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EXECUTIVE SUMMARY

1. Introduction

The European Union and the world economy went through a deep financial and economic crisis in 2008 and 2009. The first signs of recovery were visible in 2009 and were confirmed in the first half of 2010. These developments and the quickly evolving world market situation are a compelling call for the importance of remaining competitive.

This year's edition of the annual *European Competitiveness Report* looks first at the implications of the economic downturn for productivity — the key factor for competitiveness in the long run — and at some of the main future determinants of EU competitiveness on world markets: the changing pattern of trade in intermediate products and EU manufacturing supply chains; foreign corporate R & D and innovation activities in the EU; European competitiveness in key enabling technologies; and innovation and competitiveness in the creative industries.

2. Overall competitiveness performance

With the exception of the 2001 slowdown, the period 1995–2006 has been one of remarkable stability for industrialised countries. In the EU in particular, it has been a period of sustained growth, increasing participation in employment and increasing income per capita. In the US and some European countries, however, this stability was hiding the accumulation of significant imbalances that ultimately led to a downturn of a severity unseen since the early 1970s' oil shocks. In the EU, with the sole exception of Poland, all Member States saw a drop in their production in 2009, from around 3 % in Belgium or France to double-digit drops for Ireland and the three Baltic states (Estonia, Latvia and Lithuania). Even if some individual countries have experienced similar recessions in the recent past, this recession is unusual for its combination of a large drop in economic activity and its scope — synchronised global downturn with all advanced economies in nose-dive.

Beyond the issue of recovery, it is legitimate to ask what could be the impact of the crisis on economic performance in the medium to long term. The *European Competitiveness Report 2009* examined the potential impact of the recession on competitiveness. All in all, the conclusion was that the recession need not have a negative impact on the rate of technical change in the years to come because a recession includes two types of mechanisms: those that impinge negatively on economic efficiency, but also those that improve our ability to increase productivity in the future. Furthermore, understanding those mechanisms makes it possible to design economic policies to tone down the negative effects and amplify the positive ones in order to speed recovery and boost future growth.

The first chapter of the present edition of the report examines the potential impact of the boom years 2000–07 on competitiveness. The abovementioned accumulation of large imbalances has the potential to distort significantly the allocation of resources among and within our economies.

Seen in retrospective, the boom period 2000–07 was also a period of growing imbalances, notably in the housing sector in the US but also in Europe: some Member States saw investment in dwellings increase by the order of magnitude of several percentage points of GDP. For a decade or more, in some countries, particularly the UK, Denmark, Ireland and Spain, the prices of dwellings increased over their fundamental value. The distortion did not affect all countries, but in those affected it was not a minor one. In countries like Spain, for instance, at the height of the boom (around 2005–06) housing prices were increasing by 15 % annually. For years millions of agents in the private sector, notably households, made consumption-saving decisions counting on house prices increasing in a way that *ex post* appeared not to be sustainable. Indeed, in countries affected, the fast growth of housing prices led households to overinvest in housing and to overstate their wealth, pulling down their saving rate. If houses constituted an attractive investment for locals, so they did for foreigners as well, directly or indirectly.

The period 2000–06 also witnessed a substantial change in the lending/borrowing position of many European countries. In those with a housing bubble, the demand for credit fuelled capital inflows. When the boom came to an end, the magnitude of the adjustment was proportional to the magnitude of the accumulated distortions. Once the value of houses dropped — or was believed to be going to drop in the future — a large portion of perceived wealth vanished, leading to a major adjustment of consumption and saving patterns. Consumption dropped and saving increased to recompose the latter. Hence, countries affected by bubbles found themselves in a classical demand-side recession caused by the consumption-saving adjustments performed by households. Other countries, not necessarily affected by these imbalances, were affected through a drop in external demand.

The *European Competitiveness Report 2009* examined the potential impact of the recession itself on competitiveness. The *European Competitiveness Report 2010* examines the potential impact of the boom years and, in particular, whether these growing imbalances had an impact on competitiveness via the distortion of prices, wages or the allocation of investment.

For instance, during the boom some countries experienced large increases in unit labour costs, a measure of the nominal cost of labour. However, it does not seem that the evolution of unit labour costs has had a significant effect beyond accompanying the corresponding increases in the general level of prices. In principle, raising the nominal cost of labour may affect the competitive position of domestic firms in international markets. However, when the international market shares are compared to the evolution of unit labour costs, there is no obvious relation. Part of the explanation for this apparent paradox may lie in the fact that wage inflation takes place mostly in non-tradable sectors, notably services, and, in particular, in the construction sector.

In short, if the boom years have affected competitiveness, that is, the ability to increase productivity in the forthcoming years, the evidence remains elusive. Nevertheless, this is not to say that exiting the crisis may not be a slow adjustment process in some EU countries. For instance, it is possible that a part of those large capital inflows has not been used productively in some of the so-called deficit countries, therefore hampering the ability of these countries to generate income in the future while at the same time increasing the interest burden on these economies.

3. Trade in intermediate products and EU manufacturing supply chains

A large and growing number of products, especially in the high-tech area, consist of many different components that are manufactured in various parts of the world. Manufacturing production processes also require many kinds of services from different parts of the world if firms are to develop, produce and market their products.

However, this multi-country nature of products is no longer typical only for complex high-tech goods. Components and services are purchased abroad for many products. This is the case for direct inputs, when firms purchase both domestically and foreign-produced intermediate inputs, but also in an indirect way: components imported from a particular country might already include inputs from other countries, which are then used indirectly in the final product.

A prominent feature of the globalisation of today's economy is the increasing adjustment and adaptation of production structures to more international sourcing structures and cross-border production networks. Firms distribute their production activities and develop supply chains in different geographical locations according to the comparative advantages of the locations. So these developments can be said to have led to increased trade in intermediate goods.

Important shifts in the composition of EU-27 intermediate trade have taken place during the last decade

Trade in intermediates accounts for the largest part of overall trade, with an average share of about 50 % of both imports and exports. There are, however, big differences across countries. This share has increased little over the last decade or so, and has been driven mostly by industry specialisation. The shift towards more knowledge-intensive sectors in the EU has led to an increasing role for imported intermediates.

Large shifts have taken place in the geographical structure of trade in intermediates for the EU-27 countries. BRICs (Brazil, Russia, India and China) have become more important for EU exports and imports. They increased their share in EU-27 imports by 5 percentage points during the last decade. Gains of market shares can in general be related to relative price changes or increased product quality. Product quality upgrading also explains part of the EU-12 ([1]) market share increase within the EU.

([1]) The EU-12 are the 12 countries which joined the European Union in 2004 and 2007.

A large part of trade in intermediates consists of two-way trade, i.e. most countries are both exporters and importers of intermediates, which blurs the common perception of certain countries being predominantly outsourcing or target countries. Smaller emerging economies, including most of the EU-12, are more specialised in trade in intermediates as compared to larger ones, both in imports and exports. This raises the more general question of whether trade in intermediates might help countries to integrate into the world economy and how this shapes patterns of specialisation in both production and trade.

Increasing sourcing of inputs, trade of intermediates and inter-industry linkages

The growing trade in intermediates means that inter-industry linkages across borders have increased over time. For instance, when demand for cars increases in a particular country, more intermediate goods have to be imported than was the case a few years ago. Between 1995 and 2005 imports of intermediate goods increased in all manufacturing industries and in almost all EU countries. During the same period of time, the share of imported intermediates in total intermediates has also grown, indicating an increasing role of imported intermediates in final products. There are, however, some distinct industry differences in the use of imported intermediates. High-technology industries import more intermediate goods than other industries: imported intermediates accounted for 55 % of total inputs in high-technology manufacturing industries in 2005. On the other hand, foreign trade plays a smaller role in service industries than in manufacturing. Among service industries, the largest share of imported intermediate goods in 2005 (26 %) was in transport services.

Detailed information from a leading European mobile phone producer on supply chains shows that Europe captures 55 % of a particular phone's total value added. The phone was assembled both in Europe and China. When it was assembled and sold in Europe, the European share accounted for 68 %. But even when it was assembled in China and sold on the US market, Europe still captured as much as 51 % of the value. This shows that the final assembly, though important, represents only a fraction of the overall value added of a high-tech product like a mobile phone. The value is largely detached from the physical flows of goods within the supply chain. The major parts of the value are attributed to design, R & D, brand, marketing and distribution and management of these activities.

The financial crisis hit intermediate trade relatively harder and disrupted supply chains

There is a risk that the economic crisis of 2008–09, characterised by trade flows collapsing by more than the drop in GDP growth rates, might have changed sourcing patterns and firms' supply chains. Trade in intermediates, and especially in parts and components, was hit harder by the crisis than other types of goods. Trading volumes of parts and components slumped by some 38 % compared to pre-crisis levels. As a result, the relative importance of parts and components in EU-27 trade declined both in EU-27 trade overall and in almost all sectors in which vertical supply chains play a major role. These vertical supply chains are particularly important for the industries producing electrical machinery, mechanical equipment and motor vehicles.

The automotive industry has one of the highest shares of the parts and components trade. During the recent recession its exports and imports registered the biggest falls, of some 45 % compared to before the crisis. Such disruptions to international supply chains might have resulted from changes in the sourcing strategies of multinational corporations, such as shifting to domestic suppliers. Inventory adjustments have also contributed to the decline. An upturn in EU-27 trade can be expected if the marked decline in parts and components trade is primarily driven by the inventory cycle, as empty stocks have to be replenished. However, the recovery may be delayed if there is a reversal of the trend towards ever more complex international vertical supply chains.

Globalisation and localisation of the value chain

Trade in intermediates constitutes only one of many business activities in the value chain. As the mobile phone example shows, large parts are attributed to more knowledge-intensive activities, like management, design and R & D. These are especially important for high-tech industries, which tend to locate them close to the firm's headquarters, where it is easier to control and manage them. So EU firms' R & D and innovation activities are still predominantly domestic, though they are becoming increasingly internationalised as adapting products to foreign markets necessitates the presence of product development close to those markets. Firms also seek to ensure access to scientific and technological capabilities, human capital and other resources, which is another motive for the foreign location of R & D activities. Localisation decisions are not based on local preferences but on strategic considerations concerning the provision of strategic resources.

4. Foreign corporate R & D and innovation in the European Union

Corporate research, development and innovation (R & D & I) activities were long seen as one of the few business areas still relatively insulated from offshoring and globalisation. This perception has lately been changing rapidly. Over the last 30 years, globalisation has changed international trade and foreign direct investment flows considerably, reshaping and transforming R & D & I processes and the knowledge and skills that enable firms to compete in domestic and international markets. As a result, a growing number of firms, in particular large multinational enterprises, started locating R & D & I activities outside their home countries.

Firms decide to (re)locate R & D & I activities abroad by weighing a number of important considerations against each other. Potential benefits include: local development and design of new products and services to capture new markets and growth opportunities; gaining access to new sources of scientific and technological capabilities, skills and talent; and reducing R & D & I capacity bottlenecks. Potential costs include foregone benefits of R & D & I centralisation, including economies of scale and scope, the need for more coordination and complexities in the transfer of knowledge, given its often 'tacit', cumulative, localised and context-related nature.

The European Union has been an important player in this emerging internationalisation of R & D & I, as documented by a number of datasets (patents, R & D expenditure of foreign affiliates and various surveys). The analysis points to some important differences across countries, sectors, technologies and firms, as well as to some of the likely effects of the increasing and uneven degree of internationalisation on productivity and employment in the European Union.

EU performance in the emerging internationalisation of R & D & I

In a global perspective, the EU is still in a position of strength, but the global competition to attract R & D & I flows is set to continue rising. R & D & I internationalisation is predominantly a matter for the triad of the US, EU and Japan, with smaller roles for countries like Canada, Switzerland, South Korea and Israel. The bilateral flows between the EU and the US clearly take prominence on a global scale. For instance, from 2001 to 2007, US multinational firms significantly increased their R & D expenditure in the EU, still the main location for their R & D (the EU single market attracted more than 60 % of all US overseas R & D expenditure in this period). The EU, however, is facing growing global competition in this field, from both developed and emerging economies. R & D expenditure of US subsidiaries in the BRICs is still relatively low (altogether representing about one 10th of the value for the EU-27 in 2007), but is growing fast.

The considerable increase in R & D & I cross-border links is evident at extra-EU and in particular intra-EU levels, as further documented by the locations of patent applicants and inventors. For instance, some 17 % of all European Patent Office patents resulting from inventions made in the EU were foreign-owned (9 % by non-EU and 8 % by EU-based organisations); in 1990, only 10 % of such patents had foreign owners (6 % non-EU and 4 % EU-based organisations). Moreover, the last two decades have seen an increase in the number of both domestic and foreign-owned patents resulting from inventions made in the EU, which suggests that the internationalisation of R & D & I did not squeeze out domestically owned patenting.

Altogether, the various sources of evidence confirm the rise of R & D & I cross-border links and flows, indicating at the same time a possible slowdown in recent years and showing that domestic activities still account for the bulk of R & D & I, particularly in the large countries.

Uneven levels and trends across EU countries, sectors, technologies and firms

Cross-border R & D & I links between the EU-15 countries tend to be relatively strong, but are often limited to the large and medium-sized R & D-intensive Member States. In contrast, links between the EU-12 and EU-15 countries, and in particular within the EU-12, tend to be rare.

Medium-sized or small Member States tend to have a higher degree of internationalisation and in some cases relatively higher R & D & I inflows than large countries. Patent data suggest that strong country links in terms of R & D & I often appear to be explained by a common language, geographical proximity or a long history of economic integration. Key examples are the links between the Nordic countries, and the links between a large country and a smaller neighbour, such as Germany and Austria, the UK and Ireland, or France and Belgium. There are at least five countries in the EU (Czech Republic, Ireland, Hungary, Austria, Slovakia) where foreign-owned firms currently account for more than 50 % of total R & D expenditure in manufacturing.

Services tend to be less internationalised than manufacturing, but their share of total overseas R & D expenditure is rising. Also, different sectors and technologies present different internationalisation levels and dynamics. For instance, a high and increasing level of internationalisation is generally found in technology-intensive sectors, such as information technologies, telecommunications and pharmaceuticals (characterised by high R & D intensity and fast rates of technological change). A high, but more or less stable, internationalisation level is found, for instance, in the food industry, possibly reflecting the presence of a number of large multinational enterprises and a high degree of product variation and innovation in response to differing consumer tastes.

Internationalisation is mainly pursued by a small number of large R & D-intensive firms. Typically, firms move R & D & I to high-income countries to access knowledge, while relocation to low-income countries is driven by the quest for new markets.

EU firms are increasing their R & D & I outside the EU

EU firms are increasingly seizing opportunities to start or expand R & D & I abroad (extra-EU), particularly in the US. The outward internationalisation of EU firms has increased considerably over the last two decades and is catching up with the top levels of R & D & I internationalisation that US firms overall still tend to hold. For instance, between the periods 1991–95 and 2001–05, the share of all EU patent applications (in the OECD triadic database) resulting from inventions made outside the EU increased from 4 % to 11 %. It is worth comparing the outward internationalisation dynamics among the triad (US, EU and Japan): the EU more or less caught up with the US (11 % share of patent applications from inventions made abroad in the period 2001–05), leaving Japan well behind (3 % in the same period).

Patent data and R & D expenditure surveys both indicate that the US is by far the preferred location for overseas R & D & I of the EU-27 — as a whole and across countries, sectors and technologies. R & D-intensive European firms, sectors and technologies (such as pharmaceuticals, cosmetics or semiconductors) tend to have a somewhat higher level of outward internationalisation.

Foreign-owned firms innovate differently in the EU than domestically owned companies ...

Foreign-owned firms tend to have lower innovation input intensities than domestically owned companies, but achieve similar innovation outputs. This suggests that the innovation efforts of foreign-owned firms are based to a considerable degree on knowledge and technologies received from the group or parent company. Many of the differences between foreign-owned and domestically owned firms can be explained by related firm characteristics, e.g. foreign-owned firms are larger, have higher absorptive capacities or operate more often in technology-intensive sectors.

Cooperation with domestic partners, in particular domestic research organisations (including universities), is common among foreign-owned firms, a sign of their embeddedness in the host countries' innovation systems and of potential spillover effects. Foreign-owned firms can act as agents of international technology diffusion and as links between organisations in the host country and foreign sources of knowledge.

… but both groups of firms contribute to productivity growth and employment creation

Foreign-owned firms have significantly higher productivity levels (measured by sales per employee) than domestically owned companies. They also show higher levels of productivity growth, though differences in relation to domestically owned firms are considerably smaller and less significant here. Productivity growth of foreign-owned companies is mainly related to output growth of old products and the effects of product innovation, but not process innovation. There are no major differences between foreign-owned firms, domestic group enterprises and domestic unaffiliated firms in the way in which innovation affects productivity levels.

Foreign-owned companies also differ from domestically owned firms in the way in which they transform new technologies into employment growth. General productivity increases as a result of job cuts are on average compensated by the employment-creating effects of higher sales from old products and product innovation in the foreign-owned firms. Together, these effects result in net employment growth in foreign-owned companies.

5. European competitiveness in key enabling technologies

Because they can generate new growth, spur innovation, increase productivity, help tackle environmental and climate challenges and give rise to new applications, key enabling technologies are attracting growing interest, and the importance of staying competitive in these technologies cannot be overstated.

Trends in six key enabling technologies (KETs) — nanotechnology, micro and nanoelectronics (including semiconductors), industrial biotechnology, photonics, advanced materials and advanced manufacturing technologies — are reviewed from a variety of perspectives: (i) state of development; (ii) existing and future applications; (iii) current market volume and future potential; and (iv) European competitiveness in comparison with North America, east Asia and the rest of the world.

There is considerable uncertainty about how fast the markets for applications of the six technologies — nanotechnology in particular — will grow in the medium term. A contributing factor to the uncertainty is that there are no agreed definitions of key enabling technologies. A broad definition is likely to lead to a more optimistic assessment of potential market volume than a more narrowly defined technology. With this in mind it is hardly surprising that the potential market for key enabling technology applications in 2015 (as reflected in the literature) covers a very wide range.

Most applications of key enabling technologies are still at a conceptual or pre-competitive stage, and it is not possible to use market data to assess how competitive Europe is compared with the rest of the world. Instead, patent data analysis and a number of case studies are used to analyse Europe's competitiveness in these areas.

Strong European position in advanced manufacturing technologies and industrial biotechnology

The overall conclusion is that European producers of KETs are well placed in all six technologies, representing between a quarter and a half of all patent applications analysed. Europe is the world leader in advanced manufacturing technologies and shares the lead with North America in industrial biotechnology. In photonics, nanotechnology and micro and nanoelectronics, Europe contributes less to total output than North America and east Asia.

Europe is in principle holding its position in all six technologies. In recent decades it has neither lost nor gained ground, despite increasing competition from east Asia, which in the past decade has made great strides in most of the technologies. At the same time the contribution of North America to global technology output has gradually diminished. Germany is the main producer of key enabling technology patents in the EU, followed by France and the United Kingdom.

Importance of skills and venture capital and of maintaining a manufacturing base

Maintaining a strong European manufacturing base in each key enabling technology is critical if the EU is to benefit fully from productivity and innovation effects. Direct interaction between research and development, manufacture and application in user industries is needed if new fields of application are to emerge and good facilities for new technologies are to be developed.

KET research is often at the cutting edge of technology. Complex technologies and new technological challenges have to be addressed. In such a context progress depends on bringing together different scientific disciplines and fields of technology in a joint endeavour. More coordination is needed between research and industry, going beyond any coordination by market mechanisms. Providing incentives for networking and clustering can help to achieve this. In some areas global networks of the leading organisations from research and industry are ideal; elsewhere regional networks (clusters) can spur technology development. Clusters can be particularly helpful in linking research and commercial applications. Best practices for facilitating the flow of know-how, ideas and personnel between industry and research institutions should be circulated between and within Member States.

With Europe facing a likely shortage of skilled labour, promoting higher education and training in KETs will be essential. Strengthening cross-disciplinary education is a main challenge in that context. Higher education institutions need to offer curricula that are better geared to meeting the specific demands of KETs. Students need to be made aware of the career opportunities offered by cross-disciplinary studies. Education and training may be complemented by immigration policies to address the shortage of skilled personnel.

Venture capital markets are important for commercialising research results in KETs through spin-offs and other types of start-ups. To work, venture capital needs a supportive regulatory environment, and public programmes may need to step in to address any failures by European private venture capital markets to provide sufficient funds for start-up and early-stage financing.

The role of regulation

In some KETs there is a particular focus on health, environment and safety issues. Cases in point are nanotechnology, industrial biotechnology and advanced materials. Procedures, standards and implementation tools (e.g. test methods and guidance documents) are needed to deal with health, safety and environmental issues and to provide incentives for further technological advances and innovative dynamics. Legislation has to be flexible enough to adjust to technological progress within each KET.

Industrial standardisation, intellectual property rights and enabling and promoting spin-offs are of critical importance to the transfer of technology. All in all, an integrated, coherent policy approach is required if KETs are to increase productivity and wealth. This should bring in regional, national and international levels and the various policy domains, including research, innovation, education, competition, industry, taxation, health and environment.

6. Innovation and competitiveness of the creative industries in the EU

The creative industries have large growth potential. A survey in the EU Member States in early 2010 found that more than 97 % of respondents thought the creative industries were 'important' or 'very important' in supporting innovative activities, encouraging economic growth and creating new jobs. Creative industries are at the crossroads between arts, business and technology. They range from information services, such as publishing or software, to professional services like architecture, advertising or design ([2]). Creative industries are among the fastest-growing sectors in the EU, creating new jobs, playing key roles in global value chains and spurring innovation.

Creative industries are increasingly a source of growth in the EU

Creative industries account for 3.3 % of total EU GDP and 3 % of employment, and are among the most dynamic sectors in the EU. Although employment growth was uneven across subsectors, overall employment in the creative industries increased by an average of 3.5 % a year in 2000–07, compared to 1 % a year for the EU economy as a whole. Software consulting accounted for more than half of creative industries' employment growth in the EU-27 in 2000–07. Indeed, the employment growth rate for software consultancy in the EU-27 was about 5.2 % per year on average in 2000–07. Within software publishing, the video games industry is one of the fastest-growing industries worldwide. The Baltic states and other new Member States have the highest annual employment growth rates in the creative industries. Among the EU-15 countries, Portugal and Ireland report a higher than average increase. The fast growth of the creative industries in the EU is partly due to catching up in the less developed EU countries. Demand factors and a strong entrepreneurial culture are further job creation factors. Creative industries are dominated by micro firms (95 % have fewer than 10 employees) coexisting with very large corporations. They typically include large shares of self-employed and highly skilled professionals.

The increasing importance of skills and creativity in the EU job market is clearer when one looks at professions that are 'creative' in essence, regardless of whether they belong to the 'creative industries' proper or to more traditional activities. Occupations considered as 'creative' include, for example, professions such as mathematicians or engineers, along with writers, creative and performing artists and artistic or entertainment professions. What they all have in common is that they produce intangible assets such as ideas, knowledge and information that increase firms' value added. In the EU-15, creative occupations grew at around 3 % per year on average between 2002 and 2008, with the highest growth for artistic and entertainment occupations (5.7 %), followed by social science and related professionals (5.0 %), and architects, engineers and computing professionals (each 3.2 %). Creative occupations are growing within and outside the creative industries, indicating that creativity is spreading to other sectors. Similar trends can be observed for the new Member States (though fewer data are available here).

