths in medium–high technology manufacturing industries and knowledge services and is fast becoming Eurasia´s production base for medium–high and high-technology products. The aim of UBTYS 2011-2016 is to strengthen national R&D and innovation capacities in order to upgrade the industrial structure towards high–technology industries.

Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

Evolution of the contribution of high-tech and medium-tech products to the trade balance for Turkey between 2000 and 2011



Source: DG Research and Innovation - Economic Analysis unit
Data: COMTRADE
Notes: "Textile fibres & their wastes" refers only to the following 3-digits sub-divisions: 266 and 267.
"Organic chemicals" refers only to the following 3-digits sub-divisions: 512 and 513.
"Essential oils & resinoids; perfume materials" refers only to the following 3-digits sub-divisions: 553 and 554. "Chemical materials & products" refers only to the following 3-digits sub-divisions: 591, 593, 597 and 598. "Iron & steel" refers only to the following 3-digits sub-divisions: 671, 672 and 679.
"Metalworking machinery" refers only to the following 3-digits sub-divisions: 731, 733 and 737.

The overall contribution of high-tech and medium-tech products to Turkey's trade balance was negative for each year over the last decade. Nevertheless, as the graph above illustrates several high-tech and medium-tech industries have improved their contributions to the Turkish trade balance, in particular road vehicles, electrical machinery, apparatus and appliances and machinery specialized for particular industries.

On other hand, industries with the biggest decreases in their contributions to the trade balance are power-generating machinery and equipment, plastics in primary forms and medical and pharmaceutical products, indicating a possible relative decline in world competitiveness.

Total factor productivity is growing strongly in Turkey, and so is the employment rate. Clear progress is also visible in R&D intensity and in the share of population aged 30-34 having successfully completed tertiary education. However, the overall values are still at a low level. Greenhouse gas emissions have increased over the last decade, despite some improvements in patenting in environment-related technologies. Patenting in health-related technologies has also grown, but from a very modest level.

Key indicators for Turkey[19]

TURKEY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth (1) (%)	EU average (2)
ENABLERS															
Investment in knowledge															
New doctoral graduates (ISCED 6) per thousand population aged 25-34	0.19	0.17	0.21	0.23	0.21	0.22	0.20	:	0.31	0.34	0.38	:	:	7.3	*1.69*
Business enterprise expenditure on R&D (BERD) as % of GDP	0.16	0.18	0.15	0.11	0.13	0.20	0.21	0.30	0.32	0.34	0.36	:	:	8.4	*1.26*
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.32	0.36	0.38	0.37	0.39	0.39	0.37	0.42	0.40	0.51	0.48	:	:	4.3	*0.74*
Venture Capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation															
Composite indicator of research excellence	:	:	:	:	:	12.2	:	:	:	:	13.8	:	:	2.5	47.9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	3.6	3.4	3.8	3.8	4.7	5.0	5.5	6.6	6.7	:	:	:	:	8.2	10.9
International scientific co-publications per million population	18	17	22	33	40	42	45	52 (3)	56	62	66	71	:	7.9	300
Public-private scientific co-publications per million population	:	:	:	:	:	:	:	2	2	2	2	2	:	-0.7	53
FIRM ACTIVITIES AND IMPACT															
Innovation contributing to international competitiveness															
PCT patent applications per billion GDP in current PPS€	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.6	:	:	:	14.9	3.9
License and patent revenues from abroad as % of GDP	:	:	:	:	:	:	:	0.00	0.00	0.00	0.00	:	:	:	0.58
Sales of new to market and new to firm innovations as % of turnover	:	:	:	:	:	:	15.8	:	:	:	:	:	:	:	14.4
Knowledge-intensive services exports as % total service exports	:	:	:	:	8.2	14.1	13.9	16.6	18.7	18.8	21.3	:	:	17.3	45.1
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-10.66	-7.79	-6.74	-6.09	-5.84	-4.79	-2.94	-1.95	-0.82	-3.88	-2.83	-2.22	:	-	4,20 (4)
Growth of total factor productivity (total economy) - 2000 = 100	100	93	98	102	112	117	120	:	:	:	:	:	:	20 (5)	103
Factors for structural change and addressing societal challenges															
Composite indicator of structural change	17.0	:	:	:	:	12.9	:	:	:	:	18.6	:	:	0.9	48.7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64	:	:	:	:	:	:	:	:	:	4.8	4.8	4.7	:	-1.2	13.6
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	29.5	:	:	:	:	:	:	:	38.4
Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.004	0.002	0.01	0.004	0.01	0.01	0.01	0.01	0.01	:	:	:	:	17.5	0.39
Health-related technologies - patent applications to the EPO per billion GDP in current PPS€	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.02	:	:	:	:	10.9	0.52
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES															
Employment rate of the population aged 20-64 (%)	:	:	:	:	:	:	48.2	48.2	48.4	47.8	50.0	52.2	:	1.6	68.6
R&D Intensity (GERD as % of GDP)	0.48	0.54	0.53	0.48	0.52	0.59	0.58	0.72	0.73	0.85	0.84	:	:	5.8	*2.03*
Greenhouse gas emissions - 1990 = 100	159	149	153	162	167	176	187	203	196	198	:	:	:	39 (6)	85
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 30-34 who have successfully completed tertiary education (%)	:	:	:	:	:	:	11.9	12.3	13.0	14.7	15.5	16.3	:	6.5	34.6
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	72.4	:	:	:	:	:	:	:	*24.2*

