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Innovation Union Competitiveness report 2011

New perspectives

Smarter policy design
- building on diversity

1. Diversity of European countries

Highlights

The design of innovation policies can not be homogeneous across countries. Research and innovation systems in Europe are diverse and face different challenges. Policy responses can be inspired by general guiding principles and knowledge, but should be tailored-made and take into account the economic structure of a country and its capacity to generate, diffuse and use specific knowledge to its economy. A close analysis of the European Research Area (ERA) reveals the heterogeneity of research systems. Country groupings can help designing policies and facilitating peer-learning by providing a framework of reference for closer comparison and benchmark between research systems. The analysis in this report identifies nine country groups with strong comparable characteristics.

1.1. Selected variables of the national research and innovation systems

Research and innovation (R&I) are key for the future economic competitiveness and social progress of Europe. Thus, R&I support policies have gained importance and are now placed at the heart of public intervention, including EU policies[1].

While general guiding principles for R&I policy are widely accepted and applicable, their definition and translation into specific policy measures, instruments and programmes need to be context-specific. R&I systems in Europe are diverse and face heterogeneous challenges. "One size-fits-all" strategies and policies cannot be applied across countries and tailor-made policies need to be adapted to the local conditions.

This section of the report analyses the heterogeneity of national R&I systems across Europe and identifies groups of countries with (relatively) similar features in their research conditions and innovation performance. These clusters can help improve policy learning and define better targeted policies.

It should be noted that the groupings accruing from this analysis are not meant to be prescriptive, but rather they constitute a framework for potential use of Member States in their policy analysis, learning and benchmarking exercises.

The European Research Area (ERA) is not a homogeneous research system and aggregate values mask large differences between individual countries.

As table N.P.1.1 shows, values in research intensity, the relative importance of the different research actors, their linkages, the innovation results, the economic structure, the framework conditions, or the openness of the system, vary largely across European countries.

[1] "Europe 2020" places innovation at the heart of the next 10-year Strategy (http://ec.europa.eu/europe2020/index_en.htm)

Table N.P.1.1 Key selected variables of the national research systems in Europe

	R&D Intensity 2009 (1)	BERD Intensity 2009 (2)	GOVERD Intensity 2009 (3)	EPO patent applications per million population 2007	% share of population aged 25-64 having completed tertiary education 2009	as % of total employment: Employment in primary sectors 2010 (4)	Employment in Industrial sectors 2010 (4)	Employment in business and financial sectors 2010 (4)	Employment in high-tech and medium high-tech manufacturing 2009 (5) (6)	Employment in knowledge-intensive activities 2009 (5)
Belgium	1,96	1,32	0,17	139	33,4	1,7	12,9	21,4	5,2	41,4
Bulgaria	0,53	0,16	0,29	4	23,0	20,3	20,3	20,5	3,8	26,0
Czech Republic	1,53	0,92	0,33	16	15,5	3,5	28,0	13,3	9,5	29,2
Denmark	3,02	2,02	0,09	194	34,3	2,7	12,6	13,3	5,1	39,2
Germany	2,82	1,92	0,41	291	26,4	2,1	18,9	19,4	10,2	37,3
Estonia	1,42	0,64	0,16	17	36,0	4,4	22,7	22,4	4,1	31,8
Ireland	1,77	1,17	0,08	67	35,9	4,9	13,0	13,3	5,0	41,1
Greece	0,58	0,16	0,12	10	22,8	12,0	11,1	11,5	1,5	31,6
Spain	1,38	0,72	0,28	33	29,7	4,6	13,8	14,2	3,7	30,3
France	2,21	1,37	0,36	132	28,7	3,2	13,1	18,8	5,0	39,5
Italy	1,27	0,64	0,17	86	14,5	4,0	19,4	20,0	6,0	33,0
Cyprus	0,46	0,10	0,10	11	34,1	4,6	10,2	10,2	0,7	33,9
Latvia	0,46	0,17	0,11	8	26,1	9,2	16,3	15,3	1,4	30,1
Lithuania	0,84	0,20	0,20	2	31,0	9,1	17,7	18,4	1,8	31,2
Luxembourg	1,68	1,24	0,29	230	34,8	1,4	10,5	28,9	0,7	56,2
Hungary	1,15	0,66	0,23	17	19,9	7,0	22,8	23,1	7,9	33,5
Malta	0,55	0,34	0,03	20	13,2	2,5	15,3	15,3	4,3	38,8
Netherlands	1,84	0,88	0,23	223	32,8	2,9	10,8	11,0	2,7	37,4
Austria	2,79	1,94	0,15	217	19,0	5,1	16,2	16,6	5,0	35,4
Poland	0,68	0,19	0,23	4	21,2	13,0	22,0	22,7	4,8	28,0
Portugal	1,66	0,78	0,12	11	14,7	10,8	17,1	17,2	3,0	27,9
Romania	0,48	0,19	0,17	1	13,2	25,7	23,3	23,2	4,6	19,8
Slovenia	1,86	1,20	0,39	51	23,3	8,7	22,8	23,7	8,5	31,9
Slovakia	0,48	0,20	0,16	8	15,8	3,0	23,7	24,3	8,6	29,1
Finland	3,93	2,79	0,37	251	37,3	4,7	16,3	16,9	5,5	36,5
Sweden	3,60	2,54	0,16	298	33,0	2,2	15,3	15,6	5,0	42,3
United Kingdom	1,87	1,16	0,17	89	33,4	1,8	10,4	22,8	3,8	42,8
EU	2,01	1,25	0,27	117	25,2	5,4	16,4	15,6	5,7	35,1
Iceland	2,65	1,45	0,47	91	32,8	4,0	10,8	15,4	1,1	43,1
Norway	1,80	0,95	0,29	110	35,9	2,8	13,0	14,1	3,5	38,7
Switzerland	3,00	2,20	0,02	429	35,2	3,7	16,8	17,2	6,3	42,0
Croatia	0,84	0,34	0,23	7	17,7	16,5	21,7	6,0	3,4	27,4
Turkey (7)	0,85	0,34	0,11	3	11,5	26,5	25,2	4,9	3,0	18,4
Israel	4,27	3,39	0,21	188	:	2,5	13,5	17,7	:	:

Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Eurostat, OECD
Notes: (1) EL: 2007; IS, CH: 2008; AT, FI: 2010.
(2) EL: 2007; IS, CH: 2008; IT, FI: 2010.
(3) EL: 2007; IS, CH: 2008; IE, IT, FI: 2010.
(4) HR: 2004; CH: 2006; FR, IS, TR, IL: 2008; CZ, LU, UK, NO: 2009.
(5) LU: 2008.
(6) LT, IS: Medium-high-tech only.
(7) TR: Sectoral employment is based on a sectoral definition which does not correspond exactly to the sectoral definition used for the other countries.
(8) Values in italics are estimated or provisional or forecasts.

This heterogeneity of research and innovation systems in Europe[2] demands an analysis which goes beyond a homogeneous and unique view and policy formulation

"One size fits all strategies" are then discouraged and targeted individual analysis and policies are needed to better understand the strength and weaknesses of specific systems and identify their threats and opportunities. However, while each research and innovation system counts on specific characteristics that distinguish them from each other, some of them also

[2] The heterogeneity of the research systems in Europe can be even broaden as even within European countries, specific regions count on very different sets of conditions and therefore very different research systems. This is particularly true for countries like Italy, where the inter-regional differences are very large and it is possible to talk about two different Italian research and innovation systems, the North and the South.

share common features that allow them to be analysed together and differentiate them from the rest.

Country grouping of research and innovation systems in Europe can address the complexity related to the heterogeneity of systems in Europe, while limiting the analysis to a manageable set of reference groups

Any methodology aiming at reducing the complexity of a research and innovation system, and not taking into account all the specificities embedded in them, can only be a simplification and therefore, any results should be handled with caution. Other alternative and classifications taking more qualitative variables, e.g. cultural and historical elements, could also add new complementary insights on how to better classify Research and Innovation systems in Europe.

Box: Classifications of Research and Innovation Systems

The grouping of research and innovation systems has been an area of academic research and policy interest for already some time. Taxonomies based on the type of governance infrastructures (Cooke 1992), type of business innovation (Cooke 2004), learning capacity (Asheim and Isaksen 1997, 2002) or barriers to innovation (Kauffman and Tödtling, 2000) are just a few examples. In the European research and innovation policy context, the Innovation Union Scoreboard (previously known as the European Innovation Scoreboard) also presents a classification of research and innovation systems based on the combination of the current performance of the system and its evolution trend in the past years.

The grouping that is presented here-after aims at complementing these different approaches by providing a statistics based classification that encompass a wide range of indicators that characterise the determinants and performance of research and innovation systems. While unable to encompass all important underlying cultural and behavioural features, it provides an analytical framework of reference. In this respect, it should be noted that in no manner this classification is intended to be used normatively and the European Commission does not place any judgement on the configuration of the different groups.

In our analysis, in order to create groups of research and innovation systems in Europe, a large number of variables featuring their main characteristics, functioning and results are selected. In total, nineteen variables for which data were available were retained, and included the *total intramural expenditure in R&D* (*GERD*) as percentage of GDP, *the total intramural R&D expenditure performed by the private sector* (*BERD*), *the total intramural R&D expenditure performed by the public sector* (*GOVERD*), *the total intramural R&D expenditure performed by the higher education sector* (*HERD*), the *Human Resources in Science and Technology aged between 25-64* ,and *the ratio in top-10% most highly cited publications*. These six variables covered the research intensity in the system, the relative importance of each performing sector and the research performance of the system.

The *patent applications per million of population* and the number of *patent applications in high-tech sectors* were introduced to proxy the innovation activity of the system. The variables of the *percentage of the population working on the primary sector, industry, business and financial services*, as well as the percentage of *population working on high-tech* *manufacturing sectors and knowledge intensive services* were also introduced to control for the economic structure of the country. Finally, in order to take account of the framework conditions existing in the system, the *population density* as a proxy for the establishment of the linkages between research actors, the *GDP per capita*, as a proxy of the technological development of the country, the *natural logarithm of the GDP* as a proxy for the size of the market, and last the percentage of the *population engaged in life-long-learning activities and with tertiary education* for the availability of the skills, were also selected.

1.2. Groups of countries based on knowledge capacity and economic structure

In order to reduce the complexity introduced by the use of such a large number of variables, a multiple multivariate econometric analysis based on a Principal Component Analysis was performed. The result of this analysis revealed that two key factors could summarise a large part of the information covered by the nineteen analysed variables. These factors were first, the knowledge capacity of the system[3], and second, the economic structure prevailing in the system, and more precisely, the importance of the manufacturing industry in the system[4].

After the Principal Component Analysis, a Cluster Analysis maximising the distance between groups and minimising this distance within groups was carried out in order to group the different research systems according to the values scored on the two key factors structuring the research and innovation systems.

European countries can be analysed in nine groups based on their knowledge capacity and economic structure

As figure N.P.1.1 shows, eight different research and innovation groups could be identified:

Group 1: Very high knowledge intensity countries.
This group would be composed of Finland, Sweden, Denmark and Switzerland.

Group 2: High knowledge capacity systems with a specialisation in high-tech manufacturing
Germany would be alone in this group as its characteristics would differentiate it from all other research systems.

Group 3: High knowledge capacity systems with a mixed economic structure
This group would be composed of Belgium, the United Kingdom, France and Austria.

Group 4: Medium-high knowledge capacity systems with an economic specialisation in knowledge intensive services
This group would be composed of Ireland, Luxembourg, the Netherlands, Norway and Iceland

Group 5: Medium knowledge capacity systems with an economic specialisation in low knowledge sectors.
This group would be composed of Spain, Portugal and Estonia.

[3] This factor accounted for almost 50% of the total variance

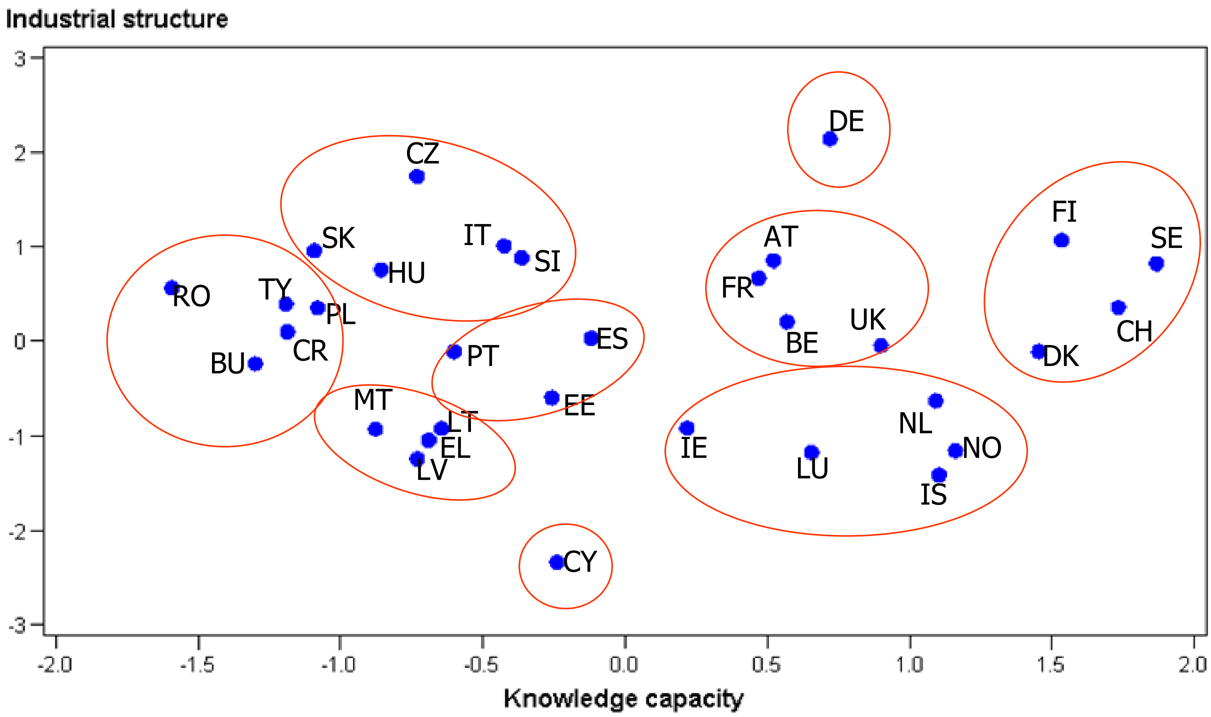
[4] This factor accounted for more than 12% of the total variance in the model. As a result, the Principal Component Analysis accounted for more than 62% of the variance introduced by the nineteen individual variables.

Group 6: Medium-low knowledge capacity with a strong role of agriculture and low knowledge-intensive services
This group would be composed of Greece, Latvia, Lithuania and Malta.

Group 7: Medium-low knowledge capacity system with a strong service-based economy
Cyprus, as Germany, would be alone as its characteristics would differentiate it from all other research systems
Group 8: Medium-low knowledge capacity with an important industrial base
This group would be composed of the Czech Republic, Slovenia, Slovakia, Hungary and Italy

Group 9: Low knowledge capacity systems with a specialisation in low knowledge intensive sector.
This group would be composed of Bulgaria, Romania, Poland, Turkey and Croatia.