New empirical evidence is given on how the creative industries strengthen regional growth. Recent findings at the regional level for 10 EU countries show that the creative industries had a positive and significant effect on the growth rate of local GDP per capita in 2002–07. However, in terms of the related but different concept of 'creative occupations', there is no consensus on the impact of the creative workforce on regional growth.

Although there are not many tradable creative services, the EU's position on the global markets is bolstered by the most tradable parts of the creative sectors. Europe is one of the world's leading exporters of creative industries' products. There was an increase in the revealed comparative advantage of the EU in publishing, music records, audiovisuals (film) and most notably in the new media (digital records) — with strong growth in video games.

Creative industries stand out because of their propensity for innovation

Some creative industries are among the most potentially innovative of all EU sectors. Firms in software consultancy and supply are the most innovative of the service industries. The architecture and advertising industries have a higher than usual share of firms introducing new or significantly improved services.

Creative industries are not only innovators themselves but have also been an important driver for innovation. As far as supply chain relationships are concerned, they account for increasing inputs in the development of other sectors. A creative industry like industrial design contributes substantially to the production process and product design innovations of several manufacturing industries, such as chemicals and pharmaceuticals, minerals, glass and ceramics, motor vehicles and tobacco. Conversely, some creative industries are major users of

[2] The concept of creative industries is very close to another concept of creative and cultural industries used in the 'Green Paper — Unlocking the potential of cultural and creative industries': http://ec.europa.eu/culture/our-policy-development/doc2577_en.htm

new technologies, playing a key role in stepping up the spread of technological innovations. Outside the ICT sector itself, publishing and software firms were among the earliest users of the Internet and e-business practices.

Reinforcing the growth and innovation potential of creative industries: action needed!

Creative industries tend to be small-scale organisations, which makes them natural candidates for small business policies. They tend to be more prone to rationing of funding, and many submarkets of the creative industries urge the authorities to provide for a level playing field of competition. Certain creative sectors may justify consideration for targeted approaches because of their public utility aspect. They do a lot to generate innovation and build knowledge. Underinvestment must therefore be avoided. Appropriate education and training are also essential to provide the sector with the skills it needs to grow.

More coordination, networking and sharing of best practices will enable all creative industries and occupations to optimise their growth prospects and contribute to the economy as a whole. EU policies can help in the dissemination of best practice.

Ultimately, the impact of the creative industries is not only economic and thus calls for more than national or local action. While the welfare effects are difficult to quantify, it is clear that some of the creative industries facilitate structural adjustment in declining regions. They can boost social cohesion and get the less well off more involved in cultural activities. Where concerted and coordinated action would increase the economic and social impact of creative industries, the EU can play a role. EU prerogative areas such as intellectual property rights or the single market for services are the bedrock of creative industries. A recent Amsterdam declaration on the 'European Creative Industries Alliance' and a Green Paper ([3]) on cultural and creative industries are some recent initiatives on competitiveness and innovation in this sector.

7. Conclusions

The *European Competitiveness Report 2010* examines the potential impact of the boom years on competitiveness. The accumulation of large imbalances has the potential to distort significantly the allocation of resources in our economies. However, a glance at the evidence shows that export performance does not seem to have been severely affected by these developments. As for productivity growth, construction and real estate activities have attracted much investment in countries affected by housing bubbles; there is no obvious impact on aggregate productivity so far but these distorted investments have the potential to hamper the ability of affected countries to generate income in the future to compensate for the interest burden.

Nonetheless, the financial and economic crisis hit international trade in intermediate goods (especially parts and components) quite hard, accounting for something like 50 % of all international trade. It also disrupted some of the established international supply chains (e.g. in the automotive industry) and resulted in some changes to multinational corporations' sourcing strategies, such as shifting to domestic suppliers. If confirmed, this may have longer-term consequences — by at least temporarily restricting the internationalisation of certain companies' activities and perhaps by delaying the recovery in some industries.

EU firms' R & D and innovation activities, especially in high-tech industries, are still predominantly domestic, but are becoming increasingly internationalised, as the need to adapt products to foreign markets brings product development closer to local markets. Firms' location decisions are also increasingly based on the provision of strategic resources, such as ensuring access to scientific and technological capabilities and to human capital. A detailed analysis of a specific high-tech product shows that the value captured has little to do with the physical flows of goods within the supply chain: major parts of the value are attributed to design, R & D, brand, marketing, distribution and management. This shows how important it is to keep a strong grip on these activities.

Maintaining and developing a position of maximum strength for the EU and the Member States in the inward and outward cross-border flows of R & D & I is crucial to keep the EU economies competitive and dynamic in the medium and long term. Inward foreign research, development and innovation offer great potential for the transfer and diffusion of knowledge and innovation across all business sectors. They can complement EU homegrown activities and help R & D & I to catch up in certain sectors and technologies, they can help achieving a critical mass and agglomeration of these capacities in certain areas and countries, and they may help to smooth and sustain a steady R & D & I effort in times of crisis. Key policies and measures for maintaining and attracting new R & D & I include: enhancing the quality of science and technology (S & T) bases and the mobility of researchers and S & T personnel; widening the scope and tightening up the enforcement of intellectual property rights, including the competitiveness and efficiency of the patenting system; promoting R & D & I partnerships and consortia — open to foreign (intra and extra-EU) business and research organisations — fostering

([3]) 'Green Paper — Unlocking the potential of cultural and creative industries': http://ec.europa.eu/culture/our-policy-development/doc2577_en.htm competition and cooperation, integration and spillovers into EU innovation systems; promoting an international regulatory dialogue and a level playing field in public R & D & I support measures; and adopting proactive standards and public procurement policies with a view to developing a dynamic single market for research, development and innovation in the EU. There may well be considerable benefits for firms, the EU's innovation systems and the economy as a whole from outward R & D & I flows by EU firms, in particular SMEs. Potential benefits include opening up and seizing opportunities in new and fast-growing markets, adapting innovative products to local requirements and preferences, and gaining access to foreign sources of knowledge which are of strategic importance for certain businesses.

The European producers of key enabling technologies seem to be well placed in the international arena, and Europe is in principle in a strong position in all six identified KETs. KET research is often at the technological frontier. However, more coordination between research and industry is needed, over and above the coordinating effect of market mechanisms. Incentives for networking and clustering can be helpful. Best practices should be disseminated between and within the Member States. Promoting higher education and training will be essential to secure a supply of skilled personnel. In addition, venture capital markets are needed to commercialise the results of KETs, and they in turn need a supportive regulatory environment. Public programmes may be needed to provide additional funds for start-up and early stage financing.

Creative industries have great potential for reinforcing economic growth and creating new jobs. They have long been among the fastest-growing sectors in the EU; they play a key role in global value chains and they spur innovation. Moreover, creative occupations are growing within and outside the creative industries, i.e. creative professions are spreading to other sectors. The EU is one of the world's leading exporters of creative industries' products. Their importance, however, is not purely economic — they can facilitate structural adjustment in declining regions and do a lot to enhance social cohesion and inclusion. EU policies can therefore play a role in strengthening intellectual property rights and the single market for services. The creative industries must be brought into the scope of SME policies; they need access to proper financing facilities and creative companies need to be helped to grow.

Introduction

This is the 13th edition of the Commission's *European Competitiveness Report* since the 1994 Industry Council resolution which called on the Commission to report annually. Competitiveness is taken here to mean a sustained rise in the standard of living of a nation or region and as low a level of involuntary unemployment as possible. For an industrial sector, the main competitiveness criterion is maintaining and improving its position in the global market.

As in previous years, the report approaches the issues using insights from economic theory and empirical research, and its ambition is to contribute to policymaking by drawing attention to trends and developments and by discussing policy options. Its main subjects continue to be related to productivity, this being the most reliable indicator for competitiveness over the longer term, and other microeconomic issues underpinning the EU's future economic developments, in particular its Europe 2020 strategy.

Chapter 1 presents a snapshot of recent economic developments in a period of financial and economic crisis and the beginning of recovery. In addition, the boom period 2000–07 is explored in order to analyse its likely impact on European competitiveness.

Chapter 2 analyses trade in intermediate products and EU manufacturing supply chains with a view to shedding light on the relative importance of trade in intermediates in overall EU-27 trade and in individual countries. The questions addressed in this chapter include the share of these products in overall trade in exports and imports, the changes over time and what factors are driving these changes and the geographical structure of trade in intermediate goods. There is also a case study from the high-tech area, which addresses the issue of who 'captures' the value of the production process. Finally the chapter examines the extent to which trade in intermediaries has been affected by the economic crisis (including a comparison with other product categories) and how the crisis has affected EU manufacturing supply chains.

The issue of foreign corporate research and development and its impact on innovation in the European Union is addressed in Chapter 3. The aim is to study why firms internationalise R & D and innovation, analyse R & D & I activities of foreign-owned firms in the EU by sector, country and technology, and examine the activities of EU firms outside the European Union. The chapter also investigates whether — and how — foreign-owned and domestically owned firms differ in their innovation behaviour and how they transform innovation into productivity and employment growth.

Chapter 4 on key enabling technologies (KETs) discusses their role in increasing wealth by boosting innovation and raising productivity, and the performance of Europe (firms as well as public institutions) in producing new technology compared to the main competing regions (North America and east Asia). The analysis looks at the industrial sectors and fields of application that are most affected by different KETs, their likely medium-term growth potential and which factors are likely to drive technological and commercial success.

The main objective of Chapter 5 is to give a comprehensive picture of the innovation performance and competitiveness of the creative industries, along with their relative size and economic performance in the EU-27 countries. It explores what drives creative industries' growth and their impact on the wider economy in different forms. These include: a direct contribution to the economy (employment and some output measures); spillovers into the wider economy; the direct, but less quantifiable, contributions of the creative industries to innovation; and their role in improving the quality of life. The scope and opportunities for policy intervention are then explored.

CHAPTER 1

Growing Imbalances and European Industry

1.1. The crisis as a major adjustment

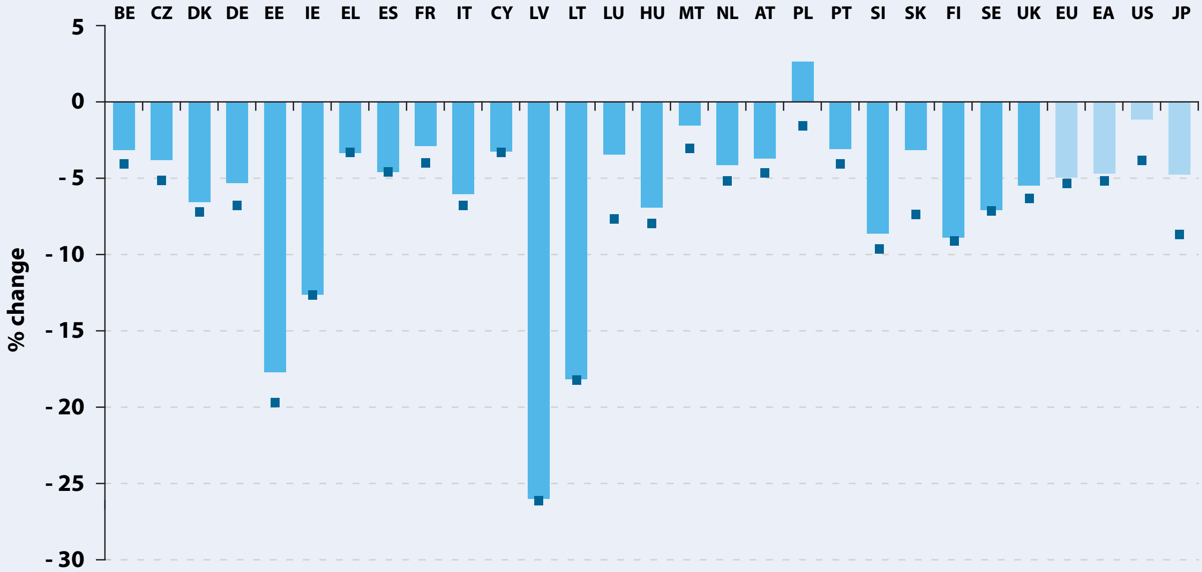
With the exception of the 2001 slowdown, the period 1995–2006 was one of remarkable stability for the industrialised countries. In the EU in particular, it was a period of sustained growth, more people in employment and higher income per capita. In some countries, however, stability concealed the accumulation of significant disequilibria that in 2008 brought on a global recession of a severity unseen since the oil shocks in the 1970s.

1.1.1. A big recession

Individual countries had experienced similar recessions in the recent past but this recession is unusual for its combination of a big drop in economic activity and its global nature: most countries in the world were touched in one way or another. In the EU, with the sole exception of Poland, all Member States saw their production fall, from around 3 % in Belgium and France to double-digit drops for Ireland and the Baltic states. Latvia suffered the biggest contraction, with a 26 % drop in GDP compared with its peak value in 2007.

While most countries emerged from the trough in 2010, none of them, again with the exception of Poland, recovered to the level of real GDP they had in 2007. The varied picture showed in Figure 1.1 reflects differing patterns during the boom period 2000–07. As will be discussed below, several Member States were affected by large speculative bubbles and were afterwards hit

Figure 1.1: The magnitude of the contraction: real GDP current (bars) and maximum (dots) drop with respect to peak (*)



(*) Seasonally adjusted data; the last data are for first-quarter 2010 when available; otherwise fourth-quarter 2009 data are used.
Source: Eurostat, quarterly national accounts.

hard by the ensuing readjustment; countries not suffering from these asset pricing distortions were quickly affected by contagion — through international trade and through problems in the international supply chain. This is particularly true of many of the new Member States.

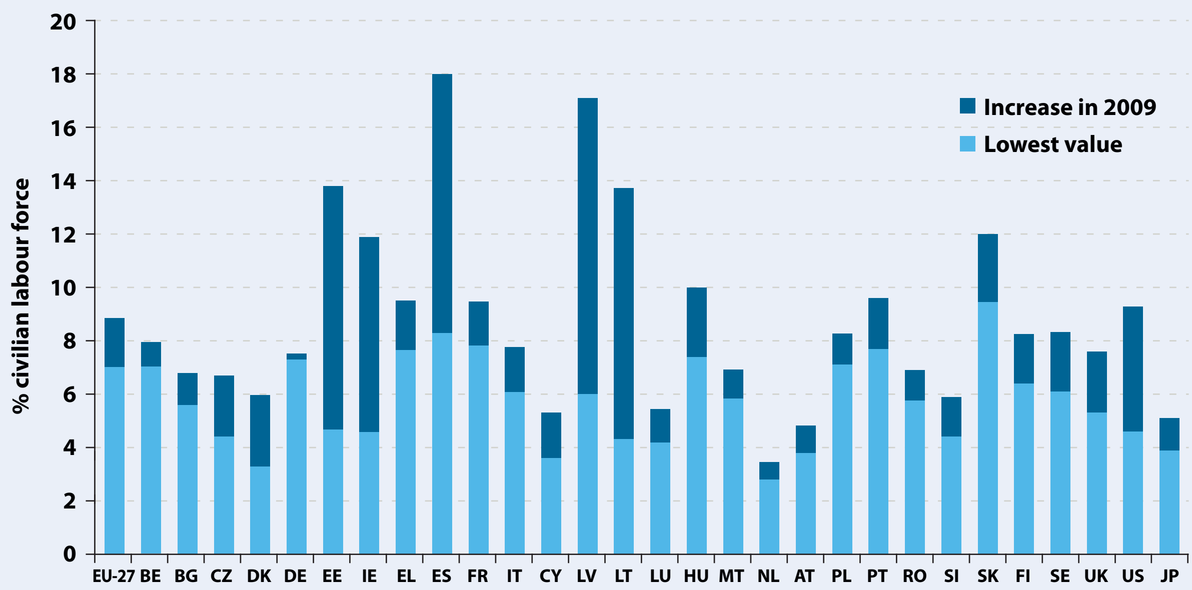
1.1.2. Sudden drop and slow recovery in the labour market

With a few exceptions, in the boom years, i.e. the period from 2000 to 2007, the unemployment rate fell in most European countries. For some, however, the crisis reversed the situation within a few quarters, and they now have significantly higher unemployment rates. The experience of previous recessions is that employment takes something like two to four times the length of the recession to return to its earlier level ([4]). So with this rule of thumb, employment is expected to remain below its peak level for one to four years in the EU.

Needless to say, the experience across Member States is quite uneven, and depends on institutional arrangements that vary considerably across the EU. Not surprisingly, the scale of job cuts and the increase in unemployment was particularly sizeable in the countries hardest hit (e.g. the Baltic states, Ireland and Spain). Given the magnitude of the recession, other countries, notably Germany, experienced only modest losses in employment. The unevenness of performance reflects the nature of the recession as well as labour market institutions. For instance, when employers regard demand shocks as temporary, they tend to smooth their labour responses ([5]); this appears to be the case with Germany, which was affected primarily by the collapse in global trade. In contrast, large labour changes and reorganisations are the best response to permanent demand shocks that involve large sectoral restructuring; this appears to be the case in, say, Spain and Ireland, both of which had major problems with a housing bubble.

In the midst of such a crisis, and over and above the issue of recovery, it is reasonable to wonder about the impact on economic performance in the medium to long term. The *European Competitiveness Report 2009* examined the potential impact of the recession on long-term productivity growth; all in all, the conclusion was that the recession need not have a negative impact on the rate of technical change in the years to come. This is because a recession includes two types of mechanisms: those that impinge negatively on economic efficiency, but also those that improve our ability to increase productivity in the future. Furthermore, understanding those mechanisms makes it pos-

Figure 1.2: Breakdown of unemployment in 2009

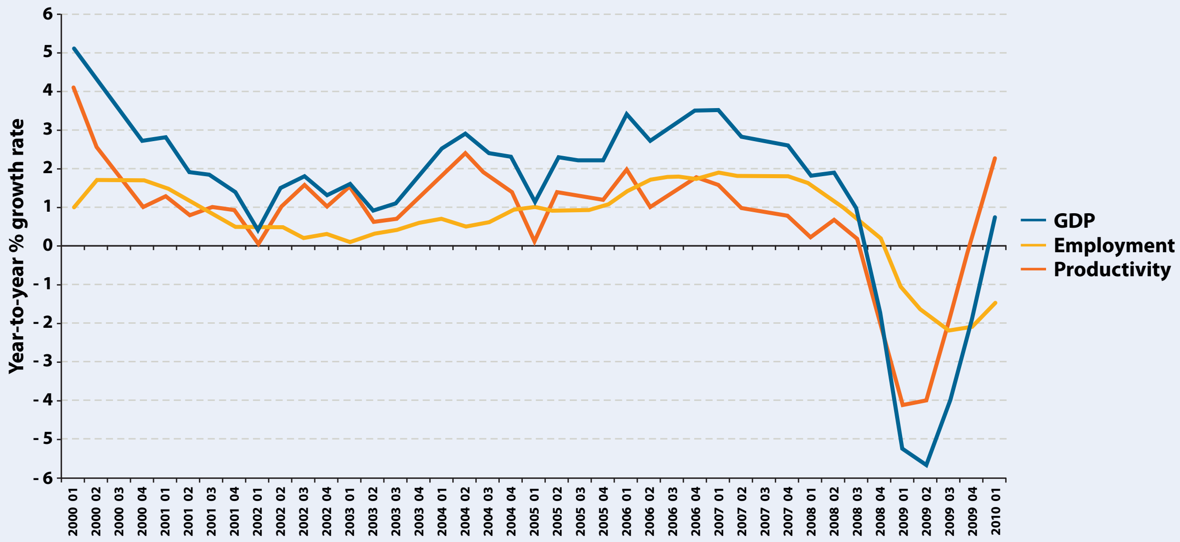


Note: The lower value indicates the lowest rate of unemployment (civilian labour force) in 2007 or 2008; the stacked bar is the rise over this initial low value up to 2009.
Source: AMECO database, European Commission.

([4]) See the discussion in Section 1.2 in the *European Competitiveness Report 2009* or the European Commission (2009a).

([5]) Section 1.4 in the *European Competitiveness Report 2009.*

Figure 1.3: GDP, employment and productivity growth rates in the EU-27



Source: Eurostat.

sible to design economic policies to tone down the negative and amplify the positive effects ([6]) in order to avoid a slow recovery followed by an era of sluggish growth ([7]).

The present edition of the *European Competitiveness Report* examines the potential impact of the boom years on competitiveness. The abovementioned accumulation of serious imbalances has a potential to significantly distort the way resources are used in our economies, and hence productivity growth in the years to come.

1.2. The years before the crisis

The period preceding the crisis was characterised by remarkable stability: steady income growth, low inflation and growing employment.

1.2.1. Aggregate trends and the crisis

Table 1.1 sets out average annual growth rates for the five-year intervals 1996–2000 and 2001–05, and for the

Box 1.1: Competitiveness and external competitiveness

Competitiveness refers to the overall economic performance of a nation measured in terms of its ability to provide its citizens with growing living standards on a sustainable basis and broad access to jobs for those willing to work. In short, competitiveness refers to the institutional and policy arrangements that create the conditions under which productivity can grow sustainably. (Productivity growth is the only source of sustained income growth, in turn the backbone of growing living standards.)

When applied to international trade, however, competitiveness, or external competitiveness, may convey a different and more specific meaning. Unless otherwise stated, in this chapter external competitiveness refers to the ability to export goods and services in order to afford imports, and hence it will be summarised by world market shares (the share of exports in total exports).

([6]) For instance, the 'Product market review 2009' (European Commission (2009b)) examines the negative impact of the crisis on R & D (Section 4.1) and, accordingly, discusses policy measures that attempt to tone down the potentially negative impact (Section 4.2).

([7]) European Commission (2009a) discusses the possible impact of the crisis on potential output and a scenario with lower permanent growth rates is not ruled out.

years 2006, 2007, 2008 and 2009. As mentioned, the unprecedented fall in GDP per capita in 2009 was somewhat uneven, but all EU countries were affected, reflecting the severity and dire consequences of the economic and financial crisis. The GDP per capita fall was particularly sizeable in some of the EU-12 countries (particularly in the Baltic states, ranging from - 13.6 % in Estonia to - 17.5 % in Latvia and Lithuania, but also in Hungary, Romania and Slovenia, at - 6 % to - 9 %), thus wiping out part of their previous performance and catch-up achievements within the EU. Some of the EU-15 countries were also severely hit, such as Ireland and Finland (with a GDP per capita fall of 8 % and 7.3 % respectively).