Source: DG Research and Innovation - Economic Analysis Unit

Data: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.

(2) EU average for the latest available year.

(3) Break in series between 2007 and the previous years. Average annual growth refers to 2007-2011.

(4) EU is the weighted average of the values for the Member States.

(5) The value is the difference between 2006 and 2000.

(6) The value is the difference between 2009 and 2000. A negative value means lower emissions.

(7) Values in italics are estimated or provisional.

[19] According to data provide by Turkish Government, values for some indicators are as follows:

- BERD as % of GDP increased from 0.16 in 2000 to 0.36 in 2010 with an average annual growth rate of 10.7
- GERD as % of GDP increased from 0.48 in 2000 to 0.84 in 2010 with an average annual growth rate of 6.2
- In 2010 the average of SMEs introducing products or process innovations was 32.6%

Methodological Notes

Symbols and abbreviations

Country codes

BE	Belgium	SE	Sweden
BG	Bulgaria	UK	United Kingdom
CZ	Czech Republic	EU	European Union
DK	Denmark	IS	Iceland
DE	Germany	LI	Liechtenstein
IE	Ireland	NO	Norway
EL	Greece	CH	Switzerland
ES	Spain	HR	Croatia
FR	France	MK	The former Yugoslav Republic of Macedonia
IT	Italy	TR	Turkey
CY	Cyprus	IL	Israel
LV	Latvia	ERA	European Research Area
LT	Lithuania	US	United States
LU	Luxembourg	JP	Japan
HU	Hungary	CN	China
MT	Malta	KR	South Korea
NL	Netherlands	IN	India
AT	Austria	TW	Chinese Taipei
PL	Poland	SG	Singapore
PT	Portugal	RU	Russian Federation
RO	Romania	AU	Australia
SI	Slovenia	CA	Canada
SK	Slovakia	ZA	South Africa
FI	Finland	BR	Brazil
		RoW	Rest of the World

Other abbreviations

: ‘not available’

- ‘not applicable’ or ‘real zero’ or ‘zero by default’

Overall performance in research, innovation and competitiveness

R&D Intensity
Definition: Gross Domestic Expenditure on R&D (GERD) as % of Gross Domestic Product (GDP)
Sources: Eurostat, OECD

Gross Domestic Product (GDP)
Definition: Gross domestic product (GDP) data have been compiled in accordance with the European System of Accounts (ESA 1995). Since 2005, GDP has been revised upwards for the majority of EU Member States following the allocation of FISIM (Financial Intermediation Services Indirectly Measured) to user sectors. This has resulted in a downward revision of R&D intensity for individual Member States and for the EU.
Source: Eurostat

Gross Domestic Expenditure on R&D
Definition: Gross domestic expenditure on R&D (GERD) is defined according to the OECD Frascati Manual definition. GERD can be broken down by four sectors of performance:
(i) Business Enterprise Expenditure on R&D (BERD);
(ii) Government Intramural Expenditure on R&D (GOVERD);
(iii) Higher Education Expenditure on R&D (HERD);
(iv) Private non-Profit expenditure on R&D (PNPRD).
GERD can also be broken down by four sources of funding:
(i) Business Enterprise;
(ii) Government;
(iii) Other national sources;
(iv) Abroad.
Sources: Eurostat, OECD

Index of economic impact of innovation
The index is composed of five indicators of the Innovation Union Scoreboard 2013:
- *PCT patents applications per billion GDP (in PPS€)* - the number of PCT patent applications filed under the PCT, at international phase, designating the European Patent Office (EPO). Patent counts are based on the priority date, the inventor's country of residence and fractional counts. (Eurostat/OECD)
- *Employment in knowledge-intensive activities (manufacturing and services) as % of total employment* - number of employed persons in knowledge-intensive activities in business industries. Knowledge-intensive activities are defined, based on EU Labour Force Survey data, as all NACE Rev.2 industries at 2-digit level where at least 33% of employment has a higher education degree (ISCED5 or ISCED6) (Eurostat)
- *Contribution of medium and high-tech product exports to trade balance* – see below
- *Sales of new to market and new to firm innovations as % of turnover* - sum of total turnover of new or significantly improved products, either new to the firm or new to the market, for all enterprises (Eurostat - Community Innovation Survey)
- *Knowledge-intensive services exports as % total service exports* - exports of knowledge-intensive services are measured by the sum of credits in EBOPS (Extended Balance of Payments Services Classification) 207, 208, 211, 212, 218, 228, 229, 245, 253, 260, 263, 272, 274, 278, 279, 280 and 284 (UN/Eurostat)