Figure N.P.1.1: Groups of Research and Innovation Systems in Europe



Source: DG Research and Innovation
Data: Eurostat and OECD, 2009

Table N.P.1.2 Key selected variables of the national research systems of the different groups

	R&D Intensity 2009	BERD Intensity 2009	PCT patent applications per billion GDP (PPS€) 2007	Employment in knowledge-intensive activities as % of total employment 2009	Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the Group 2007	GERD average annual real growth (%) 2000-2009	BERD average annual real growth (%) 2000-2009
Group 1 (DK, FI, SE, CH)	3,41	2,41	9,67	40,6	16,3	2,9	2,5
Group 2 (DE)	2,82	1,92	7,72	37,3	13,8	2,1	1,8
Group 3 (BE, FR, AT, UK)	2,09	1,32	3,78	40,9	14,1	1,9	1,6
Group 4 (IE, LU, NL, IS, NO)	1,82	0,96	4,85	38,5	16,2	2,8	1,2
Group 5 (EE, ES, PT)	1,42	0,72	1,18	29,9	11,6	7,8	8,1
Group 6 (EL, LV, LT, MT)	0,60	0,17	0,47	31,5	10,1	4,0	5,3
Group 7 (CY)	0,46	0,10	0,51	33,9	11,3	10,6	11,0
Group 8 (CZ, IT, SI, SK, HU)	1,27	0,67	1,89	32,2	10,9	3,1	3,5
Group 9 (BG, PL, RO, HR, TR)	0,72	0,29	0,38	25,3	6,2	7,1	6,7

Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Eurostat, OECD, Science Metrix / Scopus (Elsevier)
Note: (1) Elements of estimation were involved in the compilation of the data.

The results also allow for intra-group comparisons

This group classification can help identifying how similar countries, i.e. countries belonging to a group, react in terms of research and innovation policies. In many cases, countries with similar research and innovations systems follow different paths when it comes to defining their investment strategies. As table N.P.1.3 shows, in the last decade, countries with well-developed research and innovation systems benefiting from high R&D investments and scientific and technological outputs have performed differently in terms of research and innovation.

Sweden, on the one hand, the world leader in terms of R&D investment, decreased its overall percentage and private R&D investments by 0.1% , while Finland, a close follower, increased these investments by more than 3%. While this analysis does not allow accounting for the reasons of these trends, it allows identifying some interesting features of the research and innovation systems worth exploring further.

Table N.P.1.3 Key selected variables of the national research systems for countries with very high knowledge intensity

	R&D Intensity 2009 (1)	BERD Intensity 2009 (1)	PCT patent applications per billion GDP (PPS€) 2007	Employment in knowledge-intensive activities as % of total employment 2009	Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country 2007	GERD average annual real growth (%) 2000-2009 (2)	BERD average annual real growth (%) 2000-2009 (2)
Denmark	*3,02*	*2,02*	7,91	39,2	17,5	*5,4*	*3,3*
Finland	*3,93*	*2,79*	9,98	36,5	13,7	*3,3*	*3,3*
Sweden	*3,60*	*2,54*	11,01	42,3	14,7	*0,7*	*-0,1*
Switzerland	3,00	2,20	9,15	42,0	18,2	4,1	4,1

Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Eurostat, OECD, Science Metrix / Scopus (Elsevier)
Notes: (1) CH: 2008; FI: 2010.
(2) CH: 2000-2008; FI: 2000-2010; SE: 2005-2009; DK: 2007-2009.
(3) Values in italics are estimated or provisional or forecasts.

Perhaps, more interesting is the situation for countries with weaker research and innovation systems, where the differences in performance are more remarkable, mainly due to the higher effect caused by smaller variations. For example, since the year 2000, Romania has benefited from a sharp increase in overall R&D investment, although this increase has been fuelled by the public sector, while the private sector decreased its R&D investment. On the contrary, for the same period Bulgaria decreased its R&D investment, mainly due to a decrease in the research intensity of public investment, while private R&D increased. Once again, these data do not allow understanding the reasons for these different behaviours but they point out to interesting areas for further research.

Table N.P.1.4 Key selected variables of the national research systems for countries with low knowledge intensity and with a specialisation in low knowledge-intensive sectors

	R&D Intensity 2009	BERD Intensity 2009	PCT patent applications per billion GDP (PPS€) 2007	Employment in knowledge-intensive activities as % of total employment 2009	Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country 2007	GERD average annual real growth (%) 2000-2009 (1)	BERD average annual real growth (%) 2000-2009 (1)
Bulgaria	*0,53*	*0,16*	0,38	26,0	5,7	*5,0*	*9,0*
Poland	0,68	0,19	0,31	28,0	5,7	4,4	1,7
Romania	0,48	0,19	0,15	19,8	6,2	7,9	1,5
Croatia	0,84	0,34	0,88	27,4	5,1	0,8	0,0
Turkey	0,85	0,34	0,46	18,4	6,9	10,1	12,3

Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Eurostat, OECD, Science Metrix / Scopus (Elsevier)
Notes: (1) HR: 2002-2009.
(2) Values in italics are estimated or provisional.

2. Thematic diversity: specialisation at national and regional level

Highlights

In general, European countries and regions may need to identify and define areas where they need to focus their scarce scientific and technological resources in order to achieve critical mass, obtain meaningful results and develop a competitive advantage. The process of building a competitive advantage in research and innovation is a complex strategic process that needs to build on existing strengths, create networks and be linked to broader socio-economic political goals. This process is not exempt from risks and requires many data for analysis and policy reflection. Specialisation indexes show the comparative advantage of one system and the dynamics of one country or region.

Based on these indexes, the EU, as the United States, presents overall a fairly diversified scientific and technological pattern. However, the EU, unlike the United States, depicts a negative specialisation in the most dynamic, faster-growing and technology-intensive fields, such as medical equipment, telecommunications or audio-visual electronics. Moreover, in terms of key enabling technologies, the United States presents a consistent positive specialisation in ICT, biotechnology and nanotechnology, while the EU presents a mixed picture. It still lags behind on ICT and biotechnology technologies, while it has offset the lag on nanotechnology that it suffered at the beginning of the decade.

At a national level, individual Member States present more marked specialisation patterns, especially in small Member States. For example, Denmark and Ireland depict a positive and increasing specialisation in health technologies or environmental technologies, Finland in ICT and the Netherlands in nanotechnologies.

At a regional level, ICT technologies are concentrated around Finland, South East England, Belgium, the Netherlands and some core areas in France and Germany. For biotechnology, regions with large university centres at the core of the EU depict a positive specialisation.

However, it is important to remember that smart specialisation is a dynamic strategic process where regions and member states need to identify their long-term competitive advantages based on their local strengths, and define those actions that can lead them to maintain and/or create their competitive position.

While further work will be needed to assist regions and countries in this self-discovery process and evaluate the results and impacts, the specialisation indexes can provide an initial framework to identify existing strengths and help identify potential drivers and barriers leading to particular specialisation patterns and dynamics.

2.1. Evidence base for smart specialisation

Smart specialisation has recently gained political and analytical importance in Europe as a potential solution to problems of research fragmentation and imitation of research patterns, which will build critical mass, to maximise research and innovation outputs in all regions in Europe. Moreover, in the current context of fiscal consolidation, 'specialisation strategies can be conducted in ways that also enhance innovative specialisations and competitive advantages in the post-crisis period, facilitate repositioning strategies and underpin answers to severe global risks, e.g. energy shortage, climate change.'[5]

Smart specialisation as a dynamic and entrepreneurial process to identify and build competitive advantages in science and technology

The concept of smart specialisation should be understood as a dynamic 'process of finding the right areas to focus'[6]. As such, smart specialisation does not call for imposing specialisation through some form of top–down industrial policy. On the contrary, it requires an entrepreneurial process of discovery involving all stakeholders to identify and reveal what a country or region does best in terms of science and technology, and where they can expect to excel. This process of discovery needs to be attached to broader political goals and must identify governance mechanisms and criteria to guide choices.

Smart specialisation is an important policy rationale and concept for regional innovation policy. It promotes efficient, effective and synergetic use of public research and innovation investments and supports Member States and regions in diversifying and upgrading existing industries and in strengthening their innovation capacity. In a nutshell, smart specialisation is about placing greater emphasis on innovation and having an innovation-driven development strategy in place that focuses on each region's strength and competitive advantage. It is about specialising in a smart way, i.e. based on evidence and strategic intelligence about a region's assets and the capability to learn what specialisations can be developed in relation to those of other regions.

Many EU Member States and regions have a long-standing experience in developing and implementing innovation strategies. In many cases these strategies already include most or many of the elements that would justify them as being "smart", i.e. they were developed based on a sound assessment of a region's competitive assets and potential, including a SWOT analysis, a broad and intense stakeholder consultation, a deep understanding of business R&I needs, and they have developed a policy mix that covers the whole knowledge triangle. A few examples from regions that have embarked on such a smart specialisation exercise are included in this brochure. Yet many others have seen such exercises fail for want of strategic intelligence or political commitment or a lack of capacity or long-term political and budgetary commitment to implement such plans, properly evaluate them or sufficiently involve key stakeholders. For these there is a need to provide targeted assistance.

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[5] Giannitsis, A and Kager M (2009): 'Technology and specialisation: Dilemmas, options and risks?' *Expert group 'Knowledge for Growth', May 2009.*
[6] Foray D, David P A and Hall B (2009): 'Smart Specialisation: the concept', *Expert group 'Knowledge for Growth', May 2009.*

Smart specialisation requires the selection of fields to focus on resources. This process is not exempt of risks[7]

The very concept of specialisation requires the selection of specific areas to concentrate resources around specific goals and the non-selection of others. If the market is unable to identify the key areas to specialise, the cost of inaction can be high. On the other hand, if an action needs to be taken, this selection may end up 'picking up losers', which may have high associated costs.

In the field of research and innovation, it is difficult to predict the results that will accrue from investments, and increasingly, technology developments and innovation can be based on the scientific results of many different and *a priori* unrelated disciplines. As such, targeting investment decisions towards narrow scientific areas may jeopardise the potential capacity to develop new technologies and innovations.

As a result, the analysis of the scope and scale of the need to specialise requires careful consideration. The choice and development of a smart specialisation strategy is a complex process where decision makers, e.g. governments, entrepreneurs, universities, need to have a clear vision for the future, build on their strengths, be aware of developments elsewhere, create networks and communities to maximise the use of available knowledge, and finally be able to take and manage risks.

In order to render the process as efficient as possible, more information is needed. European countries and regions need data that can help them assess their comparative and competitive strengths in different scientific and technological fields. Moreover, the research agents need new data to identify other countries and regions where research in similar fields is conducted so that they can network, build on each others' findings and create synergies between researchers.

Many data are needed to inform the smart specialisation process. The specialisation indexes reveal the comparative advantage of one research and innovation system in one field and can help partially inform the process.

A large battery of indicators can contribute to an understanding and explanation of the process of selecting and building scientific and technological competitive advantages in particular fields.

The scientific and technological specialisation indexes[8] rank high in this list. They indicate the areas where a country or region exhibits a stronger position than other countries or regions, and conversely the areas of relative weakness. In other words, they represent the different weight that scientific or technological fields carry in the overall research and innovation system in comparison with the rest of the world. As such, they do not reflect the absolute, but the comparative conditions for one area in one country, and their interpretation

[7] A more in-depth review of the pros and cons of 'Smart specialisation' can be found in Pontikakis D, Kyriakou D and van Bavel R (eds) 2009: ' The Question of R&D specialisation: perspectives and policy implications', *JRC Scientific and Technical Reports EUR 23834.*

[8] The mathematical definition of the specialisation indexes are calculated according to the following formula: $RCAki = 100 \times \tanh \ln \{(Aki/\Sigma iAk)/(\Sigma kAki/\Sigma kiAki)\}$, with Aki indicating the number of publications (patents) of country k in the field i, whereby field is defined by scientific fields (patent classes). LN centres the data around zero and the hyperbolic tangent multiplied by 100 limits the RCA values to a range of +100 to -100.

needs to be carefully done. The terminology 'positive' and 'negative' specialisation does not imply any normative value; they represent standard terminology in statistical analysis of specialisation indexes.

It should be noted that the specialisation indexes do not reflect the potential use of these technologies, but the production; positive- and negative-specialisation indexes do not always correspond to the existence of favourable or unfavourable conditions for these scientific or technological fields in a given country, as they cannot measure other important variables, such as the existence of clusters of complementary activities or critical mass which are crucial to construct scientific, technological or economic competitive advantages.

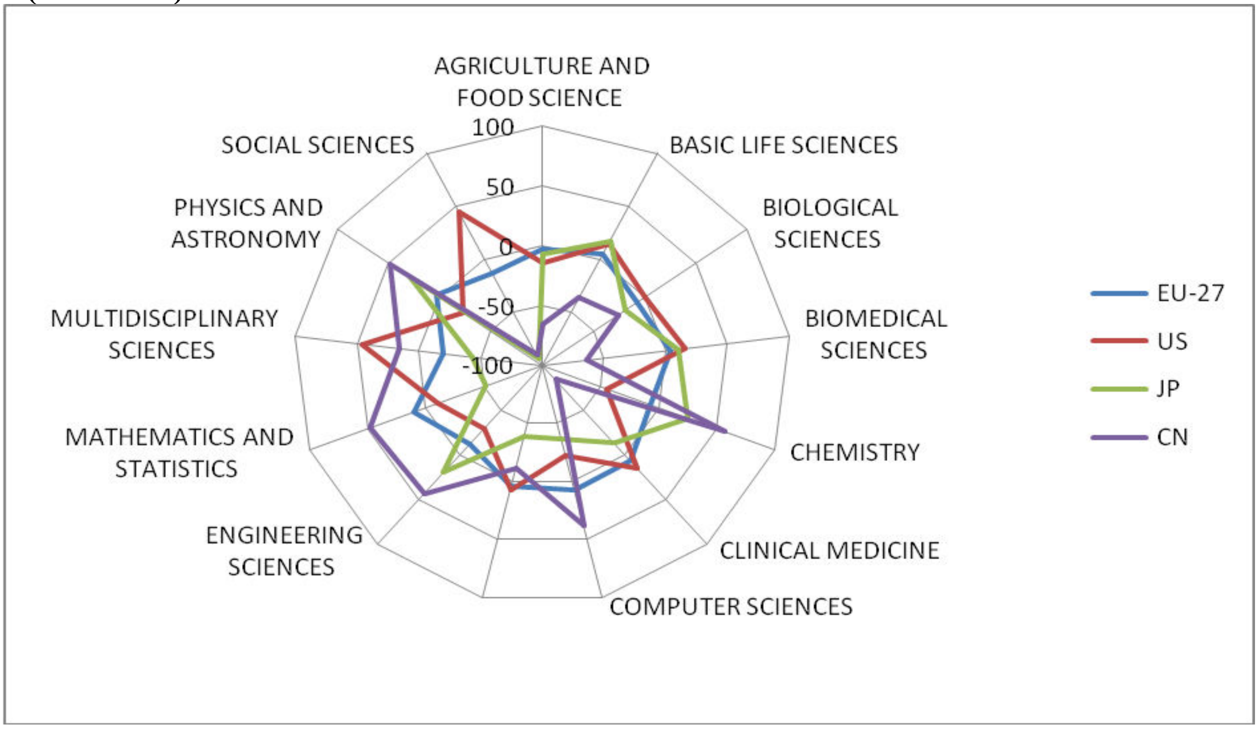
2.2. Scientific and technological specialisation of the EU

The following sections present a series of scientific and technological specialisation profiles for the EU, the United States and Japan, and analyses in more detail the specialisation indexes for Member States and their regions, in a number of particularly interesting technological fields.

The EU's scientific system is highly diversified with little relative specialisation in any particular field.

The EU has developed a diversified scientific base where most fields are represented at the average world level. To some extent, this pattern responds to the vast importance of the EU scientific production that largely influences the world patterns of scientific production. Nevertheless, the United States, which also has very large scientific production, presents a less diversified system, as it depicts a stronger specialisation in social sciences, multidisciplinary science and to a lesser extent, clinical medicine. Japan and China present less diversified scientific systems, with Japan showing a positive specialisation in physics, engineering and chemistry, and China on maths, engineering and computer science.