Table 1.2 shows that in 2009 employment contracted less in the EU-27 (- 2 %) than in the US (- 3.5 %), reflecting the lower responsiveness of EU labour markets. The crisis also has the potential to affect labour supply in the short and medium term, by changing either the total population (e.g. via reduction of immigration flows) or the participation rates. On the one hand, recessions tend to discourage labour entry (e.g. young people may decide to stay longer in full-time education) and encourage exit (early retirement for older workers). On the other hand, households affected by significant income reductions may delay retirement decisions, and formerly inactive household members

Table 1.1: Real GDP per capita growth and GDP level in PPS

	Annual growth rate of GDP per capita (1)						2009 GDP per capita
	1996–2000 (2)	2001–05 (2)	2006	2007	2008	2009	(in PPS; EU-27 = 100) (3)
BE	2.64	1.14	2.10	2.18	1.04	- 3.58	114.9
BG	- 0.21	6.66	6.59	6.17	6.01	- 5.40	41.2
CZ	1.60	3.82	6.47	5.55	1.41	- 5.46	80.5
DK	2.44	0.95	3.00	1.22	- 1.78	- 4.72	117.4
DE	1.88	0.53	3.29	2.59	1.43	- 4.88	116.2
EE	7.19	8.32	10.18	7.39	- 3.47	- 13.62	62.0
IE	8.44	3.64	2.76	3.50	- 4.91	- 7.96	131.1
EL	2.91	3.72	4.10	4.06	1.61	- 1.54	94.8
ES	3.65	1.73	2.44	1.70	- 0.73	- 4.92	103.3
FR	2.36	0.93	1.53	1.72	- 0.14	- 2.65	107.4
IT	1.87	0.31	1.46	0.82	- 1.80	- 5.20	101.7
CY	2.49	1.42	2.15	2.93	2.65	- 1.67	98.3
LV	6.34	8.86	12.85	10.55	- 4.13	- 17.57	48.6
LT	5.20	8.32	8.49	10.44	3.30	- 17.54	53.2
LU	4.70	2.37	3.92	4.83	- 1.73	- 4.85	268.0
HU	4.25	4.49	4.13	1.12	0.82	- 6.38	63.0
MT	3.88	0.33	2.65	3.10	1.61	- 2.97	77.6
NL	3.43	0.82	3.24	3.38	1.61	- 4.93	129.9
AT	2.82	1.04	2.85	3.13	1.70	- 4.03	123.6
PL	5.42	3.13	6.31	6.83	5.00	1.21	60.8
PT	3.68	0.25	1.03	1.64	- 0.17	- 3.07	78.3
RO	- 1.00	6.50	8.07	6.55	6.45	- 7.79	45.3
SI	4.35	3.57	5.44	6.22	2.39	- 7.04	86.1
SK	3.25	4.97	8.42	10.31	6.14	- 5.90	71.6
FI	4.54	2.24	4.50	3.76	0.58	- 7.27	110.5
SE	3.23	2.19	3.66	1.81	- 0.92	- 5.05	120.4
UK	3.13	2.03	2.26	1.91	- 0.06	- 5.21	116.4
EU-15	2.57	1.12	2.43	2.03	- 0.02	- 4.56	110.6
EU-27	2.70	1.43	2.77	2.39	0.32	- 4.46	100.0
US	3.15	1.45	1.72	1.15	- 0.50	- 3.34	147.3

(1) GDP per capita is measured in 2000 prices.
(2) Geometric average.
(3) PPS = Purchasing power standards.

Source: AMECO database, European Commission.

may seek to enter the labour force, particularly when labour markets are flexible and the recovery starts to generate new job opportunities. The participation rate in the EU-27 has indeed fallen from 65.9 % in 2008 to 64.6 % in 2009 (roughly the level attained in 2006 and 2007). The participation of young workers (aged 15–24) appears to have accentuated its declining trend in 2009 [8].

Labour productivity in the EU-27 appears to be recovering faster than GDP (see Figure 1.3) due to the adjustment lags of employment. Table 1.3 shows a substantial variation in measured labour productivity across countries, reflecting the patchy nature and the magnitude of economic shocks, flexibility and response in labour and market adjustments, the stage in the business cycle and the strength of the recovery, etc.

Table 1.2: Annual growth rate of employment (1)

	1996–2000 (2)	2001–05 (2)	2006	2007	2008	2009
BE	1.22	0.71	1.19	1.63	1.88	- 0.84
BG	- 0.26	1.53	3.34	2.82	3.27	- 2.03
CZ	- 0.82	0.21	1.94	2.66	1.55	- 2.03
DK	1.02	0.05	1.99	2.69	0.83	- 2.61
DE	0.81	- 0.16	0.62	1.66	1.40	- 0.30
EE	- 2.03	1.10	5.38	0.75	0.17	- 8.98
IE	5.72	2.91	4.30	3.56	- 0.82	- 7.79
EL	0.55	1.35	2.03	1.36	0.11	- 0.91
ES	3.88	3.26	3.92	3.02	- 0.61	- 6.63
FR	1.40	0.64	0.98	1.35	0.53	- 1.77
IT	0.98	1.25	1.96	1.24	0.32	- 1.13
CY	1.24	3.08	1.76	3.25	2.63	- 0.35
LV	- 0.54	1.66	4.70	3.58	0.74	- 11.86
LT	- 1.12	0.86	1.83	2.78	- 0.48	- 8.25
LU	4.13	3.13	3.64	4.42	4.71	1.09
HU	1.26	0.23	0.73	- 0.10	- 1.19	- 2.99
MT	0.75	0.83	1.31	3.18	2.42	- 0.61
NL	2.55	0.33	1.70	2.60	1.44	- 0.11
AT	0.92	0.68	1.40	1.80	1.76	- 1.47
PL	- 0.37	- 0.61	3.21	4.43	3.78	- 0.70
PT	2.11	0.28	0.51	- 0.03	0.44	- 2.29
RO	- 1.89	- 1.35	0.69	0.36	0.28	- 3.28
SI	- 0.29	0.36	1.50	2.98	2.87	- 2.59
SK	- 0.79	0.58	2.29	2.12	2.94	- 2.04
FI	2.27	0.86	1.76	2.21	1.61	- 2.87
SE	0.82	0.22	1.69	2.16	0.91	- 2.22
UK	1.26	0.93	0.87	0.68	0.73	- 1.97
EU-15	1.47	0.86	1.49	1.60	0.70	- 1.92
EU-27	1.01	0.65	1.63	1.78	0.95	- 2.03
US	1.78	0.68	1.87	1.10	- 0.44	- 3.53

(1) Employment in persons; all domestic industries (national accounts).
(2) Geometric average.

Source: AMECO database, European Commission.

(8) For details, see Chapter 3 'Youth and segmentation in EU labour markets' in 'Employment in Europe 2010' (forthcoming).

Table 1.3: Annual growth rate of real labour productivity ([1])

	1996–2000 ([2])	2001–05 ([2])	2006	2007	2008	2009
BE	2.17	0.65	1.29	1.52	- 1.09	- 0.97
BG	1.68	3.68	3.17	2.78	2.69	- 2.94
CZ	1.94	4.47	5.03	4.04	0.51	- 0.06
DK	1.08	1.18	0.81	- 0.38	- 2.31	- 0.85
DE	2.01	1.30	2.86	0.69	- 0.04	- 2.27
EE	N/A	6.50	4.82	6.53	- 2.26	3.04
IE	5.15	3.08	1.44	3.19	- 0.17	1.45
EL	2.86	3.06	- 0.53	4.64	1.88	- 0.13
ES	0.25	0.75	0.84	1.69	0.82	4.92
FR	2.13	1.44	2.72	- 0.14	- 0.24	- 0.87
IT	0.89	0.11	0.29	0.21	- 0.94	- 1.66
CY	2.08	0.96	1.46	1.47	0.92	1.26
LV	N/A	6.95	7.96	7.53	- 1.21	- 2.22
LT	4.29	6.59	6.77	5.70	1.61	- 10.90
LU	2.61	1.34	2.29	1.44	- 4.23	- 1.57
HU	2.53	3.21	3.81	1.34	1.88	- 3.98
MT	N/A	0.85	3.95	- 0.44	- 0.79	- 1.41
NL	1.75	1.58	1.58	1.56	0.87	- 3.50
AT	1.79	1.16	2.56	2.24	0.31	- 2.38
PL	6.17	3.75	2.94	2.28	1.57	5.75
PT	3.41	0.93	1.40	2.78	- 0.40	- 0.96
RO	N/A	8.95	6.20	5.43	6.45	N/A
SI	N/A	N/A	6.03	4.54	- 1.20	- 5.53
SK	4.93	4.87	6.84	8.26	2.56	0.77
FI	2.81	2.08	3.45	2.13	- 0.34	- 1.02
SE	2.48	2.80	2.88	- 0.59	- 1.69	- 1.70
UK	2.52	1.99	2.27	1.75	1.03	- 1.95
EU-15	1.77	1.23	1.80	1.09	0.07	- 0.96
EU-27	N/A	N/A	1.77	1.09	0.01	N/A
US	2.38	2.49	0.82	1.46	1.36	N/A

([1]) GDP at 2000 prices over total hours worked.
([2]) Geometric average.

Source: AMECO database, European Commission.

1.2.2. Industrial trends

At the sectoral level, the years preceding the crisis confirmed historical trends like the faster productivity growth of manufactures compared with services (see Table 1.4), notably in high-tech sectors like chemicals and pharmaceuticals. This is also true for 'Electrical and optical equipment, including ICT manufacturing', as well as the associated service industry 'Transport, storage and communication', which includes ICT services. The highest productivity and value added growth rate was in a different high-tech sector: 'Electrical and optical equipment'. Within services, value added growth was higher for 'Transport, storage and communication' and 'Financial intermediation'; the latter was an exception in the sense that it is the only services sector with higher productivity growth than the average of manufactures. Labour-intensive services like 'Construction and real estate' display negative productivity growth due to relatively higher employment growth, probably associated with the boom described in Section 1.3 below.

Table 1.4: Sectoral labour productivity; annual average % change 1995–2008

NACE – 31 sector classification	Sector	Labour productivity	Value added	Employment
A	Agriculture	3.2	1.0	- 2.2
B	Fishing	0.0	- 1.7	- 1.7
C	Mining and quarrying	1.1	- 1.7	- 2.8
D	Manufacturing	2.6	2.1	- 0.6
DA	Food products, beverages and tobacco	0.4	0.4	0.0
DB	Textiles and textiles products	1.4	- 1.8	- 3.2
DC	Leather and leather products	- 0.8	- 3.9	- 3.1
DD	Wood and wood products	1.6	0.6	- 1.0
DE	Pulp, paper products; publishing and printing	1.9	1.0	- 0.9
DF	Coke, refined petroleum products and nuclear fuel	2.8	- 0.1	- 2.9
DG	Chemicals, chemical products and man-made fibres	4.1	3.3	- 0.8
DH	Rubber and plastic products	1.5	2.3	0.8
DI	Other non-metallic mineral products	2.1	1.2	- 1.0
DJ	Basic metals and fabricated metal products	2.3	2.1	- 0.2
DK	Machinery and equipment n.e.c.	3.0	2.2	- 0.8
DL	Electrical and optical equipment	6.3	5.9	- 0.3
DM	Transport equipment	1.8	2.7	0.9
DN	Manufacturing n.e.c.	0.3	0.9	0.6
E	Electricity, gas and water supply	2.3	1.5	- 0.8
F	Construction	- 0.4	1.1	1.5
G	Wholesale and retail trade; repair of motor vehicles	1.3	2.6	1.3
H	Hotels and restaurants	- 0.4	2.1	2.4
I	Transport, storage and communication	3.0	3.8	0.8
J	Financial intermediation	2.9	3.4	0.5
K	Real estate, renting and business activities	- 1.0	3.4	4.4
L	Public administration and defence	0.5	1.0	0.5
M	Education	0.0	0.9	1.0
N	Health and social work	0.5	2.2	1.7
O	Other community, social, personal service activities	- 0.1	2.1	2.3
Total		1.3	2.4	1.0

Source: Eurostat.

1.2.3. R & D in EU industries

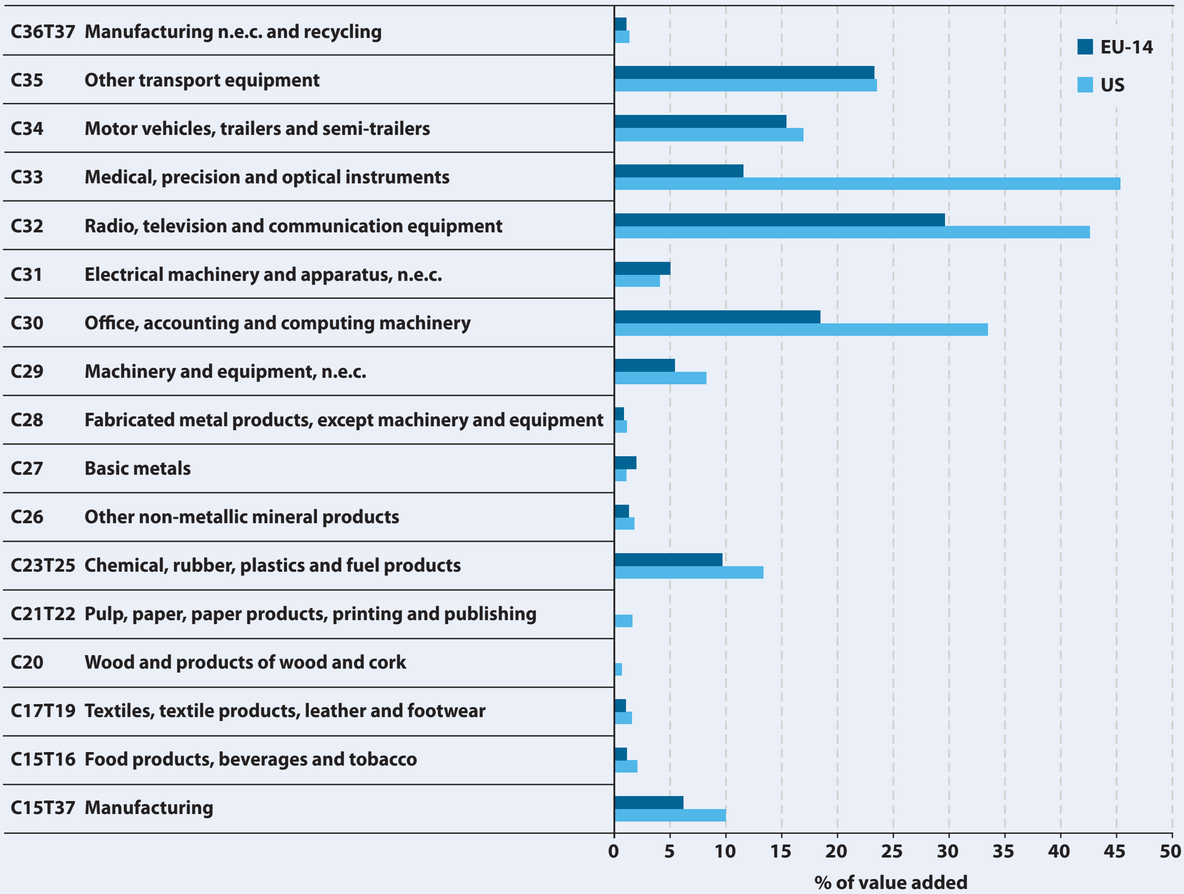
Before the crisis the US spent significantly more on R & D than the EU, both in absolute terms and as a percentage of GDP; the widest gap is in business enterprise R & D expenditure. The distribution of total manufacturing R & D expenditure shows a relatively similar pattern between the EU-14 and the US (9)(10). However, when looking at the relative effort, R & D expenditure as a percentage of value added (see Figure 1.4), it transpires that US businesses make significantly more effort than their EU counterparts, particularly in sectors considered to be high-technology. For instance, 'C33 Medical precision and optical instruments' devotes close to half of its value added to R & D in the US, compared with barely 12 % in the EU. In short, the EU does not invest enough in R & D, either in absolute or in relative terms, and a look at the sectoral distribution of R & D intensity in manufacturing clearly shows that it is the high-tech sectors that underperform compared to their American counterparts (11).

(9) The EU-14 stands for the EU-15 minus Luxembourg. No data for the EU-27 were available at this level of disaggregation.

(10) The lion's share goes to 'C23T25 Chemical, rubber, plastics and fuel products', which accounts for roughly 27 % of total manufacturing R & D expenditure on either side of the Atlantic. In the EU-14, the 'C34 Motor vehicles' sector stands out, accounting for 20 % of total manufacturing R & D, contrasting with only 10 % in the US.

(11) Even if it is debatable if these R & D expenditures are cost efficient, or what the sense is of seeking causality between R & D and performance, these differences undoubtedly reflect a thriving and innovative market economy in the US compared to the EU.

Figure 1.4: Sectoral R & D intensity



Note: Sector classification is ISIC Rev.3.1; R & D expenditure is Anberd, i.e. it includes R & D activities carried out in the business enterprise sector, regardless of the origin of funding; data for the EU-14 is 2005, for the US 2006; the EU-14 is the EU-15 minus Luxembourg; no data for EU-12 countries is available at this level of disaggregation.
Source: OECD STAN indicators (2009 edition).

1.3. Growing imbalances and external competitiveness

This period of relative stability, with the exception of the slowdown in 2001, came to an abrupt end in 2007 when signs of unrest in the US subprime mortgage market and of a slowdown started to become apparent.

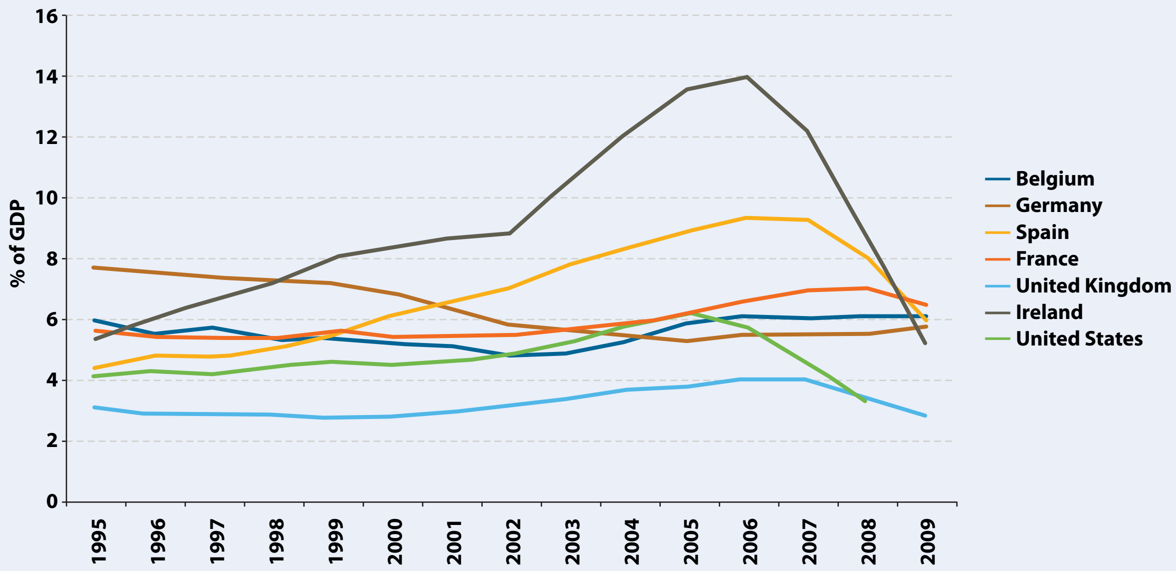
1.3.1. Soaring asset prices

Seen in retrospect, the 2000–07 period can be seen as an incubation period; these were the boom years, notably in the housing sector in the US, but also in Europe. Some Member States saw investment in dwellings — that is, housing excluding non-residential and civil engineering — increase by several points of GDP (see Box 1.2). In line with previous major recessions combined with a banking crisis, '[t]he crisis was preceded by a long period of rapid credit growth, low risk premiums, abundant availability of liquidity, strong leveraging, soaring asset prices and the development of bubbles in the real estate sector' ([12]).

This chapter examines the potential impact of the boom years on competitiveness. The accumulation of large distortions has the potential to significantly distort the way resources are allocated in European economies. The following sections examine this possibility.

([12]) From the introduction to European Commission (2009c); see Chapters 1 'Root causes of the crisis' and 2 'The crisis from a historical perspective'. See also European Commission (2010b), 'Surveillance of intra-euro-area competitiveness and imbalances'.

Figure 1.5: The rise in investment in dwellings



Note: Investment in dwellings does not comprise non-residential construction and civil engineering.
Source: AMECO database, European Commission.

Box 1.2: Accumulated distortions

For a decade or more in some countries, notably the UK, Denmark, Ireland and Spain, house prices increased over their fundamental value. Prices went up because economic players expected them to increase in a speculative spiral that made investment in dwellings attractive to households compared to other forms of investment. The distortion did not affect all countries, but where it did it was not a minor one. In countries like Spain, for instance, at the height of the boom period, around 2005–06, house prices increased by 15 % a year ([13]).

This means that for years millions of households and firms made consumption-saving decisions counting on trends in the price of houses that subsequently proved to be unsustainable. Households invest most of their savings in property. Large and sustained increases in the price of houses led them to overinvest in housing and to overstate their wealth, pulling down their savings rate. If houses constituted an attractive investment for locals, the same was true for foreigners, directly or indirectly. In 2000–06, on average, countries with a large housing boom also experienced a substantial change in their lending/borrowing position. In some cases it was a dramatic change; Spain for instance was a net lender by the end of the 1990s and was borrowing almost 10 % of its GDP annually in 2007. To see this graphically, the housing bubble can be linked to the increase in investment in dwellings, measured in percentage points of GDP, during the boom period: Figure 1.6 relates the housing bubble during 2000–06 to the change in the net lending/borrowing position in the same period. With regard to this figure, countries like Germany and Austria appear to have become lenders to countries like Spain, Ireland and Estonia ([14]).

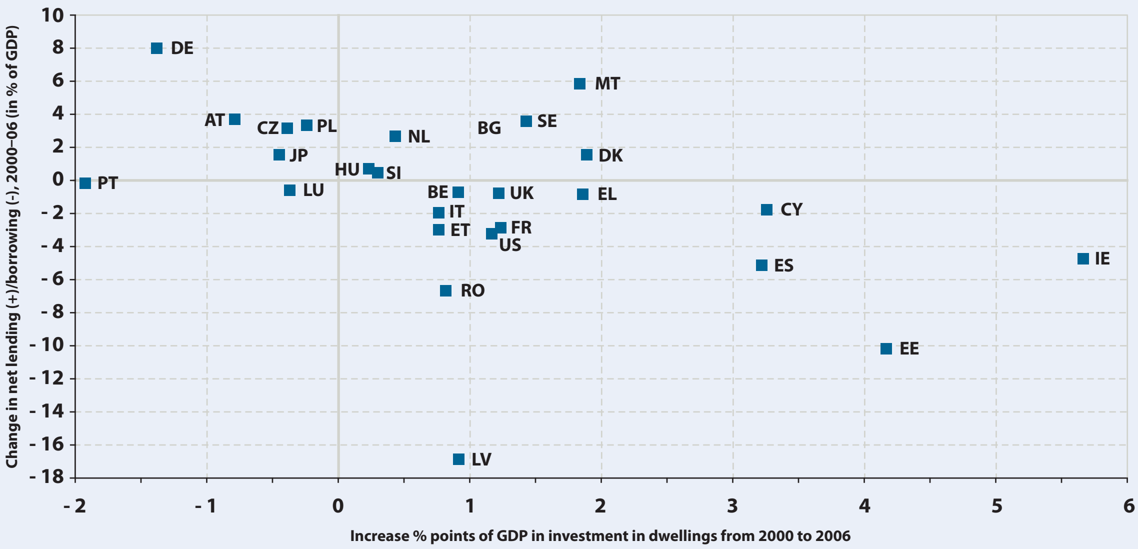
([13]) For Spain and Ireland see, for instance, Ahearne et al (2008) or Díaz and Raya (2009). For an overview of EU countries see Setzer, van den Noord and Wolff (2010).