Source: Innovation Union Scoreboard 2013

Hot-spots clusters in key technologies
Based on the total number of patent applications and patents granted by the EPO by NUTS2 regions by inventor's region of residence and by applicant's region, by priority year, period (2001-2010) there were developed clusters for key technologies: 0-25% - low innovative cluster; 26-50% - medium-low innovative cluster; 51-75% - medium-high innovative cluster and 76-100% - high innovative cluster.

Excellence in research (S&T)

Definition: It is a composite indicator developed in order to measure the research excellence in Europe, meaning the effects of European and National policies on the modernization of research institutions, the vitality of the research environment and the quality of research outputs in both basic and applied research. This core indicator is a composite of four variables:

- The share of highly cited publications in all publications where at least one of the authors has an affiliation in a given country (10% most highly cited publications considered, full counting method; source: Science Metrix calculations using Scopus data)
- Number of top scientific universities and public research organizations in a country divided by million population (world top 250 scientific universities and top 50 public research organizations considered; source: Leiden Ranking and Scimago Institutional Ranking)
- Patent applications per million population (PCT patent applications by country of inventor, 3-year moving average; source: OECD, Eurostat)
- Total value of ERC grants received divided by public R&D performed by the higher education and government sectors (transformed by using the natural logarithm, multi-year projects divided equally over time; source: DG-RTD, ERC)

The value of the composite indicator (a country score) is a geometric average of the four variables normalized between 10 and 100 using the min-max method and taking into consideration the two time points simultaneously.

Source: Group of Research and Innovation Union Impact, RTD-JRC (Ispra): Composite Indicator of Research Excellence, 2012.

Knowledge-intensity of the economy (Structural change of economy)

Definition: Compositional structural change indicators measure changes in the actual sectoral composition of the economy in terms of production and employment, business research and development (R&D), high-tech exports and technological specialization and foreign direct investments. Changes may affect the linkages among sectors and technologies, and influence the changes of the international advantages of countries.

Eight compositional structural change indicators have been identified and organized into five dimensions:

- The R&D dimension measures the size of business R&D (as a % of GDP) and the size of the R&D services sector in the economy (in terms of total value added; source: WIIW calculations using OECD, Eurostat, WIOD and national sources)
- The skills dimension measures changing skills and occupation in terms of the share of persons employed in knowledge intensive activities (both in manufacturing and service sectors considered where on average at least a third of the employees have tertiary graduates; source: Eurostat)
- The sectoral specialization dimension captures the relative share of knowledge intensive activities (in terms of value added; source WIIW calculations using OECD, Eurostat, WIOD and national sources)
- The international specialization dimension captures the share of knowledge economy through technological (patents) and export specialization (revealed technological and competitive advantage) and
- The internationalization dimension refers to the changing international competitiveness of a country in terms of attracting and diffusing foreign direct investment (inward and outward foreign direct investments).

The eight indicators in the five pillars have been normalized between 10 and 100 using the min-max method and taking into consideration three time points simultaneously. The five pillars have also been aggregated to a single composite indicator of structural change using the geometric average to provide an overall measure of country progress in this area.
Source: Group of Research on the impact of the Innovation Union (GRIU), RTD-JRC/IPSC Ispra): Composite Indicators measuring structural change, monitoring the progress towards a more knowledge-intensive economy in Europe, 2011.

Contribution of High-Tech and Medium-Tech manufacturing to trade balance
Definition: The "contribution to the trade balance" is the difference between observed industry trade balance and the theoretical trade balance.
By trade balance we understand the difference between the level of exports and the level of imports at a particular industry/sector.
The contribution to the trade balance is given by the formula:

$$\left[(X_i - M_i) - (X - M)\frac{(X_i + M_i)}{(X + M)}\right] / (X + M) * 100$$

where

$(X_i - M_i)$	=	observed industry trade balance
$(X - M)\frac{(X_i + M_i)}{(X + M)}$	=	theoretical trade balance

If there is no comparative advantage or disadvantage for any industry i, *a country's total trade balance (surplus or deficit) should be distributed across industries according to their share in the total trade. A positive value for an industry indicates structural surplus and a negative value a structural deficit.*

