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'Innovation Union Competitiveness report' 2013 edition
III. Transform:

Innovation for growth and jobs
Structural change for a more knowledge-intensive European economy

**Highlights**

*Structural change is essential for productivity growth and competitiveness*

There is a correlation between research and development (R&D) intensity and total factor productivity growth. There is also a correlation between R&D intensity and technology success in global competition. A structural change towards a more knowledge-intensive economy in Europe is therefore crucial for maintaining medium-term competitiveness and for preserving high-quality jobs and innovation in Europe. Currently, the European Union (EU) economy is less knowledge intensive than those of the United States and Japan, whereas the Chinese economy is progressing rapidly towards higher knowledge intensity.

*There are indications that EU Member States, in particular eastern and southern European countries, are making progress to upgrade the knowledge-intensity of their economies*

The overview of this chapter indicates that almost all European countries may have managed to transform their economic structures to some extent over the last decade. This transformation trend is visible in the business sector. Some very knowledge-intensive countries in Europe have been successful in pursuing this upgrading, but other knowledge-intensive Member States have tended to lose momentum.

The economic transformation is particularly noticeable in eastern and southern European countries, indicating a possible catching-up process in terms of the knowledge-intensity of their economies. Simultaneously, eastern European countries are shifting towards a greater weighting for services in their economies.

*Some Member States need to upgrade their industries while others need to stimulate new knowledge-intensive sectors*

European countries are faced with different options for transforming their economies. Some have the leeway to upgrade with more knowledge and R&D in existing industries without having to significantly modify the sectoral composition of their economies. Others may progress in both directions, enhancing the framework conditions for corporate growth strategies based on R&D investments while supporting fast-growing firms in emerging and knowledge-intensive sectors, thus transforming the sectoral composition of the economy. Yet other countries are characterised by a very high service base in their economies, calling for a policy mix of knowledge upgrading combined with service innovation.
**Introduction**

The concept of structural change refers to the long-term dynamics of the economy, through which the types and nature of existing production, consumption and trade transform through the integration of higher levels of knowledge.\(^{116}\) Previous chapters of the Innovation Union Competitiveness (IUC) report have presented Europe's increasing efforts to accumulate knowledge in a broad sense, in human resources, science and technology for innovation. Investments are growing; efficiency is enhanced by reforms at national and European levels, backed up by framework conditions for a better dissemination of this knowledge throughout the economy.

However, this report has also shown how other world economies are making similar efforts, competing at ever higher segments of the value chain. The world knowledge economy is changing. Competition is harshening from an increasing number of players in an interconnected global economy. European countries with a high level of knowledge embedded in their economies, backed up by a competitive manufacturing sector, have suffered less during the economic crisis and recovered faster. But these countries are also challenged by the globalisation of research and innovation (R&I). If European countries are to maintain sustainable economies based on high living standards and wages, we need to be able to compete on non-cost factors pursuing a real structural change towards a more knowledge-intensive economy. This requires not only accumulation of knowledge and effective dissemination mechanisms but also relevant industry structures and business strategies demanding and using this knowledge. A competitive European economy with high-quality jobs can only be based on innovative products and services.

*An economy with enterprises investing significantly in R&D is a more competitive economy*

Business enterprise investments in R&D are associated with a higher level of productivity. Investing in R&D is part of a sustainable growth strategy to compete in the higher end of the value chains. Figure III.1 shows that countries where business R&D intensity was high over the period 1981–2000 show higher growth rates of multi-factor productivity in the period after the innovation process. Most probably, this is not a strict causality link but a comprehensive picture of the relevant factors influencing the competitiveness of modern economy. Structural change towards a more competitive economy requires a structural change in the economy towards more firms operating in knowledge-intensive product and service markets. It is an

\(^{116}\) The term *knowledge-intensity* is here measured by different indicators: business R&D intensity, the KIA indicator and a new composite indicator on structural change, which includes as well trade balance data and specialisation profile of the industry. Thereby, the concept measurement provides a proxy for both the capacity of an economy to produce new knowledge-based goods and to absorb existing new technologies produced elsewhere.
economic structure with a higher level of multi-factor productivity, competing not only with factor costs but also with knowledge in the form of R&I capabilities. 

**Figure III.1: Business R&D intensity and multi-factor productivity growth**

![Business R&D intensity and multi-factor productivity growth](image-url)

This third and last part of the Innovation Union Competitiveness report therefore presents an overview of the current state of the art and dynamics of structural change in Europe. Thereafter, in subsequent chapters, it analyses more in-depth two main avenues for progress: a Schumpeterian firm renewal through fast-growing innovative enterprises, and a structural upgrading of existing manufacturing and service industries through knowledge-based innovation. Framework conditions such as innovation-driven clusters and positioning in global value chains (GVCs) are essential in this context, but the basic drivers are entrepreneurial choices and framework conditions enhancing business strategies that actively use knowledge and innovation for their long-term growth.

**1. Measuring Europe's structural change from the perspective of different indicators**

Knowledge-intensive activities (KIAs) rely on the performance of scientific and technological R&D and the exploitation of its outcomes, which requires a highly skilled labour force and capital investments. If performed successfully, they result in increased domestic and foreign competitiveness for knowledge-based goods, which is often associated with high-tech specialisation and a greater economic openness. Strong performance in all these aspects creates a mutually reinforcing dynamic that is a sustained source of growth. Monitoring
structural change towards a knowledge-based economy will therefore require consideration of multiple aspects.

*The EU has a less knowledge-intensive economy than the United States*

The embedding of skilled and highly educated labour into the economic structure is relevant to the knowledge economy. A shift towards a greater incorporation of knowledge in the economy can be measured by the share of employment of persons having completed International Standard Classification of Education (ISCED) 5 or ISCED 6. This indicator is a proxy for firm’s and market demand for knowledge and avoids 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. The weakness of this indicator is that it does not correct for over-qualifications within the workforce, which could be more important in countries hit by the economic crisis, university graduates tend to experience a high unemployment rate. Figure III.2 and Figure III.3 illustrate the EU's performance on this indicator in terms of value added. The same data can also be constructed in terms of employment (\(^{117}\)). The figures show that the EU has made some progress in the past decade in increasing its share of KIAs, but not only is this share lower by more than 10 percentage points than that of the United States, it is also increasing more slowly. In other words, Europe's knowledge-intensity gap with the United States continues to grow according to this indicator, while China's knowledge intensity is expanding rapidly.

**Figure III.2 Value added in knowledge-intensive activities as a % of GDP, 2000-2009**

\(^{117}\) Knowledge-intensive activities are defined as economic sectors in which more than 33 % of the employed labour force has completed academic-oriented tertiary education (i.e. at ISCED 5 and 6 levels). They cover all sectors in the economy, including manufacturing and services sectors, and can be defined at two- and three-digit levels of the statistical classification of economic activities.
Data on KIAs can also be presented in terms of share of employment. This is done in Figure III.4, showing that Europe is becoming more knowledge intensive as KIAs continue to increase (from 34.1 % in 2008 to 35.5 % in 2011). The EU is, however, still less knowledge intensive than the US and Japan, as this indicator also shows. It is important to note that this construction of KIAs in employment shows, contrary to Figure III.3, that the EU’s gap with the United States is not growing. The problem is to understand the effect of the crisis, which may have led to an over-qualification of the work force in certain European countries.

Almost all European countries appears to have experienced a change towards a more knowledge-intensive economic structure, including within business.

Apart from Cyprus, the Netherlands, Iceland and Turkey, all European countries have registered growth in KIAs during the period 2008–2011. When considering the private sector in particular, Finland and Belgium have also experienced a slight decrease in knowledge intensity. Among the highly knowledge-intensive countries, Denmark has achieved the highest average annual growth rate over the period 2008–2011. France has also achieved high growth in its business industries. The growth in KIA employment is particularly strong in the eastern European countries and the countries severely affected by the economic crisis, such as Ireland, Spain, Portugal and Greece. Average annual growth rates range between 2.2 % for Greece and 4.7 % for Ireland, with Portugal and Spain registering an average growth of 2.8 % and 3.9 %, respectively. These findings must be handled with care and compared to other indicators on structural change, as unemployment in these countries more severely touches

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118 A complete assessment of structural economic transformation must consider also growth in absolute values of highly-skilled manufacturing and services. The positive evolution visible in the indicators presented in this chapter should be interpreted with care as they may also be due to a relative decrease of medium- and lower-skilled industries in the wake of the crisis.
Given that structural change primarily refers to the economy, it is appropriate to look in particular at structure and change within the business industries (also illustrated in Figure III.5 and Figure III.6). Switzerland has the most knowledge-intensive business structure according to this indicator, followed by Iceland and Ireland. The United Kingdom and Sweden score high as well. Ireland has also strongly increased knowledge intensity for its business industries over the period 2008–2011 \(^{(119)}\). Norway, France and Denmark are the knowledge-intensive economies that have achieved the highest growth in their business sector knowledge intensity. On the other hand, the Netherlands has lost part of the knowledge intensity of its

\(^{(119)}\) These findings vary slightly depending on which indicators are used, as visible when comparing to the composite indicator on structural change presented later in this chapter.
economy over the crisis period. There is positive catching-up in the business industries of most eastern European countries, in particular in Romania and Lithuania.

**Figure III.5: Employment in Knowledge Intensive Activities — Business Industries as% of total employment, 2011**
There are slightly more men than women employed in knowledge-intensive business industries

Figure III.7 presents a gender breakdown of the same indicator. It allows assessment of how the knowledge-intensive workforce is structured in terms of gender composition.
## Figure III.7: Gender breakdown of employment in knowledge-intensive business industries

<table>
<thead>
<tr>
<th>Country</th>
<th>Total KIABI</th>
<th>KIABI - Aggregate 1 (1)</th>
<th>KIABI - Aggregate 2 (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Belgium</td>
<td>664</td>
<td>378</td>
<td>286</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>235</td>
<td>116</td>
<td>139</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>594</td>
<td>315</td>
<td>279</td>
</tr>
<tr>
<td>Denmark</td>
<td>412</td>
<td>232</td>
<td>175</td>
</tr>
<tr>
<td>Germany</td>
<td>5866</td>
<td>3526</td>
<td>2341</td>
</tr>
<tr>
<td>Estonia</td>
<td>132</td>
<td>30</td>
<td>102</td>
</tr>
<tr>
<td>Iceland</td>
<td>356</td>
<td>204</td>
<td>152</td>
</tr>
<tr>
<td>Greece</td>
<td>456</td>
<td>268</td>
<td>188</td>
</tr>
<tr>
<td>Spain</td>
<td>2121</td>
<td>1190</td>
<td>931</td>
</tr>
<tr>
<td>France</td>
<td>1677</td>
<td>986</td>
<td>691</td>
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<td>Croatia</td>
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<td>72</td>
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<td>Italy</td>
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<tr>
<td>Cyprus</td>
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<td>704</td>
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<td>Romania</td>
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<tr>
<td>Turkey</td>
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<td>594</td>
<td>499</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>4909</td>
<td>2928</td>
<td>1981</td>
</tr>
<tr>
<td>EU28</td>
<td>29134</td>
<td>16292</td>
<td>12842</td>
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<tr>
<td>Macedonia (3)</td>
<td>45</td>
<td>27</td>
<td>18</td>
</tr>
</tbody>
</table>

Source: DG Research and Innovation

Data: Eurostat

Notes: (1) Aggregate 1: KIABI excluding the following NACE Rev.2 sectors: mining support service activities (09), manufacture of coke and refined petroleum products (19), manufacture of basic pharmaceutical products and pharmaceutical preparations (21), manufacture of computer, electronic and optical products (26).

(2) Aggregate 2: KIABI excluding the following NACE Rev.2 sectors: mining support service activities (09), manufacture of coke and refined petroleum products (19), manufacture of basic pharmaceutical products and pharmaceutical preparations (21), manufacture of computer, electronic and optical products (26), financial service activities, except insurance and pension funding (64), insurance, reinsurance and pension funding, except compulsory social security (65), activities auxiliary to financial services and insurance activities (66).

(3) The former Yugoslav Republic of Macedonia.

In 2011, men were responsible for 55.8% of knowledge-intensive activities within business industries (KIABIs) in the EU. While the balance between men and women is similar in most Member States, there are some exceptions, as in the cases of Bulgaria, Estonia, Cyprus, Latvia, Lithuania, Poland and Slovakia, where women represent a higher share of KIABI than the men. Among the larger Member States, gender balance in KIABI employment varies: Germany follows the EU average, with similar percentages, but the United Kingdom and Italy register more unbalanced situations, with 59.6% and 58.5% of men employed in KIABIs, respectively. Outside the EU, the imbalance is higher in Turkey, with men representing more
than 66 % of employment in KIABIs, while for Switzerland and Norway this share is 61.7 % and 61.9 %, respectively.

*The structural change in Southern and Eastern Europe and the capacity of some knowledge-intensive economies to further upgrade are confirmed by technology-based indicators*

A complementary indicator on the knowledge intensity of the economy is the Organisation for Economic Co-operation and Development (OECD) classification of high-tech, medium-high–tech and knowledge-intensive services (KISs). Like the KIA indicator, this indicator includes both manufacturing and services sectors, but with a slightly higher weight on manufacturing. However, the main difference is that this latter indicator gives higher importance to technology production capacity, while the KIAs indicator also includes knowledge capacity embedded in capital acquisition (120). The maps in Figure III.8 and Figure III.9 illustrate this indicator constructed on the base of value added, not employment as the previous presentations of the KIAs indicator. This allows a complementary and more solid interpretation of the knowledge intensity and structural change in the countries struck hardest by the economic downturn; the possible bias of higher unemployment rates should not affect this indicator.

In this context, Figure III.8 also highlights a structural change in Spain, Romania, Cyprus and Slovakia. There is also a relatively marked structural change in Lithuania, Estonia, Slovenia, Greece and Ireland. The strong performance of Denmark is also visible in this map, confirming the trend towards a knowledge-intensive economy that has managed to keep structural change in motion over first last three years of the economic downturn.