([14]) This is further clarified by the examination of the Bank of International Settlements' consolidated bank statistics; see pp. 18–21 in the *BIS Quarterly Review*, June 2010.

These flows of capital further fuelled the behaviour of households, misguided by the trend in housing prices. The rising consumption rate financed by these incoming flows of capital induced a deterioration of the commercial balance with the rest of the world (see Figure 1.7 and 1.8). When the boom came to an end, accumulated distortions gave way to the corresponding adjustment process. Once the value of houses drops — or is thought to be going to drop in the future — a large portion of perceived wealth vanishes, leading to a major adjustment of consumption and saving. Consumption drops and saving increases to rebuild net wealth. Moreover, if liabilities are substantial with respect to assets, the saving rate will grow further in an effort to deleverage. In the countries most affected by the housing bubble the increase in the savings rate in 2007–09 ranges from 3 percentage points of disposable income in the UK to 11 points in Spain. That these increases are related to the previous intensity in investment in dwellings is illustrated in Figure 1.9 ([15]).

Likewise, the countries that accumulated a sizeable deterioration of net exports during the boom years (Figure 1.7) were those that suffered most from the subsequent collapse of private consumption at the outbreak of the crisis (see Figure 1.9 and 1.10).

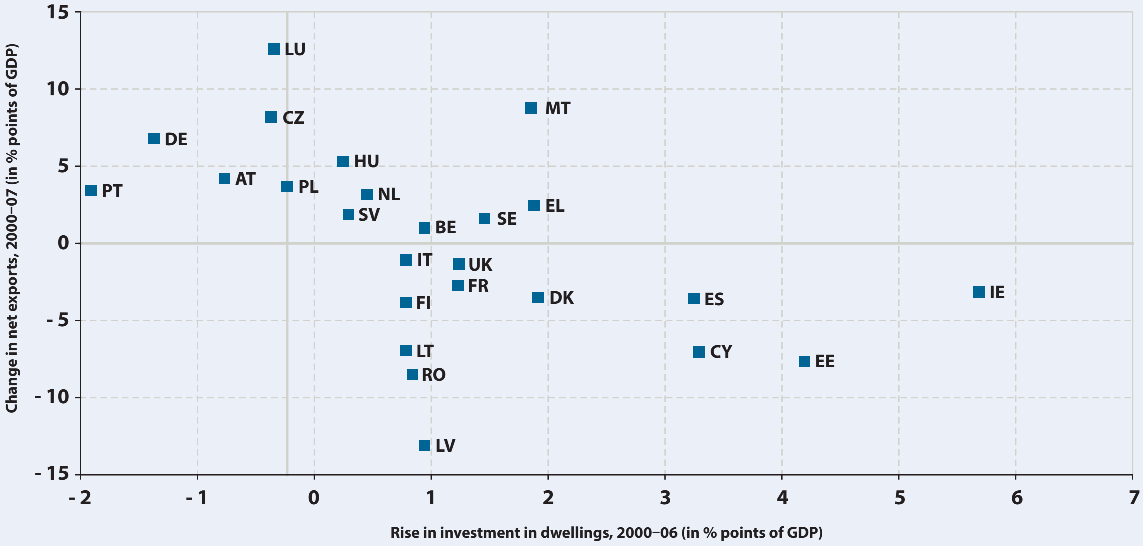
Figure 1.6: Investment in dwellings and net lending/borrowing



Source: AMECO database, European Commission.

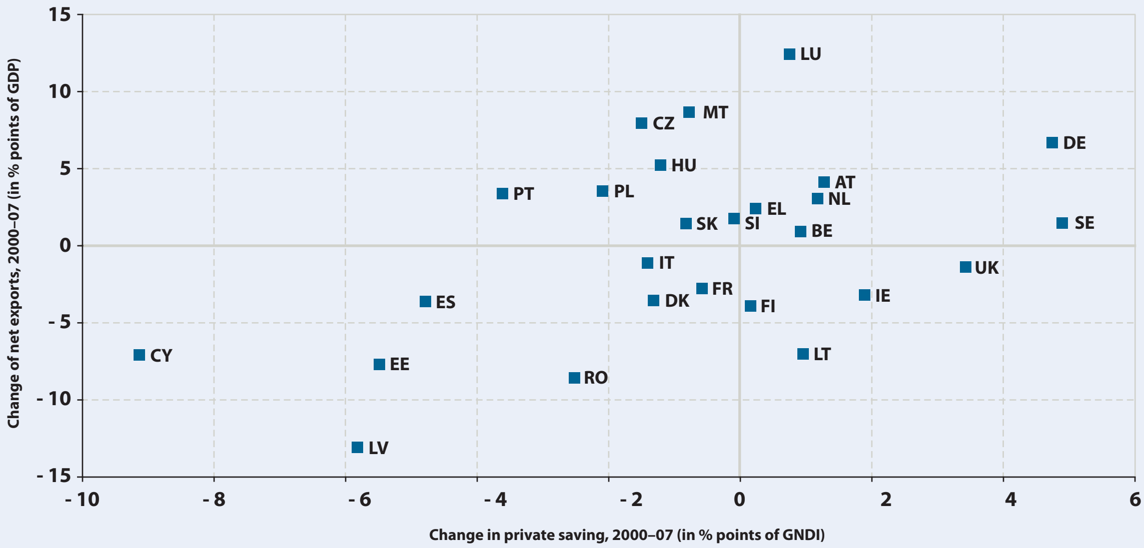
([15]) For a description of the mechanics and magnitude of the adjustment in the US, see Robert A. Solow (2009), 'How to understand the disaster', *New York Review of Books*, 56(8). Retrieved 20 May 2010 from http://www.nybooks.com/articles/22655

Figure 1.7: Changes in net exports 2000–06



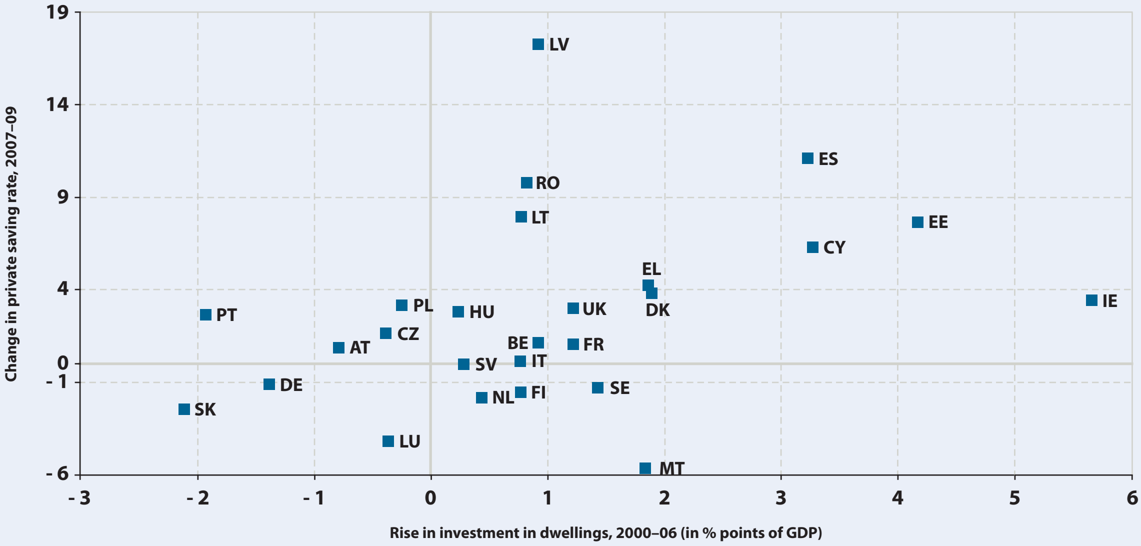
Source: AMECO database, European Commission.

Figure 1.8: Changes in saving rates and net exports 2000–06



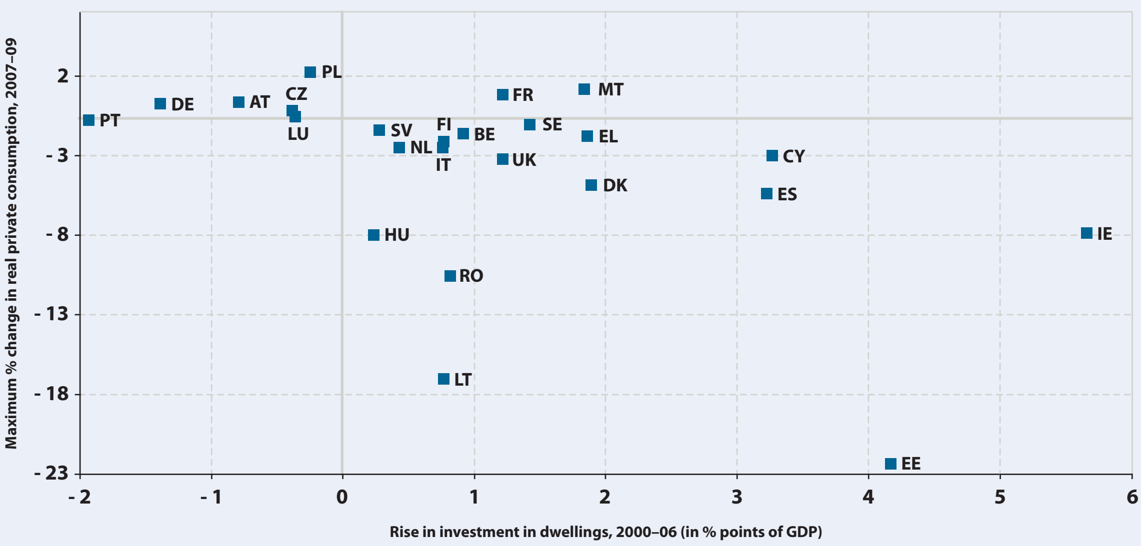
Source: AMECO database, European Commission.

Figure 1.9: The rise in the private saving rate 2007–09



Source: AMECO database, European Commission.

Figure 1.10: The fall in private consumption 2007–09



Source: AMECO database, European Commission.

Table 1.5: A summary view of the bubble

		Boom period					Crisis	
Country		Increase in % points of GDP in investment in dwellings 2000–06	Change in net lending 2000–06	Change in private saving 2000–07 (% GNDI)	Change of net exports 2000–07 (in % points of GDP)	Change in private saving 2007–09 (% GNDI)	% fall in private consumption from 2007–08 to 2009	% fall in GDP from 2008 to 2009
Belgium	BE	0.92	- 0.76	0.93	0.92	1.15	- 1.64	- 2.01
Czech Republic	CZ	- 0.39	3.07	- 1.51	7.99	1.65	- 0.20	- 1.68
Denmark	DK	1.89	1.55	- 1.32	- 3.60	3.85	- 4.84	- 4.47
Germany	DE	- 1.39	7.93	4.76	6.72	- 1.13	0.23	- 3.55
Estonia	EE	4.17	- 10.20	- 5.50	- 7.71	7.67	- 22.30	- 14.58
Ireland	IE	5.66	- 4.69	1.89	- 3.25	3.44	- 7.86	- 10.05
Greece	EL	1.86	- 0.90	0.23	2.41	4.28	- 1.79	- 0.69
Spain	ES	3.23	- 5.20	- 4.80	- 3.65	11.13	- 5.41	- 3.43
France	FR	1.22	- 3.01	- 0.57	- 2.77	1.07	0.82	- 1.44
Italy	IT	0.76	- 1.99	- 1.40	- 1.17	0.17	- 2.50	- 3.00
Cyprus	CY	3.27	- 1.88	- 9.16	- 7.10	6.31	- 3.01	- 1.75
Latvia	LV	0.92	- 16.96	- 5.82	- 13.12	17.29	- 26.62	- 18.62
Lithuania	LT	0.77	- 3.00	0.96	- 7.07	7.95	- 16.99	- 16.94
Luxembourg	LU	- 0.37	- 0.69	0.75	12.47	- 4.19	- 0.56	- 4.05
Hungary	HU	0.24	0.52	- 1.20	5.25	2.82	- 7.98	- 1.69
Malta	MT	1.84	5.79	- 0.78	8.69	- 5.66	1.16	0.26
Netherlands	NL	0.43	2.60	1.18	3.10	- 1.81	- 2.51	- 4.31
Austria	AT	- 0.79	3.61	1.28	4.11	0.89	0.36	- 1.77
Poland	PL	- 0.25	3.25	- 2.10	3.55	3.19	2.25	5.42
Portugal	PT	- 1.93	- 0.23	- 3.63	3.37	2.65	- 0.79	- 1.54
Romania	RO	0.82	- 6.73	- 2.53	- 8.59	9.79	- 10.54	- 4.54
Slovenia	SI	0.28	0.38	- 0.09	1.76	- 0.02	- 1.41	- 6.04
Slovakia	SK	- 2.12	- 5.08	- 0.82	1.44	- 2.44	- 0.67	- 5.79
Finland	FI	0.77	- 2.97	0.16	- 3.94	- 1.52	- 2.12	- 7.17
Sweden	SE	1.43	3.48	4.92	1.48	- 1.29	- 1.07	- 3.09
United Kingdom	UK	1.22	- 0.77	3.44	- 1.37	3.00	- 3.22	- 3.63
United States	US	1.17	- 3.20	0.26	- 1.23	4.57	- 0.85	- 1.28
Japan	JP	- 0.45	1.44	- 0.46	0.22	- 0.15	- 1.67	- 6.12

Source: AMECO database, European Commission.

1.3.2. Growing distortions and external competitiveness

Growing imbalances during the boom period could have had an impact on factors that will condition productivity growth, and hence could affect the performance of some Member States beyond their recovery from the recession (see Box 1.3). For instance, the real estate boom could have diverted resources from productive sectors, damaging productivity growth, or nominal wage inflation could erode the international competitiveness of domestic firms, notably in countries within the euro area.

In particular, much attention has been paid to the large changes in the trade balance of many countries illustrated in Figure 1.7. The excess of imports over exports is often associated with a loss of external competitiveness.

As the story goes, so-called surplus countries like Germany were able to compete more effectively in international markets (e.g. by keeping wages low) and then invested abroad the surplus of its trade balance, thus financing the commercial deficit of other less well-performing countries, the deficit countries like Spain. This view, however, cannot explain some of the key facts discussed in Box 1.2. In particular, it does not explain why the 'surplus' countries typically saw their saving rate soar during the boom period while deficit countries experienced the opposite, as illustrated in Figure 1.8 ([16]).

The remainder of this section argues that the deterioration of the trade balance is only reflecting capital flows — in turn reflecting differences in asset prices across countries — and that external competitiveness, as measured by export performance, was neither playing an important role in this deterioration nor being substantially affected by these developments. In other words, as we shall discuss below, in the EU trade deficits were related to significant capital flows within Member States while external competitiveness seemed to be more related to developments in productivity.

1.3.3. Rising unit labour costs, cause or consequence?

The boom years witnessed a major increase in unit labour costs (ULC) in certain countries, generally the so-called deficit countries. It has been suggested that large increases in ULC could explain, if not the crisis, at least its depth and duration.

However, the development of ULC does not seem to have had a significant effect beyond being associated with corresponding increases in the general level of prices. As discussed below, if there is a relation between ULC and export performance, it is weak and of a secondary order of magnitude compared with the deterioration of the trade balance (and hence the former cannot be the cause of the latter).

A bubble economy may affect the development of wages because the inflows of capital will not be entirely directed to the demand for foreign goods. As these flows increase demand for domestic goods beyond productivity, domestic prices will rise, thereby applying upward pressure on nominal wages and increasing ULC. But this is a nominal effect, not necessarily affecting real wages in net terms ([18]).

Figure 1.11(a) can thus be seen as not only reflecting a logical relation between nominal wages and prices, but also suggesting that real wages did not deviate from productivity that much during the boom period. This can be seen from the absence of any link between nominal unit labour costs and the share of 'compensation of labour' in national income, i.e. real unit labour costs, in Figure 1.11(b). Changes in the general level of prices have brought down real wages and left labour's share of income at its slightly declining level of recent years.

Box 1.3: Imbalances do not (necessarily) reflect distortions

If two trading countries, for whatever institutional reasons, have two different saving rates, they will always have a commercial deficit and surplus respectively, because the saving country will permanently finance a level of imports higher than exports in the consuming country. This type of equilibrium is sometimes said to entail an 'imbalance' in the literature ([17]). However, as long as prices correctly reflect preferences and technology, it does not need to reflect any fundamental problem. A typical case would be fast catching-up developing countries that constitute attractive investment opportunities.

In contrast, when some prices are sending the wrong signal, similar 'imbalances' may be reflecting true distortions that, accumulated, may lead to an adjustment process that can take the form of a recession like the current one. The flows of capital referred to in Section 1.3.1 reflected the overpricing of certain assets in certain countries. Correcting this deviation of prices from the fundamental value of the assets was the first stage in readjusting the consumption-saving behaviour of households and was the ultimate cause of the downturn.

In other words, an 'imbalance' may or may not signal an underlying problem, depending on whether it reflects some mispricing. That is most likely the reason why even *ex post* there is no consensus on whether the so-called 'global imbalances' are at the origin of the crisis (see Suominen (2010) and references therein).

([16]) Box 1.5 below examines in detail the cases of Germany and Spain. Both before and during the crisis, these countries constitute two polar cases as far as the experience of the last decade is concerned.

([17]) In European Commission documentation an imbalance only occurs when there is a market or policy failure. Hence, housing bubbles like those examined in this chapter would be indeed classified as an imbalance.

([18]) Even inside a monetary union, this nominal effect is not necessarily translated into a real effect; it will depend on the extent to which these wage distortions are concentrated in non-tradables or tradables sectors; see Box 1.4 below.

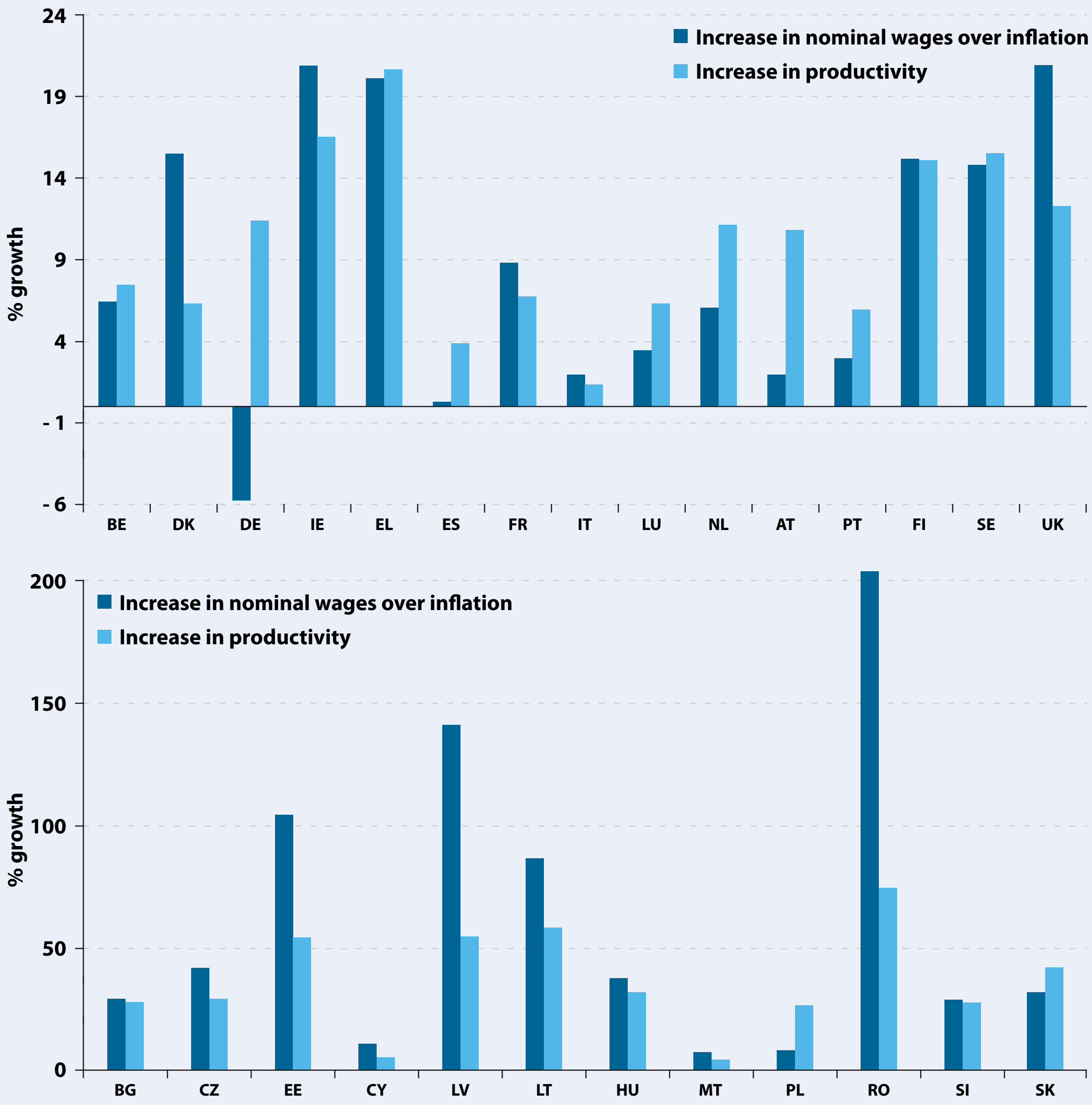
To test this conjecture one can compare the increase in nominal wages over the general level of prices with the increase in productivity. This is done in Figure 1.12, where it can be seen that, with some exceptions, wherever nominal wages increased over the general level of prices during the boom years, it was because productivity was increasing by a similar magnitude. That real wages have not grown beyond productivity in most European economies is confirmed by the general downward trend of the share of wages in national income during 2000–07: for the EU-27 as a whole, prices (harmonised index of consumer prices) grew by 18 % and ULC by 14 %, and the share of labour in income fell by 5 % (see again Figure 1.11(b)) ([19]).

Figure 1.11: Rising unit labour costs, inflation and the share of labour in income

Source: AMECO database, European Commission.