The HT & M-HT trade balance include of the following SITC Rev.3 products: 266, 267, 512, 513, 525, 533, 54, 553, 554, 562, 57, 58, 591, 593, 597, 598, 629, 653, 671, 672, 679, 71, 72, 731, 733, 737, 74, 751, 752, 759, 76, 77, 78, 79, 812, 87, 88, 891.
Source: OECD (*Moving Up the Value Chain: Staying Competitive in the Global Economy*, 2007), UN (Comtrade), RTD - Economic Analysis Unit

Investing in knowledge

Public expenditure on R&D
Definition: For the purposes of this publication, Public expenditure on R&D is defined as Government Intramural Expenditure on R&D (GOVERD) plus Higher Education Expenditure on R&D (HERD).
Sources: Eurostat, OECD

Private expenditure on R&D
Definition: For the purposes of this publication, Private expenditure on R&D is defined as Business Enterprise Expenditure on R&D (BERD) plus Private non-Profit expenditure on R&D (PNPRD).
Sources: Eurostat, OECD

BERD Intensity
Definition: Business Enterprise Expenditure on R&D (BERD) as % of Gross Domestic Product (GDP)
Sources: Eurostat, OECD

Public sector R&D Intensity
Definition: Public expenditure on R&D (GOVERD plus HERD) as % of GDP.
Sources: Eurostat, OECD

Government budget for R&D
Definition: The government budget for R&D is defined as government budget appropriations or outlays for R&D (GBAORD), according to the OECD Frascati Manual definition. The data are based on information obtained from central government statistics and are broken down by socio-economic objectives in accordance with the nomenclature for the analysis and comparison of scientific programmes and budgets (NABS).
Source: Eurostat

Structural Funds
Definition: Structural Funds are funds intended to facilitate structural adjustment of specific sectors, regions, or combinations of both, in the European Union. Structural Funds for RTDI include data from sectors involving research and development, technological innovation, entrepreneurship, innovative ICT and human capital.
Source: DG REGIO.

Purchasing Power Standards (PPS)
Definition: Financial aggregates are sometimes expressed in Purchasing Power Standards (PPS), rather than in euro based on exchange rates. PPS are based on comparisons of the prices of representative and comparable goods or services in different countries in different currencies on a specific date. The calculations on R&D investments in real terms are based on constant 2000 PPS.
Source: Eurostat

Value Added
Definition: Value added is current gross value added measured at producer prices or at basic prices, depending on the valuation used in the national accounts. It represents the contribution of each industry to GDP.
Sources: Eurostat, OECD

Venture Capital
Definition: Venture Capital investment is defined as private equity being raised for investment in companies. For data between 2000 and 2006, management buyouts, management buy-ins, and venture purchase of quoted shares are excluded. Venture Capital includes early stage (seed + start-up) and expansion and replacement capital. As of 2007 data are broken into the following stages: Seed; Start-up; Later stage venture; Growth; Rescue/Turnaround; Replacement capital; Buyouts.
Source: Eurostat, EVCA

An effective research and innovation system building on the European Research Area

Framework Programme
Definition: The Framework Programmes for Research and Technological Development are the EU's main instruments for supporting collaborative research, development and innovation in science, engineering and technology. Participation is on an internationally collaborative basis and must involve European partners. The first Framework Programme was launched in 1984. The seventh Framework Programme (FP7) covers the period 2007-2013.
Source: DG Research and Innovation

Higher Education
ISCED (International Standard Classification of Education)
ISCED 5: Tertiary education (first stage) not leading directly to an advanced research qualification.
ISCED 5A: Tertiary education programmes with academic orientation.
ISCED 5B: Tertiary education programmes with occupation orientation.
ISCED 6: Tertiary education (second stage) leading to an advanced research qualification (PhD or doctorate).

Human Resources for Science and Technology (HRST), R&D personnel and researchers
The Canberra Manual proposes a definition of HRST as persons who either have higher education or persons who are employed in positions that normally require such education. HRST are people who fulfil one or other of the following conditions:

a) Successfully completed education at the third level in an S&T field of study (HRSTE - Education);
b) Not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required (HRSTO - Occupation).

HRST Core (HRSTC) are people with both tertiary-level education and an S&T occupation. Scientists and engineers are defined as ISCO categories 21 (Physical, mathematical and engineering science professionals) and 22 (Life science and health professionals).

The Frascati Manual proposes the following definitions of R&D personnel and researchers:

- R&D personnel: “All persons employed directly on R&D should be counted, as well as those providing direct services such as R&D managers, administrators, and clerical staff.” (p.92);
- Researchers: “Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.” (p.93). R&D may be the primary function of some persons or it may be a secondary function. It may also be a significant part-time activity.

