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Even if Europe invests in research and increases the efficiency of its public research system and of its interaction with private research, the benefits of these efforts will not be reaped if the private research system itself does not find the right conditions that will maximise its return on investment and create the conditions for a structural change towards a more knowledge-intensive, smart and efficient economy, able to respond to citizens’ needs as well as to international competition. This is the perspective of part III, which places some key data related to innovation and entrepreneurship in a research perspective.
CHAPTER 1

Fast-growing innovative firms

HIGHLIGHTS

The emergence and growth of innovative and knowledge-intensive firms is crucial for structural change. At EU level, the births and deaths of companies show a dynamic panorama, more stable in the larger member states, like the United Kingdom, France or Germany, and with higher degree of change in smaller countries. In the United States firm-creation remains stable, and at a higher level than in the EU. In the United States and even more so in the newly emerging Asian economies, young, leading innovative firms are more numerous, especially in high-tech sectors, and they grow faster than in Europe.

Innovative small and medium-sized enterprises spend their resources differently depending on the home-country context. In the more knowledge-intensive economies, SMEs can spend ten times more on innovation than their counterparts in less developed countries. Concerning patenting activities, young firms less than five years old are active, and here Denmark and Norway have a higher patent intensity than the United States. Evidence shows that because of the high costs of patents (which vary from country to country) the SMEs which tend to patent are mainly above a certain threshold of size. However, above a certain number of employees (e.g. 250) size becomes less relevant as a differentiating factor.

Internationalisation activities have proven to be a path to growth and increased competitiveness for the European SMEs. Evidence shows that European firms are more internationally active when compared with firms in the United States and Japan. Size matters for SMEs: the larger the company is, the more international it tends to be.

1.1. Are European SMEs increasing their research and innovation?

This section focuses on innovative small and medium-sized enterprises as a key source of structural change in the economy. They represent the biggest share of employment and it has been shown that young and dynamic firms have a positive impact on the evolution towards a more knowledge-based economy.

Compared to the United States, Europe’s industrial tissue is dominated by well-established companies that have conquered their specific markets, which they try to expand or diversify. Globalisation and world competition are a permanent challenge, and so far large EU companies are doing well and even surpassing their US competitors. One of the characteristics of large EU firms is that they are generally much older and, as they have not been constantly challenged by emerging and growing competitors as in the US economy, they have undergone fewer changes. But it is the young, innovative and dynamic companies that are considered the motors of growth and that potentially bring about structural change. Creativity and entrepreneurship are key elements which occur more frequently in the United States than in Europe. Fast-growing dynamic firms are also associated with other successful and emerging economies, where they constitute one of the main reasons for the success, especially when they are active in knowledge-intensive sectors.

In this chapter we will analyse the degree of research intensity in SMEs and their contribution for the overall BERD as a key indicator for growth. In complement, there is an overview on how SMEs engage themselves in innovative activities (such as patenting, for example) and how they invest their resources to keep competitive and to enlarge their knowledge and markets through internationalisation. Finally, the chapter provides an overview of company dynamics with a special attention to fast-growing companies.
The highest research-intensity in SMEs is found in Switzerland and Denmark

The research-intensity of the SMEs is an essential indicator to understand their potential for growth and impact on the knowledge economy. Many new technologies are adopted and developed into disruptive innovations in the shape of new products and services by dynamic, research-intensive, fast-growing SMEs. The world of ICT provides multiple examples, such as Apple, Microsoft or Facebook in the United States, or Skype in the EU.

In this context, the EU is relatively well placed, only slightly below the levels of the United States and above those of Japan (Figure III.1.1). However, very dynamic economies such as South Korea, the Nordic countries or Belgium, Austria and Switzerland, have much higher levels of business research investments than the EU average or even the United States.

**FIGURE III.1.1 BERD performed by SMEs as % of GDP, 2008**(1)

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Source: DG Research and Innovation
Data: Eurostat
Notes:
(2) EU does not include IE, EL.
(3) US: BERD does not include most or all capital expenditure.
(4) JP: BERD by size class is underestimated.
Policy mixes addressing science–industry linkages and the commercialisation of public research results have been at the centre of policy development in recent years in Denmark. Since 2000 there has been an increase of the number of ‘gazelle’ Danish enterprises (those less than five years old), probably as a consequence of the respective policy measures, but this development was also supported by the favourable economic situation of mid-2000s. Since the newly introduced policy measures are not supported by large budgets and the economic situation is more difficult, it remains to be seen if the R&D intensity of SMEs and the R&D intensity of the business sector in general can continue the positive trend. This includes, as will be presented in this chapter, very dynamic patenting activity from the young Danish SMEs, ahead of similar activity in the United States.

Though R&D investments are still concentrated in the largest companies, as in most other European countries, the share of R&D expenditures by SMEs in Denmark is quite high: 32% of R&D expenditure in 2007 came from SMEs (with 1–249 employees) in Denmark. Manufacture of pharmaceuticals and medicinal chemistries, software consultancy and supply are the largest sectors regarding intramural R&D expenditures.

In the EU, a slightly higher share of BERD is performed by SMEs in comparison to the United States, and this share is also higher still than that of Japan

Small and medium-size firms perform a higher share of business R&D in the EU than in the United States and Japan, as shown in figure III.1.2. In the EU, the share of BERD performed by SMEs amounts to 19.4% compared with 15.7% and 6.4% respectively for the United States and Japan. South Korea is above the EU with a share of 22.8%.

Though there are some exceptions, usually the higher participation of SMEs in business R&D is associated with lower R&D intensities of the country, as, for example, in the case of the EU-12 Member States, smaller countries, and also for Spain, Greece, Ireland and Portugal. The EU countries where SMEs only account for around a quarter or less of BERD, like France, the United Kingdom, Germany, Sweden or Finland, are countries at the top of both rankings of business R&D intensity and innovation performances, and they host many of the large R&D investors and MNEs. Denmark, Belgium and Norway are the exceptions — here, a higher share of BERD performed by SMEs goes hand-in-hand with the active presence of SMEs in research in high and medium high-tech sectors (figure III.1.2 and figure III.1.1). Europe needs an increased contribution to the overall economy of technology-based companies in sectors of high R&D intensity, to counterbalance its structural composition.
**SMEs in more advanced economies invest more heavily in the production and acquisition of new knowledge. SMEs in less developed economies invest more in the acquisition of machinery**

Part II chapter 2 presented the different partners required for the collaboration of innovative firms. In spite of the different situations across countries, in general, suppliers of equipment were considered the most important collaboration partners and also one of the most important sources for new knowledge. Consequently, it is relevant to analyze how innovative SMEs spend their resources, as shown in figure III.1.3. In the EU-12 Member States, and in general in countries with a lower R&D intensity (like Portugal and Italy) SMEs dedicate over 60% of their innovation expenditure to machinery, equipment and software. Spain presents a special situation, where machinery, equipment and software correspond only to 35% of the innovation expenditure compared with 53% for intramural R&D - values very similar to those registered for France. The Netherlands also present a large share of innovation expenditure dedicated to R&D, at 47%, but with the particular characteristic that only 26% is intramural and the other 21% performed extramural. SMEs in Germany, though investing the same 47% in research, give preference to intramural R&D with a share of 40%. In Belgium, Sweden, Finland and Norway, SMEs dedicate more than 50% of their innovation expenditure to intramural R&D. In fact, in these last two countries total expenditure in R&D passes 72% and 84% of their innovation investments, respectively.

Figure III.1.3. also shows the internal structure of the SMEs in the different countries. SMEs which are in the more research-intensive countries and are better innovation-performers rely more on their internal resources to innovate and are less dependent on external sources.
**Relative to their turnover, companies in knowledge-intensive economies can spend up to ten times more on innovation than their counterparts in less developed countries**

How much of their turnover do companies spend in innovation activities? Data availability does not cover all the EU Member States, but gives a sufficiently diversified panorama within the set of countries shown in figure III.1.4. More knowledge-intensive economies, like Sweden and Finland, invest three times more than other less R&D-intensive and less innovative countries. Estonia and Malta show a very high ratio and Belgium, Romania, France, Latvia and the Netherlands have similar values well above the EU average. Well below the average, are Italy, Lithuania, Portugal, Spain, Slovakia and Luxembourg. These figures, however, have to be interpreted with care as the definition of innovation expenditures (in particular non-R&D innovation expenditures) can still be interpreted very differently by respondents to the Community Innovation Survey. Cross-country comparability is not assured.

These figures should be interpreted together with the data presented in the second chapter of Part III which concerns venture capital and the different policies, framework conditions and public support existing in each EU country. Considering the differences between countries regarding venture capital investment in the early stage (EU-27 average is about 0.2 per thousand GDP compared to the United States with 0.5 per thousand of GDP (figure III.2.4)), innovative companies in Sweden, Finland or Belgium, might more easily invest a bigger share of their turnover in innovation. Another aspect is the patterns of specialisation as shown in chapter 2 of part New Perspectives, where the differences in the economic structure of the EU, the United States and Japan are made visible and compared. In this context, the EU is lagging behind its main competitors in terms of specialisation in high-technology knowledge.

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303 Community Innovation Survey: the innovation activities comprise not only R&D, but also activities such as technology acquisition, training, product design and introduction (know-how and other knowledge is relevant for companies in the high R&D intensity sectors, especially pharmaceuticals & biotechnology and healthcare equipment).
Enterprises with innovation activities – Innovation expenditure as % of turnover, 2006-2008

Young firms (less than five years old) are active in patenting, with Denmark and Norway ahead of the United States

Young firms that want to protect their innovations face several barriers, most of them linked to the size of the company. Framework conditions, access to venture capital and the high costs involved are aspects affecting the act of patenting. Very different situations can be observed when comparing European countries. Figure III.1.5. (left panel) shows the share of young firms that filed a PCT application(s) with priority date in 2005–2007: the highest share of (PCT) patenting young firms is to be found in Denmark and Norway, (36.2 % and 31.8 % respectively), above the United States with 28.8 %. Young firms in Austria and Finland are also relatively active in patenting. Italy is the country where young companies are less active in patenting: only 4 % of them having filed a PCT patent with priority date in 2005–2007. The right panel of the figure III.1.5 presents the share of PCT patent applications with priority dates in 2005–2007 that were filed by young companies in all PCT patent applications filed by companies in the country. There is some positive but not strong correlation between the right and the left panels. Values in the right panel also depend on the patenting activities of the firms older than five years. Older firms in Denmark are obviously more active in patenting than older firms in Norway, hence a smaller share of patents by young firms in Denmark than in Norway, despite the higher share of young firms that patent in Denmark. The same remark applies to the Netherlands where the share of patents filed by young firms is small in comparison to the share of young firms that file patents in that country.
Costs associated with the application of a patent and its maintenance are extremely high for SMEs in general. So, what is the minimal firm-size, a threshold to be achieved, in order to allow an SME to engage itself in protecting its innovations? The literature agrees on the fact that propensity to patent increases with firm size.

Further investigation conducted in the frame of the IRMA project, shows some evidence on the subject and presents a few conclusions, also directly connected with the framework conditions that favour innovation. (other parameters, besides the costs involved, should be considered as supporting policies and programmes such as regional innovation programmes, programmes addressed to SMEs, support from structural funds, etc). The first one is that the size threshold beyond which SMEs use the patent system differs widely across countries. For example, this critical size is between 40 and 50 employees in Switzerland, Sweden and Belgium but is much higher in Germany or Italy. The second conclusion is that size only matters up to a point. Beyond 250 employees, the propensity to patent is largely independent of the size of the firm.

In conclusion, supporting policies intended to help SMEs to patent have to address different sizes of companies in accordance with the country.
Internationalisation activities have proven to be a way for growth and increased competitiveness for European SMEs

Internationalisation is a way for SMEs to increase performance and reinforce growth, strengthening their competitiveness and the basis for a sustainable development. In this way, the EU Single Market has enlarged the opportunities portfolio for SMEs with the chance of expansion beyond their home market. However, according to recent data, 75% of SMEs still depend entirely on their home markets.

Part II, chapter 6 of this report presented a positive trend in what concerns the degree of technology absorption of EU companies, based on increasing ownership of cross-border patents, as a sign of the capacity of European firms to absorb knowledge produced abroad. In addition, the increased participation of SMEs in European R&D programmes and other initiatives launched in the context of the ERA (like international networks) have positively contributed to giving the SMEs an international dimension.

Different studies have been launched by the Commission on the degree of internationalisation of SMEs and its impact in the future development of the companies. The most recent one, based on a survey launched during spring 2009 of almost 9 500 questionnaires completed by SMEs (micro, small and medium), covering 26 different sectors in 33 European countries, presents new conclusions relevant to the situation, drivers and effects on business performance in the period 2007–2009. In this study, internationalisation is used in the broad sense to refer not only to exports but to all activities that place the SMEs in a business relationship with a foreign partner: exports, imports, foreign direct investment, international subcontracting and cooperation.

The main results confirm that 25% of EU SMEs export or have exported during the last three years and that the partner countries are mostly other EU countries, with the exception of imports from China (all the relations with BRICs are still underdeveloped and emerging markets such as Brazil, Russia, India and China are only served by 7% to 10% of the exporting SMEs). The sectors with the highest percentage of exporting SMEs are: mining (58%), manufacturing (56%) wholesale trade (54%), research services (54%) and sales of motor vehicles (53%).

European firms are more internationally active by comparison with those in the United States and Japan

Companies involved with e-commerce (with activities based in internet) are more internationally active and, when considering export–import activities, these companies increase in intensity in direct proportion to the age of the SME. The main factor for internationalisation seems to be company size. Not surprisingly, there is a negative correlation between the population size of the SME’s home country and its level of international activity (meaning that SMEs in Estonia or Denmark tend to be more international than SMEs in Germany, France, Italy, Spain, the United Kingdom or Poland) and the proximity of a SME to a national border does not seem to have great relevance to the level of its internationalisation.

The internationalisation of SMEs is linked to higher growth of turnover and employment

There is a direct correlation between the level of internationalisation and the size of the company: the larger the company is, the more international it tends to be (whether measured by exports, imports or FDI, according to the previously mentioned report).

Other strong correlations observed:

- Internationalisation and higher turnover growth: more than 50% of the SMEs that invest abroad or are involved in international subcontracting reported increasing turnover from 2007–2008, whereas the average value for all SMEs is around 35%.
- Internationalisation and higher employment growth: SMEs with international activities reported in general a higher employment growth (10% increase for SMEs both importing and exporting) than other SMEs, whose average increase was 3%.
- Internationalisation and innovation: 26% of the SMEs with international activities succeeded in introducing new products for their sector in their home country (the average value for other SMEs is 8%).

304 See also Part III, Chapter 2.1.5
305 Internationalisation of European SMEs, Final Report, DG ENTR, June 2010.
A high rate of development by SMEs of new-to-the-market or significantly improved products can occur in all types of economies

Figure III.1.6. shows to what degree innovative SMEs can present products new to the market, and develop new products or processes. The panorama is diverse, and higher rates are achieved both by countries that perform highly in innovation (Sweden, Belgium and the Netherlands) and less highly (Italy, Portugal and Slovenia). In general, the correlation is surprisingly weak between this indicator and the level of R&D intensity of a country or of its SMEs. If one assumes that cross-country comparability is effective on this indicator, this shows that the impact of a knowledge environment with positive spillovers and the presence of favourable framework conditions for innovation (as described in chapter 2 of this Part III), are undeniably positive inducers for innovation. A very positive finding shows that in countries not yet at the highest levels of R&D intensity and innovation performance, innovative SMEs can have the similar performances to those in a more knowledge-intensive environment or region.
1.2. Is Europe creating new and rapidly growing firms?

**Firm demography does not show dramatic changes over time**

The birth of a business enterprise consists of the founding of a company. The death of a business enterprise consists of the extinction of a company, for the year in reference.306

Figure III.1.7 presents the birth rate of business enterprises in Member States providing this data for the years 2003, 2005 and 2007. Except in Lithuania where the increase is dramatic, the birth rate of businesses has remained relatively stable in these countries. Unsurprisingly, catching-up countries (Lithuania, Romania and Bulgaria) top the ranking among the Member States that provide this data. Among larger countries, the birth rate of businesses is highest in the United Kingdom where new businesses represent close to 15% of all enterprises. France and Germany are at the same level with a birth rate of about 10%, while Italy is closer to 8%. In these countries, with the exception of Germany, the slight progression of the businesses’ birth rate since 2003 has been of similar magnitude.

Figure III.1.8 illustrates the death rates of business enterprises. In Portugal, Slovakia and the Czech Republic, the death rate has increased substantially between 2003 and 2007 (before the crisis) and is larger than the birth rate, indicating that the number of enterprises in these countries has been decreasing. However, in most of the other countries providing this data, the birth rate has been higher than the death rate, indicating that more business enterprises have appeared than disappeared over the period 2003–2007.

**The survival rate of enterprises in Europe has not changed significantly over recent years**

Another perspective of business performance is given by the survival rate of companies two years after their creation. This aspect is particularly relevant due to the important role in economic growth played by young companies. The first years are crucial for start-ups and

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306 The birth and death rates are calculated by dividing the number of births and deaths of enterprises by the total number of enterprises active in the country.
**FIGURE III.1.8**  
Death rate of business enterprises\(^{(1)}\)

Source: DG Research and Innovation  
Data: Eurostat  
Notes:  
(1) The number of enterprise deaths divided by the number of active enterprises.  
(2) BE, BG, CZ, DK, EE, CY, LV, LT, HU, NL, PT, FI, SE, UK: 2006.

**FIGURE III.1.9**  
Survival rate of business enterprises\(^{(1)}\)

Source: DG Research and Innovation  
Data: Eurostat  
Note:  
(1) The number of enterprises in the reference period \((t)\) newly born in \(t-2\) having survived to \(t\) divided by the number of enterprise births in \(t-2\).
depend on internal factors but also on external factors: a favourable environment, a positive economic cycle and the sector of the company. Survival is, in general, higher in manufacturing than in services sectors.

Only 14 Member States provide the data for all the reference years 2003 to 2007. A group of 9 countries, including both catching-up and more economically advanced Member States, has had a survival rate in the range of 70–80% between 2003 and 2007. Another important group of 7 Member States is in the 60–70% range, but with higher fluctuations over time. Only 4 countries have a survival rate above 80% and 3 below 60%. The largest variations of the survival rate over time are observed in catching-up countries, in particular in Lithuania, Slovakia, Hungary, Estonia, and Romania. This may reflect a less stable economic situation within these countries, but these higher fluctuations also have a statistical origin in the smaller number of enterprises in these countries.

In general in business demographics, the services sector undergoes more turmoil than the manufacturing sector, where the birth and death rates of companies are lower. This fact is directly related to the shift that occurs in most EU countries towards a larger share of services sectors in the economy (see also Part III, chapter 3). Another factor that has to be taken into consideration is that the effect of the economic and financial crisis cannot be observed yet in these graphs as the last year available for business demography data was 2007.

**The higher share of fast-growing enterprises in catching-up countries is a sign of their economic development towards a more knowledge-intensive economy**

An economy can move towards more and larger knowledge-intensive sectors only with the emergence of new and fast-growing firms. The presence of (young) high-growth enterprises in a country is a sign of the successful development and dynamism of innovative entrepreneurial activities. Unfortunately statistics on the share of high-growth enterprises in all enterprises are available only in a limited number of countries.

In Europe, the share of enterprises growing fast (the number of enterprises with a 20% growth rate in employment per annum during 3 consecutive years, and with 10 or more employees at the beginning of the observation period as a percentage of the population of enterprises with 10 or more employees) is the highest in catching-up countries. Among the more research-intensive countries, only the Nordic countries and the Netherlands provide statistics on high-growth enterprises (figure III.1.10). These countries have similar shares of high-growth enterprises (3–4%) and are all surpassed by catching-up countries. While this observation is not surprising, it is still encouraging for the knowledge- and economic-convergence in the EU. In all European countries providing this data, high-growth enterprises represent less than 10% of all enterprises, and young high-growth enterprises (less than five years old, also called ‘gazelles’) less than 1%, except in Bulgaria, Lithuania, and Latvia. The group of young high-growth enterprises therefore represents 10 to 15% of all high-growth enterprises. Catching-up countries are also those where the share of young high-growth enterprises is the highest.