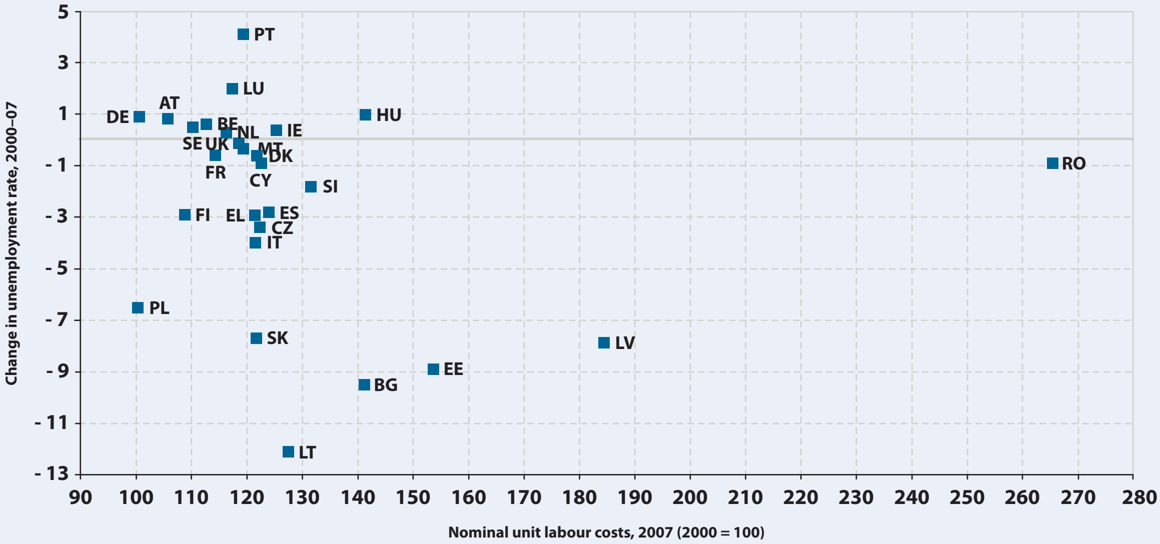
([19]) Manipulating the definition of ULC, one can prove that the gap between the growth rates of ULC and the general level of prices is approximately the percentage change in the share of wages in income.

Figure 1.12: Real wages and productivity: changes 2000–07



Source: AMECO database, European Commission.

Figure 1.13: Rising unit labour costs and unemployment



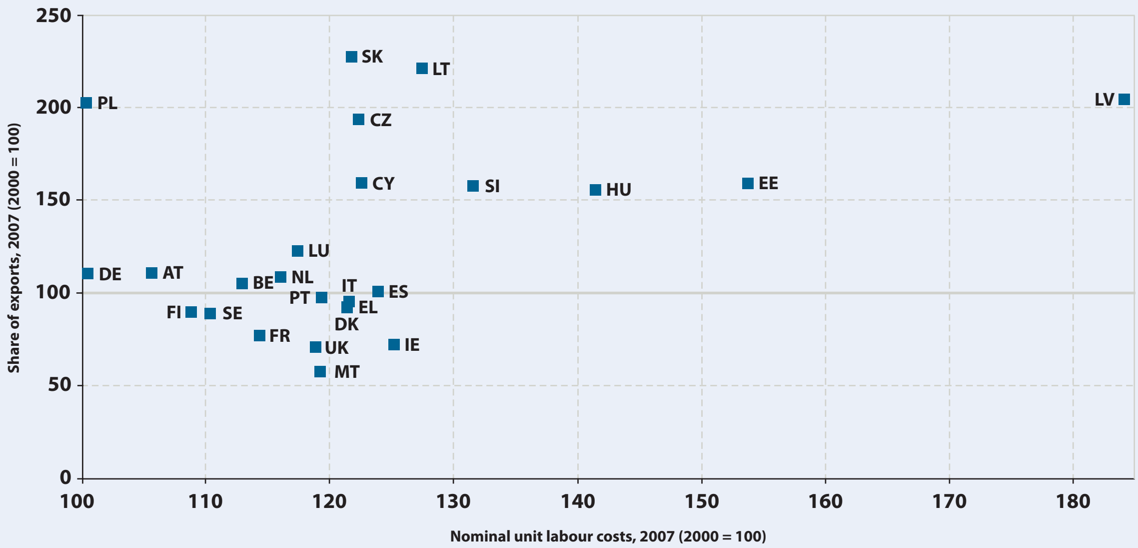
Source: AMECO database, European Commission.

It is not surprising, then, that the rise in unit labour costs bears no relation to the changes in unemployment rates during this period (Figure 1.13). In short, labour market institutions do not seem to have played any great role in the boom period beyond their ability or inability to track productivity without causing inflation (mostly in non-tradables sectors, see Box 1.4).

1.3.4. World market shares

The emphasis on nominal labour costs is generally justified by the open character of our economies. However, exports' performance, as measured by world market shares, does not seem to be affected by changing labour costs either — even if there is a good reason for this to be the case in theory, at least within the euro area.

Figure 1.14: Rising unit labour costs and changing world market shares



Source: AMECO database, European Commission.

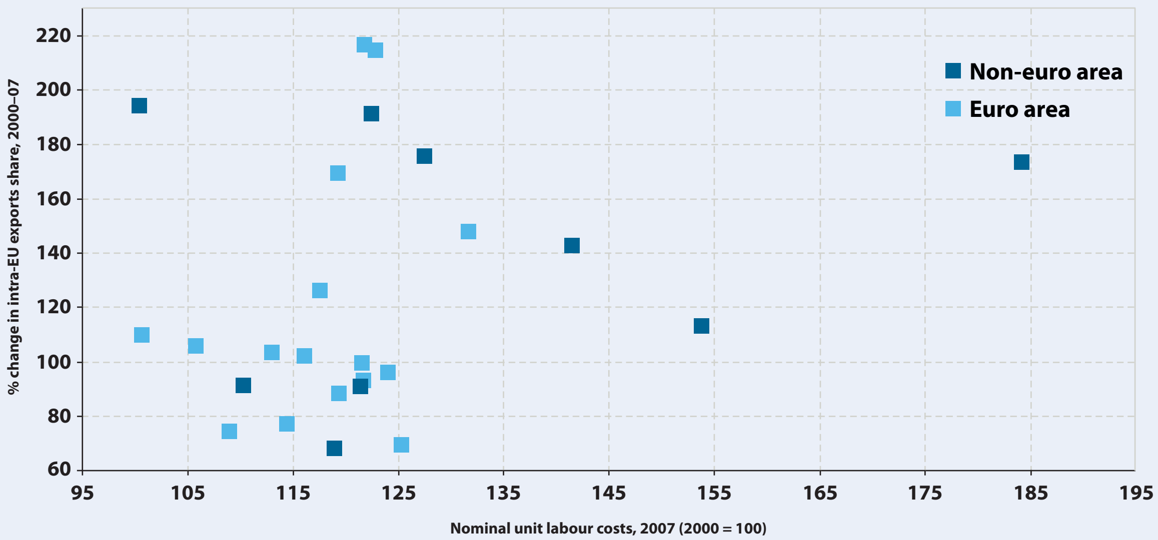
In principle, increasing the nominal cost of labour may affect the competitive position of domestic firms in international markets. This is particularly true in countries in a monetary union where there is no national currency, and hence no possibility of depreciation or devaluation. However, Figure 1.14 compares the changes in nominal unit labour costs in the boom period with changes in world market shares as measured by the share of exports in total world exports; the only obvious fact that arises from this chart is the large expansion in EU-12 Member States in this post-enlargement period. Focusing on intra-EU trade and distinguishing between euro area and non-euro area countries does not reveal any obvious pattern either.

One possible explanation for the lack of any relation between ULC and export shares is that trading sectors face competitive pressures that prevent nominal wages growing much faster than productivity or, alternatively, limit the ability of firms to pass the increasing cost of labour through to higher prices. There is some evidence for this (see Box 1.4).

The share of exports in world exports for most European countries has been roughly constant or decreasing since 2000. This general decreasing trend is most likely due to a compound effect resulting from the fast increase of the level of trade during this period, in turn due to the rise of emerging economies.

The focus, however, should be on Figure 1.18. It is in regard of this figure that it is clear that countries with a housing bubble — inside the euro area like Spain or outside it like Denmark — retained their market share reasonably well. Germany increased its export share by 10 % but the contribution of intra- and extra-EU trade is roughly the same; France lost ground in both intra- and extra-EU markets, and by the same magnitude as the UK, which is not in the euro area. This is evidence against the hypothesis that countries like Spain or France, with relatively high unit labour costs, have lost market shares to countries like Germany, with lower unit labour costs, because of a deterioration of 'cost-competitiveness' in the euro area.

Figure 1.15: Rising unit labour costs and intra-EU trade for euro and non-euro areas



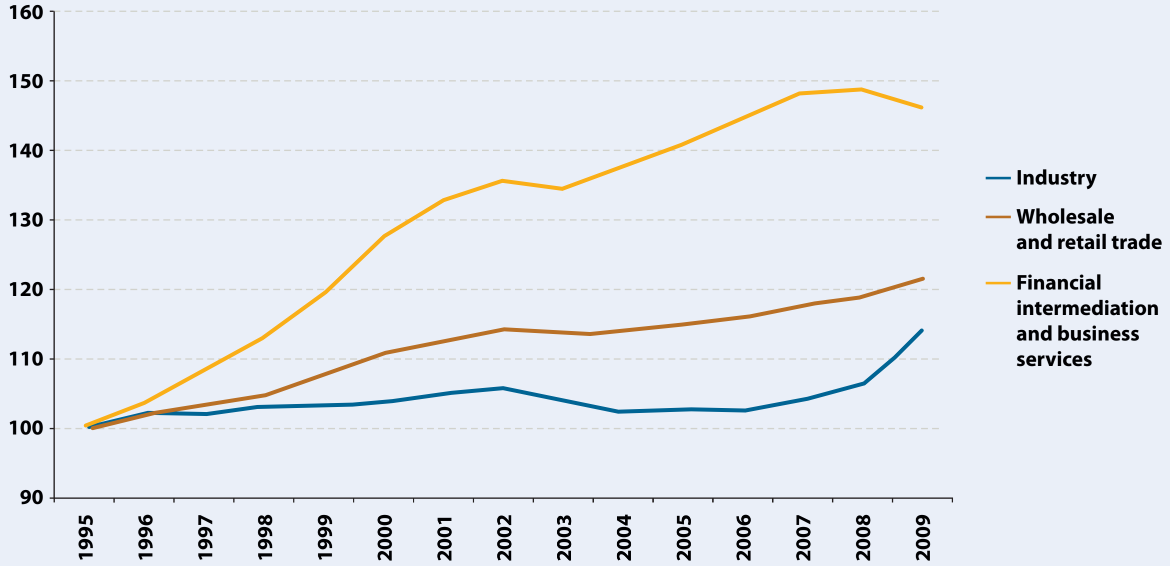
Source: AMECO database, European Commission.

Box 1.4: Unit labour costs in tradables and non-tradables

Most economic activity in large countries is domestic. The aggregate evolution of unit labour costs (ULC) may reflect wage developments in sectors not exposed to trade. A case in point is that of Spain, an economy displaying one of the largest housing bubbles as well as one of the largest increases in ULC. In the boom times the general level of prices rose by 24 %, 8 points above euro area inflation. Nevertheless, the deflator of exports rose by 15 %, a point below the euro area level. This is no exception: the long-term behaviour of ULC differs between tradables and non-tradables as illustrated in Figure 1.16 for the EU as a whole.

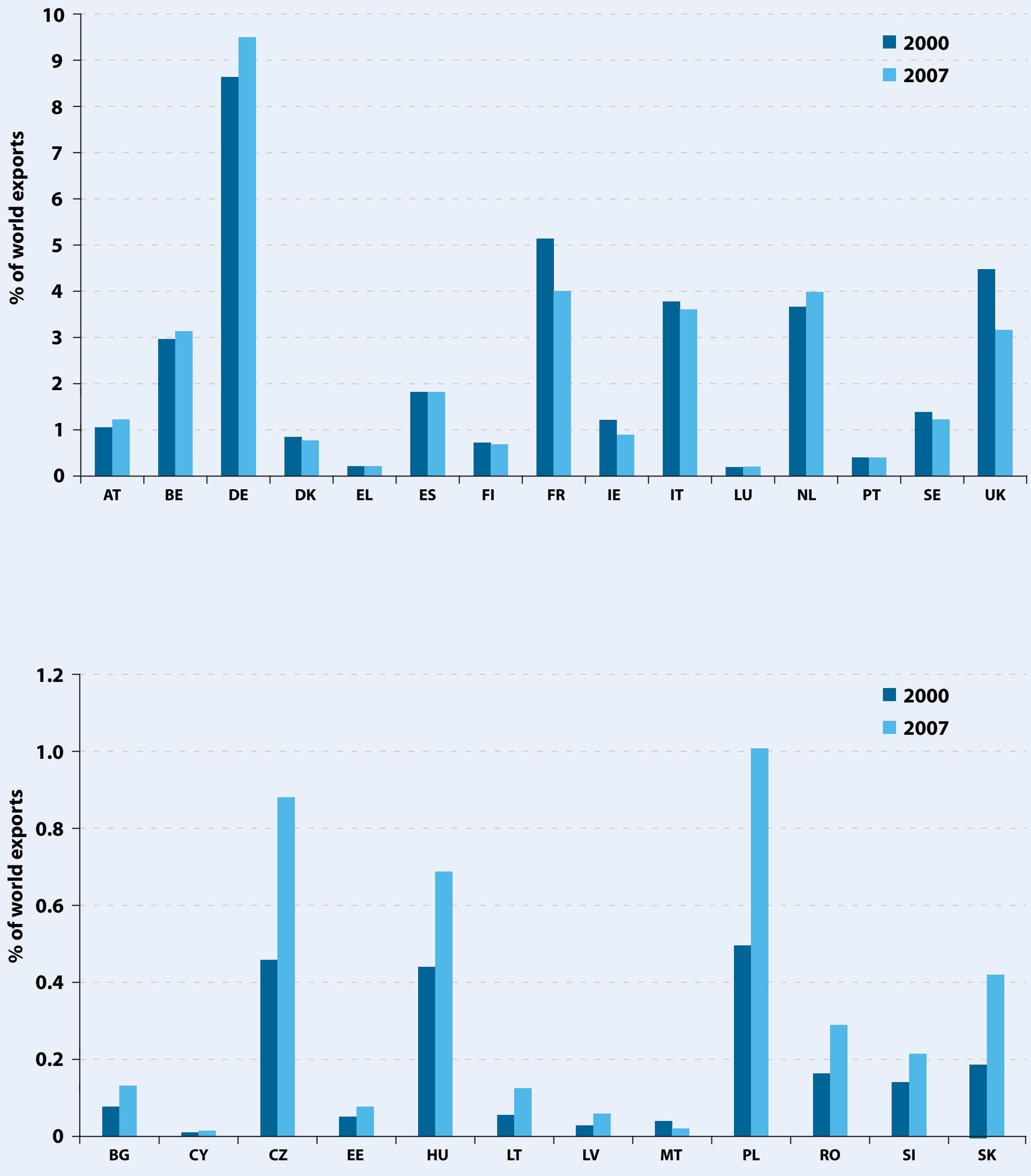
This differing behaviour may stem from two different forces. On the one hand, industry, typically producing tradables, is more exposed to international competition than are services. On the other hand, the faster productivity growth in manufacturing compared with services may also explain a large share of this differing behaviour.

Figure 1.16: Sectoral unit labour costs in the EU-27; index 1995 = 100



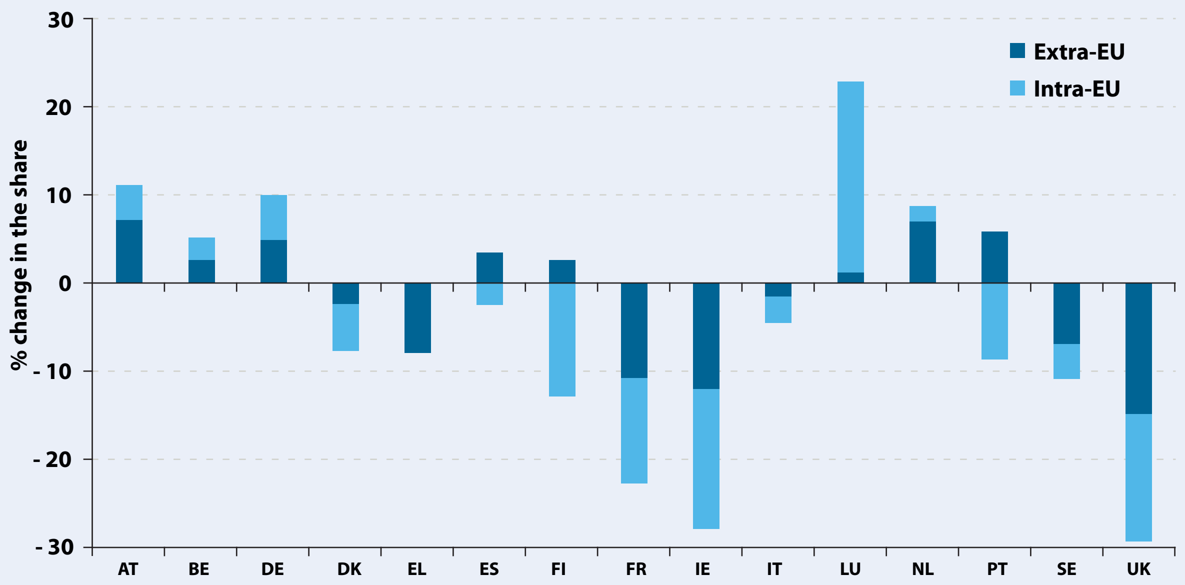
Source: European Union, *Industrial structure 2011* (forthcoming).

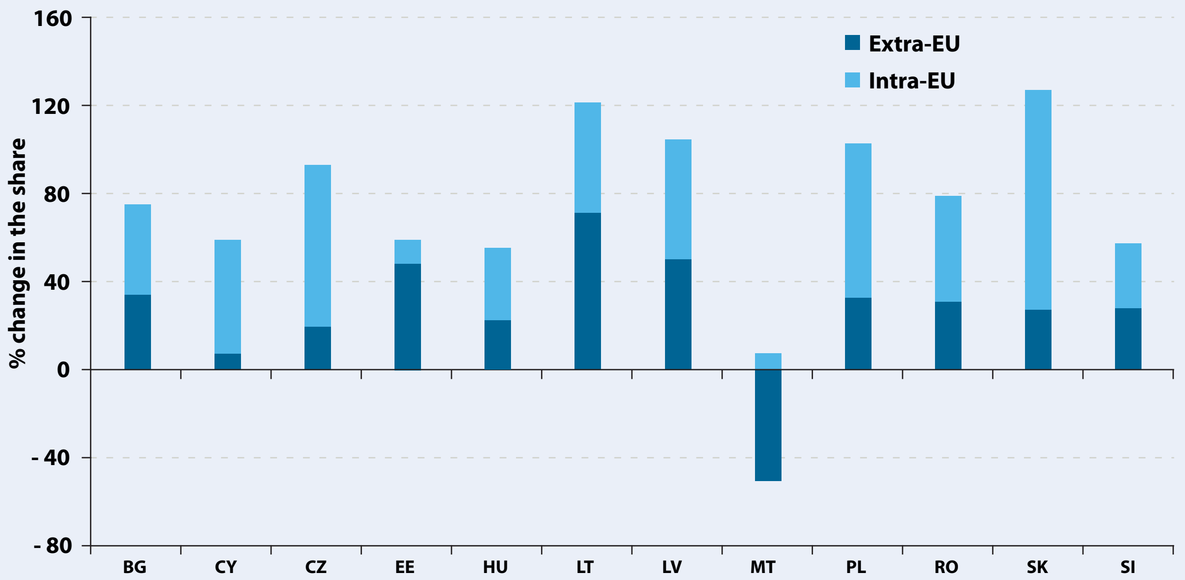
Figure 1.17: Share of exports in world exports 2000–07



Source: AMECO database, European Commission.

Figure 1.18: Contribution to changes in the share of exports in world exports 2000–07 by extra- and intra-EU trade





Source: AMECO database, European Commission and own calculations.

1.3.5. Summary

In short, net exports only reflect capital flows caused by mispriced assets, not losses of external competitiveness. In fact, there is no clear relation between the real estate bubble and the performance of exports during the boom period. In other words, the growing imbalances of the boom period do not seem to have had a very clear impact on external competitiveness; if any impact, this happened through growing nominal labour costs, and of a secondary order of magnitude compared with the accumulated imbalances and the ensuing contraction ([20]).

What about productivity growth? If large capital inflows during the boom period are not used productively to eventually generate resources to pay back the external debt, they are hampering the ability of countries to generate income in the future while at the same time increasing the interest burden on these economies.

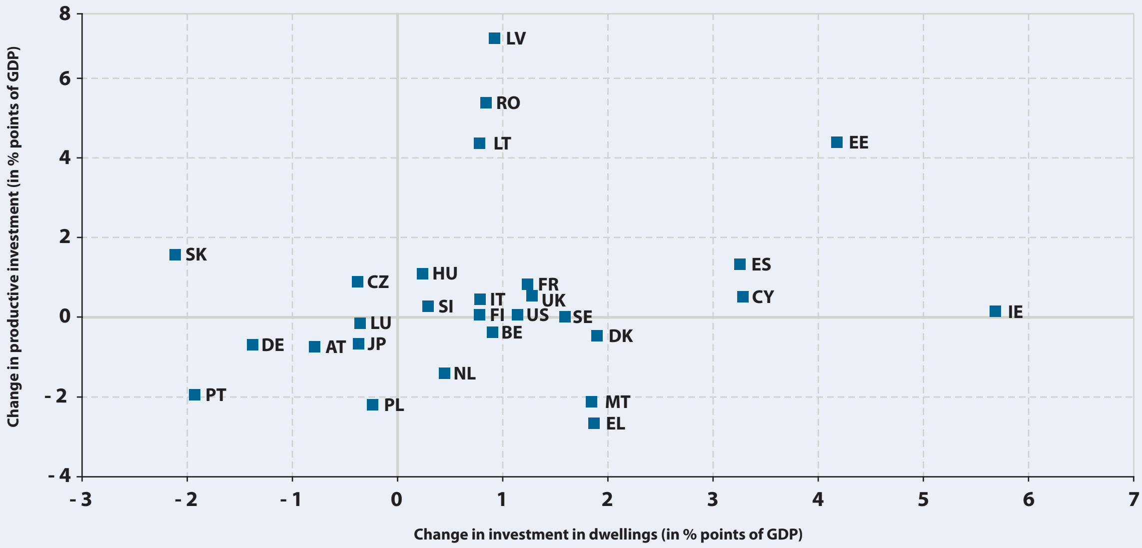
This is the possibility explored in the next section.

1.4. The impact of the boom on industry and competitiveness

From the discussion in the previous section, the boom period does not seem to have had any obvious impact on external competitiveness as measured by the ability to maintain export shares. True, the boom period has affected nominal wages and prices but there is no systematic impact on exports. Countries like France with moderate increases in ULC or even reductions in real effective exchange rates (REER) ([21]) have lost substantial international market shares (see again Figure 1.18) while others, like Spain, with large increases in ULC and REER, have more or less kept their market shares.

Nevertheless, this lack of impact on exports (external competitiveness) does not rule out the possibility that these developments may have distorted the way resources are allocated within countries and across sectors, hampering productivity growth in the years to come (competitiveness as productivity growth).

Figure 1.19: Changes in productive investment and investment in dwellings in 2000–06



Source: AMECO database, European Commission.