Therefore, the measurement of personnel employed in R&D involves two exercises:

- measuring their number in headcounts (HC): the total number of persons who are mainly or partially employed in R&D is counted;
- measuring their R&D activities in full-time equivalence (FTE): the number of persons engaged in R&D is expressed in full-time equivalents on R&D activities (= person-years).

Public and Private sector researchers
Definition: For the purposes of this publication, Public sector researchers refer to researchers in the government and higher education sectors. Private sector researchers refer to researchers in the business enterprise and private non-profit sectors.
Source: Eurostat, OECD

Small and medium-size enterprises (SMEs)
Definition: Small and medium-size enterprises (SMEs) are defined as enterprises having fewer than 250 employees.
Sources: Eurostat, OECD

Licence and patent revenues from abroad
Definition: The export part of international transactions in royalties and license fees.
Source: Eurostat, TRADE

Patent Cooperation Treaty (PCT) Patents
Definitions: The Patent Cooperation Treaty (PCT) is an international treaty, administered by the World Intellectual Property Organization (WIPO), signed by 133 Paris Convention countries. The PCT makes it possible to seek patent protection for an invention simultaneously in each of a large number of countries by filing a single “international” patent application instead of filing several separate national or regional applications. Indicators based on PCT applications are relatively free

from the "home advantage" bias (proportionate to their inventive activity, domestic applicants tend to file more patents in their home country than non-resident applicants). The granting of patents remains under the control of the national or regional patent offices. The PCT patents considered are 'PCT patents, at international phase, designating the European Patent Office'. The country of origin is defined as the country of the inventor. If one application has more than one inventor, the application is divided equally among all of them and subsequently among their countries of residence, thus avoiding double counting.

"PCT is an option for possible future patenting, that provides the applicant with a further delay before deciding to apply or not. The delay can be 6 to 12 months. The relation between the PCT option and patent value is not predictable (Grupp and Schmoch, 1999). The PCT process provides the advantage of a longer investigation of the technological potential of the invention, and in case of a negative assessment, the application can be withdrawn before entering into expensive regional (EPO) phase. Having passed this test, the PCT applications that are continued towards entering the regional phase are likely the ones of higher value. However, the argument can be reversed in the way that inventions with unclear market potential are passed through the PCT route, whereas those with an unquestionable potential are directly applied at the regional phase, since the direct path is cheaper." (Guellec & van Pottelsberghe, 2000).

Societal challenges patents comprise climate change mitigation patents and health technology patents.
Climate change mitigation patents comprise patents for renewable energy, electric and hybrid vehicles and energy efficiency in buildings and lighting.
Health technology patents comprise patents for medical technologies and pharmaceuticals.

Environment-related technologies
Definition: patent applications to EPO per billion GDP in current PPS€
The environment-related technologies refer to the following thematic areas:

A. General environmental management
B. Energy generation from renewable and non-fossil sources
C. Combustion technologies with mitigation potential
D. Technologies specific to climate change mitigation
E. Technologies with potential or indirect contribution to emissions mitigation
F. Emissions abatement and fuel efficiency in transportation
G. Energy efficiency in buildings and lighting

Health-related technologies
Definition: patent applications to the EPO per billion GDP in current PPS€
The health-related technologies refer to medical technologies and pharmaceuticals: surgery, dentistry, prostheses, transport / accommodation for patients, physical therapy devices, containers, medical preparations, sterilization, media devices, electrotherapy, chemical compounds.
Source: OECD

Community Trademark System (CTM)
Definition: The Community trade mark system allows the uniform identification of products and services by enterprises throughout the EU. A unique procedure applied by the Office for Harmonization in the Internal Market (OHIM) allows them to register trademarks which will benefit from unitary protection and be fully applicable in every part of the Community. The CTM system is unitary in character. A CTM registration is enforceable in all member states.
Source: OHIM

Country groupings – methodology
In order to create homogeneous groups of similar research and innovation systems in the European Research Area, a principal components analysis (PCA) on nineteen variables characterising research and innovation systems was carried out. The values of the variables as were obtained for 2008 or the latest available year from Eurostat and the OECD and included data for all 27 EU Member States as

well as for Norway, Switzerland, Croatia, Turkey and Israel. Table 1 presents the main values of the different factors accruing from the PCA. The first principal component explains 49.7% of the variance-. The second principal component explains 12.4% of the variance and together, the two principal components manage to explain above 62% of the total variance.