Figure N.P.2.1: Scientific specialisation in Europe, the United States, Japan and China (2004/2006)



Source: DG Research and Innovation
Data: Web of Science (Thomson scientific)/ CWTS, University of Leiden

The EU, like most other large economies, counts on a highly diversified technological system, with a comparatively slight negative specialisation in high-technology sectors, such as telecommunication, electronics or medical equipment

EU-27, like the United States and Japan, has maintained a relatively stable technological specialisation pattern in recent years. On average, large economies have diversified technological systems where few specific fields stand out. However, it is important to point out that in comparison, Japan has a relative specialisation in highly research-intensive electronic fields such as computers, office and machinery, telecommunications, audio-visual electronics, electronic components or optics. The United States specialises more on high-tech and high added-value technological fields related to medical equipment and pharmaceuticals, while the European Union seems to have a stronger specialisation in lower research-intensity sectors such as metal production or machinery-related technologies and a negative specialisation in ICT-related sectors such a telecommunications, audio-visual electronics or electronic components.

As for science, European technology tends to be highly diversified with a relative specialisation in machine-related and metal-product technologies

The European Union's technological pattern presents a fairly diversified picture with a certain specialisation in medium technology-intensive areas as metal-product-, transport- or machinery-related technologies. This pattern contrasts with that of the United States or Japan, which present a less uniform distribution of technological development. More precisely, the

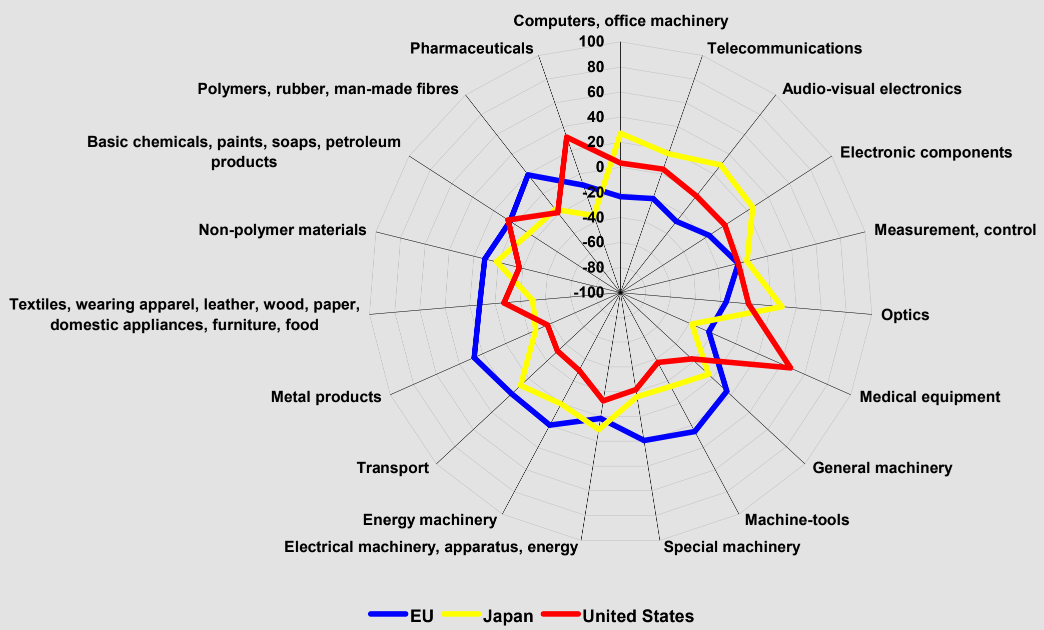
United States counts on strong specialisation on high technology fields such as medical equipment or pharmaceuticals, while Japan presents a higher specialisation in other high technological fields such as telecommunications, and electronics-related technologies.

These patterns have been stable over time and somehow reflect the differences in the economic structure of Europe vis-à-vis its main trading competitors. Although it is difficult to identify whether the scientific and technological patterns are the cause or the consequence of a given productive specialisation, these data show that Europe is lagging behind in the production of high-technology knowledge. The continuation of this pattern can cast some doubts on the competitiveness of its industry to produce and export high technology and value-added products.

While it is difficult to establish close relationships between scientific and technological specialisation profiles, some patterns can be identified.

The United States depicts a positive scientific specialisation in life science and biomedical sciences and a technological specialisation in pharmaceuticals and medical equipment. Japan shows a positive specialisation in physics and engineering and a positive specialisation in ICT-related technologies.

Figure N.P.2.2 Technological specialisation in the EU, the United States and Japan, 2005-2006



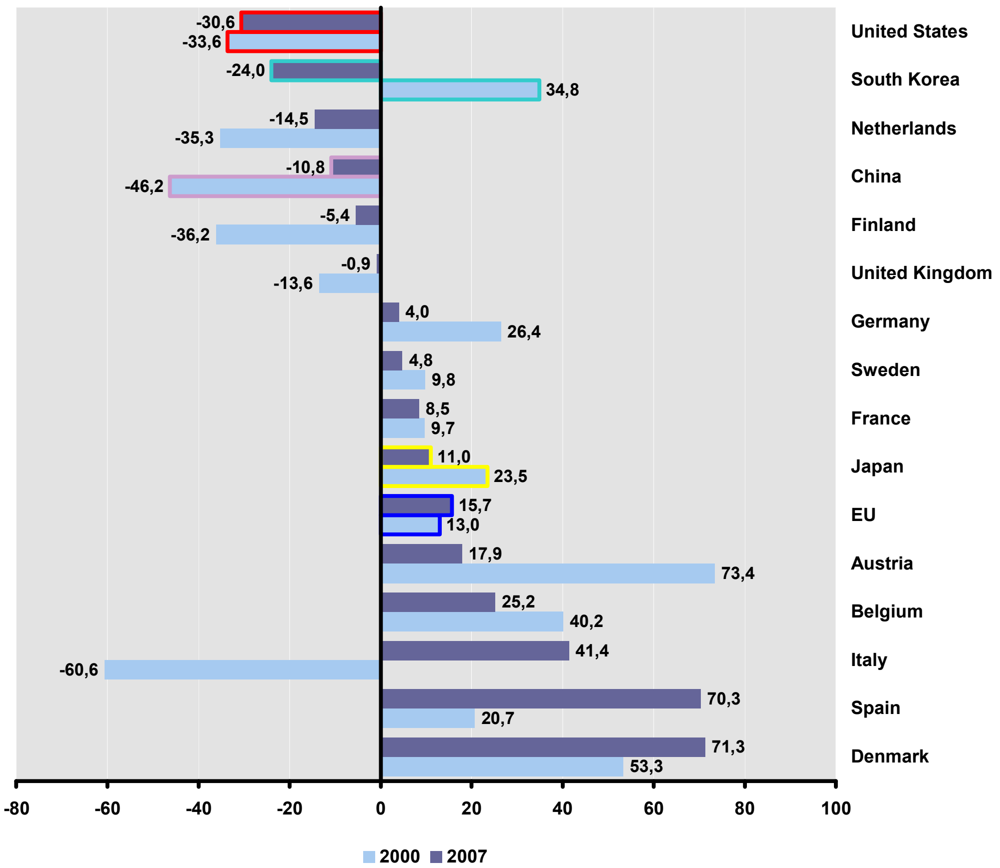
Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: JRC-IPTS, EPO, WIPO
Note: Patent applications by region of residence of the inventor(s).

2.3. Specialisation in environmental and health technologies

The European Union is increasingly improving its relative strengths in developing new technologies aimed at improving the environment, including climate change

In terms of relative specialisation in environmental technological fields, the EU depicts a positive specialisation pattern, in contrast to the United States, with a negative specialisation index. Member States such as Spain, Denmark, Hungary and the Czech Republic lead the list of countries where environmental technologies play a comparatively stronger role in the national technological production. It is important to highlight the case of Italy, which in the last decade reversed an important negative specialisation index and now has moved to become one of the most promising technological fields.

Figure N.P.2.3 Environmental technologies - specialisation index by country, 2000 and 2007



Source: DG Research and Innovation

Data: JRC-IPTS, OECD

Note: Patent applications by region of residence of the inventor(s).

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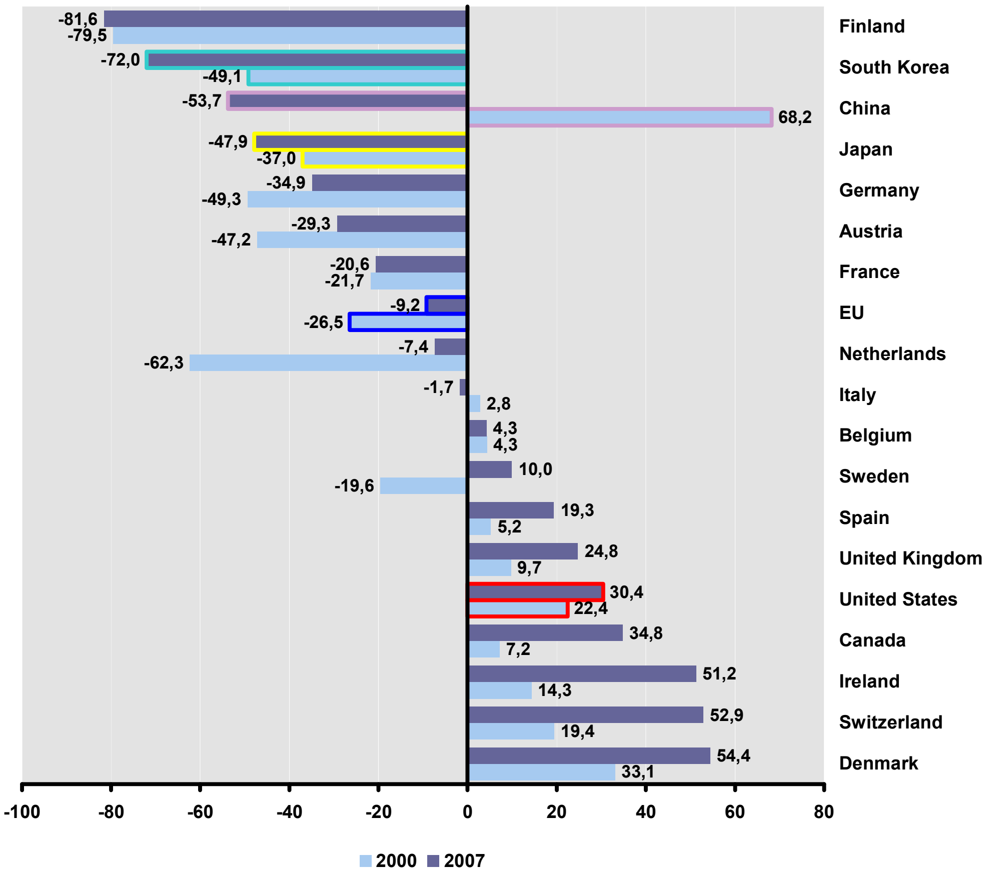
The EU suffers a negative specialisation in health technologies, where the United States has an absolute and relative advantage

The United States, overall, has both an absolute and comparative advantage in the development of health-related technologies. While the EU-27 has been catching up in the last decade, it still suffers from a negative specialisation in this field, as other technological fields are comparatively better positioned. However, within Europe, there are some countries that have developed very strong positions in health-related technologies such as Denmark, Ireland or the United Kingdom. This specialisation has been more marked over time, which suggests a process of increasing specialisation in these technologies in these countries, which most likely count on the right factors (both in terms of resources like institutions and policies) allowing to them to concentrate their research and scientific efforts towards these fields.

It should be noted that both highly research-intensive systems such as South Korea and Japan also count on a high negative specialisation in these technologies, which suggest a high specialisation in other technological fields, and likely, a lack of the right conditions to develop these types of technologies.

Figure N.P.2.4 Health technologies - specialisation index by country, 2000 and 2007



Source: DG Research and Innovation
Data: JRC-IPTS, OECD
Note: Patent applications by region of residence of the inventor(s).

Innovation Union Competitiveness Report 2011

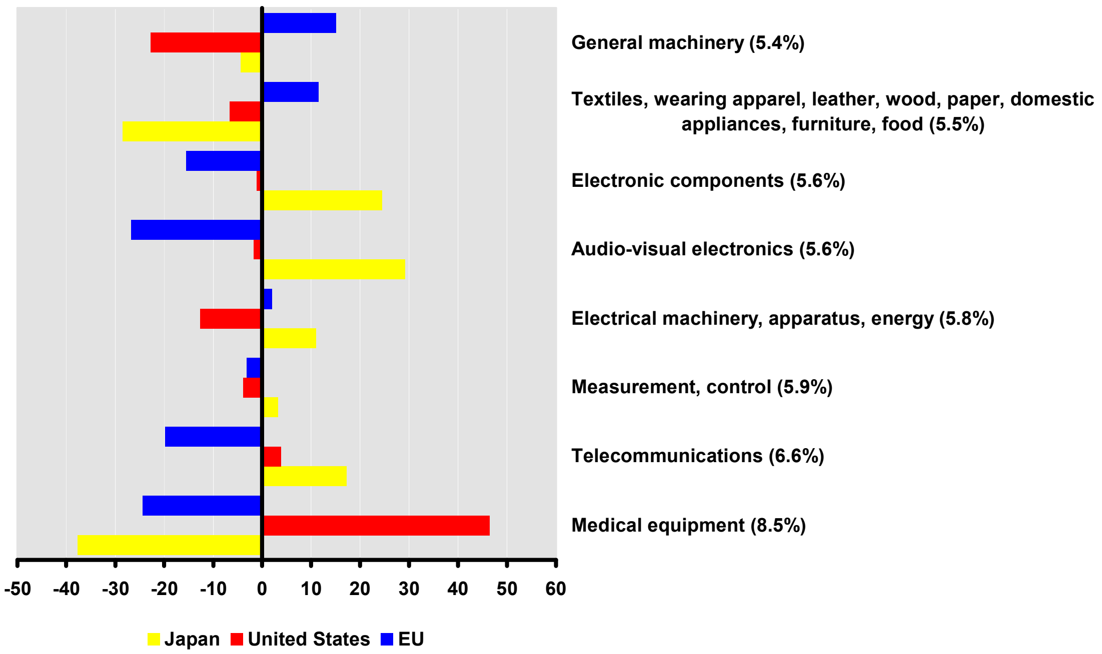
2.4. Specialisation in new growth areas and general-purpose technologies

Technological fields evolve according to their own idiosyncratic characteristics, which may include historical factors, knowledge developments or changes in economic and societal demands. As a result, comparisons across fields are difficult. However, some technological fields seem to be more dynamic over time, presenting higher growth rates in patenting activity. As figure N.P.2.5 shows, fields such as medical equipment, telecommunications or measurement and control technologies have been growing faster than other fields in the recent past.

The European Union presents a negative specialisation in the most dynamic, faster-growing and technology-intensive fields

The EU seems to lag behind in these technology-intensive sectors, as the specialisation indexes are negative for these technologies, indicating that there are fewer EU patents in these areas than there would be if patent numbers corresponded to the EU's overall technological activity.

Figure N.P.2.5 Fast growing technology fields [(1)] - specialisation index, 2004-2006



Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: JRC-IPTS, OECD
Notes: (1) Fast growing technology fields over the periods 2003-2004 and 2004-2005. Growth of patent applications between the two periods is given in brackets.
(2) Patent applications by region of residence of the inventor(s).