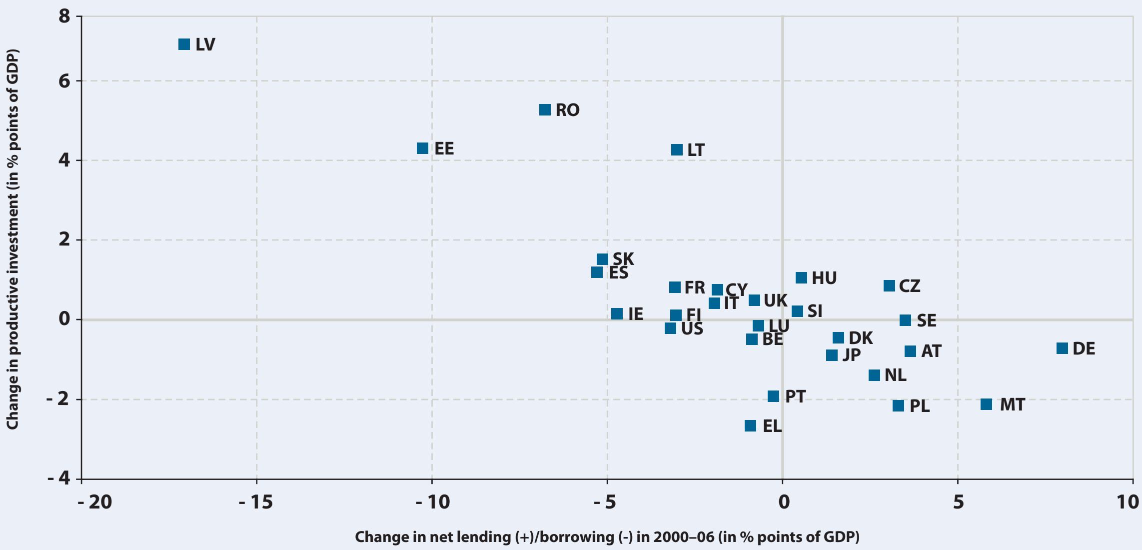
([20]) At this point it may be worth recalling that this chapter examines the impact of growing imbalances in competitiveness and external competitiveness. To conclude that the evolution of the ability to export does not seem to bear a clear relationship to these imbalances is not to say that they are not fundamental to understand the crisis and the recovery. First, countries more affected by these distortions tended afterwards to be more hard hit by the recession, as illustrated in Figure 1.10. Second, the accumulation of imbalances yielded in many cases a leveraged household and corporate sector — this is a promise of a slow recovery in countries affected by the bubble (see Kocherlakota (2010) and McKinsey Global Institute (2010)).

([21]) The real effective exchange rate (REER) is another common indicator of external competitiveness; see Graph I.1 in European Commission (2010a).

1.4.1. Has the housing bubble crowded out productive investment?

The most obvious distortion one would expect is not apparent: it does not seem that investment in dwellings crowded out productive investment at the aggregate level. (Productive investment here is gross fixed capital formation excluding dwellings but including non-residential construction and civil engineering.) In other words, countries that increased considerably their investment in dwellings also increased their productive investment.

Figure 1.20: Changes in lending/borrowing position and productive investment in 2000–06



Source: AMECO database, European Commission.

Box 1.5: Two polar cases

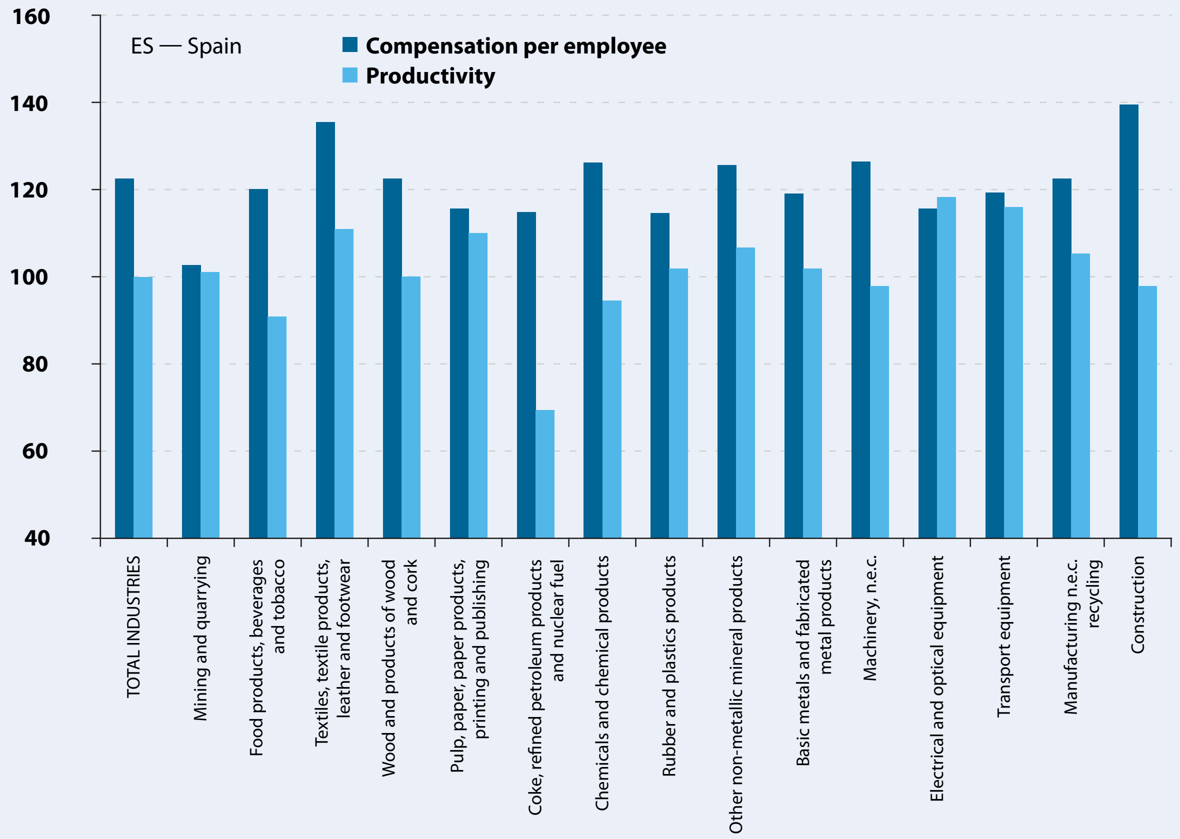
The cases of Spain and Germany illustrate two contrasting experiences in the boom period. Examining the different paths followed by these two economies may help us to understand the imbalances and the different behaviour during the subsequent adjustment.

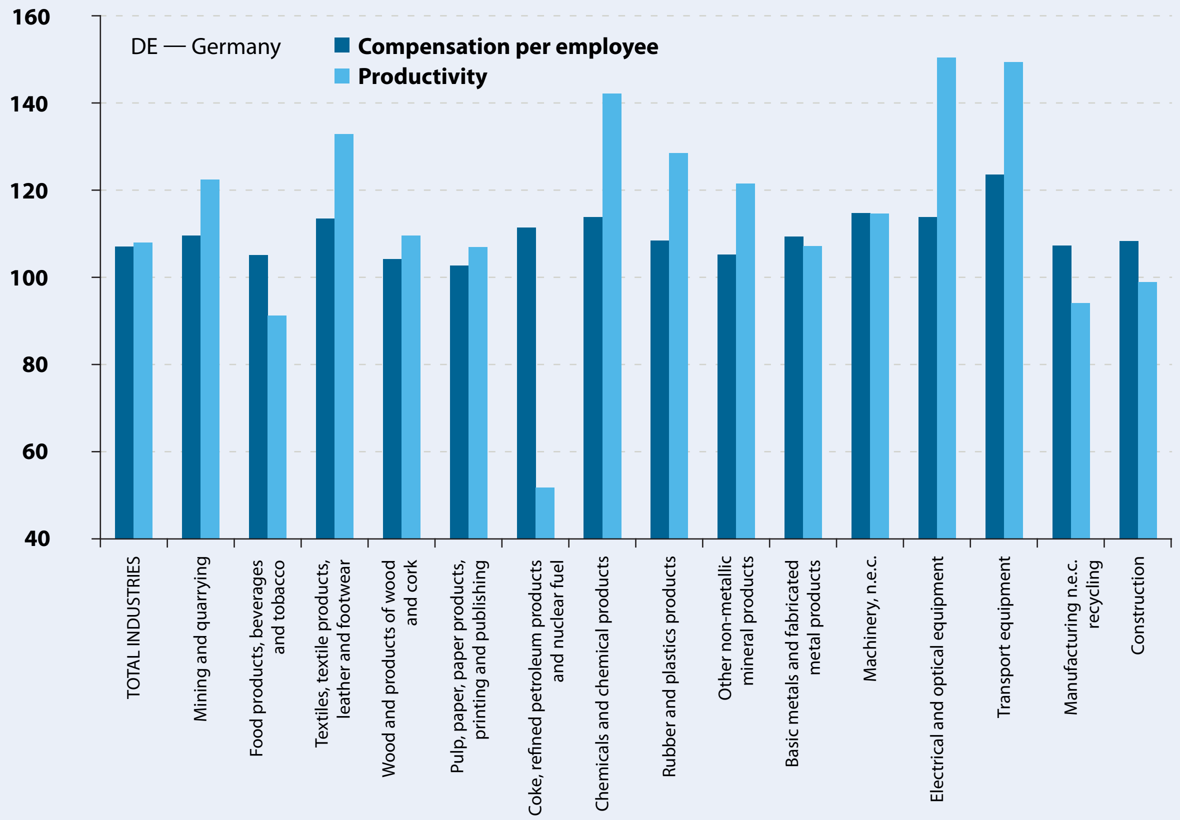
One major argument is that unit labour costs are not growing enough in Germany. Figure 1.21 shows for 2000–07 nominal compensation per employee and productivity defined as real value added per person in employment in the respective sector.

A glance at these charts reveals two significant differences. First, unit labour costs (ULC), the ratio of these indexes, are increasing in all sectors in the Spanish economy and decreasing in most German sectors. Second, productivity is up in most German sectors, often on a significant scale, while for Spanish sectors productivity is either falling or growing only modestly. In the light of the discussion about the role of aggregate ULC and export performance in the previous section, the second fact is more likely to be the relevant one, and the one explaining the roughly 10 % increase in market share of German exports in 2000–07.

This interpretation is further strengthened by Table 1.6. As mentioned above, the two countries differ markedly in their experience over recent years. In particular, ULC increased significantly in Spain during the boom period. However, these differences are not reflected in the distribution of exports between the EU and the rest of the world. If anything, between 2000 and 2007 Spain displays a slight bias towards low-tech exports. For Germany there is no obvious trend; this is consistent with Figure 1.18 above, where the increase in the world market shares of Germany is shown to be due as much to intra-EU trade as to extra-EU trade.

Figure 1.21: Nominal wages and productivity in 2007 (index 2000 = 100)





Source: EU KLEMS research database and own calculations.

Table 1.6: Export characteristics — A comparison between Germany and Spain

		Germany				Spain			
		Share of exports over total exports		Share of exports to the EU over total exports		Share of exports over total exports		Share of exports to the EU over total exports	
		2000	2007	2000	2007	2000	2007	2000	2007
CTOTAL	GRAND TOTAL	100.0	100.0	63.2	63.3	100.0	100.0	72.4	70.0
C01T05	Agriculture, forestry and fishing	0.9	0.7	65.9	75.1	6.0	5.4	90.7	90.0
C10T14	Mining and quarrying	0.2	0.2	80.5	79.1	0.5	0.5	51.8	46.4
C15T37	Total manufacturing	96.0	91.2	63.3	62.1	91.6	91.4	72.2	70.1
C15T16	+ Food beverages and tobacco	4.0	3.9	80.9	81.4	8.1	8.6	71.9	74.9
C17T19	+ Textiles leather and footwear	3.8	2.7	74.6	72.9	6.4	5.5	67.4	66.4
C20	+ Wood and cork	0.6	0.7	70.7	72.4	0.7	0.7	73.2	72.3
C21T22	+ Pulp paper printing and publishing	3.2	2.8	72.9	73.2	3.1	2.5	69.7	74.8
C23T25	+ Chemical rubber plastics and fuel	17.1	18.3	59.0	62.7	16.2	19.9	62.7	58.3
C26	+ Non-metallic products	1.4	1.2	64.2	63.1	3.3	2.9	60.1	64.8
C27T28	+ Basic metals and fabricated metal products	7.9	9.0	68.8	67.5	7.8	9.9	69.4	75.2
C29T33	+ Machinery and equipment	33.0	30.2	60.0	53.5	16.3	14.4	68.9	64.1
C34T35	+ Transport equipment	23.2	21.2	62.6	63.3	27.5	25.3	84.0	80.1
C36T37	+ Manufacturing n.e.c. and recycling	1.9	1.8	66.2	71.2	2.3	1.7	65.9	68.5
HITECH	High technology manufactures	19.1	17.3	60.8	61.1	9.3	9.5	70.8	68.8
MHTECH	Medium-high technology manufactures	48.0	46.7	59.8	57.3	42.9	41.4	79.1	74.7
MLTECH	Medium-low technology manufactures	14.1	15.9	67.4	66.4	18.8	21.6	60.0	60.3
LOTECH	Low technology manufactures	13.4	11.9	74.7	75.5	20.6	19.0	69.5	71.8
ICTMAN	ICT manufactures	11.3	8.9	66.7	60.7	6.0	4.0	76.0	78.0

Source: OECD STAN bilateral trade and own calculations.

If there is any distortion, it is that countries engaged in heavy borrowing have also increased their productive investment. It is a small effect, though; from Figure 1.20 it is clear that the largest changes in productive investment in 2000–06 occurred in new Member States, which were also the target of substantial foreign direct investment.

1.4.2. Employment growth in construction and real estate services

In 2000–07 employment in the EU-27 increased by more than 6 %, from 211 million to 224 million. The employment rate improved by more than 3 percentage points in 2000–07 (see Table 1.7). Some of the countries with low or average employment at the beginning of the decade managed to increase their rates to close to the Lisbon target (e.g. Estonia, Ireland and Latvia).

In this context, countries affected by the housing boom showed different patterns regarding manufacturing. In Spain, for example, employment in manufacturing increased (3.5 %), especially in manufacturing of food, chemicals, rubber products, mineral and metal products, machinery and transport equipment — taking into account branches with larger relative weights. At the same time, the number of people employed in manufacturing in Ireland fell by 8 %, with decreases virtually across the board.

Table 1.7: Employment rates

	2000	2007	Growth in employment rates, 2000–07, percentage points
	Employment rates, %		
EU–27	62.2	65.4	3.2
Belgium	60.5	62.0	1.5
Bulgaria	50.4	61.7	11.3
Czech Republic	65.0	66.1	1.1
Denmark	76.3	77.1	0.8
Germany	65.6	69.4	3.8
Estonia	60.4	69.4	9.0
Ireland	65.2	69.1	3.9
Greece	56.5	61.4	4.9
Spain	56.3	65.6	9.3
France	62.1	64.3	2.2
Italy	53.7	58.7	5.0
Cyprus	65.7	71.0	5.3
Latvia	57.5	68.3	10.8
Lithuania	59.1	64.9	5.8
Luxembourg	62.7	64.2	1.5
Hungary	56.3	57.3	1.0
Malta	54.2	54.6	0.4
Netherlands	72.9	76.0	3.1
Austria	68.5	71.4	2.9
Poland	55.0	57.0	2.0
Portugal	68.4	67.8	- 0.6
Romania	63.0	58.8	- 4.2
Slovenia	62.8	67.8	5.0
Slovakia	56.8	60.7	3.9
Finland	67.2	70.3	3.1
Sweden	73.0	74.2	1.2
United Kingdom	71.2	71.5	0.3
United States	74.1	71.8	- 2.3
Japan	68.9	70.7	1.8

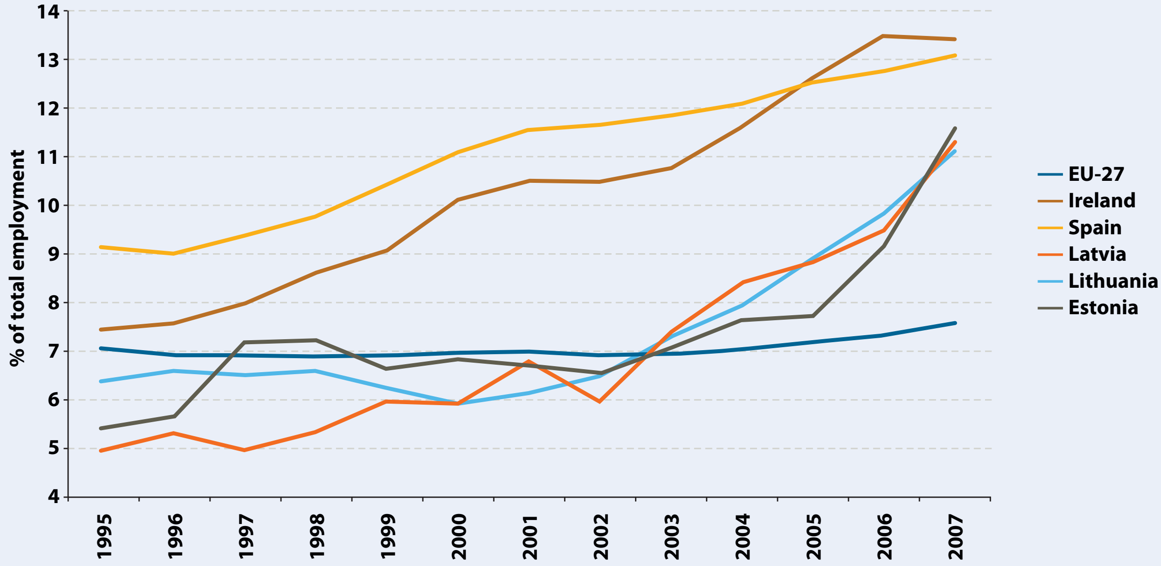
Source: Eurostat, labour force survey.

As expected, the role of construction in employment changed considerably during 2000–07 (at the EU level by 17 %, which is more than 2 million people in absolute terms). A significant drop can be observed only in Germany, Austria and Portugal, while the role of construction gained in importance in almost all the other countries, especially in Ireland, Spain and the Baltic states (see Table 1.8) ([22]). Generally, this can be explained on the one hand by rising demand for housing requiring huge numbers of construction workers, and by huge infrastructural development works (motorways, roads, railways, etc.) on the other. The share of construction in total employment exceeded 13 % in Ireland and Spain (see Figure 1.23). This could have caused tensions in the labour market but the role of immigrant workers became important: they helped to alleviate capacity constraints in the sector and at the same time contributed to the increasing demand for housing ([23]).

([22]) Bover and Jimeno (2007) examined the relationship between house prices and labour demand in the construction sector. They found substantial cross-country differences in the time series correlation of house prices and sectoral composition of employment. Countries with more building possibilities, like Spain, experienced a high sectoral allocation of employment and displayed larger elasticities of labour demand in construction with respect to house prices than countries that were not affected by the housing boom.

([23]) See Aherne et al. (2008).

Figure 1.22: Employment in construction out of total employment



Source: Eurostat, national accounts.

Another activity related to the housing boom is the banking sector. The role of the financial sector in employment increased, especially in the countries affected by the housing boom and where the role of external financial sources became more important in those years. Significant increases occurred in most new Member States (the Baltic states, Bulgaria, Romania, Poland) and in Ireland ([24]). Finally, the growing importance of housing investment was reflected in the growing number of employees in the real estate sector (almost 500 000 people — a 24 % increase at the EU level). Real estate, renting and business activities together registered an increase of 5.8 million employees (26 %), with 'other business activities' (NACE 74) playing the most significant role.

([24]) More widely available and lower-cost housing financing contributed to the rapid growth of mortgage debt in several countries (IMF, 2008). For instance in Ireland, residential mortgage lending grew annually by 25 % on average in the period 2000–06 (Malzubris, 2008). In Estonia credit inflows progressively accelerated: gross debt liabilities increased on average by 32 % annually in 2005–07 and by 20 % in 2000–04 (Lamine, 2008).

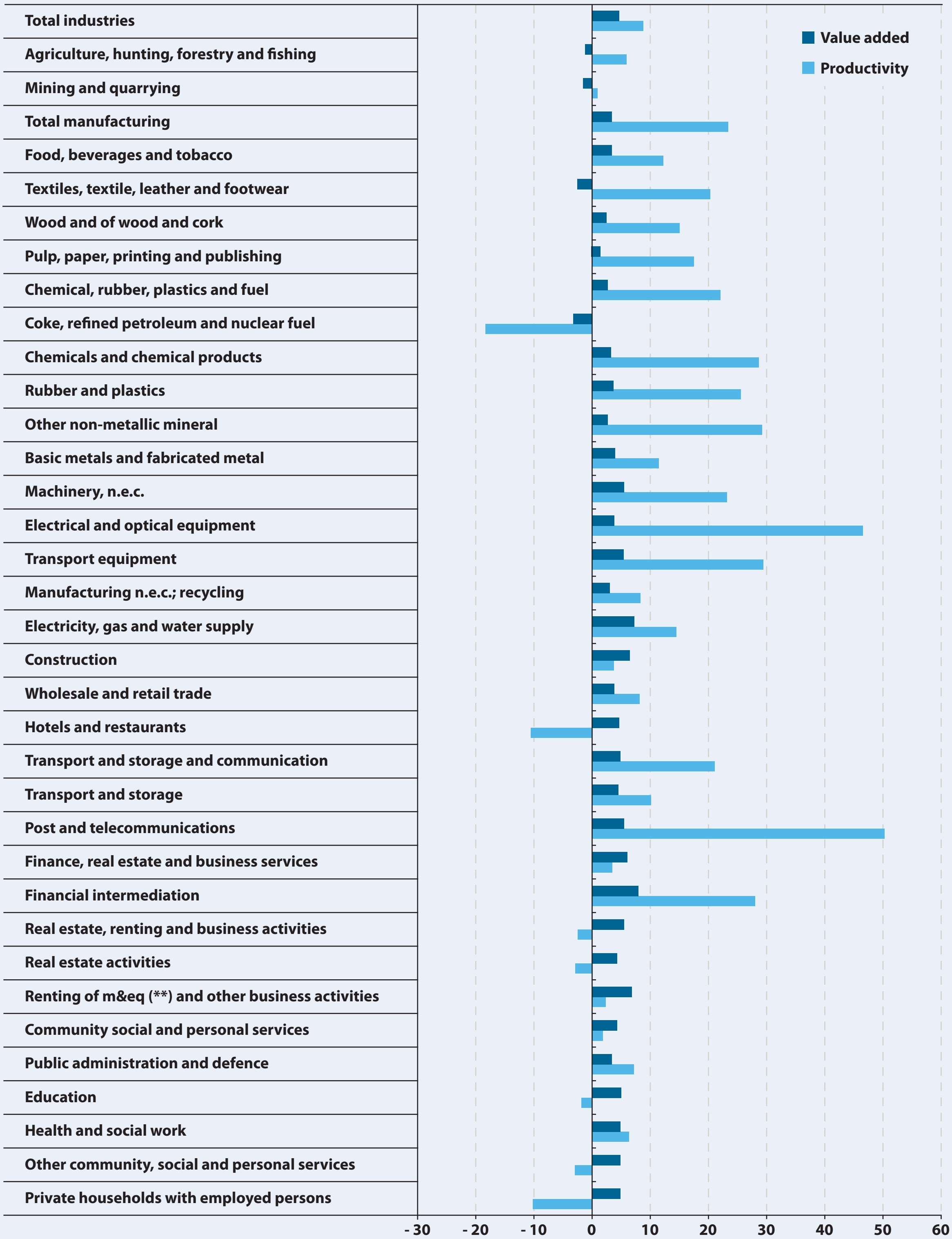
Table 1.8: Employment changes between 2000 and 2007