Table 1: Results of the Principal Component Analysis

	Eigenvalue	Proportion	Cumulative
Factor 1	9.44203858	0.4969	0.4969
Factor 2	2.35266703	0.1238	0.6208
Factor 3	1.96210394	0.1033	0.724
Factor 4	1.23153877	0.0648	0.7889
Factor 5	1.01292575	0.0533	0.8422

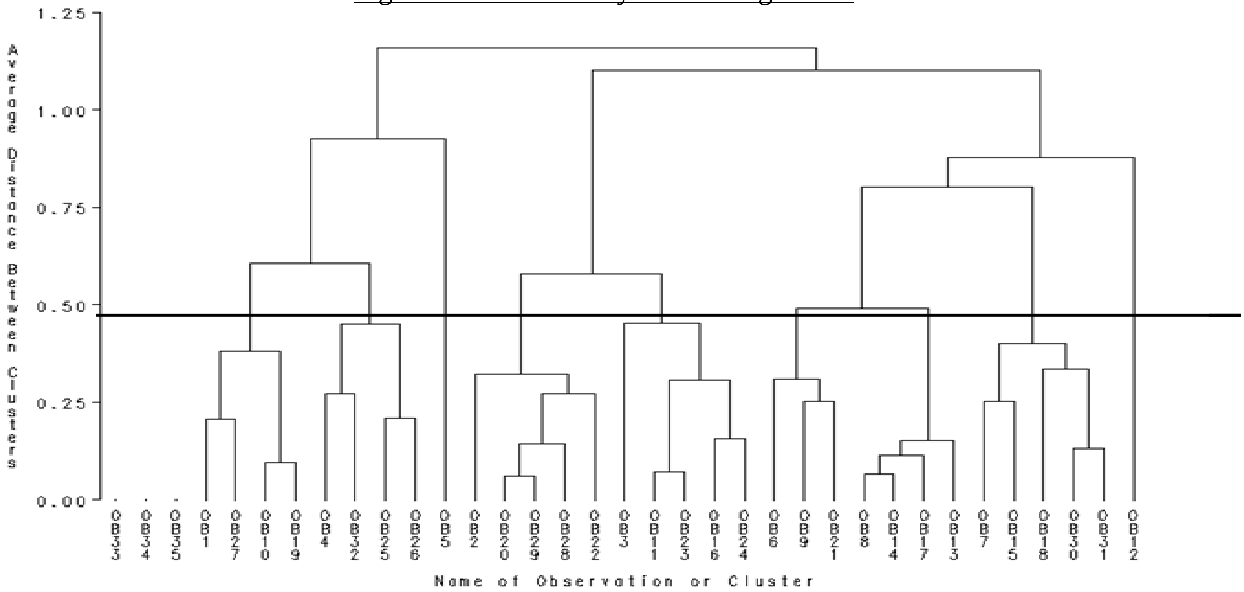
Table 2 presents the correlation matrix between the main components and the individual variables that can help interpreting the nature of these factors. To a great extent, Component 1 corresponds to the economic and technological development of the country. As shown by the correlation matrix, this factor is closely related with per capita GDP, investments in R&D, HRST, research excellence, patents and levels of skills and employment. The second component represents the sectoral specialisation, as it is shown by the coordinates of industrial employment and employment in medium-high and high tech manufactures.

Table 2: Correlation matrix between the principal components and the individual variables

	Factor1	Factor2	Factor3	Factor4	Factor5
GERD as % of GDP	**0.88045**	0.34761	0.1694	0.09631	-0.06329
BERD as % of GDP	**0.86653**	0.37803	0.0769	0.10575	-0.03081
GOVERD as % of GDP	0.07583	0.26135	0.55564	-0.44498	0.49791
HERD as % of GDP	**0.77148**	0.08173	0.20893	0.25351	-0.41071
HRST as % of total population	**0.84051**	-0.32415	0.24602	-0.09118	0.16476
EPO patent applications per million population	**0.85114**	0.24681	-0.1413	0.04174	-0.02927
EPO high-tech patents per million population	**0.82359**	0.28775	-0.08296	0.01004	-0.02086
Population aged 25-64 having completed tertiary education	**0.76955**	-0.39397	0.23008	-0.10595	0.04449
Participation in life-long learning	**0.8845**	-0.00273	0.21098	0.24563	-0.03637
Employment in primary sectors	-0.63319	0.01507	0.40398	-0.07697	-0.32419
Employment in industrial sectors	-0.5726	**0.60788**	0.22957	0.32484	0.2158
Employment in business and financial sectors	0.59243	0.03313	-0.52275	-0.38809	0.16055
Employment in high-tech and medium-high-tech manufacturing	-0.07533	**0.88354**	0.0989	0.10371	0.24159
Employment in knowledge-intensive services (KIS)	**0.90799**	-0.08451	-0.00034	0.15404	0.08702
Population density	-0.05817	-0.08058	**-0.69541**	0.49535	0.29596
Employment rate	**0.70931**	-0.29551	**0.44466**	0.10663	0.07883
GDP per capita	**0.75882**	-0.09803	-0.28462	-0.27672	0.20282
GDP natural logarithm	0.17245	0.584	-0.29413	-0.48494	-0.41219
Research excellence (highly-cited scientific publications)	**0.89965**	0.08266	-0.2061	0.04531	-0.10682

Based on the findings of the PCA, a hierarchical cluster analysis is carried out in order to gather the regions in homogeneous groups. Figure 1 presents the dendogramme presenting the different groups as well as the bar separating the different country groups.