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307 Alternatively, high-growth enterprises can also be defined in terms of turnover.
308 A size threshold of 10 employees was set to avoid having the growth of very small enterprises distort the picture. The 10-employees threshold is low enough to avoid excluding too many enterprises.
When high-growth is defined in terms of turnover, the share of high-growth enterprises is significantly higher than when it is defined in terms of employment in all countries. This is due to the relatively high costs of labour. Enterprises therefore reach the 20% growth-rate during three consecutive years for turnover more easily than for employment, which indicates that many enterprises grow faster in turnover than in employment.

**The US business environment is more fertile for the growth of innovative firms**

As analysed in the 2010 EU Industrial R&D Investment Scoreboard, it appears that the main reason for the R&D intensity gap between the EU and the United States has its origins in a smaller number of young innovative companies in high R&D intensity sectors (mostly ICT).

As seen in Part I chapter 5, the difference in industrial structure (i.e. the fact that EU high-R&D-intensity sectors are much smaller relatively than those of their US counterparts) explains most of the R&D-intensity gap with the United States, namely in the corporate part. By increasing the number of large European companies in high-R&D-intensity sectors the overall EU R&D-intensity targets would be more easily reached. If we take into account the age of the Scoreboard companies, the analysis provides additional insights concerning the origin of the EU’s R&D intensity gap. Younger companies (i.e. those created after 1975 but not acquired by other companies) show a higher R&D intensity than older ones, and are much more numerous in the US than in the EU (54.4% versus 17.8%). The younger companies based in the EU are less R&D intensive than their US counterparts (4.4% versus 11.8% (figure III.1.11)).

These differences in the rates of formation and growth of companies may be a major cause of the smaller size of these sectors in the EU compared to the United States, which proves to be a friendlier environment for the growth of companies. To add to this situation, there is a “sectoral” specificity: there are sectors, like biotechnology, internet, software, computer hardware and services and telecoms equipment, that evidence an above average share of R&D performed by young

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 companies\(^{310}\). They are called the “young sectors”. For most of these sectors, the United States have a bigger share in their economy than the EU.

In this chapter we analysed the contribution of SMEs to R&D investments and innovation, as well as firm dynamics. Innovation and growth of firms are essential elements for progress towards a more knowledge-intensive economy. The chapter showed that the EU is still well placed compared to its world competitors, only slightly below the United States on the research intensity of SMEs. For the European SMEs to realize their full potential for innovation and growth, besides the R&D intensity, it is essential that they have the right legal, financial and commercial framework conditions. The next chapter will analyse these aspects.

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CHAPTER 2

Framework conditions for business R&D

HIGHLIGHTS

Given the key role of research in fostering innovation, it is important to see what conditions exist in Europe for developing research-based innovation and promoting R&D investment by firms. Whatever policies are implemented by Member States, the framework conditions are critical in determining the final effects of these policies in the market. Figures show that business R&D investment is lower in Europe by comparison to its main competitors. Also, the rate of return-to-R&D of firms from European countries has been generally lower as compared to that of US firms in the period since the mid-1990s. In addition, policy documents such as the Innovation Union Flagship Initiative point out that framework conditions for business R&D are rather unfavourable in Europe. Analysis in this chapter shows that framework conditions for business R&D vary considerably across European countries and the need for harmonisation appears rather obvious. The Northern European countries hold the top positions on many indicators quite systematically. Many initiatives are also in place at Community level and already show some concrete results. However, further efforts seem to be needed.

Supply-related framework conditions supporting R&D and knowledge transfer vary across countries. Regarding public funding of business R&D, the United States, Germany, and Finland prefer direct funding, while Belgium, Denmark, Hungary, Ireland, the Netherlands and Portugal opt increasingly for tax incentives. There are also a few Member States that place very little emphasis on publicly funded business R&D: Poland, Slovakia and Greece. At the Community level, the most concrete measurable results are the increase in direct public funding of SMEs in the Seventh Framework Programme, with a share of SME participation reaching 15 % in FP7. Concerning the availability of private financial services, venture capital is most available in the United Kingdom, Sweden, and Switzerland, after the United States. Early-stage venture capital is also significantly used in the other Northern European countries, Belgium, the Netherlands, and in Portugal. Venture capital is perceived most accessible by the end user in the Northern European countries. Private credits are generally both available and perceived as accessible in small Member States such as Luxembourg, Malta and Cyprus. The need to harmonise the supply-related framework conditions across Europe is sufficiently clear, the most striking confirmation being the total cost of patenting and of maintaining a patent for 20 years, which is 20 times higher in Europe than the United States (40 times higher in the case of SMEs) — most of the difference coming from the maintaining cost of patents.

Demand-side policies can shape direct public demand through, for instance, public procurement. Policies can also lay the framework for stimulating private demand, through systemic policies such as the Lead Market Initiative, or standard setting. Demand-side policies at European and Community level are quite numerous and already show some concrete results, such as the increased number of standards issued by European Committee for Standardisation (CEN) over recent years or the fact that Lead Market Initiative and innovation-friendly regulations at EU level are being developed in sectors generally related to fast-growing S&T fields. This shows a political will at European level to facilitate the transfer of knowledge from research to technology and towards the market. Demand-side framework conditions for business R&D are yet again diverse at country level, and generally more developed in the major research-intensive countries outside Europe. When considering public demand stimulation, Luxembourg and the Northern European countries are the best places for public procurement of advanced technologies within Europe. Local competition (i.e. at national level) is overall perceived to be more intense in EU-15 old Member States compared to EU-12 Member States, and particularly strong in Germany, Austria and the Netherlands. At the same time, the countries most involved in foreign competition appear to be Belgium and the Netherlands. When looking at the private side of demand, firm-level technology absorption appears at its highest yet again in Northern Europe, Austria and Germany. While user confidence in innovation is greatest in India, Spain, Ireland, China and the United States, the capability of consumers to absorb new technologies is most developed in Japan, the United States, China, South Korea, and in European countries such as Sweden, Denmark, the United Kingdom, Belgium, the Netherlands and Switzerland. The EU has fewer entrepreneurs compared to China and the United States, with Finland leading within Europe in terms of entrepreneurial activity. About half of Member States have raised the level of their entrepreneurial activities between 2004 and 2009. The highest fear-of-failure rate when starting a business is perceived in Romania, France, Greece and Spain, and lowest in Norway and Finland. The regulatory environment appears to be most conducive to the operation of business in the United Kingdom, Ireland and the Northern European countries. Countries that experience the least easy conditions in which to do business are Greece, Italy, Czech Republic and Poland.
Research-based innovation is one of the main sources of innovation in the world. Although in absolute terms non-technological innovation appears to have a greater weight in the economy\(^{311}\), a significant part of non-technological innovation would not be possible without technology obtained through the exploitation of research results. For instance, the ‘general purpose technologies’ commonly affect an entire economy and have an impact on the pre-existing economic and social structures. Examples of innovation based on general purpose technologies include steam engines, electricity, railroads, automobiles, electronics, the computer and the Internet. The most-used recent example is certainly that of information technologies, which penetrated the whole economy and have triggered changes in the business models of many services sectors (e.g. banking, creative industries, etc.).

In addition, many countries in Europe and beyond Europe are considering further developing their manufacturing industries, with an important share of high-tech and medium high-tech manufacturing\(^{312}\). Manufacturing industry has an important place in the economy in countries such as Germany. France is constantly concerned not to de-industrialise/ or de-manufacture the country\(^ {313}\). Another example is the United Kingdom - a highly services-oriented economy, which has lately published its intentions of strengthening the national industrial policies\(^ {314}\).

Given the key role of research in fostering innovation, it is important to see what conditions exist in Europe for developing research-based innovation and promoting R&D investment by firms. Data indicate that business R&D investment is currently lower in

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\(^{311}\) In terms of economic structures, the current weight of the services sector in the European economy is estimated at around 70%.

\(^{312}\) According to Eurostat figures, the added value of high-tech and medium high-tech manufacturing industries count for nearly half (46.4%) of the manufacturing value added in EU-27.


Europe (1.04 % of GDP) than in Japan (2.68 %) and the United States (1.85 %). Economic analysis shows that business R&D spending can be low for two main reasons, which can occur simultaneously— these being supply and demand shortfalls. Whereas the supply problems could be too high a cost of capital or too low quality R&D, demand shortfalls refer to firms finding market opportunities too small compared to their costs. From a policy point of view, the rate of return to R&D is therefore a key concept. Figure III.2.1. shows that the rate of return to R&D of firms from a number of European countries (France, Germany, Italy, Denmark, and the United Kingdom) has been generally lower compared to US firms in the period since the mid-1990s.

In line with the evidence presented above, recent important European policy documents such as the Innovation Union Flagship Initiative point out the unfavourable framework conditions for research and innovation in Europe and therefore the need to improve them. The Innovation Union Initiative highlights the fact that private investment in research and innovation is currently held back both by supply-side conditions such as poor availability of finance in many countries and costly patenting arrangements, and demand-side policies related to market fragmentation, slow standard-setting and the lack of strategic use of public procurement. Consequently there is a need to address the bottlenecks which exist on the path from idea to market, in order to get research and innovation to flourish in all areas.

It has to be mentioned that in technologically weak countries, low business R&D spending cannot always be explained solely by supply or demand shortfalls and/or low rates of return to R&D. In these countries there is often no real interest and demand for domestic R&D or innovation, hence there is no related market for such activities which could support or even create rates of return. In weak technological and innovation systems more structural factors are at work: insufficient knowledge, weak technological capabilities at the firm level, sectoral specialisation patterns, the lack of sufficient clusters and networks, the absence of critical firm size, and weak supportive policies. The consequence is that in these countries, research and

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innovation activities of firms cannot be explained solely by supply and demand factors and that more structural concepts have to be taken into account as well. In such a context, the very concept of structural change as a driver of R&D and innovation can be a complementary variable to understand the problems at stake. From this point of view, chapter 3 in part III on structural changes can be considered as complementary to this chapter.

This chapter on framework conditions for business R&D will provide an overview both of policies for supply-side conditions and policies for demand-side conditions which aim to increase the benefits for firms to invest in R&D, and therefore to boost investments in R&D by firms.

There are numerous factors which can be included in the two categories. Figure III.2.2. helps to identify their interplay, being a useful way to look at both the key functional steps in the innovation process (dark shading), and the key related framework conditions for innovation (lighter shading). Following the logic of supply and demand, the supply framework conditions would include access for business both to finance and to human resources, but also issues such as patent costs and appropriate ICT infrastructure such as broadband. Demand side framework conditions will encompass both public and private demand, as well as competition in the market and for the market. Finally, entrepreneurship and an excellent science base, as well as its propensity to work with innovation firms, create valuable opportunities for innovation and contribute to the capabilities of firms to innovate.

The chapter is grouped into three parts: supply and demand factors, and a section on entrepreneurship. In particular, this chapter further analyses several parts of the public financing of business R&D which are not covered in part I, chapter 3, namely State aid (section 2.1.4), European Commission funding of R&D firms through the Framework Programme (section 2.1.5) on a supply side and public procurement (section 2.2.2) on a demand side. It has to be mentioned that the choice of instruments in the overall public financing of business R&D is a matter of Member States’ own decisions and there is no straightforward interpretation that more - or any type of instrument - is better.

2.1. What are the framework conditions for the supply of business R&D?

As mentioned above, supply framework conditions include access of business both to finance and to human resources, as well as patent costs and appropriate infrastructure such as broadband. All these elements will be analysed below, apart from human resources for R&D and S&T graduates, which can be found in chapter 4 in Part I.

2.1.1. Access to finance

The existence of and access to financial services by firms are crucial when it comes to the supply of research and technology innovation by private firms - especially SMEs. This is clearly recognised by the latest policy documents at EU level. The Innovation Union Flagship Initiative stresses that ‘access to appropriate forms of finance continues to be one of the most serious constraints on innovation by firms’. A company can generally accumulate its capital from two sources - equity and debt - as well as internal finance (particularly relevant for large firms). Whereas the large multinational companies are generally provided with finance by large banks and big finance companies, in addition to shareholders and lenders, the SMEs are more likely to encounter financing gaps due to the investment risk associated with new and young businesses that need to find their way to the market.

SME financing needs vary according to the stages of the cycle of life of the SME. These stages include the seed and start-up phases, the early development phase, and the growth and maturity phases. Also the source of finance will differ according to the stage of development of the firm (see figure III.2.3.). Typically the funding sources for the seed and start-up stages are informal equity and loans from the founder and associates, as well as bank loans if available. Formal venture capital funds are likely to invest more in the more developed stages of a firm’s existence, as at the early stages the profit expectations are less clear and the risk related to investment is higher. This is why the informal venture capital market has an important role in the start-up phases of a business, through business

angels i.e. individuals who provide risk capital directly to new and growing businesses with which they had no previous relationship. At the expansion stage, the SME will usually access equity from original sources, plus trade investments or venture capital, loans from banks, leasing and factoring and retained profits. Replacement capital includes trade investment, venture capital and IPO (initial public offering).

The investment risk across all the stages indicated above can produce financing gaps in various stages of the SME’s development until the product is brought to the market and commercially sold. These gaps between development and commercial sales are often being referred to as the ‘valley of death’. Generally, Government support tries to help overcome financing gaps of companies in various ways, such as acting through grants or acting as guarantors for loans through programmes addressing young small- and medium-sized firms.

As indicated in chapter 1 of Part III, Europe has fewer young fast-growing innovative companies, often because of the financing gaps in various phases of firm development. Firstly, on the seed and start-up phases — where public research grants stop and private finance cannot be attracted — public support across Europe currently appears too fragmented. Secondly, at the expansion phase, innovative companies with high potential lack access to growth finance, in particular from venture capital funds. And finally, both large and small established innovative companies often face a shortage of higher risk loans to complement venture capital.

On one hand, venture capital is an important source of funding at the seed, start-up and growth phases, especially for young firms which are technology-based, with high growth potential. Venture capital investment focuses on high-potential companies, either those which are in new technology fields and therefore rapidly developing, or those where market or operational inefficiencies can be improved and thus enhance the
competitive situation of existing businesses. Venture-backed firms bring more radical innovations to the market, at a faster rate than lower-growth businesses which rely less on venture capital and more on other types of finance. On the other hand, banks play an instrumental role in the financing of innovation in more mature firms (as compared to high-tech start-ups). An important measure of the availability of credit for private firms is the ratio of private credit granted to the private sector relative to GDP by deposit-taking financial institutions. Private credits include loans, trade credits and other receivable accounts that establish a claim for repayment.

Banks have a key role to play in countries where there is neither a functioning venture capital market nor a functioning capital market in general. This is particularly true for many EU-12 Member States. One of the problems is that start-ups or small innovative companies have no rating and, in the beginning, no track record and therefore are often cut off from the financial markets. For certain banks and funds it is difficult to give a loan or to invest in these companies. Companies with a very small equity base, however, fully depend on external funding until they generate cash flows.

2.1.2. Availability of venture capital and private credit

The United States has considerably higher rates of venture capital investments than the EU, both in early and expansion stages. The EU Member States with highest venture capital investments are the United Kingdom and Sweden

Venture capital data are broken down into two investment stages: early stage (seed and start-up) and expansion and replacement. Early-stage venture capital is mostly used in Luxembourg, Switzerland, Belgium and the Northern Europe

Early-stage investments are generally dominated by Switzerland, the Nordic countries and Benelux, with France and Germany only around the EU average (figure III.2.4). All the Nordic countries for which data are available are above the EU average. Portugal is the only Southern European country with a level of early stage investments above the EU average. Bulgaria is the leading country within the EU-12 Member States. However, these countries generally register lower levels.

318 Seed is defined as financing provided to research, assess and develop an initial concept before a business has reached the start-up phase. Start-up is defined as financing provided for product development and initial marketing, manufacturing, and sales. Companies may be in the process of being set up or may have been in business for a short period of time, but have not sold their product commercially.

319 Expansion is defined as financing provided for the growth and expansion of a company which is breaking even or trading profitably. Capital may be used to finance increased production capacity, market or product development, and/or provide additional working capital. It includes bridge financing for the transition from private to public quoted company, and rescue/turnaround financing. Replacement capital is defined as the purchase of existing shares in a company from another private equity investment organisation or from another shareholder(s). It includes refinancing of bank debt.

VENTURE CAPITAL – EARLY STAGE (SEED + START-UP) PER THOUSAND GDP, 2009

The United Kingdom was a pioneer in providing support from government for the development of an informal venture capital market in early 1990s, targeting the increase of private equity funds at the seed and start-up phases of a business. Its example was followed by other countries in Western Europe in the late 1990s, whereas in Eastern Europe this practice is still very little developed. Among various forms of intervention, the UK Government, in cooperation with the business sector, was the first to create ‘business angel’ networks in 1997.

By the mid-1990s the UK Government had also introduced numerous and generous schemes of fiscal incentives for investors, aiming to increase the level of private equity funds. The policy focus has since (in early 2000) shifted from tax incentives and regulatory policies to initiatives aimed at increasing the access of technology SMEs to private equity funds, in a rather de-centralised manner — therefore encouraging the formation of regional clusters. Regional and local private–public funds have been established, such as the Regional Venture Capital Fund (RVCF), which was set up in 2001 and used to cover all nine regions of England. Regional Venture Capital Funds made their final investments in 2008 and have now been replaced by Enterprise Capital Funds. Devolved administrations (Scotland, Wales and Northern Ireland) were encouraged to develop and put in place their own mechanisms of support for private investment and entrepreneurship.

Sources:
1) G. Avnimelech, A. Rosiello and M. Teubal, Evolutionary interpretation of venture capital policy in Israel, Germany, UK and Scotland, in Science and Public Policy, 37(2), March 2010
3) http://www.bis.gov.uk/policies/enterprise-and-business-support/access-to-finance/enterprise-capital-funds

Box: Venture capital in the United Kingdom

The United Kingdom was a pioneer in providing support from government for the development of an informal venture capital market in early 1990s, targeting the increase of private equity funds at the seed and start-up phases of a business. Its example was followed by other countries in Western Europe in the late 1990s, whereas in Eastern Europe this practice is still very little developed. Among various forms of intervention, the UK Government, in cooperation with the business sector, was the first to create ‘business angel’ networks in 1997.

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Sources:
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3) http://www.bis.gov.uk/policies/enterprise-and-business-support/access-to-finance/enterprise-capital-funds

Business angel networks aim to enable investors and entrepreneurs to find one another early on.
The United Kingdom and Sweden are leading investment in venture capital at expansion and replacement phase

The two countries well above both the United States and the EU-27 average in terms of venture capital investments at expansion and replacement phase are the United Kingdom and Sweden, followed by Belgium and Finland (figure III.2.5). At the other end of the scale are Bulgaria and Hungary. Romania shows the highest figures in Eastern Europe.

Private credits are noticeably available in several Northern European countries, the United Kingdom, Ireland, the Netherlands, Spain, Portugal and some small Member States. The EU values are more than double those of the United States

In terms of availability of credit for private firms, the countries above the EU average of 1.27 % of GDP are: Denmark (2.19 %), Cyprus (2.17 %), Ireland (2.17 %), the United Kingdom (2.10 %), Spain (1.98 %), Luxembourg (1.97 %), the Netherlands (1.93 %), Portugal (1.80 %), Switzerland (1.68 %), Sweden (1.30 %), and Malta (1.28 %).^322

Source: DG Research and Innovation

Data: Eurostat

Note: (1) EU does not include EE, CY, LV, LT, MT, SI, SK in respect of which data are not available.
In conclusion, there are significant variations between countries regarding investments in venture capital, both in absolute and relative terms. In absolute figures, the United States and the United Kingdom invest the most funds in venture capital. As a percentage of GDP, the United Kingdom is leading, closely followed by Sweden. The United States and Switzerland follow at a greater distance. France’s position is around the EU average, whereas Germany registers lower values. Overall the Nordic countries, Belgium and the Netherlands register significant figures, whilst Eastern Europe invests less in venture capital. Among Southern European countries, Portugal depicts the highest numbers for the expansion and replacement phase and for early-stage venture capital.

Private credit is available to a significant extent in Denmark, followed at a certain distance by Sweden. It is also available in some smaller countries such as Luxembourg, Malta and Cyprus. Considerable values are recorded in Ireland, the United Kingdom and the Netherlands, and also Southern European countries (Spain and Portugal). EU-12 Member States record rather low levels of private credit (apart from Cyprus and Malta).

Whereas the United States has considerably higher values than the EU concerning venture capital investments in both early-stage and expansion phases, EU private credits values are double those of the United States.