NACE	Manufacturing		Construction		Wholesale and retail trade		Hotels and restaurants		Financial intermediation		Real estate, renting and business activities	
	in 1 000s	in %	in 1 000s	in %	in 1 000s	in %	in 1 000s	in %	in 1 000s	in %	in 1 000s	in %
EU-27	- 1 873.0	- 4.8	2 428.6	16.7	2 403.3	7.7	1 582.3	18.3	188.7	3.2	5 807.2	26.4
EU-15	- 2 229.7	- 7.5	1 608.8	13.4	1 518.9	6.0	1 387.2	18.0	110.1	2.2	5 141.8	26.0
Belgium	- 69.2	- 10.5	13.0	5.3	29.1	5.0	1.9	1.3	- 6.3	- 4.3	156.0	26.1
Bulgaria	69.1	10.5	99.7	75.6	146.4	38.1	42.9	41.9	13.5	36.9	83.9	71.2
Czech Republic	60.6	4.4	28.6	6.6	34.8	4.8	15.2	8.7	2.7	3.1	140.1	32.9
Denmark	- 51	- 11.4	26.0	15.6	30.0	6.9	15	18.1	8	10.1	96.0	34.4
Germany	- 566	- 7.0	- 560.0	- 20.2	- 149.0	- 2.5	210	13.0	- 78	- 6.1	1 097.0	24.2
Estonia	3.9	3.0	35.2	89.8	9.1	11.0	3.1	15.0	2	24.7	10.5	26.0
Ireland	- 27.3	- 9.1	112.3	65.5	63.0	26.1	18.8	17.2	23.4	33.9	54.7	38.0
Greece	17.2	3.5	85.2	28.4	186.0	23.1	38.3	14.4	8.8	8.2	92.2	45.8
Spain	104.4	3.5	876.9	48.1	610.6	24.1	430.4	41.9	42.9	11.8	755.0	59.1
France	- 413.7	- 11.3	288.2	19.7	202.2	6.4	111	12.8	63.2	8.7	566.2	16.3
Italy	64.6	1.3	397.1	25.6	230.0	6.7	274.2	28.4	46.1	7.8	702.0	29.8
Cyprus	0.6	1.6	12.1	46.2	14.2	25.1	4.6	13.0	1.2	7.2	8.9	56.0
Latvia	7.8	4.9	70.5	127.0	50.2	32.4	13	60.5	3.8	23.2	29.5	49.0
Lithuania	12.8	5.1	86.1	103.6	60.8	30.4	5.4	20.5	7.8	53.8	32.2	74.5
Luxembourg	2.1	6.3	11.1	42.9	5.6	14.7	2.7	21.3	8.8	29.8	13.9	33.9
Hungary	- 56.2	- 5.7	64.4	24.5	46.4	8.5	18.2	13.7	- 0.3	- 0.4	78.0	38.2
Malta	- 5	- 14.1	3.2	36.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Netherlands	- 109.3	- 10.5	- 4.0	- 0.8	57.9	4.2	22.7	7.6	0.4	0.1	229.5	16.8
Austria	4.3	0.7	- 14.3	- 5.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	349.1	12.5	170.0	19.7	162.6	7.7	75.6	35.2	73.1	25.4	139.3	17.1
Portugal	- 129.8	- 13.0	- 52.9	- 9.0	113.7	14.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Romania	36.2	1.9	275.2	71.2	252.2	28.4	7.4	6.1	10.6	12.1	88.9	45.8
Slovenia	- 18.3	- 7.1	13.7	20.5	7.0	6.3	2.9	9.6	3	15.1	41.3	60.7
Slovakia	10.6	2.1	34.7	25.9	126.6	45.4	10.4	21.2	- 3.6	- 9.4	69.9	51.0
Finland	- 19.6	- 4.3	28.8	18.5	31.7	10.9	4.8	6.5	- 0.4	- 1.0	74.2	35.0
Sweden	- 64.7	- 8.2	56.1	25.6	26.7	5.1	14.2	12.0	- 1.9	- 2.0	113.8	23.0
United Kingdom	- 1 019	- 24.3	364	19.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note: Manufacturing and construction from NACE 6; others from NACE 31; when data for 2007 not available, 2006 was used instead.

Source: Eurostat, national accounts and own calculations.

Figure 1.23: Changes in value added and productivity in the EU-25 (*) in the boom period 2000–07



(*) The EU-25 refers to Member States as of 1 May 2004.
(**) machinery and equipment.
Source: EU KLEMS research database and own calculations.

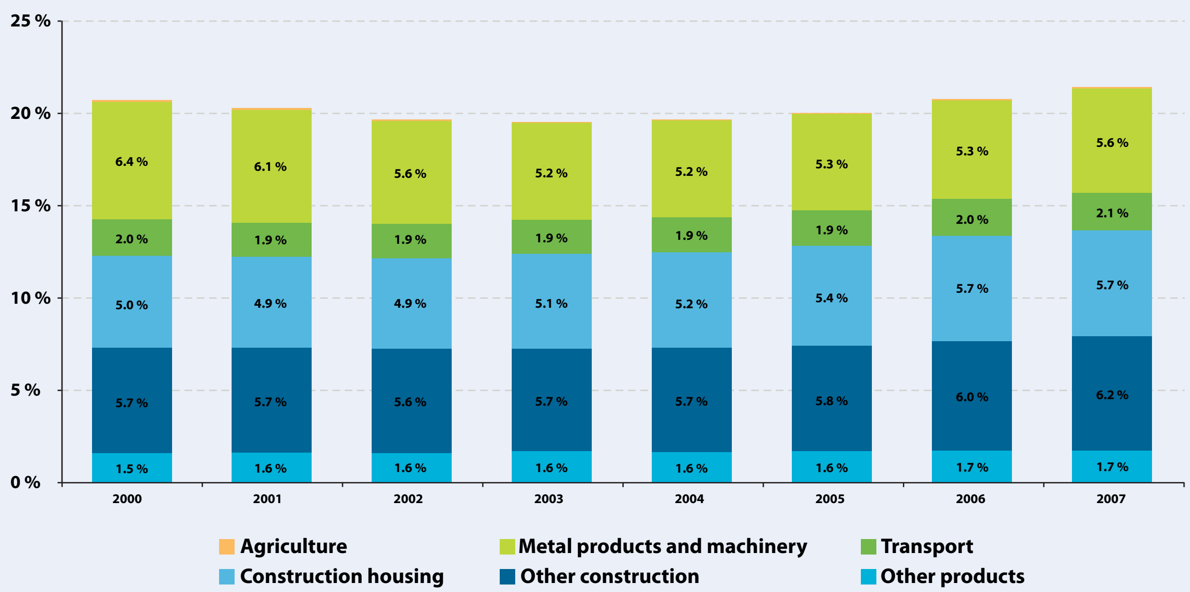
Inspection of productivity changes at the sectoral level does not reveal a very clear pattern. Again, it is difficult to disentangle the possible impact of the boom years from secular trends. Breaking down productivity changes by broad sectors shows, not surprisingly, that it is in industry where the largest increases in productivity, 10 %, are recorded (which could possibly explain the behaviour of export shares, see Figure 1.17). The only clear impact of the housing boom is in the construction and real estate sectors: productivity was down in construction by more than 5 %, mainly because of the flow of workers (particularly migrant workers) reflected in Figure 1.22.

1.4.3. The allocation of productive investment

In Section 1.4.1 we argued that aggregate productive investment was not crowded out by investment in dwellings. Another kind of distortion, however, would be that part of this productive investment was disproportionately directed to housing-related sectors to the detriment of other productive sectors. There is some evidence in this direction.

In countries affected by the housing boom (e.g. Estonia, Ireland, Spain, United Kingdom) the relative weight of manufacturing investment shrank considerably during this period. In these economies real investments were typically reallocated to the non-tradable sectors ([25]), especially to construction and real estate ([26]). These figures come, however, with a caveat: it is difficult to disentangle this drop and the increasing role of market services compared with manufacturing in the European economy (a long-term structural trend) ([27]). Figure 1.24 depicts the evolution of investment by type of assets in the EU-27. Taking into account the asset type distribution of gross fixed capital formation (GFCF), the role of housing and other construction investment increased significantly in the EU during the review period. At the same time the share of metal products and machinery dropped considerably. This points partly to less investment in tradable sectors, but it is also in line with a gross value added share and employment loss in manufacturing and the increasing role of services in general.

Figure 1.24: GFCF in the EU-27 by asset types (in % of GDP)



Source: Eurostat, national accounts and own calculations.

([25]) Brixiova et al. (2009).

([26]) In Estonia, for instance, the shares of the construction and the real estate sectors in total fixed investment exceeded the weight of the sectors in total value added, while in manufacturing the investment share fell increasingly below the share in total value added in 2005–07 (Lamine, 2008).

([27]) European Commission (2004).

1.4.4. Summary

In short, if the boom years have affected future productivity growth, the effect does not seem to be obvious. Apart from the growth in employment in housing-related sectors, there is no obvious deviation from secular trends: decreasing weight of manufacturing in employment and value added caused by faster productivity growth relative to services. If anything, there is some evidence that productive investment has been disproportionately directed to construction and real estate activities. It is not clear, however, whether the magnitude of this distortion is enough to provoke a productivity slowdown in the coming years.

1.5. The impact of the crisis on industry

Both by international standards and in comparison with other parts of the EU economy, the EU manufacturing and construction industries were very severely hit by the global recession. Output dropped in all sectors but one, and jobs were lost on a massive scale.

Table 1.9: Drop in production and labour input in EU-27 manufacturing relative to peak 2008 Q1

NACE Rev.2		Highest drop in output relative to 2008 Q1	% change in 2009 Q4 relative to 2008 Q 1 (1)			
			Output	Employment	Hours	Productivity (2)
c	Manufacturing	- 19.03	- 18.10	- 10.63	- 10.01	- 8.77
c10	Food products	- 2.87	- 2.87	- 3.55	- 2.04	0.06
c11	Beverages	- 7.40	- 6.62	- 10.17	- 8.18	2.74
c12	Tobacco products	- 12.28	- 12.28	- 9.30	- 3.21	- 5.74
c13	Textiles	- 24.23	- 23.40	- 18.56	- 17.39	- 7.78
c14	Wearing apparel	- 16.12	- 16.12	- 20.80	- 17.63	1.52
c15	Leather and related products	- 19.25	- 18.41	- 15.88	- 13.05	- 6.42
c16	Wood and products of wood and cork	- 21.47	- 21.47	- 17.82	- 16.09	- 5.27
c17	Paper and paper products	- 14.93	- 11.93	- 7.50	- 9.03	- 4.60
c18	Printing and reproduction of recorded media	- 12.03	- 12.03	- 8.85	- 6.07	- 4.73
c19	Coke and refined petroleum products	- 10.05	- 10.05	- 5.01	- 9.70	1.50
c20	Chemicals and chemical products	- 19.54	- 12.17	- 7.13	- 5.21	- 10.88
c21	Basic pharmaceutical products	- 0.29	4.65	- 4.48	- 3.25	8.27
c22	Rubber and plastic products	- 21.54	- 16.44	- 8.56	- 9.02	- 10.41
c23	Other non-metallic mineral products	- 28.03	- 28.03	- 18.15	- 14.53	- 13.19
c24	Basic metals	- 35.57	- 28.32	- 12.54	- 16.32	- 17.70
c25	Fabricated metal products	- 27.11	- 26.85	- 11.00	- 10.89	- 18.14
c26	Computer, electronic and optical products	- 22.23	- 21.98	- 12.20	- 11.89	- 11.73
c27	Electrical equipment	- 24.88	- 22.50	- 10.67	- 11.95	- 14.02
c28	Machinery and equipment n.e.c.	- 30.26	- 30.18	- 7.94	- 11.31	- 21.41
c29	Motor vehicles, trailers and semi-trailers	- 39.24	- 28.22	- 11.91	- 15.57	- 19.94
c30	Other transport equipment	- 13.64	- 13.64	- 7.87	- 7.75	- 5.07
c31	Furniture	- 22.46	- 22.29	- 15.18	- 15.09	- 8.68
c32	Other manufacturing	- 7.35	- 6.54	- 4.76	- 4.31	- 2.90
c33	Repair and installation of machinery	- 6.82	- 6.82	- 2.89	2.90	- 9.31

(1) When 2009 Q4 not available, 2009 Q3 used instead, notably for hours and productivity.
(2) Productivity is measured as output per hour; rates of change approximate rates of change of value added per hour.

Source: Eurostat, short-term business statistics.

The effects of the crisis were not identical across sectors, however. Some manufacturing sectors fared better than manufacturing as a whole, and others considerably worse. Examples of sectors outperforming other manufacturing sectors during the crisis include food products and basic pharmaceutical products and pharmaceutical preparations. At the other end of the scale, sectors such as motor vehicles, trailers and semitrailers, machinery and equipment, textiles, wearing apparel, leather and leather-related products suffered the greatest job losses and output reductions. The construction industry, being highly cyclical, also falls in the latter category.

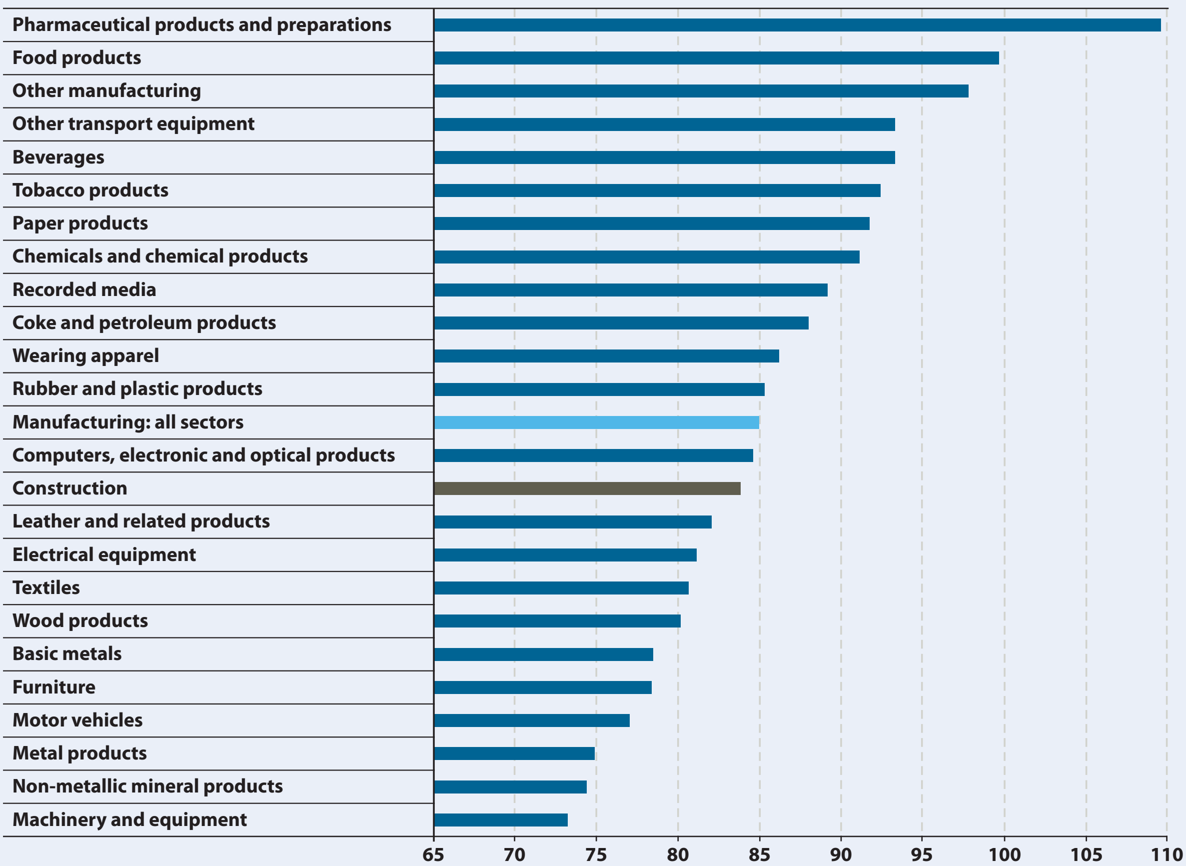
Whereas manufacturing industry as a whole started to recover by mid-2010, some of the worst-affected manufacturing sectors were still shrinking and may not yet have reached their lowest level and the start of recovery. A similar scenario might await the construction industry.

1.5.1. Output

Across the manufacturing industry as a whole, output fell by almost 15 % from its cyclical peak in the first quarter of 2008 to the first quarter of 2010. By mid-2009 output had dropped by even more, but it then started to recover and this general recovery has continued in 2010. The volume of output is now some 7 % higher than at the lowest point in 2009, and around a quarter of the total drop from the 2008 peak to the 2009 nadir has been recovered.

However, as Figure 1.25 shows, the overall recovery is not reflected in all manufacturing sectors. In some sectors (notably furniture, coke and refined petroleum products, tobacco products and beverages) output is still diminishing and may not yet have reached its lowest level. In other sectors the drop in output was far greater than the average manufacturing output loss (motor vehicles, trailers and semitrailers - 39.5 %; basic metals - 35.8 %; machinery and equipment - 30.5 %), and although output has since started to recover it still has some way to go to make up the average of nearly - 15 % across all manufacturing sectors, as reflected in Figure 1.25.

Figure 1.25: Construction and manufacturing sector output in first-quarter 2010 (index first-quarter 2008 = 100)



Source: Monthly note on economic recovery in manufacturing, construction and selected service industries, June 2010, Enterprise and Industry DG, European Commission.

The figure also shows the remarkable resilience of the pharmaceutical sector (basic pharmaceutical products and pharmaceutical preparations), where output now stands at a higher level than in 2008. The recession initially caused output to drop slightly in the pharmaceutical sector too, but it quickly returned to positive growth and has since bucked the trend of negative growth in other sectors. The food sector has also been able to keep up production remarkably well in spite of initial output reductions and despite having had to shed more than 3 % of its workforce (see the next section).

Output in the construction industry fell by 16.2 % from the first quarter of 2008 to the first quarter of 2010, and may have fallen further since. As in some manufacturing sectors, the construction industry may yet have to reach it lowest output level of this cyclical downturn before returning to positive growth.

Taking into account the change of production and employment in terms of end-use categories (intermediate goods, capital goods, consumer durables, consumer non-durables and energy) the following can be observed.

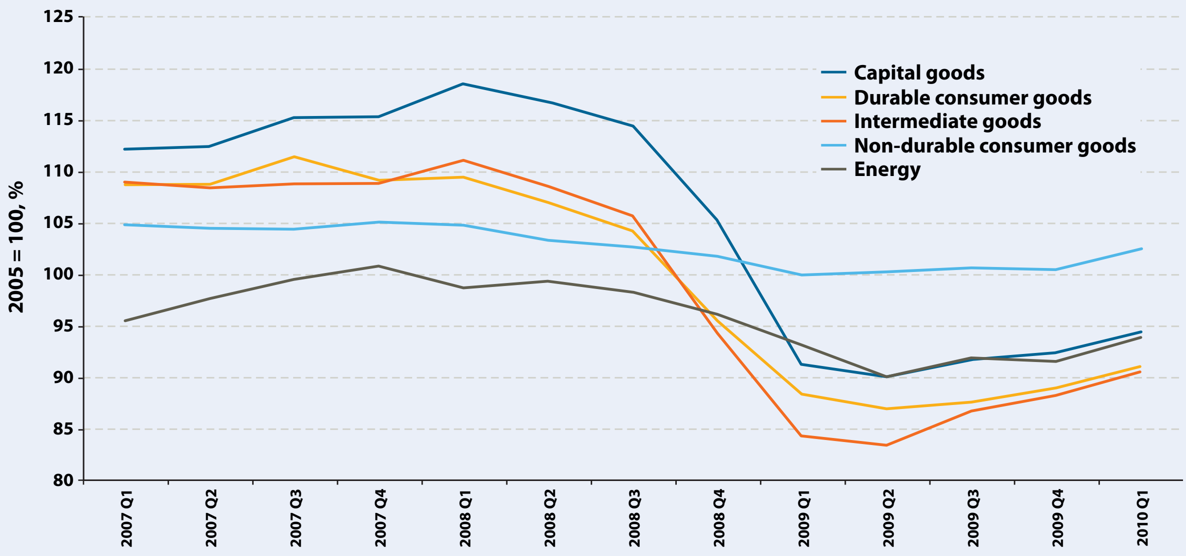
Intermediate goods (accounting for the largest weight of the total) suffered most during the crisis, indicating significantly less demand for goods used in manufacturing production. Production of capital goods showed the largest drop as compared to the period before the recession, representing very weak investment activity in the business sector. These two categories, given their large shares in total, had the most significant effect on the production index of total industry. Households responded to the changed circumstances quite rapidly, as reflected in the sharp contraction for durable goods. Non-durable consumer goods recorded only a maximum drop of 5 % compared with the pre-crisis peak.

Looking at individual EU countries' performance in industries, the largest GDP contraction and decline in industrial output occurred in small open economies like Estonia or Slovakia, but their impact on EU industrial output as a whole was not significant, because of their relatively small weights. In contrast, Germany, representing the highest share in EU industrial output, contributed considerably to the fall in EU industrial performance. Italy, representing the fourth largest weight in industrial value added, showed the second largest impact on the overall EU industrial production index ([28]).

1.5.2. Employment

Employment in manufacturing industry, which accounts for around 16 % of total EU employment, fell by 11.8 % from its peak in the first quarter of 2008 to the first quarter of 2010. Though it fell short of the 15 % reduction in output over the same period, the fall nonetheless meant

Figure 1.26: Production index change of end-use categories in the EU-27



Source: Eurostat, short-term business statistics.

([28]) European Commission (2010c).

that more than 4 million jobs were lost in manufacturing, representing nearly two thirds of all job losses in the EU from the first quarter of 2008 to the first quarter of 2010. No other part of the EU economy has suffered job losses on a similar scale.

Employment diminished in all manufacturing sectors from the first quarter of 2008 to the first quarter of 2010; in two sectors, textiles and wearing apparel, job losses were in excess of 20 %. The manufacture of leather and related products also suffered similar cuts in numbers. This is the reason for the diminished shares of overall employment for these three sectors in Figure 1.27. It is worth noting that while the job losses in the textiles and leather sectors were proportionate to the output reductions in those sectors from 2008 to 2010, the wearing apparel sector employed 22.5 % fewer people in the first quarter of 2010 than the same quarter of 2008 but the remaining workforce produced more than 85 % of the 2008 sector output, reflecting higher labour productivity.

Several manufacturing sectors reported job losses of less than 5 % during the period: food products (- 3.1 %), basic pharmaceutical products and pharmaceutical preparations (- 4.0 %) and coke and refined petroleum products (- 4.9 %). This explains why the relative shares of these three sectors in overall employment increased between 2008 and 2010, as depicted in Figure 1.27.

Employment in the construction industry, which represents around 6 % of total EU employment, fell by 13.9 % from the first quarter of 2008 to the first quarter of 2010, or by more than 2 million jobs. As a consequence, the share in overall employment of manufacturing and construction diminished from 30.5 % to 30.1 %.