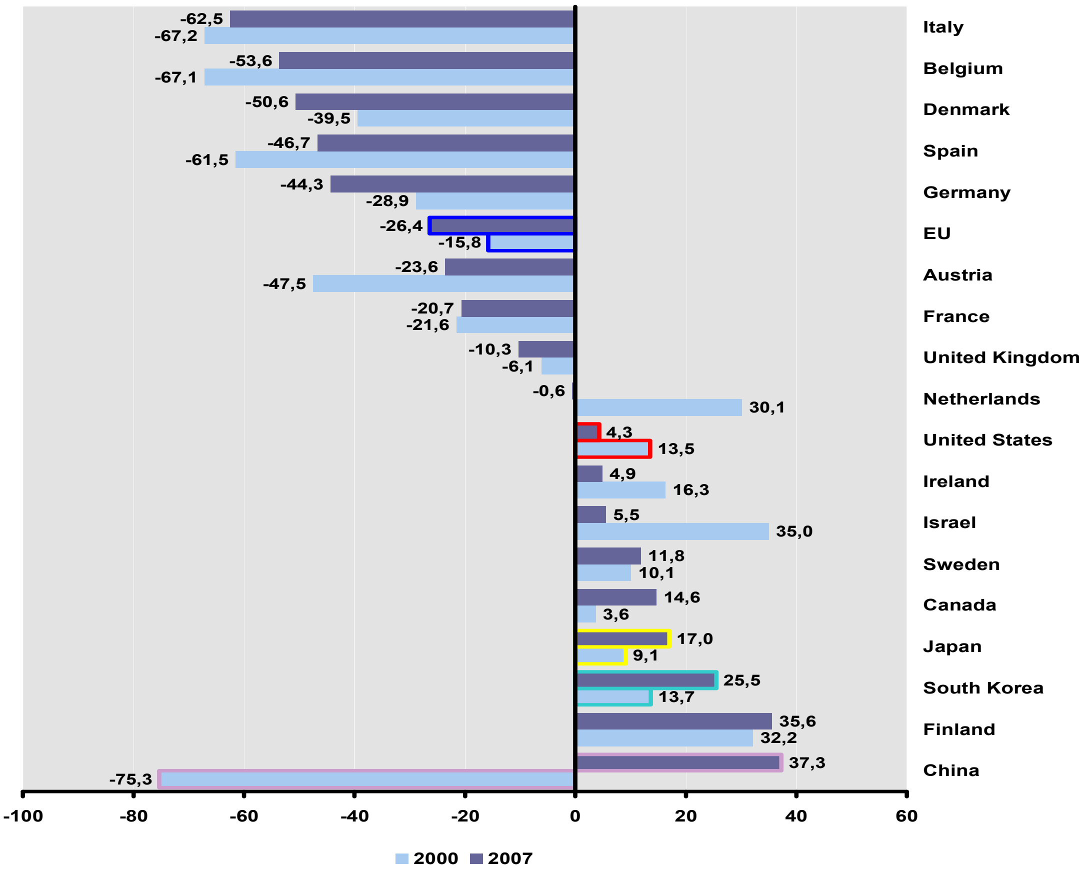
Moreover, general-purpose technologies, such as ICT, biotechnology or nanotechnology, have been at the basis of recent important technological developments and they are expected to be crucial for future economic growth.

The EU has a negative specialisation in ICT, although some Member States and especially, some regions within them, show a positive technological specialisation in these fields

The EU still shows a lower specialisation in the development of ICT technologies. Evidence at the level of firms in the IT sector suggests that the EU's R&D deficit may be due to constraints on the rapid growth of new-technology entrants in the EU compared to that of the United States[9]. With the exception of Finland, Sweden and to a lesser extent Ireland, the role of ICT in the EU has been shrinking over time. In contrast, in addition to the United States, countries in Asia, e.g. China, South Korea or Japan, have become increasingly specialised in this field internationally, which makes them an important global hub for ICT-related technological development.

It is important to note that in dynamic terms, most countries have maintained their specialisation patterns over time - China being a notable exception - passing from a large negative specialisation in 2000 to a significant positive specialisation in 2007.

Figure N.P.2.6 ICT technologies - specialisation index by country, 2000 and 2007



Source: DG Research and Innovation
Data: JRC-IPTS, Eurostat, OECD
Note: Patent applications by region of residence of the inventor(s).

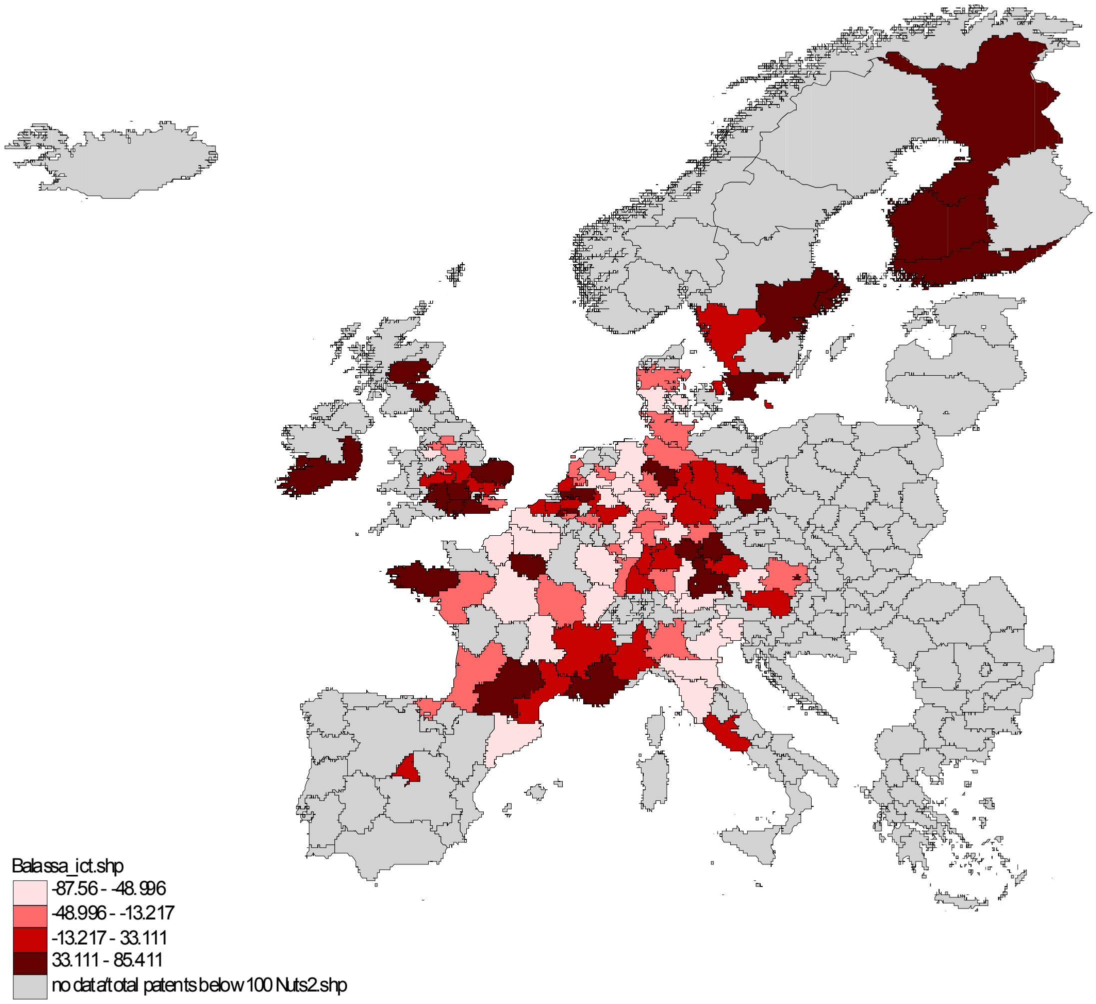
Innovation Union Competitiveness Report 2011

In recent years, many regional governments have expressed their interest in entering the biotechnology and ICT fields. The potential high returns of these technologies, either on their

[9] Source: DG Enterprise: 'European Innovation Scoreboard, 2010' (p.49).

own or in interaction with other fields, have attracted increasing interest and investment from local and regional governments. At the regional level[10], ICT technologies are highly concentrated around Finland, the South East of England and some core regions in Belgium, the Netherlands, some core regions in Germany and France, and finally in some capital regions of Île-de-France and Madrid.

Figure N.P.2.7: EU-27 technological specialisation in ICT technologies at NUTS 2 regional level: 2004–2006[11]



Source: DG Research and Innovation, JRC-IPTS
Data: Fraunhofer ISI, Eurostat Calculations: DG JRC/ IPTS
Note: Patent application by inventor's region of residence

[10] As it happened for Member States, the statistical construction of the indicator requires the analysis to be focused on those regions counting a statistical significant number of patents. Only regions with 100 or more patents in any of the analysed years are taken into account in the study. 108 regions comply with this requirement.

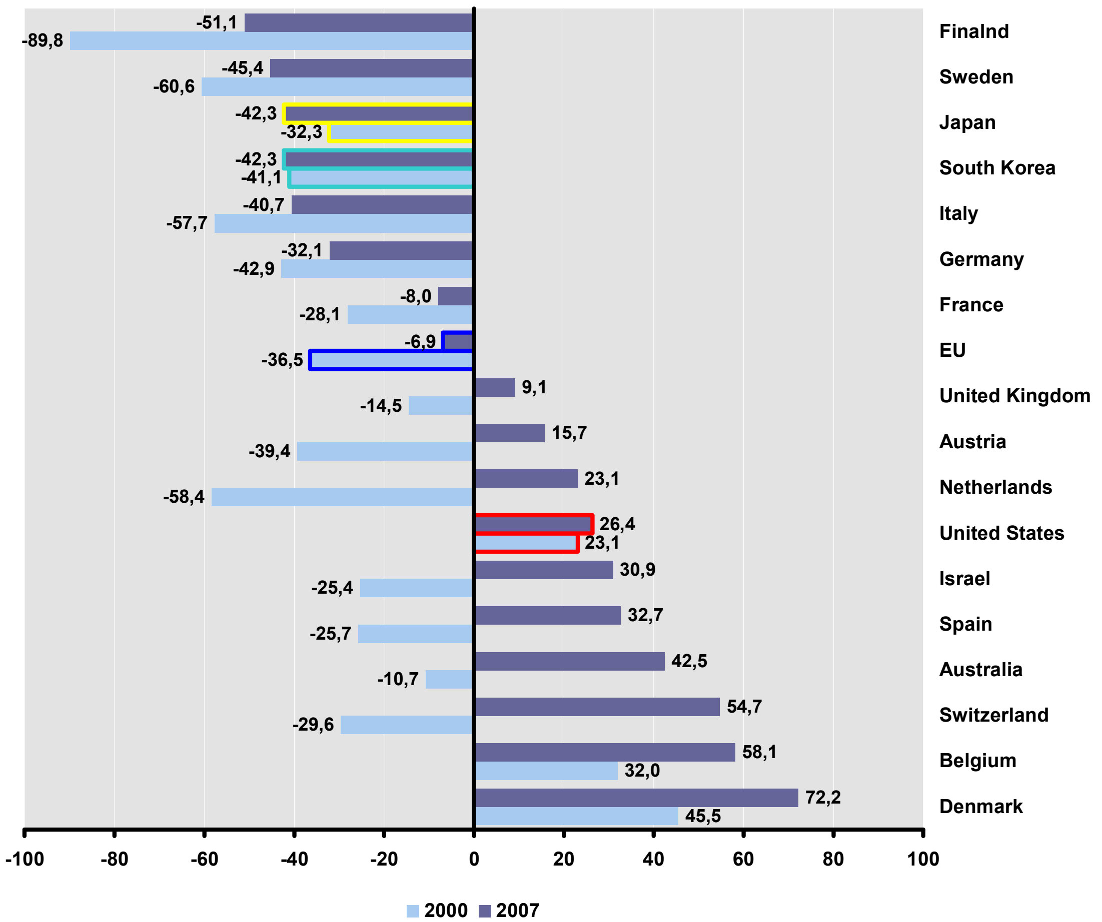
[11] The regional analysis only takes into account regions that produce more than 100 patents in order to avoid misleading interpretation of specialisation patterns in very low technology-production intensive regions. The regions are distributed in four groups gathering 25 % of the analysed regions each.

The emerging biotechnology and nanotechnology fields seem to be concentrated around core countries of the EU, such as the United Kingdom, Belgium and the Netherlands

In terms of biotechnology, the field seems to be less mature and stable than that of ICT, and many countries have experienced significant changes in their specialisation patterns over the last decade. The United States shows a positive specialisation in this field, while the EU has relatively advanced in the last decade, although still depicts a slight relative negative specialisation.

Countries like the United Kingdom or the Netherlands have reverted negative specialisation patterns from 2000 into a positive relative specialisation, which suggest a relative improvement of the conditions in these countries for biotechnology. Belgium and Denmark have increased their specialisation pattern. These data confirm the high importance of biotechnology for health technologies, as the countries with higher specialisation patterns in medical technologies also present a high specialisation pattern in biotechnologies.

Figure N.P.2.8 Biotechnology - specialisation index by country, 2000 and 2007



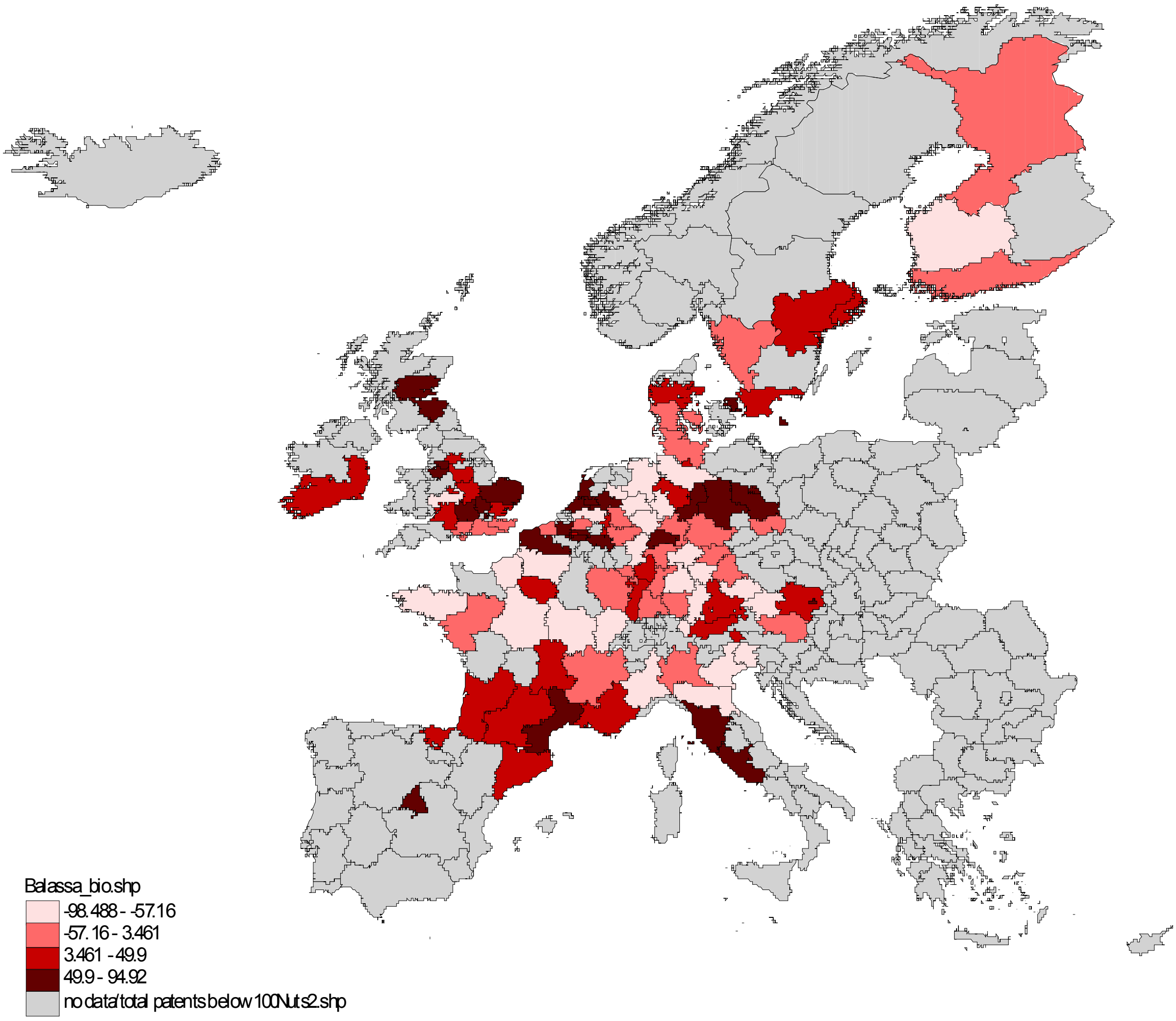
Source: DG Research and Innovation
Data: JRC-IPTS, Eurostat, Fraunhofer ISI
Note: Patent applications by region of residence of the inventor(s).