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Figure III.8: Value Added in high-tech and medium-high–tech manufacturing and knowledge intensive sectors (KIS) as % of total VA, 2011

Figure III.9: Value added in high-tech and medium-high–tech manufacturing and knowledge intensive sectors (KIS) as % of total VA, annual average growth 2008-2011
Some countries have margins to increase their R&D intensity within the existing industry structure; others are confronted with the need for a simultaneous structural transformation

In terms of mobilising R&D for a more sustainable knowledge economy, European countries face different situations and policy options. Some countries have margins to increase their R&D intensity within the existing economic sector structure (121), while others need to simultaneously push through complementary policy measures to change the very sector composition of their economies, favouring industry segments in which demand for research and skilled labour is high. Yet other countries have chosen to move further towards a service-based economy, combined with very open economies. The competitiveness of these economies is less prominent in terms of R&D intensity and more visible through other knowledge-intensive innovation indicators (122). However, given the determined upgrading of R&D investments in all Asian and other emerging economies, even advanced service-based economies probably need to be backed up with R&D centres and industrial R&D investments if they are to be sustainable and competitive in the long term.

In this respect, Figure III.10 presents, on the horizontal axis, the presence of economic sectors generally considered as providing a higher value added for the economy; that is, high-tech and medium-high–tech manufacturing and KISs. On its vertical axis, Figure III.10 gives complementary information on the business enterprise research and development (BERD) intensity of the economy, defined as business expenditures on R&D as percentage of gross domestic product (GDP). The most knowledge-intensive economies in this respect are some of the Nordic countries: Finland, Sweden and Denmark as well as Switzerland, large countries Germany and France, then Austria and Belgium, and also central and eastern European countries, such as Slovenia and Estonia.

Figure III.10 can be used to analyse two avenues to a more R&D-intensive economy (123). In broad terms, countries on the left-hand side need to increase their share of high-tech, medium-high–tech manufacturing and KIS sectors in the structure of the economy. This can be done both by promoting policies aiming to intensify the knowledge transfer from science to economy in sectors where the science and technology (S&T) capabilities are strong at national level, but also by attracting foreign direct investment (FDI) for higher value-added activities. The second option is particularly important for countries that do not have strong S&T capabilities at home. At the same time, countries in the lower part of the graphic would need to put in place measures triggering an increase in private R&D investment. The countries in the lower right corner may be there because of the high representation of services in their

121 Chapter III.3 presents data on this challenge in some industry sectors, showing that within the same industry segment firms in different countries can have different levels of research and development intensity, partly reflecting different business strategies and corporate cultures.

122 Chapter III.5 presents an analysis on innovation in services, based on a recent study by the OECD, co-funded by the Directorate-General for Research and Innovation (DG RTD). Indicators on competitiveness of business services are also presented in the analysis of global value chain income, as presented in Chapter III.4.

123 Further analysis of business enterprise investments in research and development is found in Chapter I.3.
The countries in the lower left corner could benefit from changing both the structural sector composition of their economies and stimulating higher R&D intensity within firms, thus providing better framework conditions and enhancing their firms' abilities to invest in R&D as part of their growth strategies.

**Figure III.10: R&D intensity and the economy’s sector structure**

Source: DG Research and Innovation - Economic Analysis Unit
Innovation Union Competitiveness Report 2013

Data: Eurostat, OECD

Notes:
   EL: Value added in HT plus MHT manufacturing plus KIS as % of total valued added refers to 2008; BERD intensity refers to 2007.
2. IE, ES, CH, KR: Water transport, air transport, employment activities, security and investigation activities are not included.
3. LU: Water transport, air transport, and employment activities are not included.
4. MT: Air transport is not included.
5. SE: Scientific research and development is not included.
6. IS: Water transport is not included.
7. NO: Coke and refined petroleum products is included.
8. US: Employment activities, and security and investigation activities are not included.
9. Elements of estimation were involved in the compilation of the data.
The contribution of knowledge-intensive goods and services to the trade balance is growing in both knowledge-intensive and catching-up countries

Another approach to measuring the knowledge intensity of an economy involves trade data. A larger contribution of knowledge-intensive goods and services to the trade balance is an indicator that measures the extent to which a country is competitive in high value-added goods and services, and the extent to which the trade balance is specialised in these goods and services. Trade in components and intermediates are growing. A full picture of the competitiveness at the higher end of the value chains therefore requires data on the GVC income of the country (124). Figure III.11 highlights Ireland, Germany and the United Kingdom as countries with competitive and specialised trade in value-added goods and services. Over the period 2007–2011, a structural change in the trade balance is visible in several central and eastern European countries, in particular Hungary, Slovakia and Cyprus. A reduction in the negative trade balance in knowledge-intensive goods and services is also visible in Bulgaria, Latvia, Croatia, Lithuania, and in southern Europe in Spain, Greece and Portugal.

Figure III.11: Contribution of knowledge-intensive goods and services to the trade balance

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Notes:
(1) DK, EE, IE, ES, HR, LV, MT, AT, PT, SI, FI, IS, NO, TR: Data were not available for all knowledge intensive sectors for all years.
(2) NO: 2009; EL, CY, MT: 2010.
(5) 2004: Data are not available for IE, EL, ES, FR, IS.

124 See Chapter III.4.
2. Measuring structural change through a composite indicator

Structural change is complex, but can be measured through a composite indicator taking into consideration several economic dimensions simultaneously. A complex methodology of measuring such change has been developed using a composite indicator. This approach is justified given the multidimensional and complex nature of economic structural change. An expert group to the European Commission on 'Measurement of Innovation' identified three types of indicators related to structural change: enablers, compositional variables and Schumpeterian variables. Enablers refer to the framework conditions in a country that could support or hinder novelty and variety creation by firms (i.e. business environment, attitudes to S&T or the availability of venture capital). Compositional structural change indicators measure changes in the actual sectoral composition of the economy in terms of R&D, skills, output, exports, technologies and FDI. Schumpeterian structural change indicators refer to the micro level, to the dynamics of innovation and entrepreneurship at the level of firms, technologies and markets. The group also concluded that the compositional dimension was most quantifiable and data were most 'mature', especially at the country level, as Schumpeterian dynamics often involved technology- and industry-specific qualitative changes.

Based on the shortlist of indicators identified by this expert group to measure the compositional aspects of structural change, the size of the knowledge economy can be measured across five dimensions. These express the different characteristics of a knowledge-based economy:

- Increased research intensity, as well as emergence and growth of R&D, as a specialised sector of the economy (R&D indicators);
- Increased demand for highly qualified human resources in the economy (skills indicators);
- Increased economic value creation in sectors relying on highly qualified human resources (sectoral specialisation indicators);
- Increased specialisation of countries in the development of high technologies and in exporting medium- and high-tech products (international specialisation indicators);
- Increased openness of economies in terms of foreign investments (internationalisation indicators).

Each of the five dimensions is measured by one or two indicators at three points in time to better capture change: 2000, 2005 and 2011 (or most recent year available). Data have been

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127 See Methodological annex for a full list of the indicators used.
collected for all EU Member States, Associated countries and key international benchmark countries, such as the United States, Japan, China, Israel, Brazil, India, Russia and South Korea.

The five dimensions were computed using the arithmetic average of the normalised indicators (128) within each dimension (129). Principal component analysis confirmed that the five dimensions express multiple perspectives of the same phenomena, and could therefore be aggregated into a single composite indicator on the knowledge-based economy. When indicator scores were missing for a country, the respective averages were imputed, thus the dimensions and composite scores are based on the average of the available indicators.

Switzerland, Luxembourg, Ireland, Iceland, Sweden and Belgium have the most knowledge-intensive their economies. Since 2000, almost all European countries have advanced towards this model.

The resulting scores are presented in Figure III.12 for three points in time. The figure shows a snapshot of the size of the knowledge economy in the countries studied, reflecting the outcome of past structural change. At the same time, past scores are also shown to put performances into perspective. Note that given the measurement and aggregation procedure, the performance scores should not be read as the size of knowledge economy, but rather as a ranking of countries. Furthermore, the large differences in the size of countries significantly influence their specialisation and internationalisation scores, which is why it is easier for smaller countries to make it to the top of the ranking.

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128 Indicators were normalised using the min–max method (between 10 and 100 in order to allow geometric aggregation), considering all three time points simultaneously to be able to meaningfully measure change over time. It should be noted that both FDI indicators were treated for the presence of outliers by winsorisation.

129 In the case of the R&D and international specialisation dimensions, the correlation between the indicators was positive and significant, but relatively weak (0.36 and 0.33, respectively). In this way, countries performing stronger in one of the indicators in these dimensions may compensate their weaker performance in the other indicator of the dimension.
Structural change is more pronounced in eastern and southern European countries, confirming they are catching up in terms of knowledge upgrading of the economy

For a more direct illustration of structural change, Figure III.13 ranks countries based on the changes in composite scores over 5-year and 11-year periods. Looking at the graphs in Figures III.12 and III.13 together, it is clear that countries where the knowledge share of the economy increased the most were often the ones with the lowest scores.
Data: JRC calculations

Plotting the indicators showing the size of the knowledge economy (composite scores of 2011) against structural change over the past decade (or the growth of the composite scores, 2000–2011) confirms that most of the least knowledge-intensive economies are catching up. Figure III.14 illustrates that EU Member States with relatively smaller-sized knowledge economies, such as Romania, Bulgaria, Latvia, Lithuania, but also the Mediterranean countries, have achieved greater growth than the EU in total. Among the countries that outperformed the EU in both dimensions, we find many of the smaller Member States. The country facing the most challenges in terms of catching-up is Slovakia, where the size of the knowledge economy has even been shrinking over the past decade — although the 1.5 % decline between 2000 and 2005 was reversed after 2005, and the country has achieved a modest growth of 0.5 % over the past 6 years. It is also important to note that many knowledge-intensive economies in Europe (as well as the United States) tend to lose momentum, an evolution that calls for close monitoring in the years to come.

Figure III.14: Four Quadrants Charts on Structural Dynamics
(Size of the knowledge economy, 2011 against its growth, 2000-2011)

Source: DG Research and Innovation – Economic Analysis Unit; DG JRC-Ispra calculations
Note: comparison made with regards to EU weighted average.
Considering a move to a service-based economy

Structural change towards a more knowledge-intensive economy cannot be fully understood without looking at the simultaneous change in most European countries from an industry-based economy to a service-based economy. Given that several indicators of knowledge intensity (i.e. R&D intensity, technology intensity or trade data) are all higher in manufacturing than services, the evolution towards a service economy has an impact on how the knowledge intensity of an economy (and its competitiveness) is interpreted. It is therefore important to relate the knowledge intensity to the weight of services within the economy.

Figure III.15: Employment by type of economic sector — % shares, 2011

Employment in services is growing, and decreasing in manufacturing. However, the EU has been able to maintain a larger share of manufacturing employment than the US.
The overall evolution of the EU in terms of manufacturing employment differs from that of the United States and Japan (130). The EU's move towards a service economy is visible when comparing the changes in the shares of the EU's employment in manufacturing (20.1 %) and services (62.9 %) in 1995 to those in 2011 (14.4 % and 71.5 %, respectively). Very similar evolution is shown by the economic structure of Japan over the period 1995–2010 (2010 being the last year available), with the employment share of the manufacturing sector dropping from 20.8 % to 15.9 %, while the share of employment in the services sector increased from 60.7 % to 70.1 %. The evolution of employment in the US followed the same trend until 2009, when manufacturing began to slightly increase its share in overall employment, albeit from a lower level than the EU.

Catching-up countries in Europe in terms of knowledge intensity are simultaneously moving towards more service-oriented economies

Complementing the analysis of employment shares, Figure III.16 presents the average annual growth rates of employment in manufacturing and in services, between 1995 and 2011. All employment growth rates for manufacturing are negative, and those for services are positive. The figure indicates that the highest employment growth rates for services are taking place in catching-up countries. Employment in manufacturing has decreased the least in the Czech Republic, Hungary and Poland, and the most in Malta, the United Kingdom and Ireland.

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130 This analysis is not directly presented in any figure, but the data come from Eurostat.
The following chapters provide a deeper understanding of some of the mechanisms driving a knowledge-based structural change for a more sustainable economic growth.
1. High-growth innovative enterprises

**Highlights**

*The European Union is making progress towards an Innovation Union in spite of the economic downturn*

Innovation output is crucial for productivity growth and competitiveness. The new European innovation indicator reveals that the European Union is making progress towards an Innovation Union even in the current period of economic downturn. Top innovation performers in the EU are Member States characterised by open and highly knowledge-intensive manufacturing or services sectors often coupled with strong firm dynamics in transformative technologies. Top innovation performers have a larger share of the employment in high-growth innovative enterprises (HGIEs), highlighting the key importance of this type of firm for the innovation output of an economy.

*The main market for the majority of the high-growth innovative enterprises is the national market but they also tend to focus on emerging knowledge-intensive growth sectors at international level, with this level being the main market for one quarter of the high-growth innovative enterprises.*

The chapter presents a first overview of the characteristics of high-growth innovative enterprises (HGIEs) based on a survey of 580 firms in four EU Member States and four non-EU Member States. According to the survey, the population of medium-sized and large enterprises is much higher than in the rest of the economy. This indicates that a critical size is helpful for accelerating growth. This shows again that policies to encourage growth should not only be focused on the early stages of firm development. Very few are spin-offs from public research. For most of these HGIEs, the national market is the main market, although they are also positioning themselves internationally. HGIEs are most frequently active in computer programming, management consulting, and architectural and engineering activities. The most cited factors for high growth in these firms are a skilled workforce and an active growth target.