2.1.3. Ease of access to finance

Accessibility of finance, along with the presence of financial services as such (or even size and depth of the financial system as a whole) has an important effect on a country’s real activity, economic growth and overall welfare. Therefore the simple fact that the financial services exist per se does not automatically imply that they are accessible to all the interested users within an economy.

A certain amount of data in chapter 2 (starting with this very section) is based on the World Economic Forum (WEF) survey on the perception of users on various innovation dimensions for which there are no other reliable data sources. The WEF data has both advantages and disadvantages. Firstly, it is a regular source of data, published yearly. Secondly, the survey covers a broad range of countries. The main disadvantage is however that it surveys the perception of users and therefore reports on their subjective assessments (although these perceptions nevertheless guide their decisions).

Overall, several of the Nordic countries and small European Member States are perceived to offer easier access to finance for businesses operating within the country. Sweden has the highest position both in terms of investment in venture capital and access to it by firms. Despite having the highest level of investment in venture capital among European countries, access to this capital in the United Kingdom is not perceived to be easy.

Sweden has one of the strongest positions in terms of users’ access to the available venture capital (average rank: 4.3) (figure III.2.6). This is not the case, however, for the United Kingdom, Belgium, France, and Germany, with lower positions in comparison with the Nordic countries and the Netherlands. This implies that even though the investment of venture capital is highest in the United Kingdom and more moderate in France and Belgium, the end users in these countries do not perceive that they have appropriate access to it.

**Risk Sharing Finance Facility (RSFF)**

RSFF is a European instrument that facilitates access to funding by companies — more precisely by improving access to debt financing for promoters of research and innovation investments.

The RSFF is built on the principle of risk sharing between the European Union and the European Investment Bank (EIB). It covers, through capital allocation and provision, the credit risks borne by the EIB when lending to a project promoter for investment in research, development and innovation (RDI), or when guaranteeing loans made by commercial banks and other financial intermediaries for RDI projects.

The European Union — through the Seventh Framework Programme of the European Community (FP7-EC) — and the EIB each provide up to EUR 1 billion for the period 2007–2013 (the EU contribution of EUR 500 million for the period 2011–2013 is subject to an interim evaluation). Through a leverage effect, this will enable the EIB to lend more than EUR 10 billion for high-risk/high-reward RDI investment.

The RSFF is designed for private and public legal entities promoting activities in the field of RDI, including small- and medium-sized enterprises, larger companies, universities and research organisations. The RSFF extends the ability of the EIB to provide loans or guarantees to entities with a low or sub-investment grade credit rating that the Bank would not normally be able to finance. In addition, it facilitates financing for commercial banks and other financial intermediaries that are willing to extend their lending capacities to RDI promoters. Finally, it can be used by projects resulting from European research initiatives, such as Research Infrastructures, European Technology Platforms, Joint Technology Initiatives and Eureka.
In smaller countries, firms have relatively easy access to loans within the country, particularly in the Nordic countries

Luxembourg has the highest relative position in terms of access to loans, followed yet again by Nordic countries (figure III.2.7). Cyprus and Malta also record remarkable scores. Once more the United Kingdom, Germany and France are well below the Nordic countries, Belgium, the Netherlands as regards the ease of obtaining a bank loan within the country with only a good business plan and no collateral.
Among European countries, France is leading in terms of access to local equity markets. Financing through local equity markets is perceived to be highly accessible in France, as well as in several Nordic countries (Sweden and Norway) and small countries like Malta (figure III.2.8). It appears to be common in other regions of the world such as India, the United States, Japan and South Korea.
To conclude, the countries where financial services both exist at a significant level and are accessible to the end users are generally most Nordic countries (led by Sweden) and some small Member States — Luxembourg, Malta, Cyprus (noticeably in terms of private credits). The case of the United Kingdom is a special one: with the highest level of venture capital investments in the EU both in absolute and relative terms, as well all significant values of private credits, it seems that the financial services do not sufficiently reach the end business user. Among the big countries, France is systematically around the middle of the scale both in terms of existence of financial services and access of firms to these services, whereas Germany’s
position is rather weak in both areas. Spain and Portugal record somewhat significant figures on the existence of some financial services, but the access to them is not perceived as high by firms. Overall, new Member States’ figures are fairly low (except for those of Malta and Cyprus).

2.1.4. State aid in the context of overall public financing of business research

In accordance with article 107 of the Treaty on the Functioning of the European Union (TFEU): "Save as otherwise provided in the Treaties, any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the internal market." Nevertheless, "aid to promote the execution of an important project of common European interest" and "aid to facilitate the development of certain economic activities or of certain economic areas, where such aid does not adversely affect trading conditions to an extent contrary to the common interest" may be considered to be compatible with the internal market.

State aid may be provided "in any form whatsoever", it encompasses therefore a wide range of instruments, such as: contributions of capital and assumption of losses, provision of other cash benefits (loans, subsidies), assumption of potential liabilities (guarantees, securities), sale of purchase of equity shares, reduction or exception from taxes, fees, social security contributions etc. Subsidies granted to individuals or general measures open to all enterprises do not constitute state aid.

Looking at the share of state aid for R&D out of total state aid provided in a given country (Figure III.2.9), Luxembourg (62.8) and Belgium (46.2) appear to be in first position, having awarded around half or more of its state aid to R&D. The share of state aid to R&D was also relatively high in Bulgaria (39.8), the Czech Republic (36.5), Austria (31.1) and Finland (30.8). At the contrary, Greece and Poland granted 1.5% or less of their state aid to research and development.

Therefore, even if TFEU sets out a general prohibition on State aid, it leaves room for Member states to use State aid measures when pursuing certain policy objectives. State aid for horizontal objectives (i.e. aid that is not granted to specific sectors) and concerning for example R&D or support to SME’s is usually considered as being better suited to address market failures and thus less distortive for competition than sector aid.

As matter of principle, Member States shall notify State aid measures to the Commission and they shall not implement such aid unless approved or deemed approved by the Commission with the exception when such measures are covered by De-minimis Regulation or General Block Exemption Regulation (GBER).

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Yet again, it cannot be concluded that the higher the share of a given instrument, the better (in this case state aid). The figures simply give a picture of the various modalities chosen by Member States to provide public financing to firms performing R&D.

2.1.5. Participation of industry and SMEs in the European Framework Programme

The number of firms participating in FP7 has increased considerably by comparison with FP6

In total, 26.4% of the participants in FP7 are companies (table III.2.1), and they have a similar share of the budget (23.7%). Both shares indicate a significant increase to FP6, where the participants from companies represented 19.6% of total number of participants, receiving 18.6% of FP6 funds.

### TABLE III 2.1

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>of which: companies</th>
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<tbody>
<tr>
<td></td>
<td>Total</td>
<td>%</td>
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<td>FP7 participants</td>
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<tr>
<td>FP7 EC financial contribution (euro)</td>
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<td>2185584133</td>
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</table>
**Share of private companies' participation in the FP7 as % of all participants is highest in Luxembourg, followed by large Member States (France and Germany)**

Analysing shares at national level, over 55% of Luxembourg participants in FP7 are companies (figure III.2.10). A high share of participation by private firms is also found in France (33.6%), Germany (32.7%), Portugal (30.3%), and Austria (30%). At the other side of the scale, Lithuania and Latvia register less than 20% company participation. The highest increases can be seen in Luxembourg, Slovakia, Romania, and Hungary (with more than double the share of companies in FP7 compared to FP6).
Small Member States have the highest share of EC financial contributions to companies compared to other type of participants

Luxembourg is in the lead also regarding the EC contribution for firms (45.3%) compared to other types of participants in FP7, followed by Malta (39.4%), Slovakia (39.3%) and Lithuania (32.1%) (figure III.2.11). Among countries with the highest increases between FP6 and FP7 are Slovakia, Lithuania, Romania and Hungary.

Small Member States also lead in terms of SMEs’ share in total number of FP7 participants

Countries with the highest share of SMEs in the total number of FP7 participants are Estonia (25.7%), Cyprus (24.8%), Malta (20.3%), as well as Romania (21.9%), Austria (21.5%), Ireland (20.8%), and Hungary (20%) (figure III.2.12).
In conclusion, overall firm participation in the Framework Programme has considerably increased in FP7 across EU Member States in comparison to FP6. There is a general difference between large and small Member States in terms of size of companies participating in FP7, with a higher participation of SMEs from small Member States, probably due to the structure of their economies.

2.1.6. Patent costs

The Innovation Union Flagship Initiative points out the cost and complexity of patenting as a critical issue and considers the absence of a cheaper and simpler EU patent to be a de facto tax on innovation. While it is not a tax per se (nobody collects income out of it), the complexity of European patent system is in fact an additional cost in comparison for instance to the system in the United States. It may reduce the efforts to patent, especially those of the SMEs who have low resources.

The number of patents matter because patents allow firms to appropriate the returns from their R&D investments. Patent information also provides an important source of additional/codified knowledge in that specific technological area for other firms and research activities. Patents represent a knowledge pool which increases the efficiency of technological (and implicitly scientific) efforts. If the EU had a patent system which cost less there would be more patents and more cross-border knowledge could be diffused from the information. These patents would provide conditions for a European licence market (as part of cross-border technology markets). Increased licensing would mean that more technological opportunities are turned into economic activities. This additional aspect shows the huge economic cost of inefficient exploitation of the existing knowledge, non-exploitation of existing technological opportunities and of lost economic opportunities to satisfy needs.

The cost of obtaining and maintaining a patent across Europe for 20 years is almost 20 times higher than in the United States and almost 27 times than in Japan, mainly due to maintenance costs. Furthermore, the cost of obtaining and maintaining European patents for SMEs over 20 years is 40 times bigger in Europe compared to the United States.

As can be seen in table III.2.2, an EPO patent covering 27 countries appears to be almost 20 times more expensive than an USPTO patent, almost 27 times more than a Japanese patent and over 34 times more expensive than a KIPO patent if procedural fees and maintenance fees for up to 20 years are considered (translation and services costs excluded). The main source of the higher patent cost in Europe compared to the United States is not so much the procedural cost of obtaining a patent (estimated at EUR 5,200 in 2010), but more the maintenance costs in the national patent offices which count for 97% of the total costs of European patents maintained for 20 years in 27 Member States. Thus a major barrier to valorising EU inventiveness is the high cost of patent applications and especially the maintenance cost in a large number of countries in Europe. SMEs are particularly affected by the costs of patents as they are not able to spread the costs and risks of a broad portfolio of patents. In addition, there is no cost difference in Europe between large firms and SMEs, whilst in the United States the cost of patenting is 50% less for an SME. This makes the relative cost for an SME EPO application 40 times greater than the cost of an SME applying at the USPTO. The same stands for the JPO, which applies certain reductions for SMEs.

327 European Patent Office.
328 US Patent and Trademark Office.
329 National Patent Office of South Korea.
<table>
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<tr>
<th><strong>Type of firm</strong></th>
<th><strong>EPO (EU)</strong></th>
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<td><strong>Median number of claims</strong>&lt;sup&gt;(6)&lt;/sup&gt;</td>
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<td><strong>Designated countries for protection</strong></td>
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<td><strong>Fee for grant</strong></td>
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<tr>
<td><strong>Claims Tax</strong>&lt;sup&gt;(8)&lt;/sup&gt;</td>
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<tr>
<td><strong>TOTAL PROCEDURAL COSTS without translation</strong></td>
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<td><strong>Maintaining costs for 20 years</strong></td>
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<tr>
<td><strong>TOTAL including Maintaining Costs for 20 years</strong></td>
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<tr>
<td><strong>TOTAL including Maintaining Costs for 20 years per billion GDP</strong></td>
<td>14.21</td>
</tr>
</tbody>
</table>

Source: JPO  
Data: EPO, USPTO, JPO, KIPO, National law relating to the EPC (14th edition), Bruno van Pottelsbergh and Didier Francois, ‘The cost factor in patent systems’, Solvay Business School, Université Libre de Bruxelles, 2009  
Notes:  
(1) 2010 Procedural Fees where the European patent application is filed online on or after 1 April, 2009 and has a maximum 35 pages (source: EPO).  
(2) Procedural Fees effective October 2, 2008, where the US patent application is filed on or after 8 December, 2004 and has a maximum 100 pages (source: USPTO).  
(3) Procedural Fees effective 1 April, 2009, where the Japanese patent application is filed on or after 1 April, 2004. Source: JPO  
(4) Procedural Fees effective from 1 July, 2009.  
(5) The JPO grants an exemption from or a 50% reduction of examination request fees and / or an exemption (from the first year to the third year, in some cases to the sixth year), a grace period of three years, or a 50% reduction for individuals, companies or R&D oriented SMEs that lack funds, if they comply with certain requirements.  
(6) For EPO an extrapolation from the estimation for EPO – 13 calculated in Bruno van Pottelsbergh (2009) was used. For USPTO for SMEs an extrapolation from the estimation for large companies in Bruno van Pottelsbergh (2009) was used. For JPO the value in Bruno van Pottelsbergh (2009) was used. For KIPO the value was provided by KIPO. The median number of claims is relevant for the calculation of claim tax.  
(7) For USPTO the renewal fee is due at 3.5 years. For JPO the renewal fees are included for years 1-3.  
(8) The cost per claim is 210 euro for the 18th and each subsequent claim up to the limit of 50 in an EPO patent application; US$ 52 if more than 20 claims are included in an USPTO patent application; and 4000 Yen for the claims included in a JPO patent application.
## Framework Conditions for Business R&D

<table>
<thead>
<tr>
<th>Type of firm</th>
<th>Firm Size</th>
<th>Median Number of Claims</th>
<th>Designated Countries for Protection</th>
<th>Procedural Fees</th>
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### Innovation Union Competitiveness Report 2011
Progress and difficulties in the reform of the European patent system

The reform of the European patent system aims to make it cheaper and easier to protect new inventions in the EU. The reform encompasses two main elements – the creation of a patent with unitary effect in the EU and the setting up of a unified and specialised patent court. Such a reform would remove a competitive handicap suffered by Europe’s innovators and stimulate investment in research and development.


In 2007-2009, the Council discussed the draft Agreement creating a specialised patent court with competence for current European and future EU patents. In June 2009, the Council submitted a Request to the European Court of Justice on the compatibility of the draft Agreement with the EU Treaties. Without prejudice to this request, in December 2009 the Council adopted conclusions which cover the main features of the unified patent court. However, an opinion of the Court of Justice of 8 March 2011 concludes that the draft Agreement, as it stands, is incompatible with the EU Treaties. The draft Agreement therefore has to be amended in the light of the opinion of the Court of Justice.

Despite the general approach on the EU patent agreed in December 2009, the Council was not able to reach a unanimous agreement on the translation arrangements that would be applicable to such EU patents. As a result, in November 2010 the Council concluded that the objective of an EU patent may not be attained now or in the foreseeable future. On the basis of a request of a group of Member States, the Commission proposed to launch the procedure of enhanced cooperation in the area of unitary patent protection. On 10 March 2011, 25 Member States were authorised by the Council to establish such an enhanced cooperation between them. Proposals for regulations necessary to implement the enhanced cooperation were proposed by the Commission on 13 April 2011.


2.1.7. Broadband access by firms

From the perspective of innovation, it is crucial to understand the extent to which advanced ICT infrastructure is available to the business world. Both the scope of connections of a typical business and the speed of these connections drive innovation and influence the very way businesses innovate. With various new and improved infrastructures, of which ICT plays a central role, ideas and innovations can be more easily transferred from the firm to its environment and the other way round. In addition, broadband access contributes to enabling content and skills to leverage infrastructure.

Broadband penetration among businesses is generally higher in old Member States

Broadband penetration among businesses can be measured by the share of enterprises with broadband access. Most EU-15 Member States situate themselves above or at least around the EU average of 82% (figure III.2.13). Finland, Malta, Spain and France are all above 90%. The lowest level of broadband penetration among businesses is registered in Romania (40%).
Broadband speed seems equally important to innovation as is broadband penetration. The higher the broadband speed, the better the capacity of a country’s ICT infrastructure to transmit big volumes of digital data in a given period. Increased broadband speed will provide businesses with the possibility of strengthening existing innovation processes and/or launching new ones.
Broadband speed is highest in Japan and South Korea, accompanied by most competitive prices

The 2008 data on broadband speed shows Japan in first place together with South Korea, followed by Finland and Sweden (figure III.2.14). Lowest speeds are found in Spain, Greece and Turkey. Highest improvements between 2005 and 2008 are registered in the Czech Republic (100 %), Italy (72 %), Hungary (59 %), the United Kingdom (55 %), as well as substantial increases in the Netherlands (36 %), and Portugal (25 %).

Speed of a typical broadband subscription (kbits per second), 2008; in brackets: average annual growth, 2005-2008

In the EU broadband prices are most competitive in the United Kingdom, Italy, Denmark, and Greece

Finally, broadband prices are also important as they affect the rate and extent of take-up of new generation ICT infrastructure. The existence of a substantial difference between countries on this issue is translated into national advantage or disadvantage. South Korea and the United Kingdom appear to have the most competitive prices: less than $ 2 for a Mbit/s a month (figure III.2.15). They are followed closely by Japan, Italy, Denmark and Greece, each of them with less than $ 3 per month. The highest prices are found in Poland and Turkey.

To conclude, businesses’ broadband penetration is generally higher in EU-15 Member States compared to the UE-12 Member States ones. Broadband speed is far higher in Japan and South Korea compared to Europe and the United States. The high speed in these countries is accompanied by very competitive (i.e. low) prices. Within the EU, despite the lower level of broadband penetration in comparison with the old Member States, some EU-12 Member States have seen high improvements in the broadband speed. This applies at least to the Czech Republic and Hungary.
2.2. What are the framework conditions driving the demand for research-based products?

Demand-side framework conditions in this chapter will encompass both public and private demand. In addition, this section will look at competition in the market and for the market, and standardisation-related costs.

Demand-side framework conditions provides incentives for innovation and reduces uncertainty for innovators. In addition, innovative firms are sustained by demanding consumers. The demand can both trigger innovation (its’ signals producing a reaction from the supply side), and be responsive to innovation (being ready to absorb innovations once they are produced). Public demand has a special role in triggering innovation (for instance through public procurement), as well as laying the framework for private demand through policies such as the Lead Market Initiative at the EU level.

2.2.1. Private demand for innovation

Private responsive demand is comprised of firms’ adoption of innovation (measured by indicators such as absorption of technology by private companies) and end-user demand (good proxies being consumer confidence in innovation and buyer sophistication). Consumer demand for innovation is important in defining markets where companies want to situate their innovation because of the presence of lead users who may provide feedback and have a high propensity to take up innovations.

The available statistical evidence from the executive opinion survey of the World Economic Forum shows that firms’ capacities to absorb new technologies are highest in Japan, Switzerland, the United States, Sweden, Denmark, Finland and Austria, followed by Germany and South Korea.

Consumer confidence in innovation is highest in Spain and Ireland, and outside Europe in India, China and the United States

Along with access to finance, consumer confidence in innovation is of particular importance. It is generally recognised that the knowledge economy is driven largely by technological advance and rising prosperity as it increases the demand for knowledge-based services. In addition, the ideas for innovation do not stem only from public research or firms, but also from the end users’ demand. Statistical evidence is however scarce. There are not many indicators available for measuring consumer demand. The two indicators presented below provide a first proxy.

The consumer confidence index measures user confidence in innovation and the willingness of users to adopt innovations (being a proxy of the uptake of innovation from firms). The higher the index, the more likely it is that people are buying and using innovations and perceive that innovation would improve their life. Table III.2.3. shows that the consumer confidence index is highest in Spain and Ireland, and outside Europe in India, China and the United States. Interestingly enough, Finland and the Netherlands appear to have relatively lower consumer confidence, although it is higher than that of Japan. A possible explanation for high confidence in innovation of consumers currently in locations/markets that are not as developed could be their potential expectation that all innovation should be good.