Figure 1: Cluster Analysis- Dendogramme



Source: RTD – Economic Analysis Unit (2011)

Scientific and technological strengths

The NUTS classification

Definition: The Nomenclature of Statistical Territorial Units (NUTS) is a single coherent for dividing up the European Union's territory in order to produce regional statistics for the Community. NUTS subdivides each Member State into a whole number of regions at NUTS 1 level. Each of these is then subdivided into regions at NUTS level 2 and these in turn into regions at NUTS level 3.
Source: Eurostat

Scientific Publications

Definition: Publications are research articles, reviews, notes and letters published in referenced journals which are included in the Scopus database of Elsevier. A full counting method was used at the country level. However, for the EU aggregate, double counts of multiple occurrences of EU Member States in the same record were excluded.
Source: Scopus (Elsevier); treatments and calculations: Science Metrix

Average of Relative Citations (ARC)

The ARC is an indicator of the scientific impact of papers produced by a given entity (e.g., the world, a country, a NUTS2 region, an institution) relative to the world average (i.e., the expected number of citations). The number of citations received by each publication is counted for the year in which it was published and for the three subsequent years. For papers published in 2000, for example, citations received in 2000, 2001, 2002 and 2003 are counted.

To account for different citation patterns across fields and subfields of science (e.g., there are more citations in biomedical research than in mathematics), each publication's citation count is divided by the average citation count of all publications of the corresponding document type (i.e., a review would be compared to other reviews, whereas an article would be compared to other articles) that were published the same year in the same subfield to obtain a Relative Citation count (RC). The ARC of a given entity is the average of the RCs of the papers belonging to it. An ARC value above 1 means that a given entity is cited more frequently than the world average, while a value below 1 means the reverse. The ARC is computed for the 2000-2006 period only since publications in 2007, 2008 and 2009 have incomplete citation windows.

Methodology of co-publication analysis

The methodology used for the co-publication analysis involved three types of analysis:

a) Single country publications cover co-publications that involve domestic partners only; this is the sum of all papers written by one or more authors from a given country (and non-nationals resident in that country). Although the literature usually distinguishes between domestic single publications (including one or more authors belonging to the same institution) and domestic co-publications (i.e. authors within the same country but from different main organisations), for the aim of the current analysis the sum of the two categories have been used under the heading of "single country publications".

b) EU transnational co-publications refer to international co-publications which involve at least one author from an EU country. This category includes both co-publications by authors from at least two different EU Member States (as defined by research papers containing at least two authors' addresses in different countries) and co-publications between one or several authors from the EU together with at least one author from a country outside the EU.

c) Extra-EU co-publications is a sub-category of the broader EU transnational co-publications. It refers exclusively to international co-publications involving at least one EU author and at least one non-EU author, as defined by the authors' addresses in different countries.

An important methodological issue is the way in which a co-publication is quantified. The full counting method has been used in this report, meaning that a single international co-published paper is assigned to more than one country of scientific origin. If, for example, the authors' addresses signal three different countries in the EU, the publication is counted three times – once for each country mentioned. Therefore, in a matrix of co-publications between countries, the number of publications mentioned is not a completely accurate indicator of the number of publications being co-authored, but rather how often a country or region is involved in co-publications.

Public-Private co-publications

Definition: Number of public-private co-authored research publications. The private sector excludes the private medical and health sector.

Source: CWTS / Thomson Reuters

Scientific Specialisation

Definition: The relative scientific specialisation index (RCA) is calculated for 28 disciplines on the basis of publications from 2000-2002 and 2004-2006. The fields 'multidisciplinary' and 'social Sciences'' have been excluded. The formula used is the hyperbolic tangent function for the ratio of the share of a domain or discipline in a country compared to the share of the domain in the total for the world: $RCA_{ki} = 100 \text{ x } \tanh \ln \{(A_{ki}/\sum_i A_{ki})/(\sum_k A_{ki}/\sum_{ki} A_{ki})\}$, with A_{ki} indicating the number of publications of country k in the field i, whereby the field is defined by 28 scientific disciplines used in the classifications.

LN centres the data on zero and the hyperbolic tangent multiplied by 100 limits the RCA values to a range of +100 to -100. Scores below -20 are considered a significant under-specialisation in a given scientific field, scores between -20 and +20 are around field average and mean no significant (under-) specialisation, and scores above +20 mean a significant specialisation in a given field. The RCA indicator allows the assessment of the relative position of a field i in a country beyond any size effects. Neither the size of the field nor the size of the country has an impact on the outcome of this indicator. Therefore, it is possible to directly compare countries and fields.