Innovation Union Competitiveness Report 2011

Biotechnology is highly concentrated in a few regions in Europe

Regions with large university centres in the South East of England, Scotland, the south of France, Belgium, the Netherlands, Denmark, Germany, Madrid in Spain and Lazio in Italy are more highly specialised in science-dependent biotechnology.

Figure N.P.2.9: EU-27 technological specialisation in biotechnology at NUTS 2 regional level: 2004–2006[12]



Source: DG Research and Innovation, JRC-IPTS
Data: Fraunhofer ISI, Eurostat. Calculations: DG JRC/IPTS
Note: Patent application by inventor's region of residence

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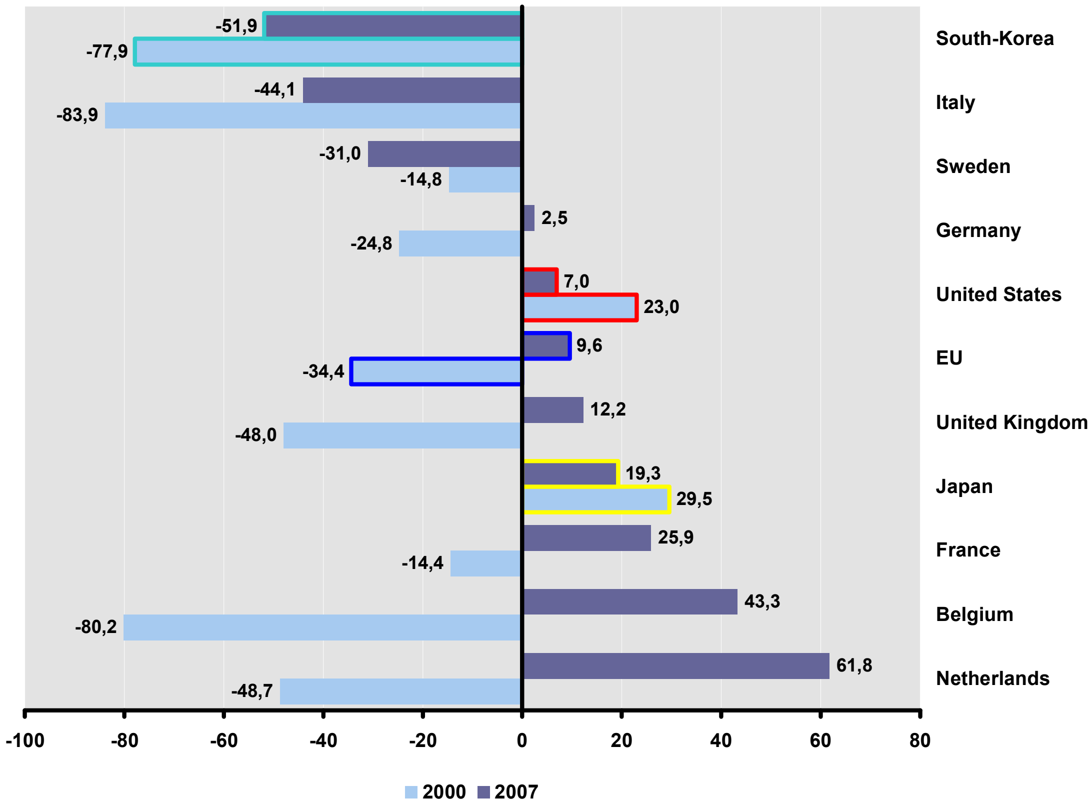
[12] The regional analysis only takes into account regions that produce more than 100 patents in order to avoid misleading interpretation of specialisation patterns in very low technology-production intensive regions. The regions are distributed in four groups gathering 25 % of the analysed regions each. .

In nanotechnologies, the EU is catching up with Japan and the Unites States. Within the EU, the Netherlands, Belgium and France are developing an important specialisation

The field of nanotechnology, like biotechnology, is more novel than that of ICT, and in the last decade, many countries have managed to develop an important specialisation in this field. While still emerging and not consolidated, the dynamic analysis of the specialisation indexes reveals that some countries seem to be becoming better positioned, suggesting the existence of significant comparative advantages for the development of these fields, e.g. Belgium and the Netherlands.

Overall, the EU shows a small positive specialisation in these fields comparable to that of the United States. This value mask high internal differences, as a few countries in Europe, The Netherlands, Belgium, the United Kingdom, France and Germany, seem to concentrate the large majority of patents. This geographical concentration of the nanotechnology patents at the European core seems to suggest that the field requires large investments and benefits from large concentration and spillover effects.

Figure N.P.2.10 Nanotechnology - specialisation index by country, 2000 and 2007



Source: DG Research and Innovation

Data: JRC-IPTS, OECD

Note: Patent applications by region of residence of the inventor(s).

Innovation Union Competitiveness Report 2011

3. Trust and dialogue between science and society

Highlights

Among European citizens there is a widespread agreement that science and technology make our lives healthier, easier and more comfortable. However, since 2005 the share of Europeans experiencing a general trust in science has declined from 78% to 66%. This being said, Europeans trust science more or less at the same extent as citizens of the United States and Canada, with the exception of science for nuclear power, about which Europeans are more sceptical.

The majority of European citizens consider that science and technology are important to solve environmental problems, but there are differences inside Europe between the Northern Europeans (most supportive) and citizens in East European countries (less supportive). Data for EU-15 suggest that trust in the biotechnology industry is in decline, with some exceptions such as France and Greece where there has been an increase of trust. Levels of optimism about computers and information technology and solar energy have been high and stable over the period. A majority of the Europeans express trust in nanotechnology with differences across countries.

European citizens feel that decisions about science and technology should be made in dialogue with them by scientists, engineers and politicians, and the public should be informed about these decisions.

The large majority of European research-active universities surveyed have strategies of public engagement with society although there is a diversity of aims. In European countries there is a wide array of tools, ranging from a more informative to a more participatory approach. The main actors behind public engagement activities are the ministries of science and technology, the institutes for science and technology or, less frequently, institutions or organisations specifically dedicated to this.

3. Trust and dialogue between science and society

The relationship between science and society in contemporary societies has been characterised by an evolution (Bauer et al., 2007) [13] from an initial stage based on diffusion of scientific literacy to the last stage of confidence and trust crises. Within this context, it is important to ask questions such as: do European citizens trust science? What are the differences in public support for some of the main technologies? What are the differences among European countries? Is there any difference between the US and Europe? Are scientists trusted as a source of information by European citizens? What are the policy tools needed to engage in dialogue with society in Europe?

At the European level, data on public opinion on science and technology has now been collected for more than twenty years, and is increasingly more systematic and complete. On the other hand, data on the policy dimension respond to a more recent demand, which is why this kind of information is less consolidated. The enlargement of the EU and the rise of new needs and approaches in the dialogue between science and society requires a systematic collection of data. This is a task for future editions of this chapter: bringing together experiences and information by different evaluation exercises done within European countries and at EU level, such as evaluation studies, foresight exercises and related research.

3.1 Do European citizens trust science and technology?

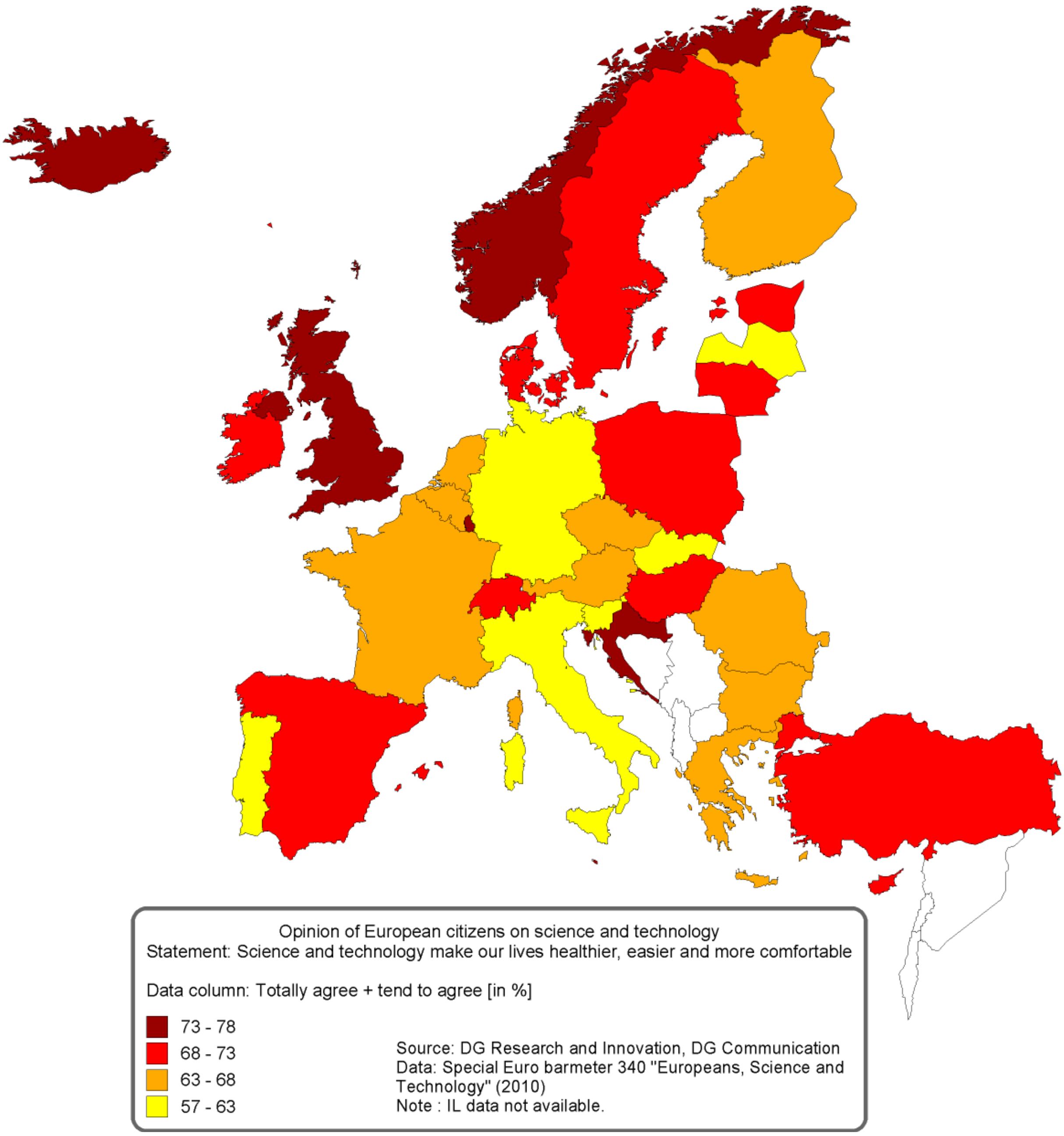
The collection of information on trust of public in science at European level has been at centre of a substantial body of research in the past decades but data tend to be fragmented in several initiatives without much continuity or longitudinal comparison. The exception are several initiatives of the Eurobarometer with their special surveys at the European level.

Two thirds of the European citizens trust science and technology to make their lives healthier, easier and more comfortable — a clear decline in trust since 2005

Support and trust in science depend on the social and economic context of a country. Therefore it is necessary to analyse trust at country level, to map the differences within the EU. Figure N.P.3.1. presents an indicator on optimism about science and technology. When asked whether science and technology make our lives healthier, easier and more comfortable, 66 % of Europeans on average agree in 2010, compared to 78 % in 2005.

[13] Bauer, M., Allum, N. and Miller, S.(2007a) What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. *Public Understanding of Science* 16: 79-95.

Figure N.P.3.1. Share of European citizens considering that science and technology makes our lives healthier, easier and more comfortable



The highest trust in science and technology can be found in Malta, Iceland, the United Kingdom, Luxembourg and Norway

Table N.P.3.1. shows that there is widespread agreement among individual European countries that science and technology makes our lives healthier, easier and more comfortable. In five countries, three quarters or more of respondents agree with the statement: Malta at 78%, Iceland at 77%, the United Kingdom at 76% and Luxembourg and Norway at 75%. Finland saw 20% of respondents disagreeing that science is making our lives healthier, easier and more comfortable, and this is well above the EU-27 average of 12% of respondents.

The largest decline in trust has taken place in Germany, Italy and Poland. In all countries, except Norway, Hungary and Luxembourg, citizens have lost part of their trust in science. The survey also showed that in a knowledge-intensive country as Finland, 20% of the respondents disagreed with the statement of optimism towards science and technology.

Table N.P.3.1 Trust in science and technology in European countries, 2005-2010

QC6.1 I would like to read out some statements that people have made about science, technology or the environment. For each statement, please tell me how much you agree or disagree. Science and technology make our lives healthier, easier and more comfortable.

	% Totally agree + Tend to agree		
	2010 (1)	2005 (2)	Difference
EU	66%	78%	-12
Luxembourg	75%	73%	2
Spain	72%	73%	-1
Denmark	70%	73%	-3
United Kingdom	76%	79%	-3
Greece	63%	67%	-4
Slovenia	62%	66%	-4
Netherlands	65%	70%	-5
Bulgaria	63%	68%	-5
Czech Republic	63%	69%	-6
France	66%	73%	-7
Ireland	70%	77%	-7
Austria	64%	71%	-7
Latvia	62%	71%	-9
Malta	78%	87%	-9
Belgium	67%	77%	-10
Finland	67%	77%	-10
Hungary	69%	79%	-10
Sweden	69%	81%	-12
Cyprus	69%	81%	-12
Estonia	72%	86%	-14
Poland	69%	83%	-14
Romania	64%	78%	-14
Lithuania	68%	83%	-15
Slovakia	59%	74%	-15
Portugal	61%	77%	-16
Italy	59%	76%	-17
Germany	57%	86%	-29
Croatia	74%	71%	3
Turkey	71%	74%	-3
Iceland	77%	81%	-4
Norway	75%	73%	2
Switzerland	70%	82%	-12

Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 340 "European, Science and Technology" (2010)
Notes: (1) Eurobarometer 73.1
(2) Eurobarometer 63.1