### Table III.2.3: Consumer confidence index

<table>
<thead>
<tr>
<th>Country</th>
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<th>2008 (rounded)</th>
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<tbody>
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<td>:</td>
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<tr>
<td>Spain</td>
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<td>66</td>
</tr>
<tr>
<td>Ireland</td>
<td>66</td>
<td>65</td>
</tr>
<tr>
<td>China</td>
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<tr>
<td>United States</td>
<td>58</td>
<td>60</td>
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<tr>
<td>Italy</td>
<td>54</td>
<td>56</td>
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<tr>
<td>Iceland</td>
<td>:</td>
<td>53</td>
</tr>
<tr>
<td>United Kingdom</td>
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<tr>
<td>Slovenia</td>
<td>48</td>
<td>47</td>
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<tr>
<td>South Korea</td>
<td>:</td>
<td>44</td>
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<tr>
<td>Finland</td>
<td>44</td>
<td>42</td>
</tr>
<tr>
<td>Netherlands</td>
<td>38</td>
<td>:</td>
</tr>
<tr>
<td>Japan</td>
<td>:</td>
<td>24</td>
</tr>
</tbody>
</table>

Source: DG Research and Innovation Data: Levie (2009)
Note: (1) Levie’s survey is applied on a sample of private consumers in 30 countries. The questionnaires comprise three questions to which respondents have to answer on a five point scale, ranging from strongly agree to strongly disagree: (i) In the next six months, are you likely to buy a new product or service? (ii) In the next six months, are you likely to try products or services with new technology? (iii) In the next six months, will new products or services improve your life? The confidence index is the average percentage of people that agree or strongly agree to each of the three statements.

Consumers in Sweden, Switzerland, Norway, the United Kingdom, the Netherlands and Luxembourg have the highest propensity to absorb new technologies

Buyer sophistication indicates the capability of consumers to absorb new technologies, and also their capacity to understand their own needs and to indicate them to the producers. The assumption at stake is that the buyers will buy more innovation if they understand its added value and how to use it. According to figure III.2.16, buyer sophistication is highest in Sweden, the United Kingdom, the Netherlands and Luxembourg. Outside Europe, buyer sophistication is also high in Japan, followed by the United States, China, and South Korea.
Perceived Buyer Sophistication

Source: DG Research and Innovation
Data: World Economic Forum, Global Competitiveness Report, 2010
Note: Averages; Question: Buyers in your country make purchasing decisions

(1= based solely on the lowest price, 7 = based on a sophisticated analysis of performance attributes) (2009-10 weighted average)
2.2.2. Strategic use of public procurement as part of public demand for innovation

Public demand for innovation has a role when the risk for innovating companies is high. Governments try to mitigate the firm’s risk by providing grants or acting as guarantors for loans. However, these types of government support are granted mainly during the development stage and decrease as the product approaches the market (figure III.2.17), whereas the investment risk becomes highest in the stages between development and commercial sales, i.e. during the demonstration and scale-up phases. The high risk occurs when a supplier needs to commercialise because demand is uncertain. As a result, many products and companies fail at the demonstration and scale-up stage. The knowledge that a real market for the product exists reduces the risk and enables a supplier to invest in anticipation of future revenues. Providing such information is the role of demand-side measures such as the Lead Markets Initiative, public procurement, etc., which will be dealt with further.

Innovation through public procurement has great potential to trigger innovation in industry: public procurement is an important part of local (national) demand, and local demand is an important factor in the decisions of multinational companies when they choose where to locate their activities and how to generate innovation in the specified location; public procurement can also contribute to redressing market and system failures in creating markets for innovative products which meet specific needs; finally, public demand for innovation contributes to the improvement of public services and especially public infrastructure.

Whereas overall public procurement is highest in EU-12 Member States, in terms of procurement of advanced technologies, Luxembourg, Denmark, Sweden and Finland appear leading. However, reliable data on public procurement is scarce. Overall, public procurement makes up about 16% of GDP in the EU. However, the share of GDP which is openly advertised for tender (figure III.2.18) is much lower.

lower due to the fact that publication is only required above a certain threshold value.

Most EU-12 Member States register the highest shares relative to GDP of public procurements which are publicly advertised. Therefore the potential for innovation seems to be high in these countries. It is, however, possible that in countries with strong decentralised administrations, like Germany, the number of below-threshold calls will be higher and might cause an underestimation of the shares of public procurement for these countries.

A second indicator measures the perception of suppliers as regards government purchasing of new technology. Public procurement of advanced technologies can boost innovation but it can also concern imported advanced technologies. The two cases obviously have different relevance for policymaking. In the first case, public procurement of new technologies has a concrete effect in enhancing the national innovation efforts. In the second case it enhances the purchase of innovative products through imports. Despite high levels of overall public procurement, EU-12 Member States score rather weakly regarding government procurement of advanced technology products (figure III.2.19). It is Denmark, Sweden and Finland, together with Luxembourg, which are best rated for procurement of advanced technology among EU-27, in line with the United States, China and South Korea.
Catalytic procurement: the case of Swedish Energy Agency

Catalytic procurement occurs when the state is involved in procurement or even initiates it, but the purchased innovations are in the last instance used exclusively by private end-users.

Introduced around 1990 to promote the emergence of new energy-saving products, technology procurement continues to be part of the tool box of the Swedish Energy Agency today. Among other ongoing policy initiatives, the Agency continues to facilitate market introductions of new energy and environmentally friendly technologies by providing support for technology procurements. It is also considered as a useful tool for the future: the establishment of more ‘Energy Agencies’ is one of the suggestions made for the ongoing Swedish ‘Innovation for Growth’ initiative by the Royal Academy of Science in cooperation with most major policy actors in Sweden. In other words, the aim is to give suitable existing public bodies the task of driving innovation in areas that are deemed socially important.

The general perception of a survey carried out by the ERA–PRISM project (‘Research Policies in Small Member States’, funded within FP7 and coordinated by the Malta Research Council) is that it would be easier to raise innovation on the political agenda if the innovation goal was more often combined with largely accepted objectives such as the ‘green goal’. For instance in Sweden, catalytic procurement for environment continues even after others do not.

Forward Commitment Procurement used in the United Kingdom

Forward Commitment Procurement harnesses the power of public procurement to transform the market, creating the conditions for investment in the goods and services necessary in the shift towards the low carbon economy. It must be public procurement because of the special role of the public sector as agents for the social good by being a lead market for innovation that society needs.

Conceptually Forward Commitment Procurement is simple:

A public-sector body has an unmet need that current products and services cannot deliver. Rather than compromise, the public-sector body offers to buy in the future a product or service that can deliver what it needs, when it needs it, at a price it can afford. It addresses directly the key issues of information, investment and contractual risks and stimulating investment in innovative goods and services. Transfer market risk stays with the procurer, whereas technical risk remains with supplier. The public sector becomes the supply chain manager for the products and services required to deliver the social or common good.

Source: Fergus Harradence, Procurement of Innovation in the UK, A Presentation to the ERA-PRISM Policy Dialogue Workshop, 14 June 2010
FIGURE III.2.19
Perceived government procurement of advanced technology products, perception of suppliers 2009

Note: Averages; Question: In your country, government procurement decisions result in technological innovation? (1 = strongly disagree; 7 = strongly agree) (2009-10 weighted average)

Innovation Union Competitiveness Report 2011
2.2.3. Lead markets and innovation-friendly regulations in support of a single innovation market in Europe

Systemic policies such as the Lead Market Initiative are important parts of the public demand for innovation. In addition, lead markets and innovation-friendly regulations can contribute to the activation of a potential single innovation market.

There is a paradox in the European Single Market. The Single Market for products was created in early 1990s and European manufacturing industries were able to grow and gain global leadership in many industries. The paradox lies in the movement of European countries' economies towards services, which has the knock-on effect that only smaller and smaller parts of the economies can then enjoy the benefits of a single market. For instance, the innovative small digital-services companies cannot access the Single Market and, therefore, have great difficulties in growing. They usually introduce their innovations in Europe in their national market first, and then move to the US because the cost of accessing the US market is no more than the cost of accessing other national markets in Europe. This is creating large costs for Europe.

The creation of a single market for innovation in Europe is one of the explicit objectives pointed out by the Innovation Union Flagship Initiative. Without going beyond the scope of this chapter, it has to be mentioned that the same flagship initiative emphasises the importance of pursuing a broad concept of innovation — both research-driven innovation and innovation in business models, design, branding and services — for developing a single innovation market. The creation of a single innovation market demands measures such as an adequate and affordable protection of patents, an increasing share of public procurement for innovation, and modernising standard-setting which enables interoperability and fosters innovation in fast-moving global markets. All these elements are addressed in various parts of this chapter.

In addition, the Innovation Union Flagship Initiative indicates that the potential of the Single Market should also be activated through systemic policies such as the Lead Market Initiative and innovation-friendly regulations. The improvement of the regulatory framework in key areas such as those linked to eco-innovation and to the European Innovation Partnerships is a specific commitment of the flagship initiative. Beyond their role in creating a single innovation market and therefore helping to address specific bottlenecks from idea to market, systemic policies at European level have a crucial role in addressing some of Europe's major societal challenges. Initiatives such as the Joint Technology Initiatives, Joint Programming and Lead Market Initiative (LMI) have already been established in order to address societal challenges; however, they have tended to operate in isolation. They are all foreseen to operate in the future under the umbrella of European Innovation Partnerships (EIPs), which are instrumental for the implementation of the Innovation Union Flagship Initiative. The partnerships will bring together policies on the supply side (such as R&D funding, Joint Programming, Joint Technology Initiatives, European Technology Platforms), and those from the demand side (such as the Lead Market Initiative, and innovation-friendly regulations such as the Strategic Energy Technology Plan).

This section will analyse systemic policies at European level, including the LMI and innovation-friendly regulations such as the Strategic Energy Technology or SET Plan. More precisely, it will explore whether these systemic policies are operating in the fast-growing domains in science and technology or if, on the contrary, there is a time lag in the development of policy initiatives compared to the development of science and technology. If the policies are operating in fast-growing domains, it would confirm a natural assumption that advances in S&T are significant drivers of policy developments in the field of research and innovation and it would show a political will at European level towards facilitating the transfer of knowledge from research to technology towards the market.

European policy initiatives are generally developed in sectors related to fast-growing science and technology fields, but some expanding fields are not covered, including research fields that could generate non-technological innovation (such as business models or branding).

In comparing the sectors of the European initiatives with the fast-growing science and technology fields, one can 333 Thus far JTIs and ETPs have been supply-side policies. They have been advised by various evaluations that they should complement this with demand-side activities.
The Single Market is one of the European Union’s greatest achievements. Restrictions between member countries to trade and free competition have gradually been eliminated, with the result that standards of living have increased.

The Treaty of Rome (1957) establishing the European Economic Community (EEC) set out four freedoms for Europe: free movement of goods, free movement of services, free movement of capital and free movement of people. The first of these was established relatively quickly. The 1957 Treaty made it possible to abolish customs barriers within the Community and establish a common customs tariff applied to goods from non-EEC countries. This objective was achieved on 1 July 1968.

Progress on the other areas was slower. Given that customs duties are only one aspect of barriers to cross-border trade, other trade barriers hampered the complete achievement of the common market in the 1970s. Technical norms, health-and-safety standards, national regulations on the right to practise certain professions and exchange controls all restricted the free movement of people, goods and capital.

In June 1985 the Commission, under its then President, Jacques Delors, published a White Paper setting out the far-reaching goal to abolish, within seven years, all physical, technical and tax-related barriers to free movement within the Community. The aim was to stimulate industrial and commercial expansion within a large, unified economic area.

The enabling instrument for the Single Market was the Single European Act, which came into force in July 1987, and set a deadline for the gradual establishment of the Single Market for 1992. With the changes brought about by the Single European Act in place, a large number of laws were passed addressing the technical, regulatory, legal and bureaucratic obstacle on the ways to free trade and free movement. The free movement of capital was marked by the Economic and Monetary Union which came into being in 1999.

Nevertheless, the Single Market still has many areas where potential is untapped or not fully exploited. The Commission has also for example focused its attention on opening up the market for services in the last decade. On 13 April 2011, the Commission adopted the Single Market Act, an action plan to further unlock the potential of the single market for economic recovery and growth and to boost citizens’ confidence. Through 12 ‘levers’, with a key action for each, the Single Market Act sets out the ambition of the European Union to deliver concrete legislative and policy results in the run up to the 2012 anniversary of the 1992 achievements.

notice that the European policy initiatives are generally developed in sectors related to the fast-growing S&T fields (Table III.2.4).

However, there are a few fast-growing fields which are not represented in any European initiative mentioned above. These are mechanical engineering scientific fields (which have risen with 40.6% in terms of publications between 2000 and 2006), as well as the technological sectors of thermal processes and apparatus (58.2%) and engines, pumps, turbines (54.94%). Another fast-growing field which is partially reflected in only one LMI (sustainable construction) is geological engineering, with a considerable growth rate of 68.8% between 2000 and 2006.

Finally, the table below does not show any remarkable presence of social sciences as an instrument to understand and shape technologically-related structural change and its extended social and economic implications.

It may also show that the European initiatives analysed in table III.2.4 do not put a great emphasis on non-technological innovation such as business models or branding.
### TABLE III.2.4
Fast growing S&T fields vs. European policy initiatives sectors

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<tr>
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<td>Computer sciences 115 %</td>
<td>IT methods for management (72.59 %)</td>
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<tr>
<td></td>
<td>Digital communications (62.9 %)</td>
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<tr>
<td>Health sciences 41.9 %</td>
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<tr>
<td>Geological engineering 68.8 %</td>
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<td></td>
</tr>
<tr>
<td>Civil engineering 64.2 %</td>
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<td>Urban Europe</td>
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<td>Environmental sciences 52.4 %</td>
<td>Environmental technology (54.73 %)</td>
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<tr>
<td>Materials science 47.3 %</td>
<td>Materials, metallurgy (34.08 %)</td>
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<tr>
<td></td>
<td>Micro-structural and nanotechnology (141.73 %)</td>
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<td></td>
<td>Semiconductors (64.4 %)</td>
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<tr>
<td>Other engineering sciences (41.29 %)</td>
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<tr>
<td>Mechanical engineering 40.6 %</td>
<td>Thermal processes and apparatus (58.2 %)</td>
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</tr>
<tr>
<td></td>
<td>Engines, pompes, turbines (54.94 %)</td>
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<tr>
<td>Moderate growing scientific fields</td>
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<tr>
<td>Information and communication sciences (34.41 %)</td>
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<tr>
<td>Electrical engineering (31.67 %)</td>
<td>Electrical machinery, apparatus, energy (45.57 %)</td>
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<tr>
<td>Fuels and (nuclear) energy (30.45 %)</td>
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<tr>
<td>Chemistry (28.72 %)</td>
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<tr>
<td>Agriculture and food sciences (25.78 %)</td>
<td>Agriculture, Food Security and Climate Change</td>
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<td>Biological sciences (21.45 %)</td>
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<td>Other social and behavioural sciences (18.9 %)</td>
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<tr>
<td>Low growing scientific fields</td>
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<td>Aerospace engineering (1.8 %)</td>
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<tr>
<td>Plant and animal sciences (no data on growth rate)</td>
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334 Source: DG Research, Data: CWTS — Leiden University /Web of Science (Thomson Reuters).
335 Source: WIPO — PCT patent applications.
<table>
<thead>
<tr>
<th>European Technology Platforms</th>
<th>Lead Market Initiative</th>
<th>JTs</th>
<th>SET Plan</th>
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<tr>
<td>Embedded Computing Systems (ARTEMIS)</td>
<td>EHealth (telemedicine/homecare and clinical information systems)</td>
<td>Embedded Computing Systems</td>
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<tr>
<td>Networked European Software and Services Initiative (NESSI)</td>
<td>Sustainable construction</td>
<td>Innovative medicines initiative</td>
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<td>Nanotechnologies for medical applications (NanoMedicine)</td>
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<td>European Technology Platform on Sustainable Mineral Resources (ETPSMR)</td>
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<td>Plants for the Future (Plants)</td>
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</table>
2.2.4 Building competitive and open national markets

Local competition and foreign competition are considered necessary ingredients for innovation. It is broadly considered that competition between firms increases the level of innovation in the economy, although with certain differences between industries. Some evidence cited by the same NESTA report shows that some sectors dominated by large firms achieve high levels of innovation, whereas in industrial sectors dominated by smaller firms with significant competition between them, the innovation level is lower. In addition, foreign competition and foreign ownership have the potential for providing sources for innovative ideas/products to the domestic firms. On one hand, there is the overall competitive pressure of foreign competition. On the other hand, foreign firms operating in a local market, especially the multinational enterprises (MNEs), are able to provide the domestic firm with resources (such as finance, technology, knowledge and managerial expertise) which might not be provided by smaller, domestic firms.

Local competition is perceived to be more intense overall in Western European countries compared to the EU-12 Member States, and is particularly strong in Germany, Austria, and the Netherlands.

The indicator used for the local competition is based on the WEF survey asking corporate CEOs to indicate the strength of competition between firms within a given country (the sample included between 80 and 100 responses per country). The intensity of local competition is perceived to be very strong in Germany, Austria, the United States, and Belgium. At the other end of the scale there are both EU-12 Member States (Latvia, Lithuania, Romania and Bulgaria) and Southern European countries (Italy and Greece).

FIGURE III.2.20 Perceived Intensity of Local Competition

Data: Averages; Question: How would you assess the intensity of competition in the local market in your country? (1 = limited in most industries; 7 = intense in most industries) (2009-10 weighted average)

In addition to the two indicators above which look at competition within a national economy, other indicators consider the competition of an economy in a broader context. Both trade as percentage of GDP and net FDI inflows relative to GDP are further indicators that show the extent to which a national economy is open to foreign competition. In particular, the level of FDI in a given country reflects overall the attractiveness of that country.

337 The OECD definition of this indicator is the following: the trade-to-GDP-ratio is the sum of exports and imports divided by GDP. This indicator measures a country’s ‘openness’ or ‘integration’ in the world economy. It represents the combined weight of total trade in its economy, a measure of the degree of dependence of domestic producers on foreign markets and their trade orientation (for exports) and the degree of reliance of domestic demand on foreign supply of goods and services (for imports). The trade-to-GDP-ratio is often called the ‘trade openness ratio’. However, the term openness-to-international-competition may be somewhat misleading. In fact, a low ratio for a country does not necessarily imply high (tariff or non-tariff) obstacles to foreign trade, but may be due to the factors mentioned above, especially size and geographic remoteness from potential trading partners. For example, it is generally the case that exports and imports play a smaller role in large economies than they do in small economies.
Whereas the Netherlands is well exposed to foreign competition, the most open economy seems to be Belgium, as reflected both by high exposure to foreign competition and substantial net FDI inflows.

Figure III.2.21 illustrates trade (imports plus exports) as a % of GDP, giving an indication on this exposure.
As regards FDI, figure III.2.22. on net FDI inflows relative to GDP (2008) shows that Cyprus – and Ireland – benefited from high levels of FDI in 2009, followed by Estonia. These countries have also experienced high increases of their FDI intensity between 2008 and 2009.
2.2.5. Speed and cost of standardisation

Standardisation is an important tool for removing trade barriers for industry and consumers. The use of standards to support innovation is one of the advantages that draw a lot of attention to standard setting. The interest results from the supposition that agreed standards ensure that the risk taken by both innovators and early adopters is lower, due to the fact that they will not develop a redundant technology. Therefore standards help to increase investment in innovation.

However, as an instrument, standards need to be carefully used. The timing of issuing set standards is an important issue: too soon and a technology might be not sufficiently mature to deliver high performance. Too late, and divergence in standards may emerge. While regulation is the responsibility of governments, standard setting is largely the responsibility of industry bodies.

At European level, the European Committee for Standardisation (CEN) is a major provider of European standards and technical specifications in all areas of economic activity with the exception of electrotechnology and telecommunication. The two committees responsible for standardisation in the remaining two fields are the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunications Standards Institute (ETSI). The CEN standards have a unique status: they are also national standards in each of their 31 Member countries (including the EU-27 Member States). Once a standard is set and published (adopted) by CEN, that standard will be adopted by all these countries and every conflicting national standard will be withdrawn. In this way, CEN standards facilitate the reach of a far wider market with much lower development and testing costs.

The overall number of published standards at CEN increased by over 40% between 2000 and 2009

As shown in table III.2.5, the number of published standards has increased from 1,105 in the year 2000 to 1,454 in 2009. The sectors with the highest numbers of standards published in 2009 have been: transport and packaging (260 publications), mechanical engineering — machinery (233 publications), healthcare (166 publications), and building and civil engineering (158 publications).

The sectors with an increasing number of standards publications between 2000 and 2009 are: non-metallic food materials, chemistry, transport and packaging, mechanical engineering — pressure equipment, pipes, tanks and accessories, mechanical engineering — machinery, healthcare. In contrast, sectors with a decreasing number of issued standards between 2000 and 2009 are: utilities and energy, general mechanical engineering, metallic materials, health and safety, environment, household goods, sports and leisure, building and civil engineering.