*Skilled labour, research and development capacities, intellectual property rights framework and entrepreneurship are highly relevant for HGIEs*

Asked about specific framework conditions for further innovation and growth, the majority of HGIEs see the need for public policy to improve framework conditions governing skills development, in-house research and development (R&D) and intellectual property (IP) protection. The share of respondents having received public support is much higher in the EU than in non-EU countries. The need for policy adjustments seems to be less pressing in Germany, the United Kingdom, Switzerland, the United States and Japan, than in France, Poland and South Korea. Other recommendations from the survey concerning policies to promote HGIEs are: a) focus policies on the specific needs of the country and industry concerned; b) enhance continued education for employees; and c) target high-growth consulting and coaching for entrepreneurs.
1.1. Innovation output performance in Europe — a new innovation indicator

Measuring the impact of innovation policies is vital for the development and monitoring of evidence-based policymaking. Innovation is the cornerstone of any strategy aimed at transforming an economy facing increased global competition. In order to monitor the performance and progress of each Member State and of the EU as a whole more effectively in this area of strategic importance, the European Commission has developed a new indicator for measuring innovation output.

The new innovation indicator shows that the EU is making progress towards an Innovation Union in spite of the economic downturn

Innovation output is wide-ranging and differs from sector to sector. Measuring it entails quantifying the extent to which ideas for new goods and services stemming from innovative sectors carry economic value added and are capable of reaching the market. The new indicator is therefore based on four components: technological innovation as measured by patents, employment in knowledge-intensive activities (KIAs), the competitiveness of knowledge-intensive goods and services, and employment in fast-growing firms within innovative sectors. The indicator has been developed using international quality standards and state-of-the-art statistical analyses. Four principles are applied when identifying components and underlying data: policy relevance; data quality; international availability and cross-country comparability of underlying data; and robustness of results. Results for the new innovation indicator show strong performance differences between Member States, and thus potential for peer learning, but they also show that the EU as a whole is progressing, despite the crisis. The EU appears to have increased its performance in 2011 compared to 2010. Progress in this period was strongest in knowledge-intensive service (KIS) exports. Most Member States have likewise increased performance. However, given that longer time series are not yet available, it is too early to observe any trends.

Data are currently only available for some key non-European partners (United States and Japan) and for some Associated Countries (Switzerland, Iceland, Norway and Turkey). Japan is outperforming all EU countries and is the number one performer in the new innovation indicator. Japan performs well in all sub-indicators. It performs particularly well in the contribution of medium- and high-tech products to the trade balance and Patent Cooperation Treaty (PCT) patent applications. The United States performance is similar to that of the EU. It performs well in employment in KIAs as percentage of total employment and near the EU average for the other components.

\[131\] However, further refinements are needed to bring the indicator to its full potential. (see EC Communication “Measuring innovation output in Europe: towards a new indicator”, 2013)

\[132\] Although the indicator refers to 2010 and 2011, a mix of different reference years has been used for its underlying components.
### Figure III.1.1 Innovation output, 2000 and 2011

![Bar chart showing innovation output for various countries in 2000 and 2011.](image)

### Figure III.1.2 Innovation output - performance by Member State

(EU2010 = 100 (1))

<table>
<thead>
<tr>
<th>Country</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>126.4</td>
<td>127.5</td>
</tr>
<tr>
<td>Germany</td>
<td>125.9</td>
<td>126.1</td>
</tr>
<tr>
<td>Ireland</td>
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<td>124.8</td>
</tr>
<tr>
<td>Luxembourg</td>
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<td>120.7</td>
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<tr>
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<td>119.7</td>
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<tr>
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<td>117.9</td>
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<tr>
<td>France</td>
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</tr>
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<tr>
<td>Bulgaria</td>
<td>66.7</td>
<td>64.9</td>
</tr>
</tbody>
</table>

Innovation Union Competitiveness report 2013

**Source:** DG Research and Innovation - Economic Analysis Unit

**Data:** Eurostat, OECD

**Note:** (1) EU: Croatia was not included in the EU average.
Top EU performers on innovation output are characterised by open and highly knowledge-intensive manufacturing or services, coupled with firm dynamics in transformative technologies

Sweden is the top EU performer for the European innovation indicator. It shows strong performance in all components. Performance slightly improved in 2011 in comparison to 2010. Sweden performs particularly well as regards patents, where it is the second best performer in the EU. This is mostly the result of strong patenting in the information and communication technologies (ICT) sector. The Swedish company Ericsson is among the most prolific of EU companies filing for patents. Sweden also has a relatively high level of patenting in biotechnology and medical technology. Despite a strong technology orientation within the Swedish economy, the high share of wood and paper exports impacts negatively on its contribution of medium/high-tech goods to the trade balance, which is only average. Sweden performs extremely well (best performer in the EU) as regards employment in fast-growing innovative firms as a percentage of total employment in fast-growing firms. This is a result of the high share of computer programming, scientific R&D, and architectural and engineering companies (all with high innovation scores) among fast-growing enterprises.

Germany's performance is notably high on patents and on the share of medium/high-tech goods exports in trade balance, where it is the best EU performer. The good performance in patents is explained by the above average share of industries with a high patent intensity in Germany (ICT, automobile industry, medical equipment, energy technology). Companies like Siemens, Bosch and BASF are among the top patent producers in Europe. The existence of large and export-oriented automobile, other transport equipment and machinery industries also explains the high score as regards the contribution of medium/high-tech exports to trade balance. When it comes to the export share of KISs, Germany’s strong performance is explained by the fact that it is an important hub for knowledge-intensive transport services, such as passenger and freight transport by air, an important software exporter, and a major exporter of research, professional and technical services. Germany also performs well as regards employment in fast-growing innovative firms as a percentage of total employment in fast-growing firms. This is a result of the high share of activities with high innovativeness scores, such as computer programming and information service activities, among fast-growing firms.

Ireland is one of the top performers for the European innovation indicator. It ranks third in the EU after Sweden and Germany. This is a result of good or very good performance for all of the indicator’s components with the exception of patent applications. Ireland performs particularly well as regards employment in KIAs, the export share of KISs, and employment in high-growth enterprises in innovative sectors as a share of employment in all high-growth firms. The relatively low performance in patents is linked to limited research capacity, the economic structure and the division of work within international (American) companies, which have European headquarters in Ireland (contributing to value added but less to patenting). Ireland performs above the EU average in the contribution of medium/high-tech goods to the trade balance, mainly as a result of its exports of medicinal and pharmaceutical products. The strong
performance in KIAs and the outstanding performance in the export share of KISs is explained by the economic structure of the country, with financial services and computing services being relatively important in the Irish economy.\(^{133}\) Ireland is the largest software exporter in the world, after India (computer services exports of EUR 32 billion in 2011). Ireland performs well as regards employment in fast-growing innovative firms as a percentage of total employment in such firms. This is a result of a high share of computer programming companies among them.

Luxembourg is a top performer for the European innovation indicator. Performance is especially strong in employment in KISs and in KIS exports. As regards patents and the contribution of medium/high-tech manufacturing exports, Luxembourg’s performance is however, below average and stagnating. The relatively low performance in patents is linked to the economic structure of Luxembourg, which has a relatively small capital goods sector, limited research capacity and lack of large manufacturing companies, which are typically very active in patenting. The large international companies headquartered in Luxembourg conduct large parts of their research and patenting outside the country. Luxembourg has by far the best scores among all Member States as regards share of knowledge intensive services in services export as well as employment in KIAs (nearly twice the EU average). This is due to very strong specialisation in the financial services sector, which has been Luxembourg's main growth engine since the early 1980s and which has a very high innovation coefficient. The fees earned by asset managers alone constitute around half the total (goods + services) of Luxembourgish exports. Apart from the strong financial sector, others, such as insurance, communication (Voice over Internet Providers), satellite operators, and air freight transport services contribute to the high share of KISs exports (the highest in the EU). Luxembourg has only a small technology-intensive manufacturing sector (manufacturing represents only 6.5 % of total value added, the lowest share of all EU Member States). The contribution of medium/high-tech goods to the trade balance is hence low.

\textit{Innovation output is closely associated with fast-growing innovative enterprises}

As indicated above, the new European innovation indicator is constructed around four pillars: technological innovation as measured by patents, employment in KIAs, the competitiveness of knowledge-intensive goods and services, and employment in fast-growing firms of innovative sectors. While the second and third pillars are more structural, the first and fourth are also underlying drivers in a Schumpeterian transformative mode. Given that the top performers for the European innovation indicator combine manufacturing and services or evolve towards a predominant service economy, the fourth pillar is particularly relevant since it covers firm growth dynamics in innovative sectors, which can be both manufacturing and service sectors. Figure III.1.3 illustrates the close correlation between fast-growing innovative

\(^{133}\) The OECD 2013 economic survey of Ireland suggests that Ireland’s innovation capacity should be assessed with care. The high value of indicators measuring knowledge-intensive industries or indicators measuring export share of knowledge-intensive services (mainly computer software) may be related to multinationals located in Ireland.
enterprises and overall innovation output (which in turn is closely correlated with total factor productivity growth, as seen in Chapter III.1).

**Figure III.1.3: Innovation performance and dynamics of fast-growing innovative firms**

![Graph showing innovation output indicator and employment share in HGIEs](image)

Source: DG Research and Innovation - Economic Analysis unit

Data: Eurostat

Figure III.1.4 focuses on the employment structure in innovation-driven economies. It shows that the top innovation performers have a larger share of their total employment in HGIEs. Despite their relatively small share in the economy, these firms have vigorous spillover effects spurring innovation and fostering transformation into a knowledge-based and more sustainable economy. Some countries, like Denmark and Finland, may have margins of manoeuvre to further stimulate employment share in these fast-growing innovative enterprises and thus step up from very good to top innovation performers.
1.2. General characteristics of high-growth innovative enterprises

Which then are these high-growth innovative enterprises? Some general features can be identified, although there is still a lack of knowledge about the precise characteristics of HGIEs, the framework conditions under which they thrive, and the policies that could support their emergence and growth.

This section presents the findings of a survey and study focused on HGIEs and HGIE support policies, initiated by the European Commission’s Directorate-General for Research and Innovation (DG RTD) and coordinated by Empirica (134). The study will be referred to as the “HGIE study”. The survey encompasses a sample of 580 HGIEs in eight countries: Germany (100), France (99), the United Kingdom (84), Poland (49), Switzerland (39), the United States (150), South Korea (44) and Japan (15).

In this study, HGIEs are defined as firms belonging to 36 three-digit NACE sectors identified by the European Commission as being particularly innovative (135), whose number of employees has grown at least one third over a period of three years during the past five years. (136) So, in

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134 Policies in support of high-growth innovative enterprises, a study coordinated by Empirica Gesellschaft für Kommunikations- und Technologieforschung mbH, 2013.
136 For Poland, the target was revised to 22% in the past two years in order to be able to find a reasonably high number of enterprises qualifying for the survey. Only originally growing enterprises were considered; enterprises which had grown due to mergers and acquisition were not included. The size threshold for enterprises to be
this study, HGIEs are identified as high growth firms from innovative sectors. Their activity does not necessarily need to be technology-related (e.g. it may also be related to marketing or organisational innovation). This definition is fully consistent with the definition of HGIES used in the new innovation indicator launched by the European Commission\textsuperscript{137} and welcomed by the European Council.\textsuperscript{138} This section will present the characteristics of the HGIEs surveyed for this study.

**Three industries are predominant among high-growth innovative enterprises**

Three industries dominate the population (\textsuperscript{139}) of HGIEs: 1) computer programming (NACE 620), 2) management consulting (NACE 702), and 3) architectural and engineering activities (NACE 711). More than half (56\%) of all HGIEs stem from these three industries. Figure III.1.5 shows the nine largest industries where HGIEs are found (all others are subsumed under 'Other industries').

![Figure III.1.5: HGIEs by sector in % of all HGIEs](image)

Source: DG Research and Innovation; HGIE study

Innovation Union Competitiveness report 2013

Data: Empirica survey HGIE, 2013

Note: "All HGIEs" refers to all the HGIEs in the universe of enterprises in the address data from Dun & Bradstreet.

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\textsuperscript{137} COM (2013) 20.

\textsuperscript{138} European Council of 24-25 October 2013.

\textsuperscript{139} This refers to the universe of enterprises in the address data from the Dun & Bradstreet company; i.e. all HGIEs of this universe, from which the sample for the interviews of the study was drawn.
Medium sized and large enterprises are over-represented among HGIEs

As shown on Figure III.1.6, the majority (58 %) of HGIEs surveyed are small, having between 10 and 49 employees. There is a considerable share (33 %) of medium-sized HGIEs (50 – 250 employees). It is however noticeable that the share of medium-sized HGIEs is larger than the share of medium-sized enterprises in the data universe of Dun & Bradstreet, which has been used for the study; for small enterprises it is the other way round. The share of large enterprises (9 %) among HGIEs is also much higher than in the overall economy, namely 0.2 % of the number of enterprises in Europe in non-financial sector. This may indicate that for many enterprises a minimal size is required to take off for high growth.

**Figure III.1.6: HGIEs by size class in % of respondents**

![Figure III.1.6: HGIEs by size class in % of respondents](image)

Source: DG Research and Innovation; HGIE study
Data: Empirica survey HGIE, 2013

High growth is generally not a start-up phenomenon

As shown in Figure III.1.7, the majority of HGIEs in the sample are older than 10 years: 59 % were founded between 1988 and 2003, 24 % before 1988, 14 % between 2004 and 2008, and only 2 % after 2008 (which effectively means founded in 2009 so that the companies qualify for three years of consecutive growth up until 2012). High growth is apparently generally not a start-up phenomenon but may take place once the initial struggles involved in establishing a firm in the market have been overcome.