Source: ISI, Science Citation Index; treatments and calculations: Fraunhofer ISI

Technology Categories

Definition: The four manufacturing industry technology categories are defined as follows (NACE Rev 1.1 codes are given in brackets):

(1) High-tech: office machinery and computers (30), radio, television and communication equipment and apparatus (32), medical, precision and optical instruments, watches and clocks (33), aircraft and spacecraft (35.3), pharmaceuticals, medicinal chemicals and botanical products (24.4).

(2) Medium-high-tech: machinery and equipment (29), electrical machinery and apparatus (31), motor vehicles, trailers and semi-trailers (34), other transport equipment (35) excluding building and repairing of ships and boats (35.1) and excluding aircraft and spacecraft (35.3), chemicals and chemical products (24) excluding pharmaceuticals, medicinal chemicals and botanical products (24.4).
(3) Medium-low-tech: coke, refined petroleum products and nuclear fuel (23), rubber and plastic products (25), non-metallic mineral products (26), basic metals (27), fabricated metal products (28), building and repairing of ships and boats (35.1).
(4) Low-tech: food products and beverages (15), tobacco products (16), textiles (17), wearing apparel; dressing and dyeing of fur (18), tanning and dressing of leather, manufacture of luggage, handbags, saddlery and harness (19), wood and products of wood and cork, except furniture (20), pulp, paper and paper products (21), publishing, printing and reproduction of recorded media (22), furniture and other manufacturing (36), recycling (37).

Technological Specialisation
Definition: The relative technological specialisation index (or RCA) is calculated for 19 technology domains on the basis of PCT patent applications (at the international phase, designating the EPO). The data were classified by earliest priority date and country of residence of the inventor.
The formula used is the hyperbolic tangent function for the ratio of the share of a domain in a country compared to the share of the domain in the total for the world: $RCA_{ki} = 100 \times \tanh \ln \{(A_{ki}/\sum_i A_{ki})/(\sum_k A_{ki}/\sum_{ki} A_{ki})\}$, with A_{ki} indicating the number of PCT patent applications (at international phase, designating the EPO) of country k in the field i.LN centres the data on zero and the hyperbolic tangent multiplied by 100 limits the RCA values to a range of +100 to -100. Scores below -20 are considered a significant under-specialisation in a given scientific domain, scores between -20 and +20 are around domain average and mean no significant (under-)specialisation, and scores above +20 mean a significant specialisation in a given domain. The RCA indicator allows the assessment of the relative position of a field i in a country beyond any size effects. Neither the size of the domain nor the size of the country has an impact on the outcome of this indicator. Therefore, it is possible to directly compare countries and domain.
Source: JRC-IPTS, based on EPO and WIPO data

Economic impact of innovation

Index of economic impact of innovation
See definition in section *Overall performance*.

EU Industrial R&D Investment Scoreboard
Definition: The EU Industrial R&D Investment Scoreboard presents information on the top 1000 EU companies and the 1000 non-EU companies. The Scoreboard includes data on R&D investment along with other economic and financial data. It is the source for the ICT Scoreboard, which provides data on the ICT companies with the largest R&D budgets globally.

Upgrading the manufacturing sector through research and technologies

Knowledge-Intensive Activities (KIAs)
Definition: Knowledge-Intensive Activities (KIAs) are defined as economic sectors in which more than 33% of the employed labour force has completed academic-oriented tertiary education (i.e. at ISCED 5 and 6 levels). They cover all sectors in the economy, including manufacturing and services sectors, and can be defined at two and three-digit levels of the statistical classification of economic activities.
Source: Eurostat

Knowledge-Intensive Services (KIS)
Definition: Knowledge-intensive services (KIS) includes the following sectors (NACE Rev.1.1 codes are given in brackets): water transport (61), air transport (62), post and telecommunications (64), financial intermediation, except insurance and pension funding (65), insurance and pension funding, except compulsory social security (66), activities auxiliary to financial intermediation (67), real estate activities (70), renting of machinery and equipment without operator and of personal and household goods (71), computer and related activities (72), research and development (73), other business activities (74), education (80), health and social work (85), recreational, cultural and sporting activities (92).
Source: OECD

Knowledge-Intensive Services exports
Definition: Exports of knowledge-intensive services are measured by the sum of credits in EBOPS (Extended Balance of Payments Services Classification) 207, 208, 211, 212, 218, 228, 229, 245, 253, 260, 263, 272, 274, 278, 279, 280, 284.
Source: UN

Competitiveness in global demand and markets

Contribution to trade balance
See definition in section *Overall performance*.

High-Tech and Medium-Tech manufacture
See definition in section *Overall performance*.

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