339 www.cen.eu.
340 www.cenelec.eu.
### Table III.2.5

Number of published standards, 2000-2009

<table>
<thead>
<tr>
<th>Sector</th>
<th>2000</th>
<th>2001</th>
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Source: DG Research and Innovation
Data: CEN

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**Chapter 2: Framework Conditions for Business R&D**

366
The time needed by CEN to get a standard on the market has been reduced by half in the last decade

Figure III.2.23. shows that the time needed to publish a standard by CEN has decreased from an average of 80 months in 2000 to 40 months in 2010, showing an increase in the efficiency of the standardisation bodies. A large number of standards (75 %) are developed within three years in 2010, from a base of only around 15 % in 2000.
2.3. Enhancing entrepreneurship

The development of human resources with innovation-relevant skills and in particular entrepreneurship, are crucial conditions for the emergence of innovation that can be commercially valorised in the market. Entrepreneurs contribute to the stimulation of new economic activity, due to the fact that they exploit new technological or commercial opportunities that existing firms did not exploit previously.

The main data source in this section is the Eurobarometer survey, which has a relatively small sample size. Therefore, the data on entrepreneurship should be considered as a first estimation which could be benchmarked against other surveys (i.e. the GEM surveys).

The EU has fewer entrepreneurs compared to China and the United States. Finland has the highest rate of entrepreneurial activity. At the other end of the scale are Belgium, Denmark, France, Luxembourg, Malta, Slovakia and Slovenia.

In 2009, 13% of EU citizens (on average) have been involved in entrepreneurial activities. The EU is significantly surpassed by China (27%) and the United States (21%), whereas Japan records similar rates (14%). The lower levels of entrepreneurial activities in European countries compared to China and the United States reflect the relative risk-aversion of Europeans and their preference for employment over self-employment. It could also show that there are good income alternatives available, through jobs and social security.

Among EU Member States, Finland has the highest rate (25%) of entrepreneurial activity, followed by Cyprus (18%), Ireland and Romania (16% each of them). Belgium, Denmark, France, Luxembourg, Malta, Slovakia and Slovenia, on the other hand, had entrepreneurship rates below 10%.

In the countries with the highest rates of entrepreneurial activity, there is a prevalence of the early-stage over established business.

Early-stage entrepreneurial activity is important due to the fact that it fosters the future output of enterprises. Early-stage entrepreneurial activity (for recently started or taken-over businesses or businesses being started) was somewhat higher in Finland, Romania, Cyprus, Ireland and Sweden (10–14%, compared to an EU average of 7%). In all these countries, there is a prevalence of early-stage entrepreneurial activity over established business.

Share of surveyed respondents engaged in an entrepreneurial activity(1): early-stage(2) and established business, 2009

FIGURE III.2.24

Source: DG Research and Innovation
Data: Eurobarometer, Entrepreneurship in Europe and beyond, 2010
Notes: (1) Q: Have you ever started a business or are you taking steps to start one? How would you describe your situation: you are currently taking steps to start a new business; you have started / taken over a business in the last three years which is still active today; you have started / taken over a business more than three years ago and it’s still active today?
(2) Early stage is the sum of embryonic entrepreneurship (respondents who were taking the necessary steps to start up a business at the time of the survey) and of new business (those who had started or had taken over a business in the last three years and which was still active at the time of the survey).
**About half of EU Member States raised the level of their entrepreneurial activities between 2004 and 2009**

Some countries have kept relatively similar levels over the two years: Norway, Estonia, the United Kingdom, Spain, Italy, Spain, Slovenia and Belgium. A few other Member States lowered their entrepreneurial activities: Greece, Austria, Czech Republic, Hungary, Denmark and Luxembourg (figure III.2.25).

![Share of surveyed respondents engaged in an entrepreneurial activity](image)

*FIGURE III.2.25 Share of surveyed respondents engaged in an entrepreneurial activity* (total of early-stage and established business), 2004 and 2009

For entrepreneurial activity to occur in a country it is important that individuals perceive opportunities for starting a business and perceive that they possess the capabilities to start a business. Therefore out of all personal entrepreneurial traits, fear of failure is a significant obstacle preventing start-ups, and an indicator correlated closely to firm formation. In addition, the fear of failure can also reflect the different degrees of risk aversion across countries.

**Entrepreneurs in Finland and Norway have the lowest fear of failure when starting up a business**

The perceptions about business start-ups show that Romania has the highest fear of failure rate (53% of the respondents), followed by Japan (50%), France (47%), Greece and Spain (45%). The countries where respondents perceive the lowest fear of failure about starting up a business are South Korea (23%), Norway (25%), Finland (26%), and the United States (27%).
The greatest fears when starting up a business are the fear of going bankrupt, the uncertainty of not having a regular income, and the risk of losing the entrepreneurs’ own property.

Figure III.2.27, below indicates the greatest fears when starting up a business: the possibility of going bankrupt (49% of the respondents), the uncertainty of not having a regular income (40% of respondents) and the risk of losing one’s own property (37%).
In 24 countries, the three fears mentioned above were the most mentioned fears associated with a business start-up. For instance, 55% of Romanians were concerned about the possibility of going bankrupt, 43% listed the uncertainty of not having a regular income and 31% selected the risk of losing their property. In Greece, Italy, Cyprus, Slovakia and Turkey respondents were more likely to be concerned about job security than about losing their property. Respondents in Malta, China, South Korea and Lithuania were the most likely to name the possibility of personal failure, which was named among the top three most mentioned fears associated with a business start-up. Similarly, Swedish, Finnish and Norwegian respondents mentioned as one of their top three fears that a business start-up would require too much time and effort.
1. **If you were to set up a business today, which are the two risks you would be most afraid of?**

   **Key Risks:**
   - Losing property
   - Going bankrupt
   - Uncertain income
   - Need too much energy
   - Personal failure
   - Job insecurity

2. **Source:** DG Research and Innovation
   **Data:** Eurobarometer, Entrepreneurship in Europe and beyond, 2010
   **Note:** (1) Q. If you were to set up a business today, which are the two risks you would be most afraid of?
Perceived barriers to entrepreneurship are the lack of available financial support, complex administrative procedures, and difficulties obtaining sufficient information on starting up a business

Barriers to entrepreneurship run across a number of areas, from lack of available financial support through to regulation and administrative burden. Over 80% of EU citizens agreed that it was difficult to start up a business due to a lack of available financial support as shown in Figure III.2.29. Of the respondents, 71% agreed that business start-ups were difficult due to complex administrative procedures. A lower percentage of EU citizens (51%) agreed that it was difficult to obtain sufficient information about how to start up a business. A total of 81% agreed that people who had started a business and had failed should be given a second chance. Finally, opinion was split as to whether a business start-up should be avoided if there was a risk that this venture might fail: 50% agreed and 46% disagreed.

**FIGURE III.2.29**

EU – Barriers to entrepreneurship, 2009

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Don’t know / Not available</th>
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<td>It is difficult to start one’s own business due to the complex administrative procedures</td>
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<tr>
<td>It is difficult to obtain sufficient information on how to start a business</td>
<td>17</td>
<td>34</td>
<td>29</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>People who have started their own business and have failed should be given a second chance</td>
<td>28</td>
<td>53</td>
<td>10</td>
<td>3</td>
<td>7</td>
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<tr>
<td>One should not start a business if there is a risk it might fail</td>
<td>19</td>
<td>31</td>
<td>33</td>
<td>13</td>
<td>5</td>
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</tbody>
</table>

Source: DG Research and Innovation
Data: Eurobarometer, Entrepreneurship in Europe and beyond, 2010

It is perceived to be easiest to doing business in the United Kingdom, Denmark, Ireland, Finland and Sweden. The regulatory environment is less conducive to the operation of business in Greece, Italy, Poland, the Czech Republic and Romania

The regulatory environment is also important for the operation of business and for encouraging entrepreneurial activities. The World Bank produces an index on which economies are ranked on their ease of doing business, from 1–183, with first place being best (Table III.2.6). A high ranking on the ease-of-doing-business index means the regulatory environment is conducive to the operation of business.\(^\text{342}\)

\(^{342}\) This index averages the country’s percentile rankings on 10 topics, made up of a variety of indicators, giving equal weight to each topic. These topics are: Starting a business, protecting investors, dealing with construction permits, paying taxes, trading across borders, employing workers, registering property, enforcing contracts, getting credit, closing a business.
chapt Er 2:fram Ework conditions for busin Ess r&d

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To conclude, whereas the EU has fewer entrepreneurs than China and the United States, Finland is the European country with the highest rate of entrepreneurial activity. This is confirmed by the lowest fear of failure when starting a business in Finland compared to any other EU Member State.

Overall the countries with a high rate of entrepreneurial activity have a prevalence of the early-stage over established business and about half of EU Member States raised the level of their entrepreneurial activities between 2004 and 2009.

The greatest fears when starting up a business are the fear of going bankrupt, the uncertainty of not having a regular income and the risk of losing the entrepreneurs' own property. The most often perceived barriers to entrepreneurship are the lack of available financial support, complex administrative procedures, and difficulties obtaining sufficient information about how to start up a business.

It is perceived easiest to do businesses in the United Kingdom, Denmark, Ireland, Finland, and Sweden. The regulatory environment is less conducive to the operation of business in Greece, Italy, Czech Republic or Poland.

<table>
<thead>
<tr>
<th>Economy</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore</td>
<td>1</td>
</tr>
<tr>
<td>Hong Kong SAR, China</td>
<td>2</td>
</tr>
<tr>
<td>New Zealand</td>
<td>3</td>
</tr>
<tr>
<td>United Kingdom</td>
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<td>United States</td>
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<td>Denmark</td>
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<td>Canada</td>
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<td>Ireland</td>
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<td>Australia</td>
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<td>Finland</td>
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<table>
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<td>Kosovo</td>
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<td>India</td>
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CHAPTER 3

Structural change for a knowledge-intensive economy

HIGHLIGHTS

Structural change in the economy is defined in this part as two disjoint phenomena: a) increase in the share of high and medium high tech sectors (combined with the emergence of new knowledge intensive sectors), and b) increase the intensity of knowledge incorporated in more traditional sectors, including by the emergence of specific specialised sub-sectors.

In the last 15 years, the EU economic structure has been smoothly changing the weight of the manufacturing and services sectors. While manufacturing has been reducing its share in employment, the services increased their share in the overall employment to 70%. At Member States level, different situations can be observed: the countries with a higher share of employment in the manufacturing sector are either catching-up countries like the EU-12 Member States and Italy and Portugal (where the traditional sectors still play an important role in the overall economy) or the Member States with a highly knowledge-intensive manufacturing sector (Germany, Finland and Sweden).

The growing weight of the services sectors, which in general have a lower R&D intensity, has offset the increasing research-intensity in several manufacturing or in some of the services sectors. However, the gradual evolution towards a higher share of services in the economy is only part of the structural change, as economies around the world are increasingly injecting more knowledge in their activities. This knowledge accumulation can be measured both by the knowledge of the labour force in each sector and by the research intensity of each sector.

Since 2000 the EU economy has become slightly more knowledge-intensive, but the gap with the United States persists. In 2009 knowledge-intensive activities (KIAs) represent 35% of total employment on average in the EU with no large variation around this rate among European countries apart from few exceptions. Change is taking place at country level in R&D intensity in the manufacturing sector, and overall the EU is showing a structural change towards higher knowledge-intensity in the existing sectors, but with a smaller size of these sectors in the total value-added of the economy. The structural change towards higher knowledge intensity within sectors in the EU has not been sufficient in itself to raise the knowledge intensity of the economy. When benchmarking with the United States, which has a similar share of manufacturing and services in its economy, we see that there is still room for further increases in the research intensity of the high and medium high-tech industries in the EU as well as in services. The structural composition of the economy is another aspect that reinforces this trend, as discussed previously in the chapter on fast-growing companies. The capacity of SMEs and of enterprises of intermediate size to grow and to respond better to the emerging needs, is often instrumental for accelerating structural change both within traditional manufacturing sectors and towards new types of knowledge intensive activities.

Structural change from the perspective of R&D intensity can be analysed at the level of firms. The 2010 European Industrial R&D Investment Scoreboard, covering the 1000 EU top firms in terms of R&D investments (both manufacturing and services sectors), shows that in 2009 the R&D intensity of the EU companies slightly increased reaching 2.4%.

The different strategies and policies that countries and regions adopt can define a framework conducive to the stimulation of structural changes. These strategies and policies may need to be adapted to the specific circumstances of the individual countries, and sometimes they may favour moves towards higher knowledge intensive activities within existing sectors, building on the existing experience, and sometimes they may require a shift towards new sectors.
3.1. Is the economic structure in Europe becoming more knowledge intensive?

Structural change has been part of economic analysis since the late 1930s, and several definitions have been discussed. The concept points at a fundamental widespread change of the economic structure which can be influenced by policy decisions, by permanent changes in the resources, or by changes in the education and skills profile of the population of a region/country. In the perspective of the present chapter, structural change implies the transformation of an economy towards higher value creation. In general terms, we can consider two means of structural changes in the economy: (1) increasing the share of high and medium high tech sectors, combined with the emergence of new knowledge-intensive sectors and (2) increasing the incorporation of knowledge in more traditional sectors and the emergence of niches of sub-sectors formed by innovative fast growing firms.

In the last 15 years the overall economic structures of the EU, and those of the United States and Japan, have not changed drastically. Nevertheless, all three are smoothly progressing towards economies with an increasing weight in the services sectors and a corresponding decrease in the manufacturing sectors. This slow trend is visible when one compares the changes in the shares of the EU’s employment in manufacturing and services in 1995 (respectively 20.1% and 62.9%) and in 2009 (respectively 15.7% and 70.4%) (figure III.3.1). The Japanese economic structure shows very similar figures and progress over the 1995–2007 period (2007 being the last year available), with the employment share of the manufacturing sector dropping from 20.8% to 17.4% while the share of employment in the services sector increased from 60.7% to 68.2%. In 1995, the economic structure of the United States showed a larger share of employment in the services sector. This fact lies in the correspondence between the bigger weight of the ICT services sectors compared to the EU. Back in 1995, the manufacturing sector in the United States had a share of employment of 13.6% and the services sector a share of 78.2%. Twelve years later, manufacturing is accounting for less than 10% of total employment and services have passed 81.6%.

**FIGURE III.3.1** Employment in manufacturing and services as % of total employment, 1995-2009

Source: DG Research and Innovation
Data: Eurostat, OECD

Fisher (1939) and Clark (1940) looked at patterns in changes in sectoral employment.
Countries with a higher share of employment in the manufacturing sector are either catching-up countries or Member States with a competitive or research-intensive manufacturing sector

It is interesting to analyse what is happening in the EU at country level concerning the changes in employment in manufacturing and in services. Figure III.3.2. represents the actual share of employment (for the year 2009) in the manufacturing and services sectors, where the Czech Republic is the only EU country with a share of total employment in the manufacturing sector bigger than 25% (one quarter of total employment). With the exception of Romania, which has a special situation, which will be discussed later in more detail, the services sector is the big employer with shares that range from 39.2% to 80.8% in the United Kingdom. Different situations can be observed: the countries with a higher share of employment in the manufacturing sector, are either catching-up countries like the EU-12 Member States (the Czech Republic, Slovakia, Slovenia, Hungary, Poland, Romania, Estonia, Bulgaria, and Lithuania) and Italy and Portugal (where the traditional sectors still play an important role in the overall economy) or the Member States with a well-developed and research-intensive manufacturing sector (Germany, Finland and Sweden). Countries like Denmark, Belgium and France have a very similar distribution of employment shares between manufacturing and services, where services represent between 76% and 78% of total employment of these countries. The Netherlands and the United Kingdom have a particular sectoral distribution in employment: they mirror the United States’ distribution of employment shares. Greece and Ireland are the EU-15 Member States which still have an important share of employment in the primary sector.

The growing weight of service sectors, which have a lower R&D intensity, has offset the effect of increasing research-intensity in individual sectors

Complementing the previous discussion on shares of employment, Figure III.3.3. presents the average annual growth rates of employment in manufacturing and in services between 1995 and 2009. All the growth rates of employment in manufacturing are negative. Figure III.3.3. indicates that the highest growth rates of employment in services are taking place in catching-up economies, or in countries like Ireland, which had an ICT sector boom.

In the period 1995–2009, the EU average annual growth rate of employment in the manufacturing sector was -1.7%, compared to -1.5% in Japan and -2.7% in the United States. In the services sector, the average annual growth rate between 1995 and 2009 was 0.8%, 1% in Japan and 0.4% in the United States. This implies a gradual trend towards a services economy, with a decrease in the manufacturing sector. This fact explains in part (not totally, since other aspects have to be taken into consideration) why the R&D intensity of the EU and the United States have been stagnating in the last decade. Generally, services sectors are less research-intensive. This is aggravated by the fact that in many countries the statistics on R&D in the service sectors are not accurate, nor considered by default. The growing weight (in terms of GDP) for the low R&D-intensive services sectors offsets the effect of increasing research intensities in many individual sectors. Moreover, the increase in research intensity in low-tech and medium low-tech manufacturing sectors has a limited impact on the overall business R&D intensity of the EU, the level of which is predominantly determined by the research intensity and size of the medium high-tech and high-tech industries.

344 For a comprehensive analysis of the R&D intensity in the EU and the United States, see Part I, Chapter 1, 2, 3 and 5.
FIGURE III.3.2  Employment by type – % shares, 2009(1)

Source: DG Research and Innovation
Data: Eurostat, OECD
(2) The former Yugoslav Republic of Macedonia.
(3) Malta is not included on the graph due to unavailability of data.
FIGURE III.3.3
Share of employment in manufacturing and services – Average annual growth (%), 1995-2009(1)

Innovation Union Competitiveness Report 2011

Source: DG Research and Innovation
Data: Eurostat, OECD
(2) The former Yugoslav Republic of Macedonia.
(3) Malta is not included on the graph due to unavailability of data.
The gradual evolution towards a higher share of services in the economy is only part of the structural change. In parallel, the economies in the world are increasingly injecting more knowledge into their activities. From a statistical perspective, this knowledge accumulation can be measured by two aspects: the knowledge of the labour force in each sector and the research activity of each sector. For the first aspect, a new indicator has been constructed by Eurostat, focusing on Knowledge-Intensive Activities. For the second aspect, the current statistical system focuses on the business R&D intensity using OECD taxonomy of high-tech, medium high-tech, medium low-tech and low-tech manufacturing sectors combined with the classification knowledge-intensive services. The current chapter will explore the data according to both of these aspects, relating them to the economy as share of employment.

Currently the best-known research and innovation taxonomy of industries is the distinction between high-, medium-high-, medium-low-, and low-technology manufacturing industries brought forward by the OECD. In this taxonomy, economic sectors are grouped according to their R&D intensity. This taxonomy is valid only for a small part of the statistical classification of economic activities (NACE), namely the manufacturing industry. It has a strong technological bias and excludes from the ‘high-technology’ category some of the less R&D-intensive but potentially knowledge-intensive and innovative sectors.

The knowledge economy develops largely through the structural evolution of economic activities towards more knowledge-intensive ones, beyond the R&D-intensive manufacturing sectors. This can be monitored by observing the evolution of the relative weight of the most Knowledge-Intensive Activities (KIs) in the economy. KIs are defined as economic sectors in which more than 33% of the employed labour force have 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.

Over the period 2000–2007, the EU economy has become slightly more knowledge-intensive, but the gap with the United States persists

In general, the economy is increasing the incorporation of knowledge, making use of more advanced technologies, and increasing the demand on the corresponding skills and education of those using them. As a general movement, the minimal skills required in the labour market, have been growing. The embedding of skilled and highly educated labour into the economic structure is a highly relevant aspect of a knowledge economy. A shift towards a higher incorporation of knowledge in the economy can therefore be measured by the share of employment and the share of value added of the activities with skilled employed persons that have completed ISCED 5 or ISCED 6. This new indicator captures the market demand for innovation and avoids any bias, regarding manufacturing versus services, or technology-oriented versus non-technological innovation. It is also a useful tool to benchmark the potential of a region or country for future innovation.