Such a characteristic has also been found for high-impact firms in the United States. Acs et al. (2008), using data from all US establishments and businesses, found that high-impact firms have a mean age of 25 years.
The growth of the vast majority of HGIEs started within the past 10 years

As shown in Figure III.1.8, 46% of HGIEs said their high growth started recently, between 2009 and 2012. Almost the same share (44%) stated that their high growth started between 2004 and 2008. The shares of HGIEs saying their high growth started in the period 1998–2003 (7%) or before 1998 (3%) were considerably smaller. Thus, high growth for the vast majority of HGIEs started in the past 10 years. The characteristics of HGIEs whose high growth started before 2004 are as follows: their largest share is among medium-sized enterprises (50–249 employees); the share in EU sample countries is larger than in sample countries outside the EU; highest shares in all HGIEs were found in France (18%) and Germany (12%); and their share is considerably larger in the services sector (12%) than in manufacturing (5%).
Few HGIEs are spin-offs from public research

The interviewees were asked: 'When your company was founded, was it based on research findings from another organisation?' Some 14 % of the enterprises surveyed said 'yes'. They were further asked whether this other organisation was a university, a public research organisation other than a university, or another company. The answers revealed that 25 % originated from a university, 17 % from a public research organisation and 71 % from another company. These shares amount to more than 100 %, indicating that a certain share of the HGIEs spun out from different organisation types, for example as an outcome of joint research. As a whole, therefore around 5 % of all HGIEs were spin-offs originating from universities or PROs. This demonstrates the distinction needed between on the one hand policies in favour of technology transfer and on the other hand policies in favour of HGIEs. The latter cannot be seen as a sole extension of the former policies.

Other companies in business-to-business dynamics are the dominant customers of HGIEs

The interviewees were asked what percentage of their total product or service sales was sold to certain customer groups. The results reveal that other companies in business-to-business relations are the dominant customers of the HGIEs in the sample. The average percentage of total sales to other companies was 70 %, while the average percentage for households was only 9 % and for the public sector 21 %.
For the majority of HGIEs, the national market is the main market

The interviewees were asked what their company's most significant sales market is: the regional market, the national market or international markets. As shown in Figure III.1.10, it seems that for the majority (57 %) of HGIEs, the national market is the main market. Furthermore, 25 % stated that their main market is international, and only 17 % said that their main market is regional. Even among firms with more than 249 employees, the share of firms predominantly selling to international markets is only 33 %. These figures show the potential of national lead markets and advanced customers, but they also suggest that many HGIEs may have the potential to grow further into international markets.

Figure III.1.10: Most significant sales market of HGIEs in % of respondents
The share of HGIEs with venture capital or private equity investments may be higher than average

The companies were also asked whether their assets include private equity (PE) or venture capital (VC) (140). This question was meant to find out how important these types of external finance are for high growth. As shown in Figure III.1.11, 25 % of the companies had private equity investments (PE), and 12 % venture capital (VC). PE and VC investments are similar across sizes, and across manufacturing and service sectors. While such assets affect only a minority of HGIEs, the shares of VC and private equity may be higher than in the universe of firms, i.e. including less innovative industries.

Figure III.1.11: HGIEs' financial assets including venture capital and/or private equity in % of respondents

![Bar chart showing 25% for private equity and 12% for venture capital](http://example.com/bar-chart.png)

Source: DG Research and Innovation; HGIE study Innovation Union Competitiveness report 2013
Data: Empirica survey HGIE, 2013

Most HGIEs are not part of an international group

Finally, the HGIEs operate with a certain level of autonomy. Some 15 % of interviewees said that their company is part of an international enterprise group. In firms with more than 250 employees, the share was 33 %.

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140 'Private equity is a form of equity investment into private companies that are not quoted on a stock exchange. Private equity (…) seeks to deliver operational improvements in its companies (…). Venture capital is a type of private equity focused on start-up companies' (http://evca.eu/what-is-private-equity).
1.3. Characteristics of high-growth innovative enterprises by country

In Germany, there is no innovative sector with an outstandingly large share of HGIEs. More than half of German HGIEs stem from the three industries: 1) computer programming, consultancy and related activities, 2) architectural and engineering activities, and 3) manufacture of instruments and appliances. In these three industries, most enterprises and HGIEs are small, but in computer programming as well as in architectural and engineering activities, medium size is often favourable for high growth. Furthermore, in these three industries, most enterprises, as well as HGIEs, are between 10 and 25 years old, revealing that HGIEs are over-represented in this age group.

In France, the percentage of HGIEs among all firms was found to be very high. Most firms (in absolute terms) are located in the industries of 1) architectural and engineering activities, 2) computer programming, consultancy and related activities, and 3) management consultancy activities. Relative to the number of firms within each sector, however, HGIEs are particularly present in various manufacturing industries. The most common HGIE type, based on industries, is somewhat bigger than other firms in the same sectors. There is no such difference for the age of HGIEs.

In the United Kingdom, HGIEs are relatively concentrated, with 66 % being located in 1) architectural and engineering activities, 2) computer programming, consultancy and related activities, and 3) management consultancy activities. Compared to all other UK firms, the share of HGIEs is distributed relatively equally over the various sectors, with the most in manufacture of basic chemicals. On average, UK HGIEs are larger and older than regular UK firms. A large part of HGIEs (41 % versus 12 % on average) state that their establishment was based on research findings from another organisation.

In Poland, no innovative sector has an outstandingly large share of HGIEs; the shares of industries with a reasonably high number are all below 10 %. Almost half of HGIEs are located in industry of 1) monetary intermediation, 2) wholesale of information and communication equipment, and 3) management consultancy activities. In these three industries, most enterprises and HGIEs are small, but the share of medium-sized HGIEs (50–249 employees) is 16–20 percentage points higher than the share of medium-sized enterprises overall. In monetary intermediation, the majority of HGIEs is older than 25.

In Switzerland, the percentage of HGIEs among all firms is rather low. HGIEs are mainly found in the industries of 1) computer programming, consultancy and related activities, 2) architectural and engineering activities, and 3) software publishing. The sector with the highest share of HGIEs is the manufacture of motor vehicles. The majority of Swiss respondents have fewer than 50 employees.

In the United States, compared to the absolute number of firms, the percentage of HGIEs is rather low. HGIEs are mainly found in the industries of 1) computer programming, consultancy and related activities, 2) architectural and engineering activities, and 3) management consultancy activities. The sector with the highest share of HGIEs is the
manufacture of basic pharmaceutical products. US HGIEs are significantly larger than regular US firms. Yet, at the same time, they are also significantly younger. For most of them (51%) high growth started after 2008.

In South Korea, a small share of 2% of firms was found to be HGIEs. Together with the US this was the smallest share in the sample countries. A relatively large share of Korean HGIEs (i.e. as a share of all Korean HGIEs) is in the industries of manufacture of communication equipment as well as manufacture of instruments and appliances, reflecting the country’s overall large shares of enterprises in these NACE categories. Medium-sized HGIEs were found to be over-represented compared to the share of all HGIEs in the data universe. Korean HGIEs mainly sell to other companies, and the share of HGIEs having received state support is slightly smaller than in the other sample countries.

For Japan, specific conditions for analyses apply. Assessments of characteristics of Japanese HGIEs are very limited, due particularly to the small size of the Japanese sample. The percentage of Japanese HGIEs saying they received state support was right the average of all sample countries. The share of HGIEs stating that their high growth started after 2008 was considerably larger than in the other countries, which is however due to the fact that a quarter of the Japanese HGIEs in the sample was founded after 2008.

1.4. Growth factors and barriers as perceived by HGIEs

The survey on HGIEs conducted for the HGIE study also addressed the factors and barriers influencing HGIE growth. Figure III.1.12 presents a synthetic overview of the main factors and perceived barriers for growth and of the state support policies deemed useful, according to the respondents.
The most cited factors for high growth are a skilled workforce and managers actively targeting growth.

The interviewees were asked the reasons for the growth of their company in the past five years. Figure III.1.13 shows that two characteristics stand out as fully applying to three quarters of the HGIEs in the sample: 'Our company has particularly highly skilled employees' (77 % 'applies fully'), and 'Our company's directors actively targeted growth' (74 % 'applies fully').
A further two items apply fully to the majority of HGIEs: 'Successfully introduced new products or services to the market' (54 %), which means that product or service innovation may be, but is not always, decisive for high growth of innovative firms. Meanwhile 50 % agreed fully with the statement that the company 'Has been facing strong competition', which could mean that HGIEs' success is often achieved when striving to be better than other firms. Moreover, 41 % found that 'Our company sells to a growing market' applied fully with their circumstances, which shows the importance of market dynamics.

At the other end of the scale, respondents were least likely (22 %) to select 'applies fully' for 'Our company has had easy access to external financing', 24 % for entering new international markets, 26 % for new marketing methods and 29 % for new forms of organising business.

**The most cited barriers for the growth of innovative enterprises are bureaucracy, regulation, political issues and access to finance**

The interviewees were asked an open-ended question about barriers to growth: 'In a few words: What is in your opinion the main obstacle in your country for innovative companies to grow?' The interviewees mentioned 662 single items; multiple answers were counted. The answers were coded into groups. Figure III.1.14 shows nine groups of responses and a bulk group for other items.
The two most important groups are: bureaucracy, regulation and political issues (including for example 'administrative hurdles' and 'frequently changing political requirements'), accounting for of 19 % of the answers, and difficult access to finance (18 %). The third most important group is: finding skilled personnel and employees insufficiently qualified (9 %). Further items are strong competition or cost pressure (7 %), an unfavourable business cycle (6 %), lack of support from the state (5 %), high or complicated taxation (5 %), difficult customers (4 %) and high labour costs (3 %). Beyond these nine items, almost a quarter (24 %) of answers relate to other barriers such as difficult or weak marketing, high risk or lack of willingness to take risks, and the interviewee him- or herself or the directors. Fourteen respondents (2 %) said there are no barriers.

**Figure III.1.14: Perceived barriers for innovative companies' growth — share of barriers in % of all answers**

Source: DG Research and Innovation; HGIE study

Innovation Union Competitiveness report 2013

Data: Empirica survey HGIE, 2013
1.5. Framework conditions and the HGIEs' perceived public policy needs

In the survey, interviewees were asked about the framework conditions necessary for doing business in their country and on their need for public support measures.

*Company taxation and labour market regulation are judged critically, while the higher education system is considered very or rather supportive*

The HGIEs were asked to assess whether certain framework conditions for doing business in their country were supportive for growing the company. As shown in Figure III.1.15, the tendency was to assess business framework conditions as neutral or as rather harmful. Company taxation (assessed as very harmful or rather harmful by 45 %) and labour market regulations (38 % very harmful or rather harmful) were judged most critically. The following framework conditions followed, ranked by harmfulness: national regulations on starting, running or expanding a company (23 %); product market regulations (18 %) and the higher education system (17 %); regulations for accessing private capital (12 %); and finally bankruptcy regulation (10 %).

Figure III.1.15: Assessment of framework conditions for doing business in % of respondents

Source: DG Research and Innovation; HGIE study
Data: Empirica survey HGIE, 2013
Note: Differences to 100 % = no answer / “don’t know”
HGIEs expressed a need for state policy to improve framework conditions in skills development, in-house R&D and intellectual property protection

The HGIEs did not articulate strong needs for policy measures to improve business conditions in certain fields. However, for each field except one there was a majority stating at least some need. As shown in Figure III.1.16, the field with the largest share of responses stating a strong need for state policy was enhancing company employees’ skills: 38% saw a strong need for policy measures in this field, a further 34% some need. Two other fields had a relative majority of HGIEs strongly favouring policy measures: R&D in enterprises (34% 'strong need', 31% 'some need' and IP protection (33% 'strong need', 31% 'some need'). In six other fields the HGIEs did not emphasise a need for state policy: For 'Accessing international markets', 27% saw a 'strong need' for state policy measures, 32% saw 'some need'. The same shares apply to joint research between enterprises and public research organisations. For accessing debt finance, a fifth (18%) saw a 'strong need' and a third (32%) saw 'some need'. Similar shares were found for accessing equity finance (15% 'strong need', 31% 'some need') and standardisation of product characteristics (15% 'strong need' and 29% 'some need'). Only 45% of the HGIEs saw a need for state policy to develop regional business clusters (15% 'strong need', 30% 'some need').

Figure III.1.16: Perceived needs for governmental policies to improve business conditions in % of respondents

Source: DG Research and Innovation; HGIE study
Data: Empirica survey HGIE, 2013
Note: Differences to 100% = no answer / “don’t know”
The assessments of business framework conditions and the needs for governmental policies differ somewhat by country

In Germany, HGIEs tend to assess framework conditions for doing business as neutral. Relatively large shares of HGIEs assess regulations for starting, running or expanding a business and company taxation as neutral. While most German respondents are positive or at least neutral about the higher education system, they are also most likely to select 'rather harmful' or 'very harmful'. The majority of respondents do not see a need for governmental policies to support their growth. But asked about policy measures to improve the development of regional business clusters, 'some need' was the most popular answer for all countries.

In France, according to most French respondents, the framework conditions are not particularly supportive for firm growth. A relatively large share of respondents criticise regulations on company taxation, labour markets, bankruptcy, and starting, running or expanding companies. Only regulations on access to private capital and quality of higher education system score relatively well in a cross-country comparison of survey results. Within France, just as in most other countries, respondents are very positive about the quality of the higher education system. Respondents signal a need for more state policy on better access to international markets and support for R&D activities.

In the United Kingdom, respondents are most positive about the higher education systems. Regulations on starting, running or expanding are seen as (very or rather) supportive by 20%. However, there is more discussion about the value of the bankruptcy regulation, product market regulations, regulations for access to private capital and company taxation. Only 6–8% of the respondents see these measures as supportive. Policy measures are most needed to enhance employees’ skills and support R&D activities.

In Poland, respondents are rather critical about framework conditions for doing business in their country, particularly regarding company taxation, labour market regulation and the higher education system. However, compared to other countries in the survey, regulations on access to private capital are assessed relatively positively and market regulations are assessed very positively. In many policy fields, the majority of respondents see a 'strong need' or 'some need' for measures to support growth. In three policy fields (access to equity finance, improving regional business clusters and enhancing employees’ skills), Poland has the highest share of representatives seeing a 'strong need for state policy'.