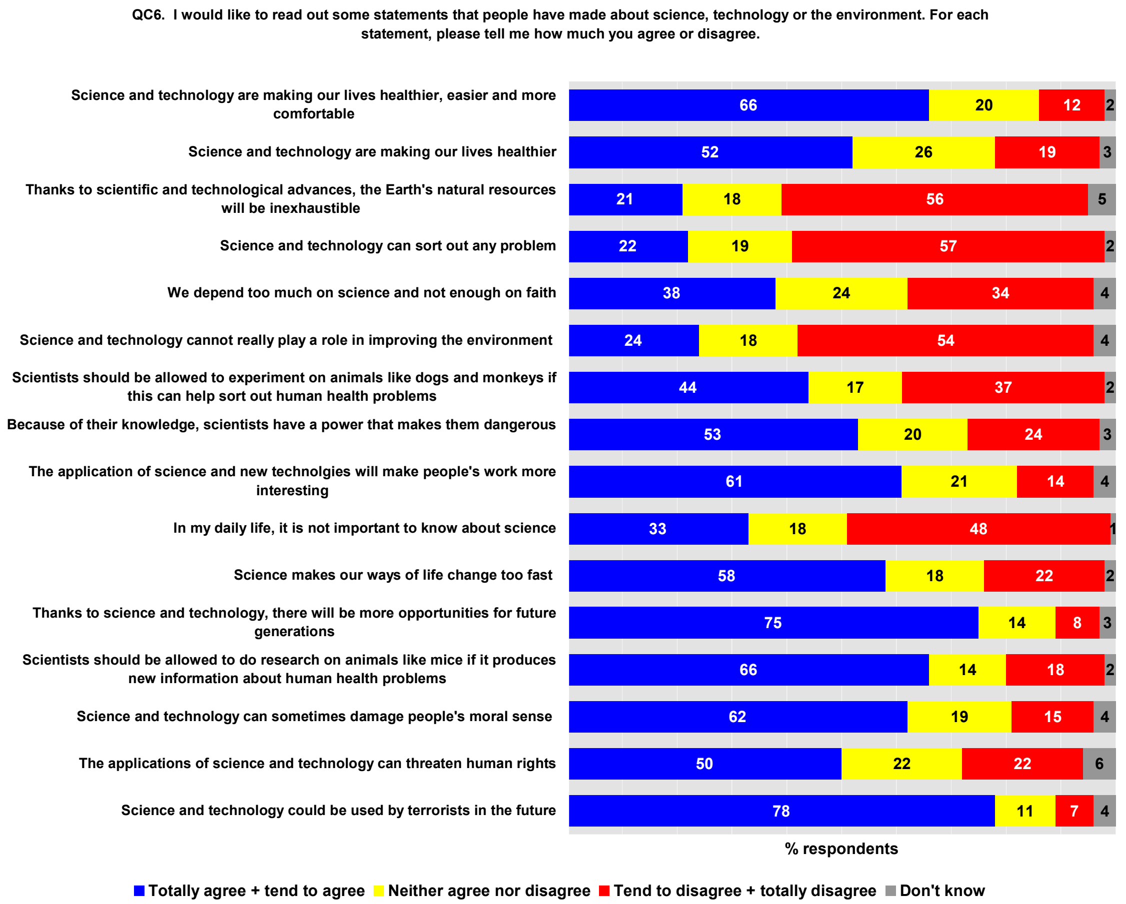
Overall, EU citizens have become sensitive and sceptical to specific dimensions of science and technology

Figure N.P.3.2. presents the average responses for the 27 EU Member States to a series of questions concerning attitudes towards science and technology. It shows that EU citizens feel strongly that science could be used by terrorists in the future, with 78 % in agreement and only 7 % in disagreement. However, EU citizens are positive about science providing more opportunities, with 75 % in agreement with this. The majority also feel that science is making our lives healthier, easier and more comfortable (66 %). It should be noted that only half of the respondents were presented with this statement whereas the other half was only asked whether science and technology is making our lives healthier. It is interesting that this latter statement obtains a lower level of agreement (52 %) which indicates that there is more doubt about the effect of science on health alone, but when considered in the context of making life easier and more comfortable, people are much more positive about the effect of science. Finally, a large majority of respondents (61 %) agree that the application of science and new technologies will make people's work more interesting.

The results also indicate some reservations about science. Two out of three (66 %) Europeans feel that experimentation using mice is acceptable only if this leads to improvement in health and well-being. However, when asked if scientists should be allowed to experiment on animals like dogs and monkeys if this can help sort out human health problems, only 44 % of respondents at EU-27 level agree while 37 % disagree. There is also a tendency to feel that science can sometimes damage people's moral sense, as 62 % of Europeans agree. Close to 6 out of 10 Europeans (58 %) feel that science makes our daily life change too quickly and 53 % feel that scientists can be too powerful and potentially dangerous.

Europeans on the whole believe that science will help, but cannot solve every problem. A slim majority of 54 % believe that science can sort all environmental problems, but very few, 22 %, agree that science can solve any problem and only 21 % believe that science will lead to the world's natural resources being inexhaustible.

Figure N.P.3.2 Optimisms and attitudes towards science and technology



Source: DG Research and Innovation
Data: Special Eurobarometer 340 (2010)

Innovation Union Competitiveness Report 2011

3.2. What is the attitude of Europeans towards individual technologies?

EU citizens have high trust in ICT, solar and wind energy, brain and cognitive enhancements, while expressing more reservations on biotechnology and technologies for nuclear energy

When analysing public opinion in science and technology, it is important to differentiate between different technologies, because attitudes can vary considerably according to the technology or scientific issue in question. Figure N.P.3.3. reports optimism for a number of technologies: ICT, solar and wind energy, mobile phones, biotechnology and genetic engineering, space exploration, nanotechnology and nuclear energy.

Data from the recent Special Eurobarometer 341 (2010) tell us that a majority of Europeans are optimistic about biotechnology and genetic engineering. In comparison, they are more optimistic about brain and cognitive enhancement, computers and information technology, wind energy and solar energy, but are less optimistic about space exploration, nanotechnology and nuclear energy.

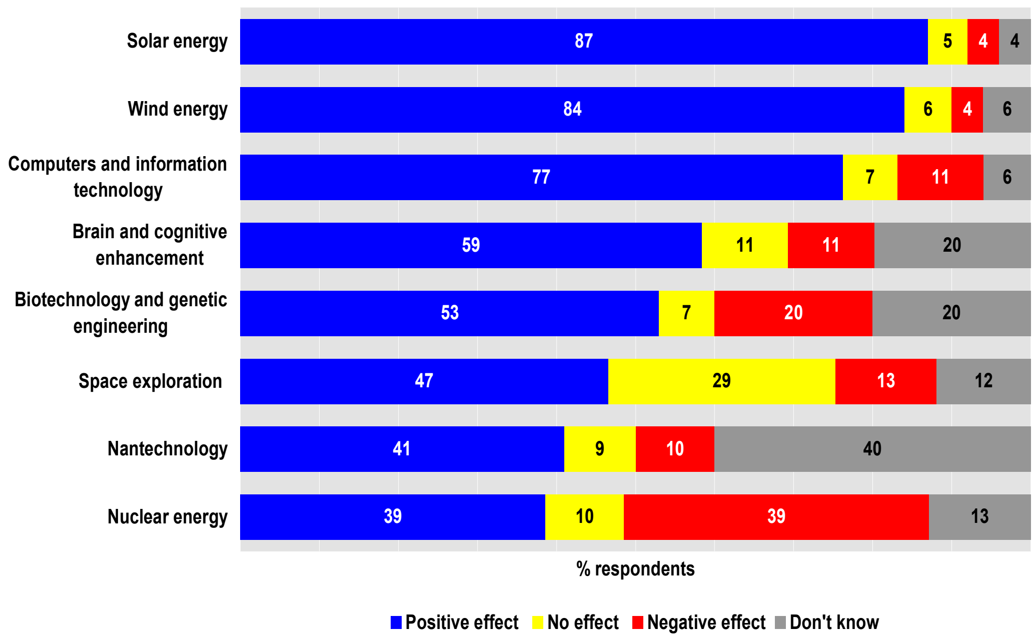
In the case of biotechnology, 53 % are optimistic and 20 % are pessimistic and the comparable figures for nuclear power are 39 % optimistic and 39 % pessimistic. Remarkably, biotechnology still elicits a rather high percentage of 'don't know' response, similarly to 2005[14]. For information technology, 77 % are optimistic and 11 % are pessimistic.

Nanotechnology is viewed rather optimistically (41 %) although there's a small minority of pessimists (10 %). However, on account of its novelty, the percentage of 'don't know' responses for nanotechnology is above 40 % — very similar to the data obtained in 2005[15].

Brain and cognitive enhancement is still relatively unfamiliar to many of the public (20 % give a 'don't know' response). However those who had an opinion were largely optimistic, with optimists outnumbering pessimists by a ratio of 5 to 1.

As shown by previous data collections, nuclear power is the most controversial in the opinions of respondents. However, compared to the data of 2005[16], optimists and pessimists have both increased, reaching the same percentage, 39 %, and with a decrease in 'no effect' responses.

Figure N.P.3.3 EU citizens' trust in individual technologies



Source: DG Research and Innovation

Data: Special Eurobarometer 341 "Biotechnology" (2010)

Innovation Union Competitiveness Report 2011

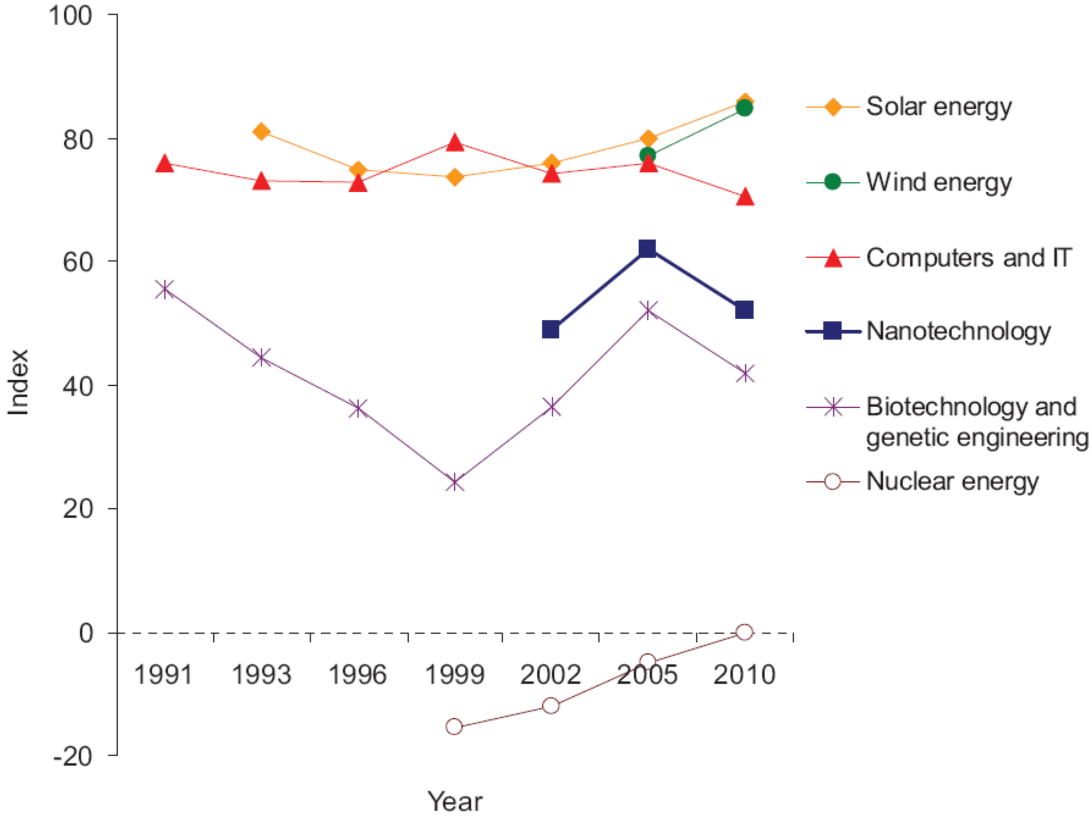
[14] Special Eurobarometer 244b 'Europeans and Biotechnology' (2005).
[15] Ibidem above.
[16] Ibidem above.

Levels of optimism about computers and information technology and solar energy have been high and stable over the period. By contrast, optimism in biotechnology, which declined steadily over the period 1991–99, rose considerably between 1999 and 2002 but from 2005 onwards, is in decline.

The trends in the index of optimism (Figure N.P.3.4.) show some interesting trajectories. The first result is that, for all of the energy technologies — wind and solar energy and nuclear power — an upward trend is seen. Supporters of solar energy tend to be also supporters of wind energy while they are divided between optimists (46 %) and pessimists on nuclear power (42 %).

Secondly, a recent noticeable trend is that of declining optimism in biotechnology, nanotechnology and computer and information technology. While computer and information technology has been consistently at around 80 % on the index, there was a small decline in the period 2005–2010. While both biotechnology and nanotechnology had been on an upward trend since 1999 and 2002 respectively, in 2010 there is a similar decline in optimism. For both nanotechnology and biotechnology, supporters remained the same, but pessimists made a slight increase, gained from those who previously opted for the ‘no difference’ option.

Figure N.P.3.4. Optimism in individual technologies, evolution 1991–2005



Source: DG Research and Innovation
Data: Special Euro barometer 341 'Biotechnology' (2010)

Overall, from the data available, there are no large differences between Europe, United States and Canada, with exception of nuclear technology, which is more acceptable in United States than in Europe and Canada, and a slightly higher optimism on genetically modified Food in the United States than in Europe

Europe and the United States are different in many social and economic dimensions and therefore it is valuable to explore what might be the differences in terms of public support and optimism in science and new technologies. Data on such comparisons are scarce and have not been updated. Nevertheless, in the past ten years some data are available from different cross-national surveys.

For example, results from the Special Eurobarometer 244b summarised in Table N.P.3.2. shows that, apart from nuclear energy, Europeans are more or less as optimistic about computers and IT, biotechnology and nanotechnology as citizens of United States and Canada (on average). Europe does not appear to be particularly hostile. However, nuclear energy is an interesting case. On the one hand, it attracts the least optimism of any of the four technologies considered. And on the other hand, Europeans are somewhat less optimistic, on average (37%), than Canadians, and considerably less optimistic (46%) than citizens of US (59%). This is in line with previous findings from the relevant scientific literature[17].

[17] For example, Gaskell, G., T Ten Eyck, J Jackson, G. Veltri. (2005). Imagining nanotechnology: cultural support for technological innovation in Europe and the United States. *Public Understanding of Science*, *14*(1), 81-90.

Table N.P.3.2 Optimism in new technologies in the United States, Europe and Canada

Do you think each of the following technologies will improve our way of life in the next 20 years.	% Europe	% United States	% Canada
Computers and IT	82	86	83
Biotechnology	75	78	75
Nanotechnology	70	71	68
Nuclear Energy	37	59	46

Source: DG Research and Innovation Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 244 "Europeans and Biotechnology" (2006)

On genetically modified (GM) food, Europeans and Canadians have rather similar views on average. The only difference to note is that the Canadians see GM food as slightly more morally acceptable as do Europeans. People in United States see GM food as being more useful for society, less risky, more morally acceptable, and have somewhat more confidence in its regulation.

Table N.P.3.3 Perception of GM Food and Nanotechnology

	Europe	United States	Canada
GM Food			
Useful for society	4,55	5,15	4,42
Risky	6,11	5,3	6,08
Morally acceptable	4,59	6,22	5,44
Confidence in current regulatory arrangements	3,85	4,25	3,85
Nanotechnology			
Useful for society	7,19	6,8	6,73
Risky	4,23	4,28	4,66
Morally acceptable	7,07	7,08	6,59
Confidence in current regulatory arrangements	5,29	4,83	4,69

Source: DG Research and Innovation Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 244b "Europeans and Biotechnology" (2006)

From the scientific literature, Scheufele, Corley et al. (2009) also found differences between the United States and Europe which focus on the impact of religious beliefs on attitudes to nanotechnology. They found that American citizens were significantly less likely to consider nanotechnology as morally acceptable as were Europeans. Another recent study by Vandermoere and Blanchemanche et al. (2010) reaffirms the diversity between the United States and Europe, studying the impact of religious and moral beliefs on the acceptance of nanotechnology food applications. Their study shows that religiosity has no or only a marginally significant effect on people's attitudes toward nanotechnology in Germany, contrary to Scheufele, Corley et al. (2009). Instead, for German respondents, moral covariants other than religion were negatively correlated to acceptance of nanotechnology's food applications.

In 2010, 54% of respondents at the EU level consider that science and technology play a real role in improving the environment — a slight increase compared to 2005

Climate change is at the centre of political, societal and economic debate in Europe, and confidence in technology related to this issue is a key factor for consideration. A majority of Europeans are of the view that science and technology can play a role in improving the environment. The survey shows that 54% of respondents disagree with the statement that science and technology cannot play a role in improving the environment. Only 24% at the EU-27 level agree that science cannot play a role.