Knowledge-Intensive Activities represent 35% of total employment on average in the EU. Between 2008 and 2009 there was a slight increase

Knowledge-Intensive Activities (KIs) can be measured as a share of employment. In this sense, Europe is becoming more knowledge-intensive since its shares of employment in the knowledge-intensive activities have grown. Central and Northern Europe are more knowledge-intensive, while the Southern European countries and in general the EU-12 Member States have a smaller share of employment in knowledge-intensive activities (figure III.3.4). In 2009, KIs represented 30–40% of total employment in the vast majority of countries, and 35% in the EU on average. Luxembourg stands out with 56% of employment in KIs, while Romania and Turkey are below all other European countries, with less than one fifth of total employment in KIs. Apart from the Netherlands and Cyprus, the share of KIs in total employment increased slightly in 2009 compared to 2008 by 2.4% (Table III.3.1).
### FIGURE III.3.4

Employment in Knowledge-Intensive Activities (KIA) as % of total employment, 2009

<table>
<thead>
<tr>
<th>Employment in knowledge intensive activities (KIA) as % of total employment, 2009 (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.2 - 56.3</td>
</tr>
<tr>
<td>40.2 - 48.2</td>
</tr>
<tr>
<td>32.2 - 40.2</td>
</tr>
<tr>
<td>24.2 - 32.2</td>
</tr>
<tr>
<td>16.1 - 24.2</td>
</tr>
</tbody>
</table>

Source: DG Research and Innovation
Data: Eurostat

Note: (1) MK: 2008.
IL: data not available
The map above (figure III.3.5) shows the growth registered in the KIAs, as % of total employment, over the period 2000-2008. The Central and Northern countries, with the exception of Norway, Luxembourg and Switzerland, register smaller growth rates, while Portugal, Slovenia, Spain and Turkey show a catching-up progress towards more knowledge intensive economy. In contrast, Bulgaria, Austria, Iceland and Croatia decreased the % of employment in KIA, over the same period. One should note that the two maps (figure III.3.4 and figure III.3.5) are not completely comparable since there is a break in series in the year 2008. The first map uses the definition of KIA based on the NACE Rev. 2 classification while the second map, the growth in KIA from 2000 to 2008, is based on NACE Rev. 1.1.
The analysis can also focus on the knowledge-intensity of the business sector (i.e., excluding KIAs in the public sectors). The table III.3.1 presents the data for KIAs in the business sector (which includes also business services). This breakdown gives also an indication of the market demand for innovation, a very pertinent factor in favour of the sustainable development of innovation.

KIAs in the business sector represent 10–20% of total employment in the large majority of countries in 2009, with 13.4% in the EU on average. This share is also in slight progression with a growth of 1.5% compared to 2008.348

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**TABLE III.3.1**

**Employment in Knowledge Intensive Activities (KIA) as % of total employment, 2008 and 2009**

<table>
<thead>
<tr>
<th></th>
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<td>41.2</td>
<td>41.4</td>
<td>0.5</td>
<td>14.9</td>
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<td>-2.8</td>
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<td>25.6</td>
<td>26.0</td>
<td>1.3</td>
<td>8.3</td>
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<td>28.1</td>
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<td>3.9</td>
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<td>11.3</td>
<td>1.6</td>
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<td>15.0</td>
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<td>-3.3</td>
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<td>8.1</td>
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<td>1.0</td>
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<td>-1.5</td>
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<td>15.9</td>
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<td>8.2</td>
<td>8.9</td>
<td>8.1</td>
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<td>2.9</td>
<td>8.8</td>
<td>8.8</td>
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<td>5.6</td>
<td>5.8</td>
<td>3.7</td>
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<td>31.9</td>
<td>4.5</td>
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Source: DG Research and Innovation
Data: Eurostat
Note: (1) The former Yugoslav Republic of Macedonia.

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348 The KIA classification was developed in 2010 by Eurostat on the basis of NACE Rev. 2 currently in use. To have historical values for reference years prior to 2008, the KIA classification is established on the basis of NACE Rev. 1.1.
Employment in high-tech and medium high-tech industries plus in knowledge intensive services (KIS) has in general not increased between 2008 and 2009.

The analysis of KIAs can be complemented by an analysis of structural change building on R&D investment level as main measurement of the knowledge-intensity of the economy. Such an analysis would build on the taxonomy of the OECD, focusing on high-tech and medium high-tech sectors together with knowledge-intensive services. In other words, we can say that while the KIA classification was based on the level of the skills of the human resources working in the sectors, the OECD taxonomy is related with the R&D intensity of the different sectors. Total employment in high-tech and medium high-tech industries and in knowledge intensive services ranges between 30% and 55% of total employment, except for Romania with 24.4% and Turkey with 21.5% (figure III.3.6). Belgium, Luxembourg, Sweden, Denmark, Finland, the United Kingdom, Iceland and Norway evidence a rate of employment in the high-tech and medium high-tech industries and knowledge intensive services well above the 50% of total employment.
Employment in high-tech and medium high-tech manufacturing and in knowledge-intensive services (KIS) as % of total employment – growth, 2008-2009

Figure III.3.7 visualises the annual growth rates of employment in high-tech and medium high-tech industries and KIS between 2008 and 2009: high growth for Ireland and Estonia, followed by Spain and Lithuania. The Netherlands, Lithuania and Cyprus decreased their share of employment in the same sectors.
However, the research-intensity has not grown evenly across the different sectors (Table III.3.2). While in general terms, there is a slight increase in total employment in research-intensive sectors in Europe, it is mostly the research-intensive services that are increasing. Following the general movement of the European economy towards a more service-based economy, the Knowledge-Intensive Services present a positive growth over the period of 2008-2009 (the only exceptions are the Netherlands and Cyprus), while the high-tech and medium-high-tech sectors have experienced a clear negative growth over the same period. The exceptions are Germany, Sweden, Ireland and Italy, countries with a manufacturing sector bigger than the average. For these same countries, the growth of employment in Knowledge-Intensive Services, as share of total employment, remains positive, although more modest.

<table>
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<th>Medium-High-Tech(2)</th>
<th>Knowledge Intensive Services (KIS)</th>
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Source: DG Research and Innovation
Data: Eurostat
Innovation Union Competitiveness Report 2011

Notes:
1. The values for EE, HR and MK for 2008 and for EE, CY and HR for 2009 are considered to be unreliable or uncertain.
2. The values for CY and LU for 2008 and for MT for 2009 are considered to be unreliable or uncertain.
3. The former Yugoslav Republic of Macedonia.
Trends in R&D intensities of companies based in selected Member States:

Finally, structural change from the perspective of R&D intensity can be analysed at the level of firms. The European Industrial R&D Investment Scoreboard analyses data on the 1,000 top EU firms in terms of R&D intensity, covering firms active both in the manufacturing and the services sector.

Worldwide corporate R&D investment growth was high (6.9%) in 2008, but the trend was decreasing, aggravated by the economic and financial crisis that affected business investment globally — albeit with visible sectoral differences. The 2010 Scoreboard showed that, in comparison with 2008, the EU’s growth of corporate R&D investment was higher than that of the United States (8.1% compared with 5.7%), and well above the average growth of 6.9%. Individual sectors contributed differently to the growth: the EU’s largest growth came from the medium R&D-intensity sector (automobile and parts sector), while in the case of the United States the sectors with high R&D intensity showed significant growth above the average (5.7% plus). This confirms the trend observed over the period 2000–2009, showing a strengthening of high R&D-intensity sectors in the United States and a reinforcement of the medium-high R&D-intensity sectors in the EU.

Comparing data from the Scoreboards compiled between 2003 and 2008, the average R&D intensity of the EU-1,000 companies fell because net-sales growth was higher than R&D investment growth (figure III.3.8). In 2009, R&D investment growth was higher than net-sales growth, leading to a small increase in R&D intensity from 2.3 to 2.4% for the EU-1,000. Higher R&D intensity in 2009 than in 2008 can be observed in most of the countries in figure III.3.8: Finland (continuing the sharp R&D intensity increase due to Nokia largely maintaining R&D despite falling sales), Germany, France and Italy. For companies from the Netherlands and

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Note: R&D intensity is defined as R&D expenditure / sales.
Chapter 3: Structural Change for a Knowledge-Intensive Economy

3.2. Is the manufacturing sector becoming more research intensive?

3.2.1. R&D intensity in the manufacturing sector

The technology gap between the EU and the United States in the manufacturing sectors is growing — in high-tech as well as in medium-high and low-tech industries

Technological change is a major factor for competitiveness, and in the case of manufacturing industries, for advantage gains. The technology gap is visible in the distribution of manufacturing value added and the average R&D intensity by type of industry for the EU and the United States. These values, as well as research intensity in competing firms, are of a comparable order of magnitude (although not identical) in both economies. The overall level of business R&D intensity in an economy is strongly influenced by the research intensity in high-tech and medium high-tech industries. In chapter 5 of Part I of this report, we saw that in the EU, most of the sectors that perform the majority of BERD, in particular in the high-tech sectors, have become more research intensive during the last decade. But, at the same time, the weight of these same sectors in the EU economy has decreased thus provoking a counter balance effect. And the main reasons for the gap of the EU benchmarked with the United States, Japan or South Korea are a smaller and less research-intensive high tech industry (compared to the United States) and the structure of the economy, more dominated by the services sector (when comparing to South Korea).

The EU has seen a substantial increase in the R&D intensities of the low- and medium-tech manufacturing sectors

The knowledge incorporated in the manufacturing industry has increased significantly in all sectors. There has been a drastic change from layout to production chain in the technologies used today, the equipment used in industry, the incorporation of ICT, not to mention managerial and organisational aspects. Consequently, there has been a substantial increase in the R&D intensities of the low- and medium-tech manufacturing sectors at EU level.

3.2.2. Knowledge-intensity and economic weight of individual sectors

In order to secure economic competitiveness in high-Value-Added activities, the European Union will have to shift its economic structure to more knowledge-intensive (including research-intensive) activities. The economic structure of the EU and its individual Member States is the result of its competitive position in the global value-added chain of activities. As such, it conditions the levels of R&D investment, primarily in the private sector, as covered in Part I, chapter 5 of this report. In addition, levels of R&D intensity also condition the economic structure, as they reflect the ability of a country to compete internationally in specific sectors or segments of these sectors. In other words, there is a cause–consequence relationship between BERD and economic structure. The existing economic structure affects the BERD investments, which in return affects the resulting economic structure of a country, and its position and capacity to compete in a globalised market.

As a result, it is important to understand the moves of overall BERD investments by decomposing it between increases in BERD intensity and shifts in the economic structure towards more research-intensive activities. Total business R&D intensity is determined by the research intensity of individual economic sectors and by the relative weights of these sectors in the economy. Progress in total business R&D intensity can therefore be obtained through an increased research intensity of individual economic sectors and/or an increase in the share of research-intensive sectors in the economy. Figure III.3.10 and figure III.3.11 depict the impact...
Reconversion and modernisation of traditional sectors — The textile industry

Lessons can be drawn from successful reconversions: the EU has a higher ‘technological specialisation’ in textiles compared to its competitors the USA and Japan. How has this transformed the activities in this sector?

Case studies on the textile industry: Italy, Spain, Portugal, France and Sweden

The textile sector is an important part of the European manufacturing industry, playing a vital role in the economy and in social well-being in numerous regions of the EU. In 2006 there were 220 000 companies employing 2.5 million people and generating a turnover of EUR 190 billion. The textile and clothing sector accounted for 3% of total manufacturing Value Added in Europe. How have countries like Italy, Spain and Portugal, where textiles and clothing are a traditional manufacturing sector, coped with the competition from China and India?

During the 1980s and 1990s, some countries (such as France and Sweden) invested in a technological upgrade of their textile sector so that their 1995 BERD intensity was respectively 2.03% and 1.33% — values well above the R&D intensities registered for Portugal, Italy and Spain (respectively 0.13%, 0.11% and 0.43%), as shown in the Figure III.3.9. And even if these three latter countries had strong increases of their BERD intensity of the textile sector over the period 1995–2007, with growth values varying from 12.10% in the case of Portugal to 16.59% for Italy, this cannot be compared with the level of incorporated knowledge for the equivalent sectors in France and Sweden, which reached a BERD intensity of 4.26% and 3.86% in 2006. Given the global evolution of the textile market, the competitiveness of the textile sectors of Spain, Portugal and Italy are at risk if the BERD intensity is not substantially raised.

![BERD Intensity (BERD as % of value added) in the textile sector](image-url)

Source: DG Research and Innovation
Data: OECD
Notes: (1) SE: Textiles includes wearing apparel and fur and leather and footwear.
(2) ES: 2002
that these two different forces have had in European economies in terms of volumes of private investment over a time span of more than ten years.

**Most EU Member States have increased the overall BERD intensity of their economic sectors, while the economic weight of the most knowledge-intensive sectors has decreased**

Figure III.3.10. represents the gains in private R&D based on gains in BERD intensity\(^ {351} \) in economic sectors at country level over the period 1995–2007. As shown, all the countries (with the exception of Poland), registered positive gains, in line with an overall increase of knowledge in the European economy and an increase in R&D intensity at EU level. However, progress was uneven across Member States. Denmark, Finland, Austria and Sweden made higher progress than Germany and Spain. Italy shows more modest progress compared to Austria or the Czech Republic. These data suggest that some countries have intensified their R&D investments in existing sectors, probably to match the tough international competition in high R&D sectors, such as ICT, while some other countries have made more moderate progress.

These increases in BERD intensity can respond to either (1) a strategy to move towards higher-value-added activities within sectors, or (2) a reaction aimed at maintaining its competitive position in view of the increases of foreign competitors.

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**FIGURE III.3.10 BERD Intensity\(^ {1} \) gains / losses if the economic structure remains constant over the period 1995-2007\(^ {2} \)**

Source: DG Research and Innovation
Date: OECD
Notes: (1) For the purposes of this graph BERD Intensity is defined as BERD as % of value added.

\(^{351}\) BERD intensity is defined as the value of private R&D investment as a percentage of total Value Added.
Figure III.3.11 presents the effect on BERD intensity caused by changes in the economic structure over the same period as the previous figure. In other words, it presents the shifts in the economic structure towards more (or less, if negative) research-oriented activities.\textsuperscript{352} As in the previous case, European countries differ in their evolution. Overall, most European economies, with the exception of Germany, Austria, Hungary and the Czech Republic, have experienced an evolution towards a lower weight of research-intensive sectors in the economy, mainly due to the long-term shift from manufacturing to services, in, for example Denmark and the United Kingdom, or construction, as in Spain.

While structural change is largely influenced by the evolution of international economic drivers, the strategies and policies that countries and regions adopt can define a framework conducive to the stimulation of structural changes. These strategies and policies may need to be adapted to the specific circumstances of the individual countries, and sometimes they may favour moves towards higher-value-added activities within existing sectors, building on the existing experience, and sometimes they may require a shift towards new sectors. More precisely, in Europe, there are countries which still have margins to increase knowledge-intensity in existing sectors, as their production may focus on low- or intermediary-value-added goods or services. Some other countries are close to the “technological frontier”\textsuperscript{353} and therefore may need to change the weights of its sector composition in their economy, favouring the expansion of more knowledge-intensive sectors. Specificities of each country and their different strategies concerning R\&D and innovation such as smart specialisation\textsuperscript{354}, international exports or the creation of clusters are directly connected to these strategies. At this point it should be noted that these strategies should be the result of a wide-ranging

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\textsuperscript{352} BERD intensity gains result from calculating the gains due to changes in BERD intensity, if the economic structure had remained constant (BERD intensity 2007 – BERD intensity 1995) \textsuperscript{*}VA 1995.

BERD intensity gains result from calculating the gains due to changes in BERD intensity, if the economic structure had remained constant (BERD intensity 2007 – BERD intensity 1995) \textsuperscript{*}VA 1995.

\textsuperscript{353} The technological frontier is defined as the state-of-the-art level of technological development for one specific sector. The products and services offered at the technological frontier are knowledge-rich and of the highest-value-added.

consultation to identify particular strengths that support strategies in an international competitive contest.

This chapter aims to introduce some insights into the current situation of the EU by analysing the changes that have occurred in the sectoral composition of the EU as a whole by tracking the evolution of each sector over a period of 12 years.

In addition to the overview presented for the EU (together with a breakdown for the EU-15 and the EU-12) similar graphs for each country are included in the country information sheets found at the end of the report they identify potential solutions to stimulate the needed structural shift in the national economies. In order to achieve this goal, this chapter will analyse the changes that the EU, EU-15 and EU-12 experienced in a time span of more than ten years, both in the research intensity of the economic sectors and in the shifts of weight that different sectors carry on the economy. More precisely, four variables will be analysed: (1) changes in R&D intensity, (2) changes in the value added, (3) overall level of R&D intensity and (4) share of the sector in total value added.

The following three graphs show the evolution of the research intensity of individual economic sectors (sectoral research intensity) and the evolution of the weight of individual sectors in the economy (provided by the respective value added). Sectors above the x-axis are sectors whose research intensity has increased between 1995 and 2007. Sectors on the right-hand side of the y-axis are sectors whose economic weight has increased over the same period of time. The size

![Figure III.3.12](image-url)

**EU(1) – Share of value added versus BERD Intensity – Average annual growth, 1995-2006**

Source: DG Research and Innovation
Data: OECD
Notes: (1) EU does not include BG, EE, IE, EL, CY, LV, LT, LU, MT, AT, PT, RO, SI.
(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.
of the bubble reflects the share of the sector (in value added) in the economy. Red sectors are the high-tech and medium-high-tech sectors, i.e. the most research-intensive sectors of the economy. The others are represented in blue. The graphs therefore allow rapid identification of the size of research-intensive sectors in the economy of the country, as well as their evolution in terms of research intensity and of their weight in the economy. It also illustrates the internal structural change of some low or medium-tech sectors such as rubber and plastics, or textile and clothing or food products, where the overall R&D intensity has grown rapidly over the period, demonstrating an intra-sectoral specialisation towards more knowledge-intensive activities.

One caveat: the lack of available data for all 27 EU Member States. The main OECD source used only covers 18 Member States. Also, from this perspective, the inclusion of analysis at the level of the services sectors would be desirable, but data availability makes it impossible at this stage.

The first graph (figure III.3.12), in which all the available EU Member States are aggregated, illustrates the decrease of the weight of the manufacturing sectors (by the positioning of the majority of the bubbles in the left side of the graph). It is also clear that most of the high-tech and medium-high-tech sectors are in the upper side of the graph, thus showing an increase in BERD intensity. The move towards more research-oriented sectors has some notable exceptions: electrical machinery and

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**FIGURE III.3.13**

EU – 15 Member States(1) – Share of value added versus BERD Intensity – Average annual growth, 1995-2006

Source: DG Research and Innovation
Data: OECD
Notes:
(1) EU – BE, DK, DE, ES, FR, IT, NL, FI, SE, UK
(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.

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In order to ensure inter-sectoral BERD comparability, the OECD ANBERD database was used. Available data only allowed for the analysis of 17 Member States, albeit representing around 90% of the total EU BERD.
Innovation Union Competitiveness Report 2011

Source: DG Research and Innovation
Data: OECD
Notes: (1) EU: CZ, HU, PL, SI.
(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 structural change towards higher R&D intensity within sectors in the EU has not been sufficient in itself to raise the knowledge intensity of the economy. When benchmarking with the United States, for example, we see that there is still room for further increases in the research intensity of the high and medium high-tech industries. The structural composition of the economy is another aspect, as discussed previously in chapter 1 of Part III on fast-growing companies. This aspect alone is linked to the development of lead markets and obstacles to the growth of new technology-based firms. An economy can move towards more and larger knowledge-intensive sectors only with the emergence of new and fast-growing firms.

FIGURE III.3.14
EU – 12 Member States(1) – Share of value added versus BERD Intensity – Average annual growth, 1995-2006

Source: DG Research and Innovation
Data: OECD
Notes: (1) EU: CZ, HU, PL, SI.
(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.
CHAPTER 4

Achieving economic competitiveness

HIGHLIGHTS

This chapter addresses the different factors conducive to improved competitiveness, in particular labour productivity and the role of high-tech industries and knowledge intensive services, as well as the role of high tech exports in the overall trade balance.

There remains a significant gap between the EU’s innovation performance and that of the United States and Japan, as illustrated by the Innovation Union Scoreboard 2010. The EU’s innovation performance relative to the United States has been smoothly improving while the performance gap relative to Japan is stable. Compared to China, the EU still has a clear innovation performance lead but it is declining, as China’s performance has grown at a faster rate than of the EU.