In Switzerland, the framework conditions were assessed as more positive than in the other countries in the sample. In particular, the higher education system, taxation, labour market regulations, and regulations on starting, running or expanding businesses are considered as more supportive than in other countries. Public procurement activities are also evaluated as supportive by large shares of respondents. It is a logical consequence of the relatively high satisfaction with these framework conditions that Swiss respondents do not see much need for state policy measures to improve business conditions. The highest need for state measures is
perceived for improving IP protection (39 % of respondents). Rated second was state measures for supporting R&D within a company.

In the United States, the replies suggest that the regulation on the launch and expansion of companies and the regulation on product markets are relatively unsupportive to company growth. On the other hand, labour market and bankruptcy regulations are regarded as relatively supportive. When it comes to state policy measures for improving business conditions, American respondents hardly see any need for more government involvement. With an exception for access to finance and development of regional business clusters, scores for other fields of business support are well below the cross-country average.

In South Korea, respondents tend to assess framework conditions for doing business as neutral and a little more positive than in other countries surveyed. Korean respondents express a strong need for governmental policies to support their growth; out of all countries in the sample, Korean respondents were most likely to see a 'strong need' for policy measures.

In Japan, respondents often mentioned the "mismatch" between the job skills they needed and young workers graduating from universities. In contrast to the other sample countries, the higher education system is judged rather negatively. Company taxation is assessed more negatively than the average of all sample countries. Respondent did not indicate particularly strong needs for governmental policies supporting business ecosystems for growth-oriented innovative enterprises.

1.6. Use and assessment of state support measures by high growth innovative enterprises

In the survey, the interviewees were asked about support measures they have made use of and their assessment of those measures.

The share of HGIEs having received state support is much higher in the EU than in non-EU countries

The survey reveals that 41 % of respondents have used specific state-support measures. Of those receiving support, direct financial support is most frequent (75 %), followed by consultancy support (18 %) and participating in state-funded offers at reduced cost (14 %). The vast majority of respondents assessed the support as helpful (90 %) and only 9 % as neutral. A tiny share of respondents (1 %) reported harmful experiences with state support. Support used was coded into groups: most important are regional, national and — in EU countries —European investment support measures, wage subsidies from the labour administration, training measures and tax relief schemes. National support programmes are found to be most frequently used (38 %), followed by regional programmes (24 %) (see Figure III.1.17). Among the policy measures used there are no obvious specific measures for high growth.
The share of HGIEs having received state support is found to be much higher in EU countries (49 %) than in non-EU countries (31 %). Levels are highest in France (62 %) and Germany (55 %), followed by Poland (39 %), South Korea (36 %), the United Kingdom (33 %) and the US (31 %). By far, the lowest share is found in Switzerland (23 %). The highest share of satisfaction with state support is found in Poland (100 %), and the lowest in South Korea (81 %).

**Figure III.1.17: Types of policy measures used by HGIEs in % of all answers**

Source: DG Research and Innovation; HGIE study

Data: Empirica survey HGIE, 2013

**9 % of HGIEs are or have been located in a science or research park, 6 % in an incubator or accelerator**

The survey revealed that 9 % of respondents are or have been located in a science or research park, and of these 77 % found it helpful. Also, 6 % said they were or had been located in an incubator or accelerator, of whom 75 % found helpful. No harmful experiences were reported for either location. The most frequent benefits were networking opportunities (38 %), office space at reduced rates (36 %), and laboratory or workshop space at reduced rates (23 %). The shares of respondents located in a science or research park are highest in France (15 %) as well as Germany and South Korea (14 % each). The other countries followed way behind: Poland and Switzerland (8 %), the US (6 %) and the United Kingdom (5 %). For incubators and accelerators, shares are again highest for South Korea (11 %) and France (10 %), while Germany has the lowest share (2 %). No data can be given for Japan, due to the small number of cases.
1.7. Polices for high-growth innovative enterprises

Studies on policies to support high growth are scarce

According to Empirica (2013), the number of studies on policies to support high growth is small and, among the most prominent, are those by the OECD (2010) (141) and Autio et al. (2007) (142). The Empirica study notes that even these studies are not focused on innovative firms and do not deal in depth with the question of whether there has been market failure or possible government failure. It also questions whether resources were used efficiently.

The OECD report suggests a set of combined elements to foster high-growth small and medium-sized enterprises (SMEs): improve the business environment, encourage entrepreneurial attitudes, support training in young and small enterprises, improve access to debt and equity finance when necessary, and promote innovation and internationalisation activities of new and small firms. In practice, the OECD found that countries' policies for fostering SME growth tend to focus on R&D and access to finance, while neglecting skills upgrading and encouraging growth ambitions.

Autio et al. (2007) have produced a comprehensive analysis of policies for high growth in nine countries. They suggest that policies in support of HGEs are distinctly different from SME policies. The study mentions the following lessons learned from HGE policies in Australia, Brazil, Finland, Hong Kong, Hungary, Italy, the Netherlands, Spain and the United Kingdom: If governments seek to promote HGEs directly, the initiative needs to be selective with regard to the companies promoted, proactive in terms of scanning the environment for potential HGEs, sustained and professional, and they need to collaborate with the private sector and focus on skills.

Considerations for HGIIE policies

Empirica (2013) mentions that, given the lack of independent evaluation studies on enterprise policy measures, indications about governmental policies that may be particularly successful in promoting HGIIEs should be cautious. The Empirica study, considering the findings of the survey and insights from previous research (143), recommends, however, that policymakers take account of the following when designing such policies.

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**Industries:** The share of HGIEs is fairly similar across innovative industries and in manufacturing versus service sectors.

**Age:** The majority of HGIEs may not be start-ups but older than 10 years. High growth takes place most often after the initial struggle of establishing the firm in the market.

**Spin-offs:** Many spin-offs originate from other companies, not from public research. This may call for revised policy measures to support both groups adequately.

**Principal customers:** Other companies were the dominant customers of HGIEs in the sample. HGIEs should thus not be expected to be widely known to the public.

**International potential:** For the majority of sampled HGIEs, the national market is the main market. They may thus have potential to grow further into international markets.

**Main drivers:** The main factors of high growth appear to be a skilled workforce and directors actively targeting growth. Thus, it may be advisable to focus education (for both employees and entrepreneurs) on fostering HGIEs. For entrepreneurs, beyond basic education, targeted high-growth consulting and coaching may be valuable.

**Country and industry specificities:** HGIEs' assessments of framework conditions for doing business, perceived needs for governmental policy and use of policy measures differ across countries and industry. Hence, policies for HGIEs can be based on the assumption of similarity of HGIEs' characteristics across countries and industries, but need to consider the specific situation in the country — even the region — and industry concerned.

**Ecosystem:** Science and research parks as well as incubators and accelerators were found to be useful locations for HGIEs. They welcomed networking benefits in particular.

Drawing all results together, Figure III.1.17 summarises the key considerations for HGIE policies of the Empirica study.
2. Enhancing innovation-driven clusters

**Highlights**

**Innovation-driven clusters enable fast-growing innovative enterprises**

Dynamic and innovation-driven clusters enable firms to innovate and grow. They are highly correlated with technology development and entrepreneurship. This chapter proposes a methodology to enhance the dynamics of innovation-driven clusters using a life-cycle model that recognises specific needs at different stages of cluster evolution. Indicators and measures are presented to assist in describing this typology and to advocate public support policies at local, regional and national, and EU levels.

**Efforts to stimulate innovation-driven clusters have to be adapted to the different development stages of existing clusters**

There are certain crucial stages in a cluster evolution that warrant support or investment from public authorities. These include in particular four scenarios where premature cluster exhaustion or decline occurs when growth would have been expected: a) when decline sets in at take-off or in the early stages of exploratory expansion; b) when decline sets in later in the exploratory expansion or early exploitive expansion stages; c) when near-the-end of exploitive expansion, decline sets in much more rapidly than expected; and d) when exhaustion turns into long-term decline and transforms the cluster region into a lagging region.

The reason public authorities should consider the provision of supporting resources in these cases stems from the risk of losing much of the return on investments already made. A differentiated approach for the support of innovation-driven clusters enhances the impact on
innovation and entrepreneurship activity in the cluster, which is crucial for the development of fast-growing innovative companies.

Introduction

The cluster concept is well known and often the basis for contemporary policy and practice in economic development following the work of Michael Porter (1990) (144). Clusters are organised around one or more industries and attract investment and related companies and organisations because they enable the capture of benefits from Marshallian positive externalities such as reduced procurement costs, strong knowledge spillovers and lower transaction costs. These and other advantages such as improved market knowledge and information are amplified as strong internal and later external networks evolve (Porter, 1998; Rocha, 2004) (145).

Empirical studies by Rocha and Sternberg (2005) and Delgado et al. (2010) provide evidence that clusters also motivate and support increased new firm formation (146). Other evidence of a positive relationship between clusters and entrepreneurship is fairly extensive but limited with few exceptions to interpretive and case analyses. At the same time, there are major differences in the level of entrepreneurship at the national (Audretsch and Thurik, 2000), meso and local regional levels (Reynolds et al., 1994; Reynolds et al., 2001; Rocha, 2004) (147). Thus, geography and proximity matter in firm creation. Others argue that regions with strong clusters will 'benefit from higher start-up rates' (Rocha, 2004) (148).

2.1. Cluster dimensions and dynamics

Dynamic clusters may be defined as complex systems composed of multiple interdependent dimensions or as ensembles of interdependent dimensions whose values change over time. This dimensional view was first used in a study of the shipbuilding cluster in Northern Ireland by Klink and Langen in 2001 (149). The dimensions used by Klink and Langen together with others that have appeared repeatedly in cluster literature (150) create a seven-dimension manifold for analysing cluster dynamics. A life-cycle approach to clusters implies that certain states or stages are reached as the cluster moves through its life cycle. At each stage, these

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dimensions are expected to have specific values or qualities (\textsuperscript{151}). The dimensional profiles provide guides for policy intervention. Based on a review of the cluster literature the seven dimensions are:

1. Spatial concentration — greater in early and more dispersed in later stages;
2. Industrial/Cluster strength — scale and scope increase; decrease in later stages;
3. Knowledge — heterogeneous in early stages; more homogeneous in later stages;
4. Entrepreneurship — greater within clusters than outside them;
5. Convergence — convergence around best practices and standards increases after the early and mid-exploitive states are reached; it is correlated with a change in the nature of knowledge creation and information from heterogeneous to more homogeneous;
6. Network linkages — strengthen over the life cycle; decrease as clusters lock-in on decline;
7. Cooperation — minimal to modest initially and in the take-off and early growth stages, increase as scale and scope increase; remain strong until lock-in on decline progresses.

Figure III.2.1 depicts a staged life-cycle model for clusters largely derived from Bergman (2008) built on the work of others (\textsuperscript{152}) that evidences the recent yet sustained scholarly interest in life-cycle theory as a framework for modelling cluster development and evolution.

\textsuperscript{151} While this life-cycle perspective implies a deterministic model, its use in this paper is as a benchmark for assessing the progress of a cluster or deviations from the theoretical model. No judgment is made about what the dynamics should be.

Figure III.2.1: Cluster life-cycle analysis

General life-cycle theory gained recognition from its application in business, industry and technology development (Klepper, 2007; Utterback and Abernathy, 1975) (153). It assumes that a growth process has an origin, a take-off leading to or initiating extended growth that begins at the first inflection point of the model, after which growth occurs at an increasing rate (Figure III.1.2) but later slows after the middle part of the cycle and rapidly declines to zero and then reaches an asymptote. At exhaustion, cluster growth may remain in stasis but usually experiences a long period of decline (lock-in) or reinvention, whereby a new cycle of growth is initiated. The state of the dimensions varies as the cluster moves through or deviates from the model framework.

While the life-cycle model implies a deterministic cluster process, it may evolve in a quite different and erratic fashion, may never complete the process and/or may reach an asymptote prematurely. Thus, the model provides a benchmark against which to assess cluster development. Factors that may 'cause' the cluster to deviate include natural events such as hurricanes, earthquakes, droughts, tornadoes, climate change and floods, and societal or man-made occurrences such as business cycles, new technology (especially radical ones), change in political leadership, war, post war recovery and conditions that eliminate competition (e.g. a region dominated by mafia-type leaders).

2.2. A life-cycle approach to cluster dynamics

The Pre-Cluster Stage

Even larger industries are mostly randomly spaced and not concentrated geographically at this stage and are relatively small (often branch plants). There are therefore no industries to support a cluster. The number of firms in the larger industries at this stage is small and their relative strength is low, indicating that industry presence in the study area is less intensive than average industry intensity in other locations. Knowledge is dispersed and highly heterogeneous, and the level of entrepreneurship is low and focused on non-productive entrepreneurship (154). There is no strategic convergence around a cluster concept at this stage as there is no cluster. There is limited business or industry networking. Finally, a low level of intra- or inter-industry dependence (buying and selling to each other) exists.

Support can improve workforce capability and quality, and maintain the infrastructure, support the provision of business assistance, and promote economic cooperation via, for example, promotion of collective buying or selling cooperatives. At the macro level, assistance for workforce improvement, business assistance, development planning, and infrastructure and support for lagging regions via a regional policy regime is a possibility. At best, the region can implement business attraction and retention policies and hope a segment of the economy will attract enough firms for a cluster take-off. In summary, at the pre-cluster stage, a region’s economic ecosystem is under-developed as there is no basis for clustering.

The Take-Off Stage

At take-off, one or more industries begin to emerge and exhibit signs of clustering. An area within which most companies in the industry are contained can be identified. Yet, the density of firms is modest. The strength of the core industry and the emerging cluster is growing, demonstrating that the core industry is evolving into a lead cluster sector. It is during this stage that cross-industry cooperation begins to appear, as represented by small but increasing flows (buying and selling) between industries.