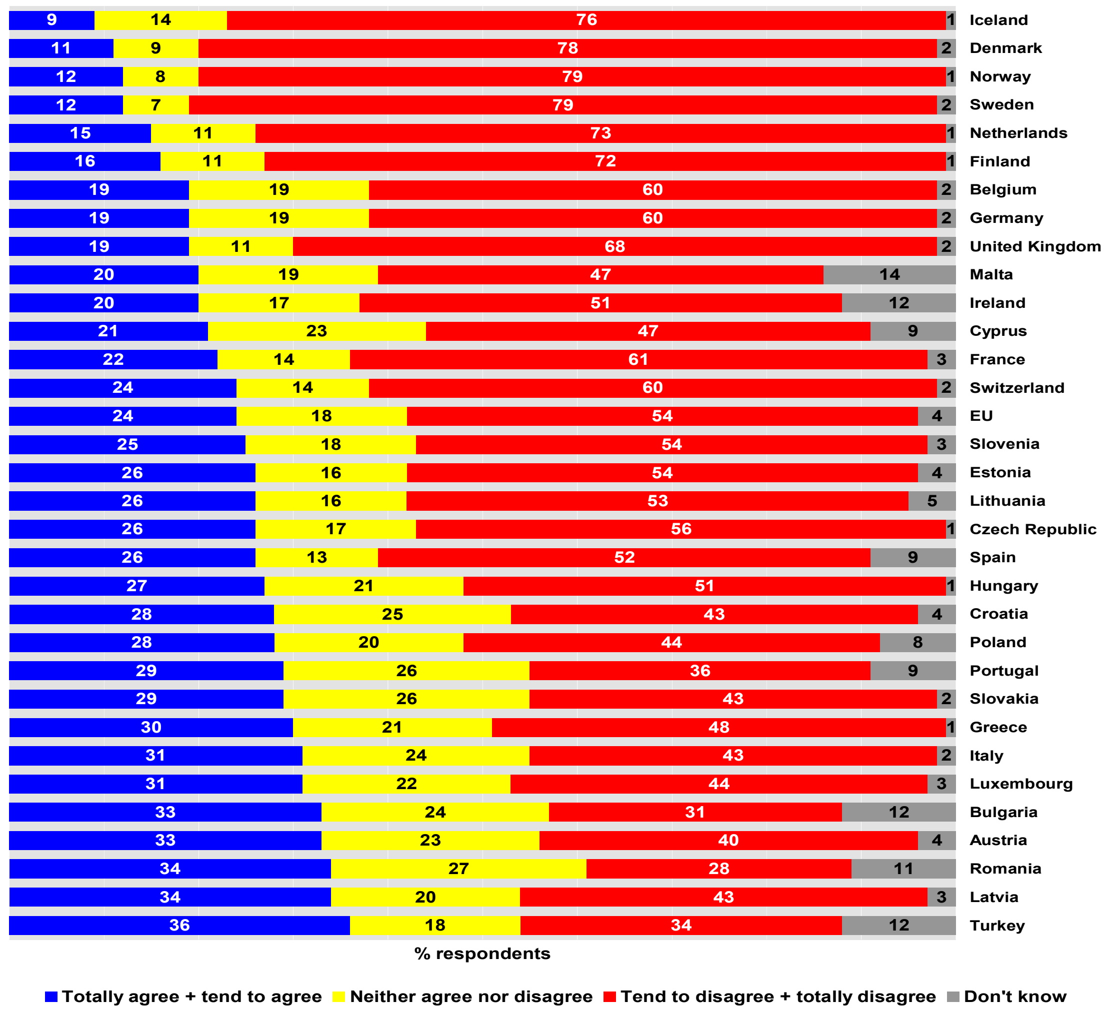
Figure N.P. 3.5. shows large differences between countries, with Northern Europeans most inclined to find that science and technology can play a role in improving the environment. In both Sweden and Norway around 8 in 10 respondents (79%) disagree with the statement that science cannot play a role in improving the environment. Five further countries showed more than two thirds of respondents who disagree: Denmark at 78%, Iceland at 76%, the Netherlands at 73%, Finland at 72% and the United Kingdom at 68%. At the other end of the scale, Romanians express the lowest level of belief that science can help in environmental improvements: only 28% of respondents disagree with the statement and 34% of respondents agree.

Results for a similar statement in 1992 show that this rate of disagreement was higher at the time (60%). Those who believe most in the positive role of science in the environment are found in Denmark and Norway, where respectively 71% and 70% of citizens disagree with this statement. Citizens in Sweden (66%), Finland (65%), Belgium (65%), the United Kingdom (63%), the Netherlands (63%) and the Czech Republic (61%) also have disagreement rates above the 60% mark. Men, younger populations and the most educated have the highest rates of agreement (i.e. a low level of trust).

Figure N.P.3.5 Trust in science and technologies for improving the environment

QC6.6 I would like to read out statement that people have made about science, technology or the environment. Please tell me how much you agree or disagree.

Science and technology cannot really play a role in improving the environment.



Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 340 "Europeans, science and Technology" (2010)

The same question was present in the 2005 Eurobarometer 224 survey on Science and Technology, where 50 % of the EU respondents expressed trust that science and technologies would improve the environment. There is a slight shift towards disagreement with the statement, suggesting a more positive overall view of the role science and technology in environmental issues.

Seven countries show the opposite trend. In Belgium the 65 % of respondents who disagreed in 2005 has now fallen to 60 % (-5), Ireland (-8), Malta (-7), the Czech Republic (-5), Portugal (-4) Poland (-3) and Slovenia (-2). This effect is counteracted by some countries that show a major shift towards disagreement: respondents in Iceland rose from 49 % of respondents in 2005 to 76 % of respondents in 2010 (+27) and Spain from 32 % of respondents in 2005 to 52 % of respondents in 2010 (+20) who disagree.

Public trust in biotechnology is in decline

Citizens' attitude towards biotechnology has been the object of much research, particularly in Europe because of the debates and public controversies raised by this technology in the past[18]. Hence, as in the previous section, we consider the level of trust in specific technologies, this time biotechnology and nanotechnology.

Table N.P.3.4. analyses the situation in Europe with country level data.[19] It presents trends of the index of optimism for biotechnology over the period 1991–2010. In all countries, with the exception of Austria, the index has positive values, indicating more optimists than pessimists. But in only three countries (Finland, Greece and Cyprus) do we see an increase in the index from 2005 to 2010. The table also shows little change in optimism over the last five years in Spain, Ireland, the United Kingdom, France and Estonia, and that the non-EU countries Iceland and Norway stand amongst the most optimistic countries. However, in the rest of Europe there is a consistent decline in optimism about biotechnology.

[18] Bauer, M. W., & Gaskell, G. (2002). *Biotechnology: The making of a global controversy*. Cambridge: Cambridge University Press.
[19] The EU-15 countries are ordered from the most to the least optimistic in 2010, followed by the 10 new Member States of 2004, then Romania and Bulgaria and finally Iceland, Norway, Turkey, Switzerland and Croatia (also ordered from most to least optimistic).

Table N.P.3.4 Change in biotechnology's trust surplus deficit, 1999-2010

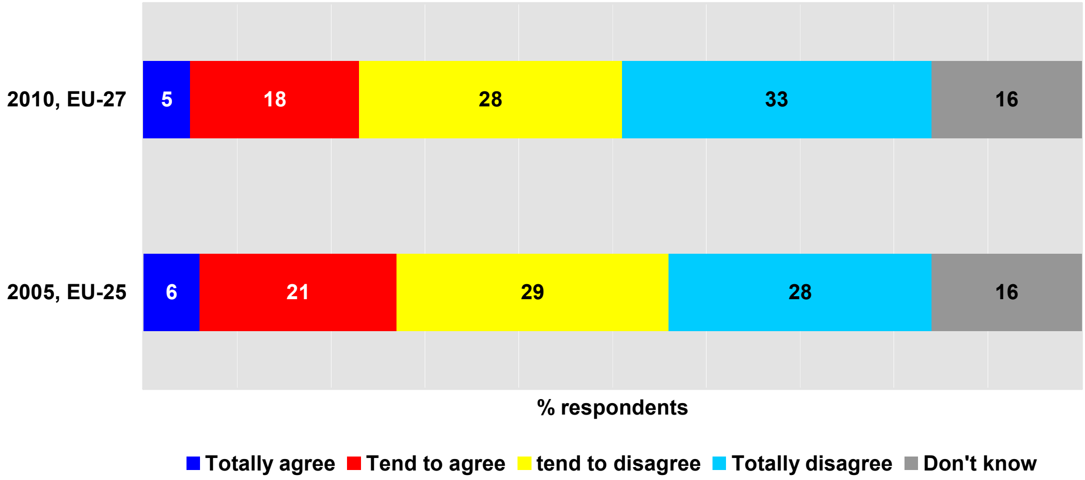
	1991	1993	1996	1999	2002	2005	2010
Spain	82	78	67	61	71	75	74
Sweden			42		61	73	63
Finland			24	13	31	36	59
Portugal	50	77	67	50	57	71	54
Ireland	68	54	40	16	26	53	51
United Kingdom	53	47	26	5	17	50	50
Italy	65	65	54	21	43	65	48
France	56	45	46	25	39	49	46
Denmark	26	28	17	-1	23	56	45
Greece	70	47	22	-33	12	19	35
Belgium	53	42	44	29	40	46	32
Luxembourg	47	37	30	25	29	55	32
Netherlands	38	20	29	39	39	47	31
Germany	42	17	17	23	24	33	12
Austria			-11	2	25	22	-7
Cyprus						74	78
Estonia						79	76
Malta						81	64
Hungary						62	58
Czech Republic						71	53
Slovakia						55	48
Latvia						60	43
Poland						59	41
Slovenia						47	33
Lithuania						66	28
Romania							36
Bulgaria							24
Iceland							79
Norway							70
Turkey							49
Switzerland							32
Croatia							25

Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 341 "Biotechnology" (2010)

EU citizens express a low level of support for GM food, relative to other applications of biotechnology

Figure N.P.3.6. presents the levels of support for GM food for both EU-27 in 2010 and for comparative purposes EU-25 in 2005. In 2010, combining ‘totally agree’ and ‘tend to agree’, we find 27% in support. By the same token, 57% are not willing to support GM food. The comparison between 2010 and 2005 shows no substantial changes in the public’s perception of GM food.

Figure N.P.3.6 Support for GM Food (EU)



Source: DG Research and Innovation

Data: Special Eurobarometer 341 "Biotechnology" (2010)

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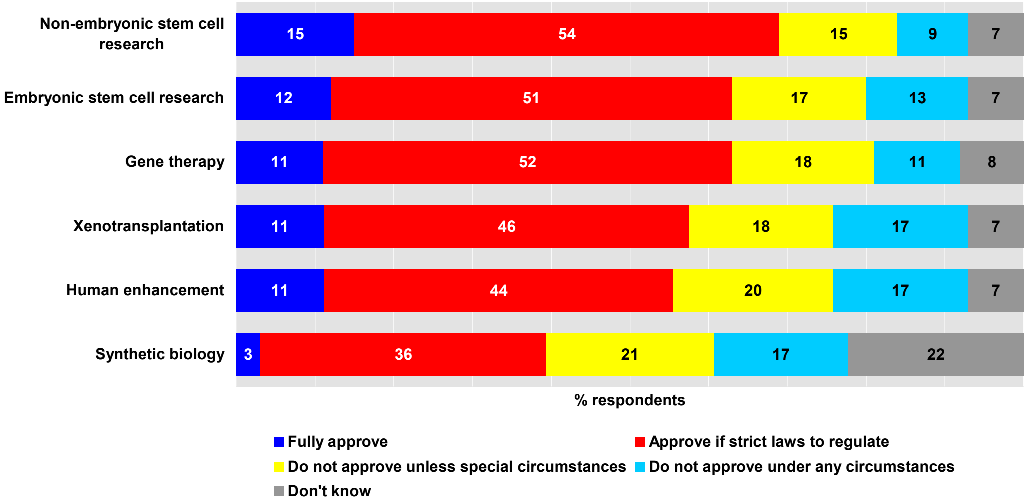
The figure below focuses on biomedical research and presents the overall results for the EU-27 countries as a whole. Some of the applications of this kind of biotechnology are very novel.

In general, levels of approval are rather high. If we combine the two positive statements, some 68 % approve of stem cell research and 63 % approve of embryonic stem-cell research. Levels of approval for gene therapy are similar, at 64 %. In addition, the greater majority of the European public expressed an opinion on regenerative medicine (less than 10 % gave ‘don’t know’ answers). Also, xenotransplantation is now approved by 58 % of respondents. Synthetic biology remains puzzling for European respondents with one quarter of them choosing the ‘don’t know’ option.

Consistently with optimism on brain and cognitive enhancements, as shown in Figure N.P.3.7., there is a clear support for medical applications of biotechnology and those aimed at human improvement (56 % approval).

Figure N.P.3.7 Levels of approval of biomedical research and synthetic biology (EU)



Source: DG Research and Innovation
Data: Special Eurobarometer 341 "Biotechnology" (2010)

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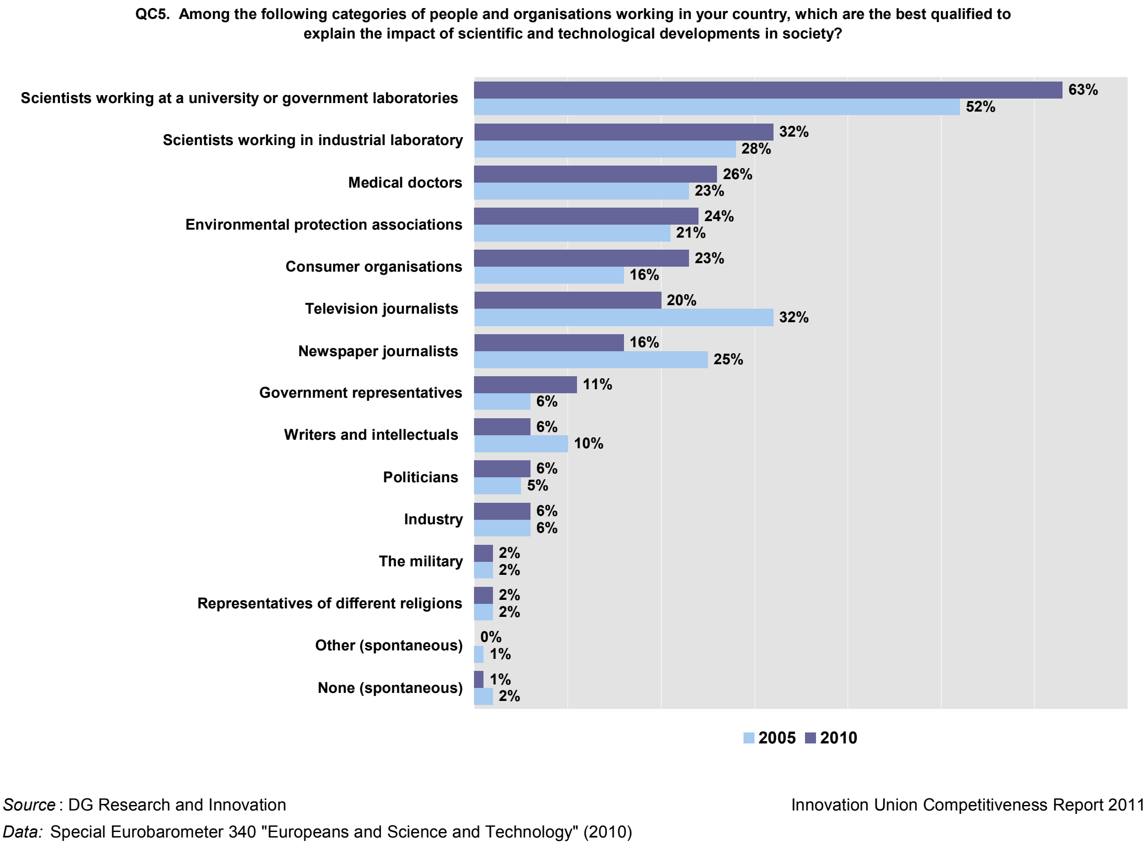
3.3. Which are the key actors and policies for a dialogue between science and society?