One impact of the economic and financial crisis has been on EU labour productivity: in 2009 it fell back to the levels of 2000 and is now below the productivity levels of both the United States and Japan. Member States show very different situations. Luxembourg is leader in labour productivity, with almost twice the EU-19 average; the Netherlands, Ireland, Belgium and France have comparable levels as those of the United States.

A feature common to the bigger Member States like France, the United Kingdom and Germany, is the decrease in their share of high tech exports in total exports. This is directly linked to the emergence of the Asian economies which have the largest share of high-tech products in their exports, almost double that of the EU. However it should be noted that high-tech exports do not as such necessarily reflect the knowledge intensity of an economy. A distinction between different types of high-tech exports should be made in what concerns the value added and initial origin of the product.

The regions in Europe are very different and have specific innovation performances even within Member States. The most innovative regions are located in the most innovative Member States: Finland, Sweden, Denmark, Germany and the United Kingdom. But there are regions that are exceptions, since they perform well above the average national environment in what concerns innovation. Large differences in competitiveness among regions are observed in some Member States, e.g. Italy, Spain and Portugal.

4.1. Is Europe improving its innovation capacity?

The United States and Japan are holding their lead over the EU

The Innovation Union Scoreboard 2010 (IUS) includes an analysis of EU performance compared with that of the United States and Japan based on a set of 12 comparable indicators. The figure III.4.1. shows that the EU’s performance gap relative to the United States has been slightly increasing, while the performance gap relative to Japan is stable. The United States is performing better than the EU on 10 indicators (Figure III.4.2.). In Public R&D expenditure and knowledge-intensive services exports, the EU is performing better. Overall there is a clear performance lead in favour of the United States, although the EU is catching up on several indicators, including scientific excellence and technological performance.

357 The IUS report, its annexes and the indicators’ database are available at http://www.proinno-europe.eu/metrics.
FIGURE III.4.1  EU innovation performance compared to main competitors(1)

Source: DG Research and Innovation, DG Enterprise
Data: Innovation Union Scoreboard 2010
Note: (1) Performance is measured as 100 * (X / EU) - 1 where X refers to the value for the indicator for the country X and EU to the value for the indicator for the EU. The values in the graphs should be interpreted as the relative performance compared to that of the EU e.g. the United States in 2010 is performing 49% better than the EU.

FIGURE III.4.2  EU innovation performance compared to the United States

Source: DG Research and Innovation, DG Enterprise
Data: Innovation Union Scoreboard 2010
Note: (1) Left: The indicators highlighted in red reflect a performance gap for the EU; those highlighted in green reflect a performance lead for the EU. Right: Relative growth compared to that of the EU. Red coloured bars show that the United States is growing faster than the EU; green coloured bars show that the United States is growing slower than the EU.
Though holding its lead over China, the EU is losing ground

Compared to China, the EU still has a clear innovation performance lead. Using the same set of 12 indicators used for comparison with the United States and Japan (Figure III.4.3.), the EU is performing better than China in most indicators. However, the EU’s lead is declining, as China’s innovation performance has grown at a faster rate than that of the EU. The EU has increased its lead in most-cited publications and public R&D expenditure.

The Regional Innovation Performance Index (RIPI) confirms that the innovative capacity of the EU is concentrated in the most developed countries

In chapters 3 and 4 of part III, we have analyse different factors conducive to improved competitiveness, such as labour productivity and the role of high-tech industries and knowledge-intensive services. European regions are very different and have specific innovation performances, even inside a single country. Governments are engaged in designing policies which are relevant and adequate at the local level358, for which it is necessary to know the main determinants of potential growth and why different regions present different performances. The map below (figure III.4.4) shows the innovation capacity of 201 regions of the EU given by the Regional Innovation Performance Index. This figuration has been calculated using a composite indicator based on 16 of the 29 indicators used in the EIS 2009.359

The most innovative regions are located in the most innovative countries, as is the case for Finland, Sweden, Denmark, Germany and the United Kingdom. But there are exceptions — regions that perform well above the average environment, such as Lombardy and Emilia-Romagna in Italy, the Basque Country, Navarre, Madrid and Catalonia in Spain, West Slovenia, the capital city regions of Hungary and Slovakia, and Prague.
Regional Innovation Performance Index, 2006

Source: DG Enterprise, MERIT

Low innovation performance
Medium - Low innovation performance
Average innovation performance
Medium - High innovation performance
High innovation performance

Source: DG Research and Innovation
Data: DG REGIO

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4.2. Is Europe improving its productivity and competitiveness?

In 2009, EU total-factor productivity slowed down to the levels of 2000 and fell well below the productivity level of the United States and Japan.

Since the year 2000, four countries show a negative total-factor productivity growth\(^{360}\): Italy, Spain, Portugal and Luxembourg, with stronger decreases for Italy and Luxembourg (figure III.4.7). The other countries have a good position for the last year available, but have registered different evolutions since 2000: Austria, Belgium, Ireland, Denmark, Germany, Finland, Sweden and the United Kingdom increased their productivity up to 2008, showing an abrupt fall for this year, and recovering over 2009–2010 (for values as in 2006). The Netherlands were stable for four years from 2000–2003, growing until 2008 and decreasing afterwards. Two exceptional situations were represented by France and Greece. France, though following a similar trend, experienced only a slight increase in the period 2000–2008 followed by a fall to values above those registered in 2000, and Greece had stronger increases over the same period, and smaller decreases in 2008.

It is interesting to note that the productivity of the United States progressed more than France, Italy or Germany in the period 1995–2000. Japan is evidencing a more limited progress for the same period.

This report has at several places suggested a link between R&D investment and innovation performance, and between total factor productivity of a country and its level of R&D investment. The figure III.4.6 seems to indicate a correlation between the change of the total factor productivity and changes in R&D investment.

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360 Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production. As such, its level is determined by how efficiently and intensely the inputs are utilised in production.
Chapter 4: Achieving Economic Competitiveness

R&D Intensity (average) and total factor productivity\(^{(1)}\) (evolution), 2000-2009

![Graph showing R&D Intensity (average) and total factor productivity](image)

Source: DG Research and Innovation
Data: Eurostat, DG ECFIN
Notes:
(1) Total factor productivity, total economy, 2000=100.
(3) EL, LU, IS, CH: R&D Intensity is not available for every year. The R&D Intensity average is the average of the available values.

Factor productivity, over the period 2000-2009 and the average level of R&D intensity for the corresponding period.\(^{361}\) The countries that have achieved higher levels of R&D intensity and are leaders in innovation performance, also achieved higher levels of productivity. This is the case for Finland and Sweden, but also for Japan and the United States. It is interesting to note that the positioning of the different countries is in line with the country grouping model constructed in the part New Perspectives, chapter 1. based on the knowledge capacity and economic structure of each country.

Europe has a lower labour productivity growth than the United States

Though labour productivity is considered to be only indirectly connected to innovation, and even more distant to research investments, it is a way of measuring the outputs of the research and innovation systems.

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\(^{361}\) Naturally, other co-evolving factors can explain this correlation, given the complexity of productivity growth.
**FIGURE III.4.7**

Total factor productivity (total economy) by country, 1995-2010 (2000 = 100)

Source: DG Research and Innovation  
Data: DG ECFIN

**FIGURE III.4.8**

Labour Productivity – Annual real growth rate\(^{(1)}\), 2000-2009

Source: DG Research and Innovation  
Data: Eurostat, OECD  
Note: \(^{(1)}\) Derived from GDP per hour worked in PPS€ at constant prices (base year 2000).
Labour Productivity – GDP per hour worked in PPS€, 2010

Luxembourg is the leader in labour productivity, almost reaching the double value of EU-19 average; Norway, the Netherlands, and Belgium have equivalent levels similar to those registered by the United States.

Figure III.4.9 presents the estimated values for hourly labour productivity for 2010 for EU19 countries and the United States, Japan, South Korea: only Luxembourg, Norway, the Netherlands and Belgium surpass the US labour productivity; the EU19 average is clearly below the labour productivity of the United States but above that of Japan and South Korea.
International trade in technologies can be measured by the international transactions in royalties and licence fees as a % of GERD. A high and growing export of royalties and license fees is an indication of a competitive technology and innovation capacity. However, it could also indicate a domestic incapacity to absorb new technologies produced in the country. The import of technologies indicates, on the other hand, a domestic demand and absorptive capacity, reinforcing the knowledge intensity of the country. It could be related to an economic catching-up strategy, backed up by the absorption of knowledge produced elsewhere. However, it is also a sign of a weaker capacity of domestic knowledge production, since knowledge-intensive economies tend to have a positive trade balance of technologies.

**FIGURE III.4.10** International transactions in royalties and licence fees

Source: DG Research and Innovation
Data: Eurostat
Note: (1) Extra-EU-27.
The EU is a net importer of technology, but several Member States register a trade surplus

Figure III.4.10 on export of patents and licences illustrates the higher degree of international competitive-technology production of the United States and Japan when compared to the EU. In 2008, the export of royalties and licence fees of the EU amounted to 10.4% of GERD, compared to 23.0% the United States and 15.4% for Japan. Inside the EU, the United Kingdom and Sweden have high levels of technology exports (27.7% and 27.2% respectively). France, Germany and Poland have higher import than export.

Comparing export with import, it can be seen that the EU has a trade deficit in royalties and licences, while the United States and Japan strongly expand their export while maintaining a lower and more stable level of import. The United Kingdom, Sweden and France have a trade surplus, while Finland and Poland have higher import than export.

The emerging Asian economies have the world’s largest share of high-tech products in their exports — almost double that of the EU

Countries commercialise the results of research and technological developments in international markets. The share of high-tech products and knowledge-intensive services exported is a way of measuring the performance and innovativeness of a country’s products, technologies and processes.

The figure III.4.11 shows in what degree high-tech products are relevant to the total exports. Hong Kong, Singapore, South Korea and China have the highest shares of high-tech products in their export. This is the confirmation of a coming trend observed since 2000, when China had less than 18% of high-tech exports in all its exports. While China has been continuously growing, there has been a marked decrease in the EU, Japan and the United States. During the same period the EU was reduced to a share of 15.4% and Japan and the United States to 16.3% and 19.2% respectively. In 2006, the EU had a share around 17% of high-tech exports in total exports.

FIGURE III.4.11 High-Tech exports as % of total national exports, 2008(1)

Source: DG Research and Innovation
Data: Eurostat
(2) China: Hong Kong is not included.
(3) EU: Intra-EU exports are not included.
FIGURE III.4.12  High-Tech exports as % of total national exports, 2008

Source: DG Research and Innovation
Data: Eurostat
Notes: (1) EU: Intra-EU exports are not included.
(2) The former Yugoslav Republic of Macedonia.

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To better interpret high-tech exports as an indicator for a knowledge-based economy, a distinction should ideally be made between different types of high-tech exports, namely in what concerns the value added and the initial origin of the product. This is particularly clear for the ICT products, where computer assembly is counted. Countries with a low-cost labour force such as China have had a competitive advantage and have consequently taken over the manufacturing part of the value chain for many such products. The consequence is that high-tech exports do not necessarily reflect the knowledge intensity of an economy. The examples of Ireland and Malta (figure III.4.12), which are specialised in ICT exports, further illustrate this analytical effect, because their R&D intensities are quite low, although their export industries are highly focused on the manufacturing of ICT products for multinational enterprises.362

**Technology-driven industries increasingly dominate EU imports from China**

In 2007, the share in EU imports from China of these industries was already higher than in intra-EU imports, while high-skill industries recorded rapidly rising shares between 2000 and 2007, providing evidence for China’s technological upgrade. Moreover, China (as well as India and even Russia) has been successful in price competition in high-skill industries and gained market shares in the EU. In a longer-term perspective, this ‘industrial upgrading’ is the most serious challenge to the EU in maintaining its competitive advantages in high-value-added products and services.

**The bigger Member States, like France, the United Kingdom and Germany are decreasing their share of high-tech exports in total exports**

Focusing on the situation of EU-27 at country level, the tendency is to an increase of the share of high-tech exports in total exports, namely for the bigger and more advanced countries, like the United Kingdom, France and Germany, with values around the EU average or below (figure III.4.13).

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362 See also ‘Made in China’ tells us little about global trade, by Pascal Lamy, FT Published: January 2011.
In some Member States the contribution of knowledge-intensive services to trade balance is growing

The growing importance of services sectors in most European countries is a fact that is discussed and presented in different parts in this chapter. Unlike manufacturing goods, for which data show more consistent results, performance of services sectors are affected by various factors such as fiscal measures (for the financial services, for example) or geographical situation (peripheral countries), and the coverage does not encompass all the Member States. Nevertheless, it is relevant to analyse the service sectors from the

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363 To improve the quality of data available on services, at EU and Member States level, the European Commission will launch specific studies.
Contribution of Knowledge-Intensive Services (KIS) to the trade balance, 2002 and 2007

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Contribution of Knowledge-Intensive Services (KIS) to the trade balance, 2002 and 2007

Perspective of innovation, and how they changed between 2002 and 2007. Focusing on the contribution of knowledge-intensive services in the trade balance (figure III.4.14), it is clear that countries such as Denmark and Greece experienced a strongly positive evolution. Ireland still had a very relatively high contribution of knowledge-intensive services to its trade balance, but this contribution decreased over the period 2002–2007. From a lower level, Germany, the Netherlands and Latvia had a positive evolution, while Hungary, the Czech Republic and Portugal reduced the gap. Conversely, Sweden, Poland, Bulgaria and Malta increased the knowledge-intensive service trade deficit over the same period.
There is a strong regional dimension of competitiveness, not captured by national level measures

The European Commission has created a new regional competitiveness index for all NUTS2 regions.\textsuperscript{364} This index allows the performance of a region to be assessed in relation to all the other EU regions. The set of 69 indicators used in this index are divided in three pillars: 1) the basic group, with the key drivers for all types of economies; 2) the efficiency group, with the key aspects for a developing region; 3) the innovation group, with the key drivers for the advanced economies. These three sets are assigned different weights, based in the GDP per head of a region. It is a dynamic way of assessing the progress of an individual region, as it identifies the more urgent needs at different stages of development. As an example, a less developed region might benefit more by improving institutions and education, when compared with a more advanced one, which might need to invest more in innovation to stay competitive.

The economic and financial crisis impacted differently on the indicators used to measure innovation and competitiveness. In the map (figure III.4.15), the overall competitiveness resides in the Nordic regions, the Netherlands, in Southern Germany and South-East England. Large differences in competitiveness among regions are observed in some Member States as Italy, Spain and Portugal. These results give evidence to the strong regional dimension of competitiveness, not captured by national level measures. In the less knowledge-intensive economies of the EU, the most competitive regions tend to be isolated and mainly surrounded by less competitive regions. Most of these Member States have a high concentration of factors of competitiveness around the capital city region, with still very limited spillovers to neighbouring regions. At the contrary, in the most knowledge-intensive economies of the EU, there is a more even distribution of the competitiveness factors.

FIGURE III.4.15  Competitiveness index, 2010

Competitiveness Index, 2010

Index - Values range between 0 (low) and 100 (high)

- <30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- > 70

EU27 = 55
Source: JRC and DG REGIO

Source: DG Research and Innovation
Data: DG REGIO

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Addressing societal challenges

**HIGHLIGHTS**

Research and Innovation coupled with market development measures can help provide a solution to the societal challenges, such as climate change, a healthy aging or energy dependency that Europe faces. At the same time, these fields represent new areas for potential economic growth. As a result, many of the research programmes in Europe and elsewhere, including the economic recovery packages, have oriented towards these fields.

Overall, the EU is increasingly reinforcing its position in developing new technologies aimed at addressing societal challenges. The EU accounts for around 43% of all the climate change mitigation related patents filed under the Patent Cooperation Treaty (PCT). The impressive record of the EU is due to a determined public investment decision that has in the past decade increased the funding of environmental sciences and technologies. Among the different technologies for climate change mitigation, the EU has made good progress in technologies for developing and deploying renewable energies. Nevertheless, more market pull measures would further improve the competitiveness of these new technologies, making them more affordable.

Health research has the potential to provide “exception returns”, both in terms of reduction of direct costs of treatments or labour absenteeism, and by increasing longevity and quality of life. In this field, the United States is the world leader. It accounts for almost half of all the health related patents, either on pharmaceutical or medical technologies, and its public and private research investment is much higher than any other country. In this field, the EU lags behind the United States, but the situation is not homogeneous across Member States. Denmark, Sweden or the Netherlands have developed strong specialisation capacities in particular health technologies and proportionally rank above the United States in terms of health technology patent applications.

Finally, since most societal challenges are global by nature, the EU research instruments in these fields, notably the Framework Programme, have opened themselves to further international cooperation. Environmental and health related research are two of the fields more prone to international cooperation, especially with other advanced economies such as the United States, Japan or increasingly other Asian economies.

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*Science, technology and innovation can help provide a solution to the growing societal challenges faced by Europe. The Innovation Union initiative calls for a re-focusing on innovation to address the major societal challenges*

Science, technology and innovation are increasingly regarded as key solutions to the challenges that can affect our economic progress and quality of life. Increasingly, citizens turn to science and technology to obtain an answer for mitigating climate change, improving citizens’ health or enhancing energy and resource efficiency.

The Innovation Union initiative of the European Commission has echoed these demands and has asked for a re-focus of R&D and innovation policies on the challenges our society faces. In order to provide innovative solutions, every link in the innovation chain will have to be strengthened, from ‘blue sky’ research to commercialisation.

This chapter will focus on an analysis of the way in which European research — including the role of the Framework Programme — is contributing to addressing these challenges in two particular areas that are the first objectives of the future European Innovation Partnerships: (1) Climate-change mitigation and preserving the environment (including renewable energy technologies), and (2) Healthy ageing. These two areas are of particular interest for Europe because no single country can provide the solutions to these challenges. International cooperation is needed and there is a clear European value added in pulling research resources together to avoid the fragmentation of research investment, especially in a context of fiscal consolidation.

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Many EU Member States — as well as the United States — are orienting their research policies to embrace societal challenges in the framework of their recovery packages.

In 2008 and 2009, many EU Member States undertook large policy responses, including fiscal stimuli and structural reforms, to address the negative consequences of the worst financial and economic crisis of the last 70 years. These efforts were to a large extent coordinated on the basis of a European Economic Recovery Plan (EERP) that was endorsed by the European Council.

The overall size of public investment in the stimuli packages has been roughly estimated at around 65 billion euro, i.e. 0.32% of EU GDP, and grouped under three main areas: investment in infrastructure, 40 billion euro, investment in energy efficiency, 20 billion euro; and investment in R&D, 5 billion euro.

In terms of R&D investment, the EERP encouraged Member States to research green technologies and energy efficiency. The reason for this lies on the need to focus European research on developing new environmental technologies that help mitigate climate change and pollution, and that in addition, can become important sources of economic growth.

As a result, plans to invest in green technologies can be found in several National Reform Programmes, such as those in Estonia, Spain, France, Italy, Latvia, Germany and the United Kingdom. In addition, France, Germany and the United Kingdom are also implementing research on green technologies in the automotive sector as part of their strategies, and the EERP announced two major partnerships between the public and private sectors in research on (1) a European green-cars initiative and (2) European energy-efficient buildings initiative. Both initiatives are under implementation.

The United States also implemented a similar plan to fight against the economic crisis — The Recovery Act: Transforming the American Economy through Innovation. As for the EERP, the American USD-800-billion investment plan has also emphasised the need to accelerate significant advances in science and technology that not only cut costs for consumers, but that also help to improve health and develop new technologies for the exploitation of renewable energies.

Box: The United States Recovery Act: Transforming the American Economy through Innovation

The Recovery Act has invested nearly USD 100 billion in science, technology and innovation projects across the country, ranging from the construction of a nationwide smart-energy grid and health-information technology infrastructure to growing the emerging electric-vehicle industry, expanding broadband access and laying the groundwork for a nationwide high-speed rail system.