Knowledge and information heterogeneity may be expanding, but only modestly as cohesion of the core industry(ies) is still in a nascent stage. Yet, that which does exist is highly heterogeneous. Entrepreneurship indicators such as start-ups may show modest increases and there may be an effort to form a business incubator. Yet most of the start-ups will continue to be of a non-productive form. Convergence around a strategy that envisions a cluster will not usually be a topic of major interest.

Networking may be evolving at this stage, but will not be well developed around the concept of an emerging cluster. There may be a few new firms formed with the goal of supplying inputs or marketing assistance to businesses in the core industry(ies), but this will be modest. There may be isolated instances of firms in the core industry(ies) cooperating on matters such

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154 Entrepreneurship to supplement one’s income is an example of non-productive rather than productive entrepreneurship that is aimed at economic growth and development objectives.
as joint bidding on projects or supplying goods or services in cooperation to a market segment. Cooperation in general will tend to be at a modest level as the region is not yet focused on building the cluster.

The roles for local and regional authorities at the take-off stage include providing information about the economy regarding the emergence of a core industry(ies) and providing assistance for workforce development and infrastructure maintenance and development. They also have the opportunity to provide support for business; for example, training and promotion of buyer-seller cooperatives. Local and regional authorities should communicate to all stakeholders that cluster conditions are evolving, and convey that there is a need and opportunity for productive entrepreneurship. A major role for national and regional authorities is to provide planning and advisory assistance for regions that exhibit the potential for cluster development. Continued support for lagging regions is important, as regions with an emerging cluster may also be lagging regions.

The Exploratory Expansion Stage

The exploratory expansion stage emerges shortly after a successful take-off and extends until the middle part of the steep growth segment of the S-shaped life-cycle model is reached. From the middle of this segment, growth continues to accelerate but at a decreasing rate. The upper boundary of the exploratory expansion phase is the lower boundary of the exploitive expansion phase. This phase is usually the most dramatic part of the life cycle (along with perhaps rejuvenation) as it is where trial and error is at a maximum and thus start-ups and the churn of start-ups and failures is most pronounced. The churn of ideas and knowledge during this period is why this stage is called exploratory, as it is a time of testing to discover the best trajectory for the cluster.

The cluster becomes defined around one or more core industries as this stage unfolds, and the cluster boundary is easily specified using GIS techniques. Throughout this phase, more and more companies are formed or attracted to the cluster area so that density increases and proximal relations become more pronounced. The strength of the cluster also increases dramatically with considerable growth in employment, income and wealth creation. Core industry location quotients often increase to concentration levels three or more times the provincial or national average.

This phase also sees considerable new knowledge and information being created both in the industry and supporting firms. This industry churn spills over into other organisations leading to production of more patents, not only among the companies but also via the growing involvement of research institutions that find an expanding market for their research. This interrelated activity produces considerable new and diverse (heterogeneous) knowledge and information that spills over into the local and regional community. This creates a highly positive environment for entrepreneurship; the number of start-ups and spinoffs increase and
become more focused on growth companies, while emphasis on non-productive business formation becomes of secondary interest (155).

The notion of convergence around a strategy tends to be conceptual during the early and middle parts of the exploratory expansion stage. However, later, a more formal strategy may emerge due to the continued growth of the core industry and its supporting businesses. Also, new facilitating and supporting organisations may arise, such as technology councils and venture capital or lobbying associations. In this part of the exploratory stage the focus is mostly on growing the cluster by internal processes and company attraction, including those that bring inbound foreign direct investment (FDI).

Networking in this stage evolves rapidly, with the expansion of business associations that promote cluster development and thus bring cluster industry and business representatives together in a variety of contexts; for example, training, workshops, award ceremonies, webinars, socials and speaker events. The growing cluster ecosystem includes an increasing variety of firms both in the core industry and the evolving supply chain and there are increasing flows among these as joint bidding for projects and joint delivery of products and services become increasingly commonplace. Business and related associations tend to provide forums to promote further cross-industry networking, and as cross-industry flows and buyer and supplier relations become more complex the level of cooperation increases considerably.

Given the huge dynamism in the cluster during the exploratory phase it may seem that there is little role for government. But that is not the case. Leadership from government at the local–regional level is important to continue to promote the cluster and its development. In the early parts of this phase the evolving cluster is potentially quite fragile and can sometimes rapidly fall from a seemingly sensational future to exhaustion due to unanticipated causes. Governments at the national level have standing programmes for recovery from disequillibrating events; however, local regional governments in this situation need to quickly lead efforts to access recovery resources from higher levels.

At the local and regional authorities level there are other roles to be played. In the early part of the exploratory phase there is need for government-supported grants and assurances to facilitate provision of business assistance, workforce training, entrepreneurship, and smoothing out of regulatory processes by, for example, creating one-stop services for applications, registrations and licensing. At the national or EU levels, grant programmes to assist cluster development during the latter part of the take-off and early parts of the exploratory phase are important because this is a fragile time for the cluster.

The Exploitive Stage

155 Some alternative views consider an adaptive cycle and nested systems theory approach (Martin and Sunley, 2011) and the dynamics of cross cluster interaction (Engel and Palacio, 2009).
The gains that have occurred during the expansion stage are consolidated into a more routine portfolio of functions and processes during the exploitive expansion stage. During this stage, the geography stabilises and the bounded cluster area tends to experience a reduction in the rate of spatial expansion or even end as infilling sites become the dominant locations for expansion of existing or in-migrating companies. The density of firms tends to increase especially in the early and middle parts of the exploitation stage and stabilise in the later parts.

Industry and cluster strength continue to grow as the cluster region stakeholders build deeper network relations, but the increasing trend toward interdependence evolves at a decreasing rate. A high level of interconnectedness among core industry and the supply chain is retained. However, stability will tend to occur in the later parts of this stage.

Knowledge and information will be produced at a very high rate during the early part of the exploitive stage. A high rate of patenting and cluster-related sponsored research at universities and other research organisations tend will tend to occur during the early parts of this stage but this will decrease later. The character of knowledge and information will become more homogenous. Consequently, entrepreneurship will tend to stabilise and decrease. These patterns tend to occur because the likelihood of convergence and agreement around a strategic plan during this phase is high as the core industry and related suppliers solidify agreement on best practices and standards. Once this happens, the need or motivation for R&D and experimentation by entrepreneurs for enhancing practices, processes and widgets is of less concern. Historically, this has been a critical development in the process leading to cluster decline. It is thus important during the middle to later parts of the stage that the strategic approach includes sustainability concepts and thus regeneration of the cluster when or if maturation tends toward non-sustainable processes.

There is a slowing rate of growth. One avenue in the view of cluster stakeholders may be to gain regulatory protection and tax breaks to help the bottom line of firms in the cluster and their competitiveness. But in an era where internal and external networking exists at national and global levels it is difficult to protect a cluster from external competition. Strategic plans need to focus as much on sustainability and rejuvenation as upon establishing and maintaining agreed best practices. In short, it is important that such plans include processes and procedures to ensure there is a continued flow of knowledge and information into the regional ecosystem and thus that the renewal dynamic provided by entrepreneurship is maintained at a high level. Protection from external competition is the opposite of what is needed for ensuring rejuvenation and sustaining the cluster.

Local and regional authorities have several important roles during the exploitive expansion stage. First is providing information and data on cluster dynamics to cluster stakeholders. Second is to interpret this information and data for stakeholders by conveying in the early stages the need to find general agreement on cluster strategy and best practices. This includes explaining that the strategy needs to address the issue of economic sustainability as the cluster matures. Third, there is a continued need to streamline the regulatory environment and to
facilitate compliance with measures like one-stop process facilities (online or physical). Fourth is to ensure that public infrastructure is provided and/or maintained at levels that facilitate low transaction costs for the movement of goods, services and information (bytes). There is also a continuing if not growing need to maintain workforce quality and training.

At the national level, the role of government is to provide flexible grant programmes and information to facilitate managing the cluster during the later parts of the exploitative stage. One major focus should be on sustaining the cluster and planning for its rejuvenation before it drifts into exhaustion. Maintenance of resources for productive entrepreneurship and related technological change that undergird successful innovative clusters and thus sustainability are of central importance.

The Exhaustion Phase

If efforts to rejuvenate and sustain the cluster and new growth during the later parts of the exploitative expansion stage fail, cluster growth will decline to zero and eventually into absolute decline. Given that all stakeholders of the cluster, including firms, employees, governments and non-profit associations, wish to avert a long period of decline, the focus here is on rejuvenation of the cluster.

The spatial concentration of a cluster that has reached exhaustion gradually becomes less dense as companies fold, are acquired or relocate. The spatial structure of a cluster will tend to hollow out, and industry and cluster strength will decline due to lock-in where unemployment grows and income and wealth decrease, and effective cluster networking and cooperation suffer. Knowledge and information will narrow as they become more homogenous and entrepreneurship will revert toward non-productive entrepreneurship. While a high level of cooperation may continue, it will tend to be difficult to develop a successful rebounding plan without external help. But the infrastructure and some of the industry members and associations still exist (especially in the early part of the exhaustion stage). So there are still resources to stage a comeback if organised and focused through strategic leadership.

The roles of local government and higher levels of government are major and critical to achieving rejuvenation once exhaustion sets in. That is why, in the middle and later parts of the exploitative expansion stage, it is important to seed sustained cluster development as it is easier to achieve rejuvenation when the cluster is still relatively strong. So what should governments do?

At the local and regional level it is important to continue to provide information, data and analytical support to understand the condition of the cluster. Local authorities partnered with industry and cluster associations should undertake planning to create a strategy for renewal. It is important to restore, maintain and possibly build new infrastructure. There is a need to encourage industry groups to invest in and facilitate the identification and transfer of
technological innovation to the region as these will be critical elements of a plan to renew the cluster and productive entrepreneurship regardless of other aspects of the plan. Finally, there will be major workforce development needs as the plan is formed and implemented. Local government should be promoting and facilitating the creation of the infrastructure to deliver this through secondary and post-secondary educational facilities, and industry associations.

National government and the EU levels could provide grants for planning assistance and infrastructure renewal for clusters in the exhaustion stage. Existing programmes for lagging regions are usually for cluster regions in the exhaustion phase. Further, if the cluster region can claim that unanticipated disequillibrating forces have contributed to exhaustion, then disaster recovery grants and awards may be available.
3. Upgrading manufacturing industries in Europe

Highlights

The share of manufacturing industry in the European economy continues to decrease, weakening economic sustainability

The manufacturing sector in the European economy decreased in size over the period 1995–2008, the only exceptions being the medical precision and optical instruments sector and transport equipment other than automobiles or the aerospace sector. This is a challenge for Europe, since Member States with a solid manufacturing core focused on high-tech or medium-high–tech activities and with integrated value chains have proved to be more resilient to the economic downturn and better placed to achieve higher growth in times of rebound. The upgrading of manufacturing industries provides the basis for a sustainable economic recovery.

The EU is upgrading the technology content of its manufacturing industries, but in a less determined way than the US

The EU has a smaller high-tech sector than the United States. High-tech R&D intensity is also lower in the EU than in the United States. Since 1995, the R&D intensity for many manufacturing sectors in the EU has increased at an average annual growth rate of between 2% and 4%. This applies in particular to medium-tech or low-tech industries such as textiles, rubber and plastics, and pulp and paper, as well as to large medium-high–tech industries such as chemicals, motor vehicles, and machinery equipment. However, over the same period the average annual growth rate in R&D intensity for such manufacturing in the United States was between 4% and 8%. There is also a striking difference for high-tech industries such as computing machinery, medical and optical instruments, which have seen growing research effort in the United States compared to stagnant or decreasing R&D in the EU.

Policies for upgrading manufacturing industries must be differentiated by sector

As the upgrading dynamics and the enablers for innovation differ between industry segments, a sector-differentiated policy is required to foster upgrading and innovation in manufacturing industries. The EU is a world leader in general purpose machinery and machine tools, where Sweden, Austria and the Netherlands have the highest R&D, higher than that of Japan and the United States. However, research at the level of individual firms varies significantly between European countries, both in the automobile industry and in the chemicals industry. This partly reflects differentiated products but may also indicate different corporate cultures with regard to integrating R&D investment in growth strategies. Firms consider funding and skilled personnel as being the most frequent enablers of innovation. However, the relative importance of different drivers and enablers differs between industries.
3.1. Overview of the EU's R&D dynamic in manufacturing industries

Previous chapters in this report have described how the knowledge intensity of the European economy differs from that of the United States (156). The EU has a smaller high-tech sector than the United States, with corresponding research and development also lower. Although there has been a modest catching-up in the last 15 years, it is not enough to maintain top competitiveness in the European manufacturing industry overall. A growing number of countries in the world are upgrading their manufacturing industries, injecting knowledge and investments in both high-tech and medium-tech industries.157 Europe's long-term competitiveness is at stake. Several European countries with a solid manufacturing sector that is focused on high-tech and medium-high–tech sectors have shown greater resilience in the current economic crisis (158).

**The European manufacturing industry is shrinking, although modestly upgrading in terms of R&D intensity. The competitive effect of these efforts depends partly on the upgrading efforts of main competitors outside Europe**

Figure III.3.1 shows that the share of the manufacturing industries in the European economy has lost weight in the economy over the period 1995–2008. For the period 1995–2008, up to the economic downturn, the majority of the manufacturing sectors reduced their share of value added in the European economy, with the exception of transport equipment other than automobiles and aerospace, construction, and medical, precision and optical instruments (illustrated by the leftward move of the sectors in Figure III.3.1). All the other sectors show negative growth. The positive aspect is that during the same period most sectors increased their R&D intensity. This promising trend is visible both for sectors that are already highly R&D intensive (red coloured) and the medium- and low-tech sectors such as textiles or pulp and paper industries.