The majority of European citizens — 63% of respondents at the EU-27 average — agree that scientists working at a university or government laboratories are best qualified to explain scientific and technological developments

The figure below (figure N.P.3.8.) shows that the given importance of scientists working in universities or government laboratories has increased from 52% of respondents in 2005 at the EU-25 level to 63% of respondents at the EU-27 level in 2010. The trust in newspaper journalists has diminished from 25% in 2005 to 16% in 2010, and television journalists likewise are seen as less trustworthy, declining from 32% in 2005 to 20% 2010, while the perceived quality of information from consumer organisations has increased from 16% in 2005 to 23% in 2010.

Figure N.P.3.8 Most trustworthy actors in science and technology



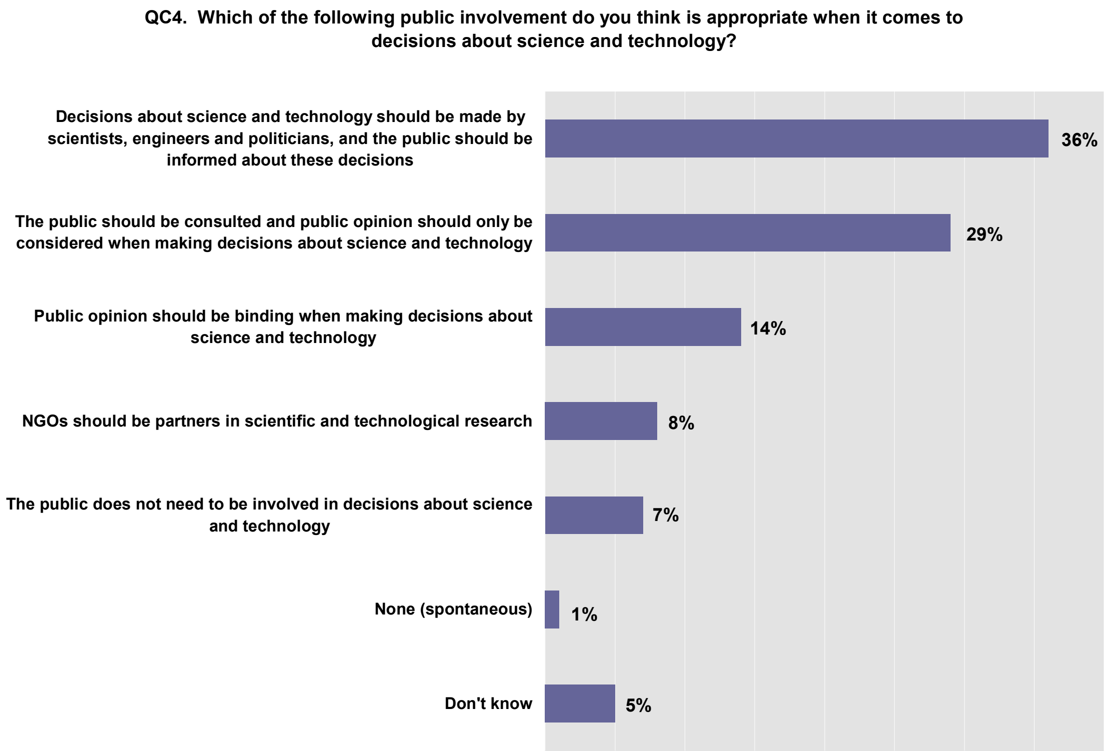
Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 340 "Europeans and Science and Technology" (2010)

Europeans feel most strongly that decisions about science and technology should be made by scientists, engineers and politicians, and the public should be informed about these decisions

The way policy decisions about science and technology are taken is also very important in determining the general attitudes of citizens towards these issues. Figure N.P.3.9. presents some evidence on public opinion in Europe. Respondents are asked to indicate their level of agreement to five statements about public involvement[20]. The relative majority of European citizens (38%) consider it appropriate that decisions should be made by experts and politicians and the public informed. However, an important minority (29%) wants a more participatory approach in which the public is consulted and taken into account when decisions are needed. The third minority of citizens by size (14%) consider public opinion's approval as a necessary condition for any decisions on science and technology.

[20] The public does not need to be involved in decisions about science and technology; decisions about science and technology should be made by scientists, engineers and politicians, and the public should be informed about these decisions; the public should be consulted and public opinion should only be considered when making decisions about science and technology; public opinion should be binding when making decisions about science and technology; NGOs should be partners in scientific and technological research.

Figure N.P.3.9 Europeans' opinions on decision-making in science and technology



Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 340 "Europeans and Science and Technology" (2010)

Citizens in Finland, Denmark and Germany are relatively more in favour of increased use of public consultation on science and technology decisions

The table below shows that in some European countries respondents are more in favour of the second statement: in Finland at 47 %, Denmark at 45 % and Germany at 43 % respondents are more in favour of more consultations with the public about science issues. There are four countries where half or more of respondents agree that decisions about science and technology should be made by scientists, engineers and politicians, and the public should be informed about these decisions, with Cyprus at 57 % of respondents, Norway at 54 % of respondents, Greece at 53 % of respondents and Slovakia at 50 % of respondents.

Table N.P.3.5. Opinion in European countries on decision-making in S&T

QC4. Which of the following public involvement do you think is appropriate when it comes to decisions about science and technology?

	Decisions about science and technology should be made by scientists, engineers and politicians, and the public should be informed about these decisions	The public should be consulted and public opinion should only be considered when making decisions about science and technology	Public opinion should be binding when making decisions about science and technology	NGOs should be partners in scientific and technological research	The public does not need to be involved in decisions about science and technology	None (spontaneous)	Don't know
EU	36%	29%	14%	8%	*7%*	1%	5%
Belgium	**35%**	31%	11%	*7%*	11%	4%	1%
Bulgaria	**44%**	23%	16%	*3%*	7%	-	7%
Czech Republic	**47%**	19%	14%	9%	*8%*	1%	2%
Denmark	36%	**45%**	7%	6%	*4%*	-	2%
Germany	29%	**43%**	10%	9%	*5%*	1%	3%
Estonia	**43%**	20%	16%	8%	*7%*	1%	5%
Ireland	**43%**	29%	9%	*2%*	7%	1%	9%
Greece	**53%**	23%	16%	*3%*	4%	-	1%
Spain	**40%**	19%	17%	9%	*6%*	2%	7%
France	27%	**36%**	16%	9%	*6%*	1%	5%
Italy	**41%**	19%	17%	8%	*7%*	3%	5%
Cyprus	**57%**	23%	10%	2%	3%	-	5%
Latvia	**45%**	25%	12%	4%	8%	2%	4%
Lithuania	**39%**	20%	21%	5%	7%	2%	6%
Luxembourg	**37%**	36%	12%	5%	7%	1%	2%
Hungary	**43%**	25%	18%	4%	7%	1%	29%
Malta	**42%**	32%	8%	4%	6%	-	8%
Netherlands	**47%**	35%	5%	6%	*4%*	1%	2%
Austria	31%	**34%**	13%	12%	*6%*	1%	3%
Poland	**29%**	24%	15%	*9%*	11%	1%	11%
Portugal	**33%**	20%	14%	*9%*	12%	2%	10%
Romania	**43%**	19%	9%	*3%*	9%	2%	15%
Slovenia	**39%**	24%	15%	9%	*8%*	2%	3%
Slovakia	**50%**	14%	14%	11%	*8%*	-	3%
Finland	32%	**47%**	*6%*	8%	6%	-	1%
Sweden	**48%**	31%	*3%*	10%	4%	1%	3%
United Kingdom	**32%**	**32%**	15%	7%	*6%*	1%	7%
Croatia	**46%**	23%	13%	*5%*	6%	1%	6%
Turkey	**42%**	23%	8%	*4%*	11%	2%	10%
Iceland	**43%**	27%	*3%*	15%	7%	3%	2%
Norway	**54%**	26%	5%	7%	*4%*	1%	3%
Switzerland	28%	**39%**	13%	8%	6%	3%	3%

Source: DG Research and Innovation — Innovation Union Competitiveness Report 2011
Data: Special Eurobarometer 340 "Europeans and Science and Technology" (2010)
Note: In bold, the highest results per country, in italics the lowest results per country; the grey rectangle shows the highest results per value; the rectangle with black borders shows the lowest results per value.

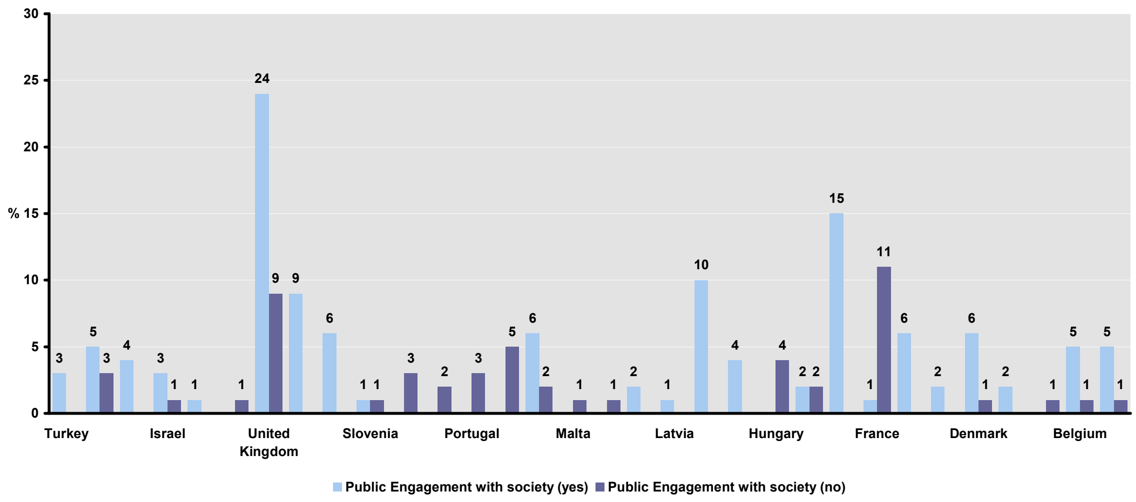
The large majority of European research-active universities surveyed have strategies of public engagement with society, although there is a diversity of aims: from increasing youth involvement, to scientific disciplines to help evaluate socio-economic impacts.

It is important to assess the role of universities in diffusing science to the public at large, considering that they are among the most trusted scientific actors according to the European public opinion (a majority of European citizens — 52% — trust scientists working at a university or a governmental laboratory). The recent collection of data about research universities of the 'European Observatory of Research-Active Universities and National Public Research Funding Agencies' by JRC IPTS provides some insights.

The observatory sample shows that a solid majority, 64% of the research-active universities do have a strategy of public engagement with the public (35% do not have one). It is necessary to clarify that the absence of a strategy does not mean that a university is not involved in public engagement activities organised by third parties (for example a regional government).

The figure below summarises this data, disaggregated per country, from which we can notice that many Eastern European countries (Slovakia, Romania, Poland and Croatia) and Portugal, Malta and Luxembourg have no PES strategy. In all other countries the majority of the universities sampled had a strategy of public engagement, with the exceptions of Slovenia and Greece. Considering the relative novelty of such policy, it is quite remarkable that two thirds of the universities in the sample did have an explicit strategy and therefore commitment on public engagement with society

Figure N.P.3.10 Public engagements with society strategy in sample of European research intensive universities



Source: DG Research and Innovation
Data: JRC-IPTS, 2010

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National policies for public engagement in science focus on mobilising funds, human resources and public trust building

The analysis of the rationales of recent national policies of public engagement helped to identify three main recurrent orientations. The first theme is the need to justify the allocation of public resources through a showcase of the benefits of investing in science and technology. Examples are the recent policies adopted by Italy, Greece, Slovakia, Germany, Latvia and Spain.

The second theme is the aim of increasing the appeal of science and technology disciplines to youngsters in order to increase the ranks. Examples are the policy initiatives in Austria, the Czech Republic, Slovakia, Poland and Estonia. Public engagement is directed to a specific target group — youths — with the aim of increasing science and technology disciplines. The third rationale is to increase public trust in science by evaluating the social impact of science and technology and involving the public at large in dialogue. This is well-developed in the United Kingdom, Denmark and partially France.

Public events where scientists and the general public can meet are to be a prominent tool in most Member States. The role of the scientists is to explain scientific and technological issues and to show the utility and future applications of their current research. The public has an opportunity to clear their minds, to clarify doubts and in general to gain knowledge on scientific and technological topics. Such events might go under different names such as 'Science Fairs', 'Open Science Week' or 'Science Days'. Such events of direct communication are now widely adopted across Europe, with an explicit policy strategy in Italy, Latvia, Germany, United Kingdom, Slovakia, Poland and Spain.

In addition, there are events specially targeting youngsters with the aim of increasing the appeal of studying scientific disciplines. This is the case for Italy, the Czech Republic, Austria, Germany, Poland, the United Kingdom, Turkey and Estonia, where there is a special interest in motivating youngsters to enrol in studying scientific disciplines.

Austria
The three ministries in charge of R&D are the main financers of such activities. The main concern of R&D policy addressing the public is to enhance the general public understanding of science and technology (S&T) and thus to gain acceptance for the allocation of (more) public funds to R&D. Another important aim is the motivation of more young people to decide on a research career, especially in natural sciences and engineering. Indeed, it is expected that the gap in engineering and R&D skills may even widen in the coming years.

Spain
The Spanish Foundation for Science and Technology (FECYT) is a non-profit organisation (created by the government in 2001) that works as a multidisciplinary and inter-sectoral platform bringing together stakeholders from the scientific, technological and business fields, including the Conference of Spanish Universities' Chancellors (CRUE), the CSIC, entrepreneurial associations and the main innovating companies. They meet because one of the strategic objectives of FECYT is to promote the dissemination of scientific knowledge so as to inform society of the results of R&D and create public awareness of the role of science. It also sets out to promote activities which producers of science and technology may carry out

to make their achievements known to society through Science Fairs and Science Weeks held annually (for example the Madrid Science Fair).

With respect to the third rationale of enhancing the trust of a country in science, specific tools are mobilised, such as science museums, which are designed to have a pedagogical role, to reassure the public of the utility and goodness of science and to provide correct factual knowledge to avoid misunderstanding that might lead to hostility. Another approach specifically aims at public consultation and public dialogue events, and it consists of a wider array of instruments. In this case, there is a clear mandate of investigating the social impact of scientific and technological issues, and therefore a large collection of 'tools' are used such as public hearings, foresight studies, public consultations and assessments, surveys, sponsoring social sciences studies and public consultations and events of public dialogues.

United Kingdom

In the United Kingdom there are specific and dedicated institutional actors such as 'The Sciencewise Expert Resource Centre for Public Dialogue In Science and Innovation' (ERC) which is funded by the Department for Business Innovation & Skills (BIS). In 2004, the Sciencewise programme was established to help policymakers find out the public's views before major policy decisions are made, a process known as 'upstream' engagement. In 2006, following a number of successful projects supported by Sciencewise, the high-level Council for Science and Technology recommended that public dialogue should be firmly embedded into Government policy-making processes. In 2007, the current Sciencewise-ERC was established

Within the domain of the participatory approach, an example is the well-studied case of GM Nation in a 2003 national debate on agricultural biotechnology that included preliminary discussion workshops with demographically selected members of the public to determine the stimulus material later used in open meetings. These meetings included expert presence and debates around a motion.

Denmark

The Danish Board of Technology has, over a number of years, harvested experiences at a series of 'conferences', making it possible to include the public and their experiences in the technology assessment. This is the 'Consensus Conference' which gives citizens — lay people — the opportunity to assess a given technological development and make up their minds about its possibilities and consequences.

The conference is open to the public and is conducted as a dialogue between experts and lay people over three days. The final document is passed on to the members of Parliament. Bridging the gap between the public, experts and politicians is thus an important aim of the Consensus Conferences held by the Board.

The role of the experts is to inform a panel of citizens about the technology and its implications. On several occasions the Consensus Conferences have caused political debate and the initiation of new regulation.