Thanks to the Recovery Act, the United States is now on track to achieve four major innovation breakthroughs that will keep America competitive in the 21st century economy and make new cost-saving, energy-saving and life-saving technology affordable for and accessible to consumers. These innovations are:

1. Cutting the cost of solar power in half by 2015. This will bring the cost of generating solar power down to the cost of electricity from the grid.
2. Cutting the cost of batteries for electric vehicles by 70% between 2009 and 2015. This means that the cost of batteries for the typical all-electric vehicle will fall from USD 33 000 to USD 10 000, and the cost of typical plug-in hybrid batteries will drop from USD 13 000 to USD 4 000.
3. Doubling the United States’ renewable-energy-generation and renewable-manufacturing capacities by 2012. This means that the over USD 23 billion investments in support of renewable energy will double the energy generation capacity from wind, solar and geothermal sources by 2012.
4. Bringing down the cost of a personal human-genome map to under USD 1 000 in five years. This means that it will be fifty times cheaper to obtain the DNA information that could unlock cures and give insights into some of the most debilitating diseases that exist today.

Source: Executive Office of the President of the United States, 2010

366 Source: European Commission, DG ECFIN.
5.1. Is European research addressing climate change and the need to preserve the environment?

Climate change will have significant costs for the economy. New technologies can help reduce the greenhouse gas emissions and therefore mitigate these costs.

In recent years, climate change has been recognised as a global phenomenon that may cause an irreversible build-up of greenhouse gases and global warming at a potentially huge cost to the economy and society. According to the Stern Report, the estimated costs of inaction in addressing climate change are high, and when all market and non-market impacts are taken into account, the costs can rise to 14.4% of per capita consumption. New technologies can help reduce the emissions of greenhouse gases and therefore mitigate the negative effects of climate change. According to the Energy Technology Perspectives, developments in new technologies such as carbon capture and storage, nuclear energy, renewable energies and end-use efficiency gains could reduce CO$_2$ emissions by up to 50% by 2050.

There are also new European initiatives in this field. As an illustration, two of the three Knowledge and Innovation Communities (KIC) selected in 2009 inside the European Institute of Technology (EIT), focus on enhancing Europe’s innovation capacity in the field of sustainable energy, and climate change mitigation. The KICs are set up as very focused and European-wide clusters.

5.1.1. Investments in science and technology for climate-change mitigation

The EU allocates a relatively important part of its public research budgets to the development of environmental technologies, including climate-change technologies.

The public nature of climate change and other environmental technologies enhances the role that public research plays in the development of new technologies. The EU devotes more public research resources to environmental-related sciences than any other research system in the world (figure III.5.1). On average, EU governments invested in 2009 almost EUR 5 per inhabitant, while South Korea invested around EUR 4 and the United States and Japan around EUR 2.

Moreover, the EU has maintained this investment in environmental research over time and has slightly increased it since 2004.

367 OECD, 2009.
369 IEA, 2008.
The energy challenge of the EU, and the World, is to assure sustainable, affordable and safe energy production with the diminishing availability and rising costs of carbon based energy, combined with the need to lower environmental impact of energy production. One of the very few candidates for large-scale carbon-free production of base-load power is fusion energy, which could potentially benefit from: (1) abundant and geographically fairly distributed fuel, (2) enhanced safety, (3) no production of CO₂ or atmospheric pollutants and (4) no long-lasting radioactive waste.

ITER is an international project aimed at developing the knowledge needed to have fusion available as a future energy alternative. The project counts on the membership of the EU, Japan, China, the United States, South Korea, India and Russia, who signed in 2006 an agreement to fund the construction of the world’s most advanced experimental nuclear fission reactor in Europe.

The EU will contribute 45% of the construction costs, i.e; an estimated investment of 6.6 billion euro, and the project is anticipated to last for 30 years, 10 years for the construction and 20 of the operation.

The construction of the key components, such as the buildings, vacuum vessel and magnets has already started and the EU is expected to deliver components of the machine in each key technology.
5.1.2. Patents for climate-change mitigation and environmental technologies

To a large extent, climate-change mitigation technologies are based on the development of new sources of low-carbon emission energies, such as renewable energies. The next section analyses the recent technological evolution of this sub-section of climate-change technologies which is of particular interest for Europe, as it also reduces energy dependency.

**Patents in sustainable energy represent a small but increasing share of overall patents**

Increasing concerns about climate change and the oil crisis of 2003–2008, which saw oil prices going up from USD 25 per barrel to a peak of more than USD 130 in 2008, have clearly intensified interest in the development of new sustainable, in particular renewable-energy technologies. Since the year 2000, the number of EPO patent applications in renewable-energy technologies has increased sharply. As shown in figure III.5.2, this growth has been overtaking the average growth of EPO patents or even of high-technology patents since 2005.

*The rapid growth in sustainable energy patents has occurred despite a slight stagnation of R&D investment*

Public expenditure in sustainable energies decreased from 1982 until the year 2000 (figure III.5.3). Since that year, R&D investments started to increase slowly again, with acceleration from 2006 onwards. On the other hand, despite this negative trend in research investment, patent activity continued to progress, which suggests that there has been a growing interest in the market for new technological applications in the field. In other words, the development of sustainable energies has benefited more from a market *pull*, than a technological *push*.

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**FIGURE III.5.2**

Long term growth of EPO patent applications in sustainable energy, high-tech and total patents, 1979 - 2007 (1979=1)

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370 Climate-change mitigation technologies include renewable energy, electric and hybrid vehicles, energy efficient buildings and lighting.
In addition to renewable energy technologies, the EU plays a leading role in developing other new climate-change mitigation technologies. The EU accounts for 40% of all world patent applications in this field.

While Japan presents the highest number of climate-change patents relative to the size of the economy371, the EU is the world leader in developing new technologies to fight against climate change in absolute terms, accounting for more than 40% of all patent applications addressing this societal challenge (figure III.5.4).

371 Please, see part 1 of this report for details.
Denmark, the Netherlands, Sweden and Germany are on the technological frontier for technologies addressing climate change

Between 2000 and 2007, innovation in climate-change mitigation technologies has been intensifying rapidly. The number of patents which address climate-change challenges has increased considerably in most countries — in Japan more so than in the EU — and represents approximately 2% of total patent applications. Denmark, the Netherlands, Germany and Japan are the countries which patent most in this area relative to their GDP (figure III.5.5). In volume, Germany and Japan concentrate a large share of these patents in the world, as well as the United States, despite its lower value in relation to GDP (half of the EU). In Europe, although these data do not measure the quality nor the impact of the patents, the high intensity of patenting in Denmark, the Netherlands, Sweden and Germany both in health and climate-change mitigation tends to indicate that these countries are at the technological frontier in both domains.

More generally, the EU is the world leader in environmental technology patents, headed by Germany

Higher public-research budgets in environmental sciences have allowed the EU to lead the race in the development of environmental technologies. As Figure III.5.6 below shows, 35% of all patents related to air- and water-pollution control, solid waste management or renewable energies have their origin in the EU. Behind the European Union, the United States and Japan account for 21% and 20% of all these patents respectively. In the EU, Germany is the largest R&D investor, representing 34% of all EU’s patents. The United Kingdom and France follow with 13% and 8%, while the rest of the EU countries account for 40.5% of all EU’s patents, i.e. 14% of the world total.

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**FIGURE III.5.5**

Climate change mitigation technologies – PCT patent applications per billion GDP (PPS€), 2000 and 2007

Source: DG Research and Innovation
Data: OECD
Notes: (1) SI: 2006.
(2) CY, LV, LT, MT, IS, MK: Zero or data not available.

373 In Figure III.5.5, data for patents related to climate-change mitigation are OECD data concerning PCT (Patent Cooperation Treaty) patent applications by inventor’s country of residence and priority year; climate-change mitigation covers the following fields: renewable energy, electric and hybrid vehicles, energy efficiency in building and lighting.
375 Note: Values are calculated based on an arithmetic average of the percentage of patents of each country in four environmental technology fields: (1) air-pollution control, (2) water-pollution control, (3) solid waste management and (4) renewable energies. As a result, these values assume an equal distribution of patents across four fields.
5.1.3. Markets demand measures to enhance technologies in climate-change mitigation and other environmental technologies

Despite substantial technological development, the use of renewable energies or other environmental technologies still require some market ‘pull’ measures. Smart regulation and public procurement can accelerate the creation of a full, effective market

Despite technological advances, renewable energies are currently still more expensive than traditional energy and, therefore, they require market ‘pull’ measures in order to fully deploy and further enhance technological advances and reductions in costs. The same is valid for many environmental technologies, for which a market needs to be developed in order to take into account the full costs of production, i.e. including pollution effects. Smart regulation and policy initiatives such as the Lead Market Initiative\(^{376}\) on recycling or renewable energies can become important means to achieve this goal. In general, these measures to develop markets have yielded excellent results when coordinated with research efforts to bring the costs of production down. Denmark represents an excellent example where wind industry has successfully developed.

\(^{376}\) Please refer to the section of Framework Condition for more ample information on the role of lead markets and innovation-friendly regulations.
Germany, Denmark and Spain have been the three EU countries with the strongest market-pull policies in Europe. The emergence of Spain as an industrial player is all the more remarkable since it started from a very low base before 1995.

This has led Europe to develop a strong world presence in the wind industry. These three countries accounted for nearly half of world production in 2009. Of special interest is Denmark, which now produces 20% of its electricity through wind power. In the same country more than 28 000 people are employed in the wind industry. Moreover, the interest of United States firms in patenting in the EU is also to be noted in the dynamic European wind-energy market have yielded excellent results when coordinated with research efforts to bring the costs of production down. Denmark represents an excellent example where wind industry has successfully developed.

The photovoltaic (PV) industry, on the other hand, represents a source of renewable energy where Europe has been less successful as other countries play an important part in the European Market. Japanese, American and, recently, South Korean firms have been active in patent applications in Europe. This reflects the importance of Asia in the domain of PV, as 7 out of the 10 largest companies in the world come from Asia, 2 from the United States and 2 from Europe (Germany).

In Europe, thanks to Germany, the production of solar energy exploded in 1995. Demand-side policies were implemented earlier here than in any other European country, and in the most active manner. The Renewable Energy Sources Act (2004) fixed very favourable tariffs that allowed Germany to have the highest annual rate of PV installation worldwide. It is estimated that 48 000 people are employed in the PV industry alone.
To reap the fruits of the new technologies oriented towards mitigating climate change, lead markets need to be developed and better regulation enforcing their use is needed in order to achieve the full benefits.

While new technologies are being developed and their benefits in reducing CO₂ emissions or abating pollution are proven, it is still difficult to estimate the full benefits accruing from them. New innovative products and processes will have to be embedded in these upcoming ‘breakthrough’ technologies, so that the full benefits can be reaped.

This will also require further policy developments to ensure that these new technologies are developed into new products that are then adopted into the market. Regulations, policies on the demand side and the setting of a price on carbon will also be required in addition to technological developments.
5.2. What contribution is science and technology making to healthy ageing?

Europe has become an aging society, and will increasingly be so. The improvements in life expectancy coupled with a fall on the fertility rates have brought about a progressive aging of European society. It is expected that in the future, this aging phenomenon will accelerate\(^\text{377}\). An aging population in need of more and better healthcare will pose important challenges to existing healthcare systems as public budgets come under stress. The increase in health costs coupled with the desire to improve the quality of health and long-term care for older citizens will require further investments in health. At present, many developed economies, including EU countries such as Belgium, France, and Germany, devote more than 10% of the national wealth to these activities (figure III.5.9). Many of these countries have sharply increased the resources devoted to these activities in the last fifteen years or so, and this trend is likely to continue as the cohorts of baby boomers grow older and require more medical assistance.

In order to sustain the system, new medical technologies capable of maintaining health in old age and bringing medical costs down, are regarded as one of the main solutions — if not the only one — to sustain Europe’s quality of life.

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### FIGURE III.5.9 Total expenditure on health as % of GDP, 1995\(^{(1)}\) and 2008\(^{(2)}\)

Source: DG Research and Innovation
Data: OECD
Notes: (1) SK: 1997; EE: 1999.

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377 See Part I, chapter 4 for a thorough description of the demographic change in Europe.
5.2.1. Investments in science and technology for healthy ageing

The United States is by far the absolute and relative largest investor in health research thanks to both public and private sectors

The United States presents the strongest investment patterns in the world, well ahead the EU. In terms of public budgets, the United States devoted more than 0.2% of the national wealth to health-related R&D, while the EU and South Korea barely invested 0.05% (figure III.5.10). At this point, it should be noted that for Europe, public R&D investment in health is likely to be higher than the values represented here. Due to the institutional complexity and diversity of centres carrying out health research, many European countries, e.g. Sweden, France, the United Kingdom and Spain, devote significant extra public R&D resources to medical research in other sections of their national budgets that do not fall directly under the ‘improvement of public health’ category, as defined by the Frascati Manual. Therefore, the values are not fully comparable.

Unfortunately, no aggregated value is available for the EU.378

In recent years however, European governments have increased public budgets related to health research. Since the year 2000, European public budgets grew at an average annual rate of nearly 6%, lower than South Korea, with an average annual growth rate above 9%, but above the United States, with average increases of nearly 4%, and Japan at 3%.

In terms of private R&D, pharmaceutical companies in the United States also invest more resources than EU companies (figure III.5.11). Proportionally, companies based in the United States invest almost twice as much in R&D as their European counterparts.

As a result, these high-technology enterprises can benefit both from their own higher R&D investments and the higher public R&D investments that generate a broader knowledge base from which they can capitalise and develop new innovative products and processes.

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378 For a thorough description of the methodology to calculate overall public R&D budget allocations, please consult the OECD ‘Science, Technology and Industry Scoreboard, 2009’.
5.2.2. Patents in healthy ageing

Health-related patents have risen in consonance with the increases in R&D investments. For our analysis, health-related technologies include both medical technologies, which are associated with high-technology, and pharmaceutical technologies that mainly refer to an area of application, not a technology per se.\textsuperscript{379}

The United States is the world leader in the development of medical-related technologies, accounting for almost half of all patents. Europe follows.

Pharmaceutical companies based in the United States filed 43\% of all the pharmaceutical patent applications under the PCT in the world in 2004–2006, while companies based in the EU filed 28\% of them (figure III.5.13).

In Europe, countries with strong pharmaceutical sectors such as Germany, with more than 25\% of all EU patents, or the United Kingdom, with 20\%, filed almost half of all the pharmaceutical patent applications in the EU.

**FIGURE III.5.12**
PCT patent applications in medical technologies – World shares, 2004-2006

- **United States**: 49%
- **EU**: 25%
- **Japan**: 11%
- **South Korea**: 1%
- **China**: 1%
- **Rest of the world**: 13%

*Source: DG Research and Innovation
Data: OECD
Innovation Union Competitiveness Report 2011*

**FIGURE III.5.13**
Pharmaceutical PCT patent applications – World shares, 2004-2006

- **United States**: 43%
- **EU**: 28%
- **Japan**: 11%
- **BRIICS**: 5%
- **Canada**: 3%
- **South Korea**: 2%
- **Rest of the world**: 8%

*Source: DG Research and Innovation
Data: OECD
Note: BRIICS: Brazil, Russian Federation, India, Indonesia, China, South Africa.*
Health-related technologies, especially those related to pharmaceutical technologies, can also provide large economic returns and represent an area for future economic growth. Health research is believed to provide ‘exceptional returns’\(^{380}\), both in terms of reduction of direct costs of treatments and increase of longevity and quality of life of citizens.

It is not easy to assess the economic impacts of health research in the economy and the well-being of citizens. It is difficult to measure the impacts of improved health, provide an economic value to it and link it back to the original research. However, despite these difficulties, it is broadly accepted that in Europe health research has largely contributed to the increase of life expectancy and quality of life of its citizens. In a context of aging population, health research will become even more important in the future, both from a social and economic perspective.

Citizens and governments with limited financial resources will look for an increasing number of medical and pharmaceutical innovations that will contribute to reducing the direct costs of treating illnesses, the indirect costs of employment losses associated with the mortality or morbidity of the labour force and to increasing the longevity and quality of life of the citizens. In the United States, an estimation of the reduction of direct costs in the treatment of illnesses generated by the research funded or conducted by the National Institutes of Health rose to more than USD 1.3 trillion (OECD 2008).

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Israel, Switzerland, Denmark then Sweden are leading in Europe in producing technologies for health

Israel and Switzerland are the countries in the world which produce the most health-related technology patents relative to GDP\(^{(1)}\), well ahead of the United States and Japan in their intensity (figure III.5.14). Denmark, Sweden and the Netherlands also have a strong technological capacity in this societal field.

As expected, countries benefiting from strong public and private research investment also achieve ample technological returns

The relationship and synergies between public and private research have a clear impact on the technological production. The correlation between both public and private R&D and pharmaceutical patents is very high. As figure III.5.15, below shows, and as previously explained in this chapter, the United States is by far the world leader in research investment and in patent productions, followed by the EU.

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**FIGURE III.5.15**

Pharmaceuticals – BERD as % of GDP and PCT patent applications per billion PPS€, 2006\(^{(1)}\)

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381 In Figure III.5.14, patent data for health are OECD data concerning PCT (Patent Cooperation Treaty) patent applications by inventor’s country of residence and priority year. Health patents include patent in medical technologies and pharmaceuticals.
5.3. Does the EU Framework Programme address societal challenges?

Most key societal challenges are global in their nature. Given common interests, the internationalisation of science and the fact that over 75% of world knowledge is produced outside the EU, how has European research tackled societal challenges through international cooperation?

The funding of FP7 is largely targeted towards addressing societal challenges

A large part of FP7 funding supports research in ICT and nanosciences, whose results can be used and exploited in many scientific and technological domains. FP7 funding is also largely funding research addressing the challenges regarding health, food, energy, environment and transport that Europe is facing.

Figure III.5.16: FP7 by thematic priorities, 2007-2009 (9.2 billion euro)

A large proportion of the FP7 Cooperation programme deals with topics in different fields related to climate change or human health.

A recent review of the monitoring of the Cooperation Programme of the FP reveals that around 1,032 topics (i.e. 43% of the total number), deal with research conducive to a low-carbon society. In terms of budget, this amounts to EUR 2.7 billion, i.e. 31.5% of the total allocated budget. In the same line, 771 topics, accounting for EUR 3.34 billion dealt with human health. These topics are not only covered in – Health –, but in many other areas.

Source: DG Research and Innovation
Data: DG Research and Innovation
Notes: (1) Selections made before 25 October, 2009.
      (2) Includes Climate Change.
      (3) Includes Aeronautics
      (4) Socio-economic Sciences and Humanities
Box: The Monitoring system to measure FP7’s contribution to sustainable development and societal challenges

In order to assess the contribution of FP7 to sustainable development, a new monitoring system has been set up, which builds accountability for the FP7 by harnessing concrete results in the field of sustainable development. This system establishes cross-referencing between all the topics of all Work Programmes in the ‘Cooperation’ Programme and the 78 operational objectives included in the Sustainable Development System. For each topic, a set of ‘micro-decisions’ is taken at the level of each operational objective when a decision is taken, and on the impacts.

Based on this approach, a better perspective can be achieved on the real nature and impact of the different FP7 cooperation programmes in addressing different societal challenges. More precisely, regarding ‘climate change’, 1,032 topics, i.e. 43% of the total, call for a research conducive to a low carbon society.

383 This does not take into account the EU contribution of EUR 800 million invested in the Clean Sky joint Technology Initiative and the EUR 470 million invested in the Fuel Cells and Hydrogen Joint Technology Initiative.
Regarding ‘health’[^384], 771 topics, leading so far to a volume of EUR 3.34 billion, are deemed to have a positive impact. As can be seen from the graphs below, this effort comes mainly, but not exclusively, from – Health – research.

**European research and global initiatives are prominent in energy, climate change, biodiversity loss, health, food security, development and reduction of poverty**

Targeted actions have primarily covered research topics that have a global dimension and/or are designed to tackle global challenges. Figure III.5.21 shows the number of topics identified in the calls for proposals from thematic Cooperation programmes.

Different regions of the world have different profiles in their cooperation with the European Framework Programme (figure III.5.22). Behind these profiles there are many individual research teams, all building on their particular strengths and interests. The industrialised countries, in particular the United States and Japan, have a stronger cooperation on enabling technologies, while the Asian countries also profile themselves on cooperation in societal challenges such as environment and health. Research teams from the EU also cooperate with African research teams on societal challenges such as food, health and environment.

[^384]: This does not take into account the EC contribution of EUR 1 billion invested in the Innovative Medicine Initiative.
FIGURE III.5.21 Targeted actions and global challenges

FIGURE III.5.22 Participation of regions of the world by thematic areas

Source: DG Research and Innovation
Data: DG Research and Innovation
Innovation Union Competitiveness Report 2011