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156 See Chapter III on Structural change, the introductory chapter 'Europe's competitive position in research and innovation' and Chapter I.3 on business investments in research and innovation.

157 The term « injecting knowledge into the economy » refers to a form of upgrading, enhancing productivity. This can take the form of developing new processes or products new-to-the-market, capitalising on R&D investments and human resources of the firm. It can also take the form of absorption of existing or new technologies into the production in new-to-the-firm innovation of products, process, organisation and business models.

158 An analysis of the evolution of the manufacturing industries in each European country can be found in the publication 'Research and innovation performance in EU Member States and Associated countries, 2013', European Commission, 2013.
The competitive effect of this upgrading depends partly on the level of upgrading in each sector in the US, Japan, China and other knowledge-intensive economies.

**The US economy displays a similar evolution but with more dynamic upgrading of most manufacturing sector**

The United States is facing similar challenges to the EU. The US economy has also registered a relatively modest structural change during the period of 1995–2008 with a contraction of the manufacturing sectors of the economy coupled with a timid upgrading of R&D effort in several industries. However, while average annual R&D growth for most European manufacturing sectors was in the range of 2–4 %, US manufacturing upgraded more intensively, with average annual R&D growth in the range of 4–8 %. At sector level, some differences can be observed when comparing with the EU. The size of the industries varies as well as the evolution of their R&D.
Figure III.3.2: Evolution of R&D and evolution of US industry, 1995-2008

Source: DG Research and Innovation - Economic Analysis unit
Data: OECD
(2) There is a break in series between 2003 and 2004 which affects BERD for Pharmaceuticals, Office, accounting & computing machinery, and Radio, TV and communication equipment.
(3) High-Tech and Medium-High-Tech sectors are shown in red. ‘Other transport equipment’ includes High-Tech, Medium-High-Tech and Medium-Low-Tech.

Focussing on the high-tech and medium-high–tech sectors (in red in Figure III.3.2), the most striking difference is the 'Office, accounting and computing machinery' and the 'Medical precision and optical instruments' sectors, which are larger in the United States. And while these two industries are upgrading their R&D in the United States, they display a decreasing level of R&D in the EU. The chemicals industry is upgrading its R&D in both continents but this process is twice as dynamic in the United States. On the contrary, the sectors 'Electrical machinery and apparatus' and 'Motor vehicles' are larger in the EU economy and they have both maintained or upgraded their R&D better than their competitors in the US economy. This sub-section will present a more detailed overview of the R&D dynamics in these three strongholds of the European economy (159).

159 Other chapters of the Innovation Union Competitiveness 2013 report presents the research and innovation dynamics in health, ICT and other growing industries (see Chapters II.1, II.4, II.5 and III.5).
The United States has more firms active in the health and ICT sectors and they are more R&D intensive than their competitors in the EU

The European Industrial scoreboard collects data at the company level, focussing on the most R&D-intensive enterprises in the EU and the United States. These data provide a complementary picture to the business enterprise research and development (BERD) data in Figures III.3.1 and III.3.2, illustrating the different sector structures in the EU and in the United States. While the BERD data are based on territory, focussing on the R&D dynamics of firms located in the EU, the Industrial scoreboard data are based on the location of the headquarters, counting all firms headquartered in the EU including their R&D investments in other continents or countries. Industrial scoreboard data are more recent than the business R&D data by manufacturing sector provided by Eurostat. There are also differences in terms of data sources and indicator constructions.

Overall, the EU remains specialised in medium-high R&D-intensive sectors that account for half of European companies' R&D investment. By contrast, more than two thirds of United States companies' R&D investment is clustered in highly intensive R&D- sectors (in particular health and ICT), as evidenced in the structural composition of EU-based and US-based companies in 2003 and 2011. The structural difference between the EU and the United States has been reinforced over the 2000–2011 period. There are contrasting differences between the EU firms and the US companies, in particular for the two sector groups mentioned: 1) health-related sectors including pharmaceuticals and biotechnology, and health care equipment and services, and 2) ICT-related sectors including technology hardware and equipment, and software and computer services.

- The United States has twice as many companies as the EU in health and 3.5 times more companies in ICT.
- In terms of R&D activities, US companies outperform their EU competitors in similar proportions, investing 2 times more in health and 3.3 times more in ICT.
- In terms of net sales, the EU shows slightly higher average sales per company than the United States in the health sector but much lower in ICT.

As a result of the R&D investment and net sales figures, the average R&D intensity of the EU companies is higher in ICT and somewhat lower in health. Figure III.3.3 also reveals that over the period 2003–2011, the high-tech industries in the United States have expanded more (from 65 % to 69 % of the scoreboard companies), while the EU experienced a lower expansion. The scoreboard companies operating in the medium-high sectors have decreased in numbers both in the EU and US economies.

If Europe is to face the growing global competition in manufacturing industries by other means than lowering salaries and other costs, then EU policies need to spur upgrading of their knowledge intensity at a faster pace than the main competitors. The world has seen the emergence of the BRIC countries (Brazil, Russia, India, China) with massive investments in R&D and other intangibles. The delocalisation of production in global value chains (GVCs) yields larger profits at the higher end of the value chain. European firms are being forced to upgrade their knowledge management within each sector in order to gain competitive advantage and gain added value in the higher components of the value chain. These efforts must to a larger extent build on the specific innovation drivers in each industry fostering sector-sensitive framework conditions.
3.2. Sector-specific business strategies for R&D investments

Europe is relatively specialised in medium-tech and medium-high–tech manufacturing sectors, with few high-tech sectors like pharmaceuticals and aircraft. Time series data on 25 sectors covering the past decade (161) reveal that the EU-28 holds competitive international positions, although not always as world leader, in at least 15 sectors:

- High-tech manufacturing sectors such as pharmaceuticals and aircraft;
- KIS sectors such as telecommunications, computer services, R&D services (162);
- Medium-high-tech manufacturing sectors such as basic chemicals; general purpose machinery and machine tools; electrical motors, generators and transformers; motor vehicles;
- Medium-low-tech manufacturing sectors: plastics; non-metallic minerals;
- A mixture of medium-high and medium-low–tech manufacturing sectors: electricity distribution and control apparatus, electricity, gas, water supply;
- A mixture of low-tech and medium-tech manufacturing sectors: food and beverages and production of relevant machinery; textiles and production of relevant machinery;
- Low-tech sectors: construction.

In these sectors, the European position seems quite strong in the short term and the value added has been rising constantly. Each of the two high-tech manufacturing sectors, pharmaceuticals and aircraft, employed around half a million people at the end of the decade and showed a neutral or increasing employment trend. The three KIS sectors where Europe is competitive employed a much larger number of employees (two to seven times larger). The two largest of these sectors kept an increasing employment trend even during the economic crisis, while the third showed a negative tendency.

There are considerable differences among European countries in innovativeness and knowledge, reinforcing the perception that large improvements can still be accomplished inside and across sectors. This requires a mix of horizontal industrial innovation policies coupled with sector-specific policies sensitive to specific innovation drivers in each industry sector. The need to building differentiated framework conditions for each relevant sector is an impending challenge. In the following sub-section, we will present evidence-based support for this approach, first describing more in detail the specific R&D dynamics in three important sectors in the European economy and then, in a second step, an overview of the main institutional settings, enablers and barriers for R&D and innovation in different industries.

161 Study financed by DG Research and Innovation, 2013, « R&D investments and structural changes in sectors ».
162 For a more detailed description of these sectors, see Chapter III.5.
The EU is world leader in general purpose machinery and machine tools, where Sweden, Austria, the Netherlands, Finland, the United Kingdom and Germany show the highest levels of R&D

The EU is the largest producer of mechanical equipment in the world, surpassing both the United States and Japan. In terms of value added, within the EU, Germany, Italy, France and the United Kingdom are the largest producers in the machinery market (representing 70% of total value added in this industry in the EU) and account for more than 80% of total BERD in the sector. Germany contributed more than a third of the EU’s value added generated in the sector in 2009. The general purpose machinery and machine tools sector also contributes substantially to the gross domestic product (GDP) of Austria, the Czech Republic, Sweden and Finland. Although the sector showed a moderate increase in production over the last decade, it was heavily affected by the last economic crisis.

Small and medium-sized companies play an important role in the sector due to the highly specialised and customised demand for products. For this reason, innovation is strongly demand-based since new products are typically customised to meet specific client needs. Many innovative ideas originate directly from client specifications. Nevertheless, half of the EU’s value added for the sector is produced by large companies. Being considered as a medium-high R&D sector, evidence indicates that R&D investments are more important in bigger firms. The sector shows comparatively high levels of R&D and acts as a partial technology provider for scale-intensive industries like the automobile industry, textiles, printing and reproduction, rubber production and plastics.

The European countries with the strongest R&D in the sector are Sweden, Austria, the Netherlands, Finland, the United Kingdom and Germany. Comparable levels can be found in Japan and the United States. According to the Industrial scoreboard, the companies headquartered in Europe with the highest R&D expenditures in the sector are ALSTOM (France), Sandvik (Sweden), Ingersoll-Rand (Ireland) and ABB (Switzerland). Major players headquartered outside Europe are IHI (Japan) and Parker-Hannifin (United States).
In some European countries, R&D in the automotive sector has doubled between 2000 and 2009

The EU as a whole is a strong player on the global automotive scene but faces fierce competition from the United States and developed Asian countries. In terms of value added, Germany is by far the largest producer in the automotive sector within the EU. Germany contributed more than 45% of the EU’s value added generated in the sector, followed by Italy, France and the United Kingdom. Taken together, these four countries account for almost 70% of total value added in the automotive sector.

Innovation expenditures in the automotive sector are considerably above the average, but are frequently driven by technological novelties from outside the sector, as is the case with machinery and equipment (see the sub-section above). Most of the value added (60% to 70%) of a modern car is now provided by a multi-tier system of suppliers. Vertical integration in automotive production is very heterogeneous. The difference between passenger cars and commercial vehicles is of considerable relevance for innovation and market development. For the period 2000–2006, the value added of the sector in the EU increased on average by 4.3% but suffered a downturn in 2006–2009, reflecting the impact of the economic crisis that hit the automotive sector in Europe.

The sector is dominated by medium-sized and large firms. In 2007, 88% of the value added of the automotive sector of the EU was generated by firms with 250 or more employees. In Italy and the United Kingdom, which are two of the main automotive-producing countries in
the EU, the share of value added by very large firms is lower, ranging at about 77 % and 78 %, respectively. Small and medium-sized enterprises (SMEs) generate about 50 % or more of value added in Denmark, Finland, Norway and Lithuania, but overall none of these countries are important producers in the sector.

The automotive sector has a particularly high level of R&D expenditure and is a leader in privately funded R&D in Europe. R&D intensity in the automotive sector is higher than in aerospace for example, and much higher than the plastic and machinery sector. In Figure III.3.5, countries are ranked according to their R&D effort in the year 2009. The countries with the strongest R&D in the automobile sector in Europe are Sweden, Germany, Croatia and Norway. R&D intensity in eastern and southern European countries is considerably below the EU average. By 2009, research in the automotive sector in Sweden had more than doubled compared to its level in 2000. It had also increased in Germany, Norway and the EU in general while, for the same period, it decreased in the United States, Japan and South Korea.

**Figure III.3.5: R&D intensity in the automotive sector, 2000 and 2009**
**R&D at company level within the same industry segment varies significantly between countries**

Europe-based automobile sector companies listed in the Industrial scoreboard (following the ICB classification) show different levels of R&D depending on where they have their headquarters. This may be an indication of differing business strategies for research and innovation (R&I) investments between countries. In fact, R&D intensity varies from 5 % in Germany, for Volkswagen, to levels below 4 % in Italy and the United Kingdom.

**Figure III.3.6: R&D at company level in the automobile sector**

![R&D intensity - Automobiles](image)

Companies with more than 250 employees

Automobiles (100)

Source: DG Research and innovation – Economic Analysis Unit
Data: 2012 EU Industrial R&D Scoreboard

A very different situation is observed in the commercial vehicle and truck sector, where companies from Sweden and Switzerland show levels of R&D much higher than, for example, firms located in the Netherlands, Spain, Finland or France. Surprisingly, Chinese-located companies reach R&D levels similar to those reached by firms located in Japan, and higher than all the other EU countries with the exception of Sweden and Switzerland.
Innovation in the automotive sector is affected by a combination of different factors. In particular, public funding and size of firm seem to correspond with differing levels of R&D and innovation. As regards innovation propensity, cooperation arrangements are also an important driver of innovation. Finally, firm size has a positive effect on R&D and innovation levels. In particular, smaller firms tend to show fewer propensities to engage with R&D and innovation.

**R&D in the chemicals sector is highest in developed Asian countries, followed by the EU and the United States**

The basic chemicals, paints and glues sector (except pharmaceuticals) is a medium-high-tech sector that is science and R&D-driven. It is a mature and consolidated sector dominated by large firms (two thirds of total value added is produced by large firms). The sector experienced moderate growth during the period 2000–2006 (in average 2.4 %/year) and declined slightly in 2006–2010 (on average – 1.4 % annually), while showing recovery signs in 2010. Although value added increased, employment has been decreasing since 2000 as the sector is becoming more capital intensive and achieving moderate productivity gains.

In Europe the chemicals sector is highly concentrated; eight countries produce 90 % of the total value added, with Germany being the largest producer. Besides Germany, in terms of specialisation and economic growth the sector is important in Sweden, the Netherlands, Belgium and Lithuania. In Eastern Europe, where the chemicals sector is small but growing, numbers of high-growth enterprises can be found (e.g. in Slovakia, Bulgaria, Slovenia, Estonia, Latvia and the Czech Republic). In terms of international competition, out of the top
25 largest players globally (\textsuperscript{163}), only eight have headquarters in the EU; the rest are located in the United States or Japan.

Figure III.3.8 shows the ranking (2009) of countries according to their R&D in the chemicals sector (not including pharmaceuticals). The sector is highly R&D intensive with an average R&D of 8.1% in the EU. In comparison with Asian countries (Japan and South Korea), R&D in the EU chemicals sector has lagged behind, but it is well ahead of the 6.0% value shown for the United States. Japan has reached a very high level of investment in R&D, which is also verified in the subsequent graph from the Industrial scoreboard.

\textbf{Figure III.3.8: R&D in the chemicals sector in 2000 and 2009}

\begin{figure}
\includegraphics[width=\textwidth]{figure3.8.png}
\end{figure}

\textit{Data:} OECD, Eurostat, UNIDO, National Bureaus  
\textit{Notes:} (1): 2001 (EU, DK, FI, LV, NO); 2002 (AT, BG, EE);  

\textsuperscript{163} The 2012 EU Industrial R&D Scoreboard (\url{http://iri.jrc.ec.europa.eu/docs/scoreboard/2012/SB2012.pdf}).  
Note: Each company is allocated to the country where its headquarters are located.
The chemicals sector demonstrates different levels of R&D engagement depending on the product and the country

Most R&D investment in the chemicals sector is intramural R&D and most of the innovation takes place in new products (46%) and production methods (37%). Evidence indicates that similar factors affect both R&D and innovation in the chemicals sector. In the case of R&D, the perceived importance of increased market share, lack of demand for innovation and public funding (local and national) tend to moderate investments in this activity. For innovation, the importance of increase in market share, flexibility and capacity of production, demand for innovation and public funds play a major part in driving innovation. Firm size is also strongly associated with both R&D investment and innovation. And there are differences between countries in terms of their capability to profit from innovation. The countries that benefit consistently from industrial innovation in the sector include the Czech Republic, France, Lithuania and Sweden.

In the 2012 EU Industrial R&D Scoreboard, two companies from Germany (Bayer and BASF) are part of the worldwide top 25 R&D investors (all sectors). In the top 25 of the chemicals sector, only five European companies are listed (DSM and AKZO Nobel from the Netherlands, Solvay in Belgium, L'Oreal and L'Air Liquide in France). This top 25 list in the chemicals sector is dominated by Japanese and American companies. The basic chemicals sector (chemicals, paints and glues) concerns traditional chemical products that are produced on a large scale. At present, the variety of products produced in the sector explains the very different R&D involvement of the producing companies per country, caused by the degree of specialisation inside the sector. For example, Bayer is registered as a chemical company but is also very active in medical and pharmaceutical products, explaining the company's high R&D investments.

Figure III.3.9: R&D intensity at company level in the chemicals sector

![Graph showing R&D intensity in the chemicals sector](image-url)
3.3. Sector-specific innovation drivers

The analysis above illustrates the diversity of R&D-based innovation dynamics depending on industry sector. However, within each industry segment there tends to be an optimal level of R&D intensity towards which most competitive firms strive (\(^{164}\)). In this context, the above analysis of the machinery, automotive and chemicals sectors shows large national differences in R&D level, both for countries and for firms. Some countries tend to have institutional settings more favourable for business models based on R&D investments. Sector-specific research and innovation policies must therefore take account of these underlying institutional frameworks with a view to incentivising firms to opt for knowledge-based and sustainable business models.

**Institutional settings drive innovation but their effect varies between sectors**

The institutional setting in a sector comprises the social, market, regulatory and policy pressures for or against innovation. Four generic institutional setting indicators are identified in this analysis: the advancement of regulations or standards, the competitiveness of the market (or the dominance by established enterprises), the sophistication of demand for innovations, and the pressure to reduce environmental impact (\(^{165}\)). Depending on the industry segment, each of these factors influences innovation to some extent.

The empirical evidence is based on the European Community Innovation Survey (CIS). Firms were asked whether their product (goods and services) and process innovations met regulatory requirements and if their innovations reduced environmental impact or improved health and safety. Regarding the hampering factors of the institutional setting, firms were asked whether their innovation activities were hampered due to the market dominance of established firms or if they did not innovate because there was a lack of demand for innovations. In a sample of 25 different sectors, these four indicators are perceived as affecting the innovative activities to a different extent depending on the sector. For many industry sectors, the domination by incumbent firms acts against innovation and is considered the main obstacle. On the other hand, a large number of sectors consider the need to meet standards and regulations of higher importance for their innovation efforts, as in the cases of the automotive (\(^{166}\)), pharmaceuticals and recorded media sectors.

Certain traditional sectors like food and beverages, textiles and chemicals, but also telecommunications, manufacture of office machinery, reproduction of recorded media and related manufactured goods, as well as services for computer and related activities, claim that the market dominance of established firms is the main hampering factor for their innovation activities. Surprisingly, in a majority of the industry sectors, firms considered a lack of demand for innovations as of reduced importance for their activities. Environmental impact

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\(^{164}\) See also the European Science, Technology and Competitiveness report, 2008/2009.

\(^{165}\) Based on the Community Innovation Survey (CIS 2006).

\(^{166}\) In the case of the automotive sector, the most important regulations concern safety standards, environmental compatibility, norms and standardisation as well as intellectual property rights regulations.
for a progress towards a greener production (also directly connected with regulations and with meeting the EU targets by 2020) is of higher importance for sectors for which the goods are directly linked with environmental sustainability. This is the case for chemicals, recycling collection, purification and distribution of water sectors, and also important to a lesser extent for the automotive, aerospace, food and beverages, rubber and plastics sectors, as well as services for R&D.

**Figure III.3.10: Institutional settings driving innovation in the sector**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Demand for innovation</th>
<th>Standards and regulations</th>
<th>Competition</th>
<th>Reducing Environmental impact (towards a greener production)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food &amp; beverages</td>
<td>Less relevant</td>
<td>52%</td>
<td>46%</td>
<td>49%</td>
</tr>
<tr>
<td>Textiles</td>
<td>30%</td>
<td>37%</td>
<td>41%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Reproduction of recorded media and related manufactured goods sector</td>
<td>Less relevant</td>
<td>Less relevant</td>
<td>73%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Manufacturing of basic chemicals, paints and glues</td>
<td>Less relevant</td>
<td>56%</td>
<td>48%</td>
<td>60%</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Less relevant</td>
<td>55%</td>
<td>47%</td>
<td>48%</td>
</tr>
<tr>
<td>Rubber and Plastics</td>
<td>Less relevant (167)</td>
<td>42%</td>
<td>42%</td>
<td>44%</td>
</tr>
<tr>
<td>Manufacturing of other non-metallic mineral products</td>
<td>20%</td>
<td>Less than 20%</td>
<td>40%</td>
<td>Less than 20%</td>
</tr>
<tr>
<td>General purpose machinery</td>
<td>23%</td>
<td>46%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Manufacture of office machinery and computers</td>
<td>Less relevant</td>
<td>Less relevant</td>
<td>47%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Manufacture of electric motors, generators and transformers</td>
<td>Less relevant</td>
<td>48%</td>
<td>40%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Manufacture of Electricity Distribution and Control Apparatus</td>
<td>Less relevant</td>
<td>30%</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>Manufacture of Electronic Valves and Tubes and Other Electronic Components</td>
<td>25%</td>
<td>???</td>
<td>30%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Manufacture of medical and surgical equipment and orthopaedic appliances</td>
<td>Less relevant</td>
<td>45%</td>
<td>42%</td>
<td>36%</td>
</tr>
<tr>
<td>Manufacture of instruments and appliances for measuring, checking, testing, and optical instruments and photographic equipment</td>
<td>Less relevant</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Automotive</td>
<td>23%</td>
<td>40%</td>
<td>40%</td>
<td>48%</td>
</tr>
<tr>
<td>Aerospace</td>
<td>Less relevant</td>
<td>43%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Recycling</td>
<td>Less relevant</td>
<td>43%</td>
<td>33%</td>
<td>52%</td>
</tr>
<tr>
<td>Performance in the collection, purification and distribution of water</td>
<td>Less relevant</td>
<td>56%</td>
<td>Less relevant</td>
<td>57%</td>
</tr>
<tr>
<td>Construction</td>
<td>40%</td>
<td>22%</td>
<td>34%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Cargo handling and storage</td>
<td>35%</td>
<td>37%</td>
<td>30%</td>
<td>41%</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>Less relevant</td>
<td>30%</td>
<td>48%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Services for computer and related activities</td>
<td>Less relevant</td>
<td>29%</td>
<td>43%</td>
<td>Less relevant</td>
</tr>
<tr>
<td>Manufacture of lighting equipment and electric lamps</td>
<td>Less relevant</td>
<td>51%</td>
<td>43%</td>
<td>45%</td>
</tr>
</tbody>
</table>

167 Given that data are not available for countries dominating the machinery and equipment production sector, we cannot expect a true representation of the entire sector. The vast majority of responding firms belonged to small-to medium-sized component producers in the sector.
Funding and skilled personnel are the most frequent capabilities and enablers of innovation while the importance of other enablers differs between industries

Establishing adequate institutional drivers is not enough. For effective innovation and upgrading to take place, policies must also enhance a firm's capacity to innovate. The capabilities and enablers of innovation are therefore considered as critical factors for an effective upgrading, and they are also sector-sensitive. Evidence from the CIS reveals that despite a favourable business environment and the appropriate institutional setting, the lack of knowledge and capabilities to actually innovate is an important hampering factor. There is sufficient empirical evidence in the literature to state that the higher the capabilities the higher the propensity to innovate (168). However, the type of capability and the impact of increased capabilities on innovation differ depending on the industry segment.

For this analysis, several indicators were chosen to indicate the lack of capabilities or enablers hampering innovation (169): lack of outside funds, lack of qualified personnel, lack of information on technology, lack of information on markets and difficulty in finding cooperation partners. Different sectors perceive these indicators differently. However, the lack of external funding (and even more so the lack of internal funding, as evidenced by CIS 2006) and the lack of qualified personnel are shared concerns by companies in the majority of the 25 sectors, highlighting them as clearly hampering innovation. This last aspect is also highlighted by firms in the service sector, where specialised staff and specific skills are crucial to an even larger extent than in the manufacturing sectors (170). For the majority of the sectors reviewed, the firms surveyed did not stress the lack of information on technologies as hampering their innovative output, although for some industry segments it applied to 30 % of the cases.

The difficulty in finding cooperation partners was also in general highlighted by 30 % of the firms, and in particular by firms providing services for computer and related activities (50 % of these firms considered that finding partners for cooperation was important for their innovation). Some sectors present a higher sensibility in what concerns access to funding; this is the case for services for R&D, services for computer and related activities, food and beverages, and in general the manufacture of machinery and instruments.

169 Other indicators were also used in the CIS, such as lack of funds within the company or the group of enterprises, lack of information on markets or cooperation arrangements on innovation activities. Figure III.3.11 only focuses on four indicators.
170 See also Chapter III.5.
Figure III.3.11: Barriers to capabilities and enablers of innovation

<table>
<thead>
<tr>
<th>Industry (Product)</th>
<th>Lack of external funding</th>
<th>Difficulty in finding co-operation partners</th>
<th>Lack of information on technologies</th>
<th>Lack of qualified personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food &amp; beverages</td>
<td>50 %</td>
<td>30 %</td>
<td>30 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Textiles</td>
<td>43 %</td>
<td>30 %</td>
<td>30 %</td>
<td>43 %</td>
</tr>
<tr>
<td>Reproduction of recorded media and related manufactured goods sector</td>
<td>48 %</td>
<td>Less relevant</td>
<td>Less relevant</td>
<td>42 %</td>
</tr>
<tr>
<td>Manufacturing of basic chemicals, paints and glues</td>
<td>36 %</td>
<td>Less relevant</td>
<td>32 %</td>
<td>30 %</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>37 %</td>
<td>30 %</td>
<td>Less relevant</td>
<td>30 %</td>
</tr>
<tr>
<td>Rubber and Plastics</td>
<td>45 %</td>
<td>30 %</td>
<td>Less relevant</td>
<td>44 %</td>
</tr>
<tr>
<td>Manufacturing of other non-metallic mineral products</td>
<td>40 %</td>
<td>30 %</td>
<td>30 %</td>
<td>41 %</td>
</tr>
<tr>
<td>General purpose machinery</td>
<td>44 %</td>
<td>10 %</td>
<td>Less relevant</td>
<td>45 %</td>
</tr>
<tr>
<td>Manufacture of office machinery and computers</td>
<td>33 %</td>
<td>29 %</td>
<td>27 %</td>
<td>33 %</td>
</tr>
<tr>
<td>Manufacture of electric motors, generators and transformers</td>
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<tr>
<td>Manufacture of Electricity Distribution and Control Apparatus</td>
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<td>Manufacture of Electronic Valves and Tubes and Other Electronic Components</td>
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<tr>
<td>Manufacture of medical and surgical equipment and orthopaedic appliances</td>
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</tr>
<tr>
<td>Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, industrial process control equipment and optical instruments and photographic equipment</td>
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<td>Less relevant</td>
<td>Less relevant</td>
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</tr>
<tr>
<td>Automotive</td>
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<td>Aerospace</td>
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<td>Recycling</td>
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<td>Performance in the collection, purification and distribution of water</td>
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<tr>
<td>Construction</td>
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<td>33 %</td>
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<td>Cargo handling and storage</td>
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<td>Telecommunications</td>
<td>41 %</td>
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<td>46 %</td>
</tr>
<tr>
<td>Services for computer and related activities</td>
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<tr>
<td>Manufacture of lighting equipment and electric lamps</td>
<td>46 %</td>
<td>28 %</td>
<td>36 %</td>
<td>46 %</td>
</tr>
<tr>
<td>Manufacture of television and radio transmitters and receivers</td>
<td>37 %</td>
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<td>41 %</td>
</tr>
<tr>
<td>Services for research and development</td>
<td>63 %</td>
<td>30 %</td>
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