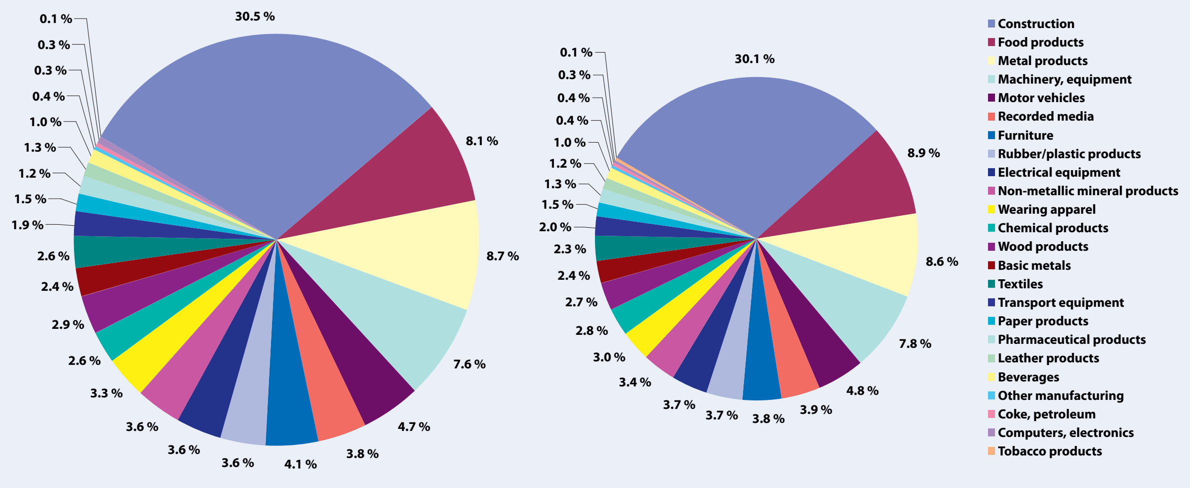
As regards end-use categories, however, the largest drops were registered in capital and intermediate goods in terms of production, while job losses were more significant in other categories (durables and non-durables). Comparing the two figures (Figures 1.26 and 1.28), it can be seen that while enterprises responded to the changed circumstances very fast by reducing production, job losses were more gradual and more protracted.

1.6. Conclusions

The European Union is in the midst of a considerable downturn. The recession originated in a major readjustment of consumption and saving behaviour of households after a boom period in which considerable distortions were accumulated — in other words, a classic demand-side recession.

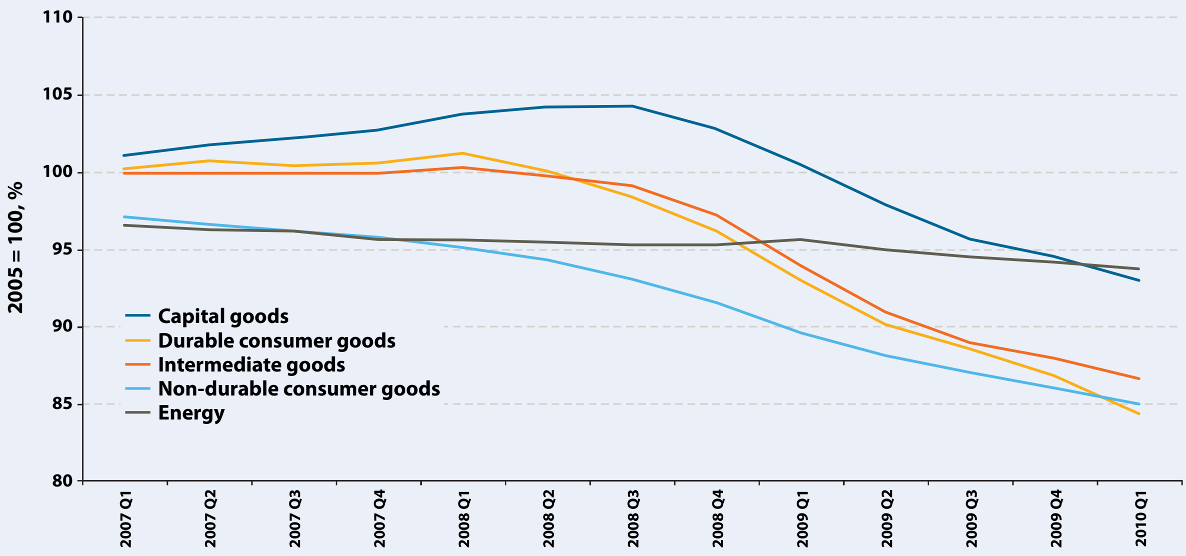
A close inspection of the boom years 2000–07 shows that if these growing distortions had any impact on competitiveness, it was probably only modest and mostly associated with distortions in the allocation of labour across sectors within countries affected by a speculative bubble. External competitiveness does not seem to have been affected by these developments; large increases in unit labour costs in some Member

Figure 1.27: Industry sectors and construction, relative shares of employment



Note: Employment in first-quarter 2008 (55 million) and first-quarter 2010 (48.5 million).
Source: Monthly note on economic recovery in manufacturing, construction, and selected service industries, Enterprise and Industry DG, European Commission, June 2010.

Figure 1.28: Labour input index change of end-use categories in the EU-27



Source: Eurostat.

States have not been reflected in the share of exports in world trade, even within the euro area. One explanation for this apparent paradox may be the different setting of nominal wages in the tradable and non-tradable sectors. In turn, these differences may also explain the growth in employment of some domestic sectors in bubble economies, notably the construction sector. Those countries that are more severely affected by the crisis are likely to undergo a longer readjustment process, especially as far as employment is concerned, because of the construction sector workers who will have to be redeployed to other sectors. Other countries which suffered collateral damage through trade and integration in the global supply chain will probably recover faster.

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CHAPTER 2

Trade in Intermediate Products and EU Manufacturing Supply Chains

2.1. Introduction

Where does your mobile come from? This simple question is not easy to answer. It has probably been assembled using components from different countries, using services both from domestic and foreign economies. This multi-country nature of products is not just a feature of more complex high-tech products such as mobile phones and cars. Rarely is a product made up entirely of components or inputs from the country where it is finally assembled or sold; at least some of the components and services involved to bring the product to the customer are often purchased abroad. This is the case for direct inputs, when firms purchase intermediate inputs for production domestically and abroad, but even more so for indirect inputs. A component from a particular country might already include other inputs from other countries, and these are thus used indirectly for production purposes. Conversely, companies might ship high-tech components to other countries where assembly of the final product takes place. The complex nature of supply chains at a detailed level of individual products has been documented in a number of case studies for various products, such as T-shirts (Rivoli, 2004), Barbie dolls (Tempest, 1996), computers (Kraemer and Dedrick, 2002), the iPod (Linden, Kraemer and Dedrick, 2007; Varian, 2007) and Boeing (Grossman and Rossi-Hansberg, 2009).

The purpose of the study

The aim of this chapter is to shed light on the relative importance of trade in intermediates in overall trade for the EU-27 and individual country groups, its specific structure and trends over time. The chapter therefore answers the following questions: What is the extent of trade in intermediate products in overall trade, in both exports and imports? Has the share of intermediate trade changed over time and, if so, was this driven within or between sectoral shifts? Are there specific differences in the way that some countries mostly act as providers and others as users of intermediate inputs?

Section 2 of this chapter analyses specialisation patterns with respect to intermediate trade across countries. The magnitude of two-way trade and the geographical structure of intermediates over time are also analysed.

The importance of trade in intermediates with respect to user industries is analysed in Section 3 for the following questions. What is the extent of intra-industry linkages across particular industry groups, including service industries, and — more importantly for this study — what is the share of imported intermediates across these industry groups and to what extent has this changed over time? Given the complex nature of the international production process, the chapter also provides a detailed case study for a particular product, addressing the question: Who captures the value of the production process?

The economic crisis has had a severe impact on trade flows, and trade in intermediates may have played a particular role. The effect of the financial crisis on intermediates trade is analysed in Section 4 where the following questions are addressed: To what extent has trade in intermediates been more affected than other product categories? Does the stronger impact on intermediates' trade stem from an overall decline in trade for industries with high shares of parts and components trade, or has there been a common break which has led to an overall disruption of supply chains?

These questions have to be addressed at different levels of analysis: at the level of the total economy, for particular industries or product groups and, finally, at the level of individual firms or even products. At the more aggregate levels, the complex nature of international linkages is reflected particularly in trade patterns reflecting aggregate supply chains. This chapter therefore also contains analyses at different levels of aggregation, using detailed trade data, and data from input-output statistics. There is also a case study for a particular product, the Nokia N95. For a detailed description of the data used, see Annex A. Each of these datasets has its merits. Detailed product level trade data allows for differentiating products regarding their use as intermediate inputs, capital goods or consumer goods or at even more detailed categories, though such a distinction might not be clear in a number of cases ([29]).

Relying solely on trade statistics, however, does not provide a complete picture of manufacturing supply chains. In particular, it does not reveal cross-industry differences with respect to sourcing structures. The reason for this is that imports of intermediate products cannot be attributed to industries using trade statistics. As an example, even if there are data on the imports of a particular intermediate product, trade data cannot show which industries imported the products, nor the extent to which the imports are used in the production process. This can, however, be studied using information from input-output tables as discussed in detail below. At the level of particular products, the actual supply chains and strategies of firms can only be revealed using detailed case studies looking at sourcing structures, national or international, for each individual component of that product.

2.2. Patterns of trade in intermediate products

Production structures are increasingly adapting and adjusting to more international sourcing structures and cross-border production networks. This is a prominent feature of the globalisation process. Accordingly, it is commonly argued that intermediate goods trade as a share of total trade is increasing because of international outsourcing. Firms distribute their production activities and develop their supply chains over different locations according to comparative advantages in a broader sense. They also take the legal situation into account in potential target countries for outsourcing. Such trends in trade structures of intermediates versus other product types for the EU-27 countries over the last decade are analysed in this section. It is based on descriptive analysis and common methods in the trade literature, with an emphasis on trade in intermediates.

2.2.1. The extent of trade in intermediates

To document the relative importance of trade for the EU-27 and the individual Member States, Table 2.1 presents the shares of imported and exported products in total imports and exports for each of the four product categories in 2008 ([30]). The share of imported intermediate inputs for the EU-27 is 53.7 %, and thus accounts for the greatest bulk of imports. Consumer goods are the second largest category, with 22.6 %, closely followed by capital goods (17.6 %). This broad structure of imports is found in most countries, with few exceptions. Along with Germany, five central and east European countries (Slovenia, Poland, Czech Republic, Hungary, Slovakia) show the highest shares of intermediates. One explanation for this could be that these countries are more specialised in manufacturing, and that industries in these countries find cross-border production networks particularly important. This will be discussed in further detail below.

Table 2.1 also indicates that exports of intermediates constitute an important part of trade for all countries. Patterns of intermediate exports are compared to the other categories of goods. Shares of the different product categories for the EU-27 are very similar to those for imports. Intermediate goods account for more than half of exports, with a share of 53.7 %, while exports of consumer goods and capital goods account for 22.6 % and 17.6 % respectively.

The observed large shares of intermediate imports and exports in almost all countries indicate that a clear distinction between typical outsourcing and target countries is not useful, so such classifications have to be made with caution. Furthermore, this points towards the existence of a significant amount of intra-product trade, which will be considered in more detail below.

So far, analyses have focused on the situation in 2008. The public and academic debate on trade in intermediates has as its major concern the changes with respect to the importance of trade in intermediates and the relative importance of cross-border production networks. On this question, Table 2.2 presents an index of nominal import and export values for 2008, expressed as an index where the value in 1999 equals 1. The respective changes in shares are expressed in percentage points for the four end-use categories between 1999 and 2008.

The value of EU-27 intermediate imports increased faster than other categories of goods, by 85 %, closely followed by consumer goods imports, which increased by 82 %. This resulted in a 2.75 % higher share of intermediates in 2008 compared to 1999. Consequently, the shares of capital goods and the mixed product category fell. However, some individual countries experienced much stronger increases in the value of intermediate imports over this period, for all product types. This group of countries mainly consists of the EU-12,

([29]) To stick to the example of a mobile phone, this can be used for personal purposes (chatting with friends) or in production processes (negotiating with clients).

([30]) Detailed explanations on data used and classifications applied in the study can be found in the annex.

Table 2.1: Share of end-use categories in total imports and exports in 2008 (in %)

	Imports				Exports			
	Inter-mediates	Consumer goods	Capital goods	Mixed category	Inter-mediates	Consumer goods	Capital goods	Mixed category
Belgium	55.4	24.8	12.2	7.6	55.8	25.6	10.6	8.0
Bulgaria	52.4	19.6	21.5	6.5	61.9	24.6	8.4	5.0
Czech Republic	59.5	17.7	19.7	3.1	55.0	15.2	21.9	7.9
Denmark	48.2	27.4	19.9	4.5	41.8	35.7	20.9	1.6
Germany	58.0	19.3	17.8	4.9	49.0	16.0	23.8	11.1
Estonia	51.9	21.7	15.0	11.4	58.0	20.9	11.6	9.5
Ireland	44.5	25.8	24.4	5.3	53.0	30.9	16.0	0.1
Greece	38.7	34.5	20.2	6.7	54.5	35.3	9.6	0.6
Spain	55.2	23.6	14.3	6.9	50.2	24.5	11.9	13.4
France	52.6	25.0	16.0	6.4	49.1	25.6	19.0	6.2
Italy	54.7	22.9	14.3	8.2	50.2	26.8	19.4	3.5
Cyprus	45.7	29.2	12.9	12.2	34.8	48.0	11.6	5.7
Latvia	46.2	27.3	18.5	8.0	56.6	26.5	13.6	3.3
Lithuania	46.7	24.7	20.2	8.4	52.4	22.2	12.0	13.3
Luxembourg	43.8	15.9	32.0	8.3	50.6	9.5	37.8	2.1
Hungary	60.8	15.4	19.5	4.3	46.7	19.5	26.6	7.3
Malta	59.4	26.4	9.6	4.6	68.2	22.2	8.2	1.4
Netherlands	51.1	20.3	24.7	3.9	52.1	20.3	24.1	3.5
Austria	54.2	22.0	17.8	6.0	55.7	18.1	21.6	4.6
Poland	57.5	17.4	20.2	4.9	51.8	28.6	13.0	6.6
Portugal	50.7	26.0	16.5	6.8	53.3	28.4	11.5	6.8
Romania	53.9	18.7	21.4	6.0	57.8	21.8	12.8	7.5
Slovenia	56.6	16.7	16.2	10.5	51.7	22.8	12.7	12.8
Slovakia	62.3	17.1	15.8	4.8	47.7	23.9	11.1	17.4
Finland	51.8	19.2	21.6	7.4	53.0	7.4	33.9	5.8
Sweden	55.1	21.7	17.9	5.2	58.1	15.4	19.9	6.6
United Kingdom	46.8	28.1	17.3	7.7	50.7	22.8	17.3	9.3
EU-27	53.7	22.6	17.6	6.1	51.2	21.6	19.6	7.6

Source: Eurostat Comext, wiiw calculations.

for which the increase tends to be above 3 % ([31]). The value of imports has also grown for these countries in the other product categories. It might therefore be more informative to look at the extent to which the structure of imports has shifted over time, as indicated by the respective shares ([32]).

Interestingly, the share of imported intermediate inputs even decreased for a number of countries. This group also includes some countries from the new Member States, e.g. Romania, Hungary and Bulgaria, along with countries from the EU-15 such as the United Kingdom and Finland. Another group of countries experienced increases in the share of intermediate goods imports. This group includes Germany, Spain, Austria, Italy and Sweden, to name a few from the EU-15, but also Slovakia, Slovenia, the Czech Republic and Poland. Thus, although there has been a general tendency towards a higher

Table 2.2: Changes in import and export values and import and export shares by end-use categories for the EU-27

	Index 1999 = 1				Change in shares (in percentage points)			
	Inter-mediates	Consumer goods	Capital goods	Mixed category	Inter-mediates	Consumer goods	Capital goods	Mixed category
Imports	1.85	1.82	1.55	1.49	2.75	0.74	- 2.38	- 1.12
Exports	1.87	1.84	1.64	1.69	1.99	0.46	- 1.94	- 0.51

Source: Eurostat Comext, wiiw calculations.

([31]) See Tables A.5 and A.6 in the annex for details.
([32]) See Table A.5 in the annex for details.

share of imported intermediate goods, almost half the countries in the EU-27 experienced a decline in the share of imported intermediates and the extent in these changes differed markedly across countries. One may note that these general tendencies are not a result of the economic crisis which hit the world economy in 2008.

A similar pattern, though at slightly different magnitudes, is found for changes between 1999 and 2007. EU-27 exports of intermediates displayed the highest growth rate, closely followed by exports of consumer goods. Growth rates of exports were higher than those for imports, though the difference is relatively small in the case of intermediates and consumer goods in particular. The specific patterns of individual countries across product categories are again rather mixed (see Table A.5 in the annex for details). One should, however, notice that growth rates for the EU-12 are often higher for product groups other than intermediates. This group of countries started from a rather low level, which partly explains the high growth rates. Within the EU-15, typical exporter countries such as Germany performed only slightly better than the EU-27 average across product categories. However, exports for other larger countries such as the United Kingdom, France and Italy grew below the average growth rate.

Finally, the extent to which there are differences in these patterns among industries is presented. Table 2.3 shows the shares of imported and exported intermediates in total imports and exports by industry for the EU-27 [33]. Imports of intermediates range from almost zero for industries manufacturing tobacco and wearing apparel, to very high shares, up to 100 %, for industries manufacturing basic metals. It turns out that these patterns are relatively stable over time and very similar across countries. Correlation analyses yield correlation coefficients for all cases above 0.8 and in most cases above 0.9 [34]. The structures for exports are very similar to those for imports, as documented in Table 2.3.

Table 2.3: Shares of intermediate imports and exports by industry for EU-27 in 2008 (in %)

		Imports	Exports
15	Food and beverages	22.5	17.0
16	Tobacco	0.9	0.4
17	Textiles	50.8	62.5
18	Wearing apparel	0.8	2.3
19	Leather	12.3	14.4
20	Wood products	95.2	97.9
21	Pulp and paper	83.4	80.1
22	Publishing	26.7	30.7
23	Coke	92.5	77.1
24	Chemicals	69.8	63.5
25	Rubber and plastics	72.7	73.4
26	Other non-metallic	90.0	91.1
27	Basic metals	100.0	100.0
28	Metal products	80.3	81.5
29	Mach. and equipment	43.6	39.7
30	Office machinery	17.4	19.0
31	Electrical machinery	75.7	73.3
32	Radio and television	37.6	32.6
33	Instruments	16.1	15.4
34	Motor vehicles	37.7	35.1
35	Transport equipment	46.4	36.2
36	Furniture and n.e.c.	19.0	18.4

Source: Eurostat Comext, wiiw calculations.

(33) With respect to imports an important aspect here is that these industries should not be considered as 'importing industries' rather than imports of products 'typically produced by those industries'. For example, 22.5 % of imports corresponding to NACE 15 (food and beverages) are considered as being intermediate products; however, these products might be used in other industries for production purposes, e.g. in the hotels and restaurants sectors. The use of imported intermediates of a particular product across industries will be considered in the second part of the study.

(34) More specifically, the correlation coefficients of trade shares are calculated by product categories in the industries considered (e.g. the share of intermediate imports in industry X) across countries or for a particular country for the first and last year available.

2.2.2. Geographical structures of trade in intermediates

Intermediate inputs can be sourced from different countries or groups of countries around the world. Table 2.4 provides information on the groups of countries from which intermediate goods are sourced, and on the countries to which they are exported. Considering the EU-27 as a whole, one sees that the bulk of intermediate products are sourced from EU-15 countries. With respect to other country groups, the advanced OECD countries account for 11.1 %, the EU-12 and BRIC countries account for equally large shares, of 8.7 %, while the Asian countries account for only 3.8 %. For these other country groups, the variation across EU-27 countries is even larger. Thus, in 2008, almost 70 % of intermediates were sourced from within the EU-27.

The sourcing structures of intermediates are somewhat different from those of the other product categories. The EU-15 and EU-12 groups account for about 70 % of imports of intermediates, consumer goods and capital goods, and an even higher share for the mixed category, at 84.6 %. But there are some differences for the other sourcing partners: for example, the BRIC countries account for 13.5 and 13.0 %, respectively, for consumer goods and capital goods, but for only 8.7 % for intermediates. On the other hand, the advanced OECD countries have relatively high shares, at 11.1 % of intermediates and 13.7 % of capital goods respectively.

Similarly, the bulk of intermediate exports from EU-27 countries are destined for the EU-15 countries. The EU-15 share is 58.1 % for the EU-27 and thus only slightly lower when compared to imports. The EU-12, the advanced OECD countries and the 'rest of world' (RoW) receive one 10th each of EU-27 exports. The share of EU-27 exports to the BRIC countries is 5.9 %, whereas only 3.3 % of EU-27 exports are destined for the Asian countries. Furthermore, the share of exports from EU-12 countries to other EU-12 countries is also very large in most cases. Together with results on import structures, this reveals that there is also a lot of intraregional trade in intermediates among EU-12 countries taking place, showing that outsourcing is important not only between advanced and less advanced economies, but also within similarly developed countries.

A comparison of the geographical patterns for EU-27 exports of the four product categories shows that the share of exports of consumer goods to the EU-15 is large (62.8 %) when compared with intermediates (58.1 %) and capital goods (48.6 %). EU-27 exports of intermediate and capital goods to EU-12 countries are larger than the other categories of goods. This pattern is reversed for the advanced OECD countries. For the other country groups, capital goods exports are more important, in particular for the BRIC countries and the 'rest of world' category.

Whether this pattern is stable over time is analysed below. Table 2.5 provides evidence for the EU-27 over the period 1999–2008. The EU-15 and the advanced OECD countries have seen large declines in market shares of total EU-27 imports, by - 4.6 and - 5.3 percentage points respectively, whereas the EU-12 and BRIC countries have gained market shares, by 3.9 and 4.9 percentage points respectively. Considering the EU-27, one thus finds a significant shift from imports sourced from EU-15 countries towards imports from EU-12 countries. Once again, there is considerable country differentiation with respect to changes in geographical patterns. A common feature is that the EU-12 and BRIC countries have gained in all countries, whereas the advanced OECD countries have lost market shares.

It remains to be considered whether these shifts are similar for all product categories or whether there is a specific pattern for intermediate products. The EU-15 countries have lost market share in all categories, but these have been more pronounced for capital goods and for the category of mixed goods. Similarly, the advanced OECD countries have lost market share to a large extent in capital goods (- 9.52 %) and in

Table 2.4: Import structures by end-use categories and partner countries for the EU-27 in 2008 (in %)

	EU-15	EU-12	Adv. OECD	Asia	BRIC	Rest of world
			Imports			
Intermediates	60.9	8.7	11.1	3.8	8.7	6.7
Consumer goods	59.0	8.8	7.8	3.7	13.5	7.3
Capital goods	55.1	6.8	13.7	7.7	13.0	3.7
Mixed category	73.9	10.7	8.8	2.2	1.1	3.3
			Exports			
Intermediates	58.1	10.1	11.6	3.3	5.9	10.9
Consumer goods	62.8	8.4	13.4	2.1	4.3	9.0
Capital goods	48.6	9.2	12.8	3.7	9.9	15.7
Mixed category	57.0	6.9	18.2	1.2	5.3	11.4

Source: Eurostat Comext, wiiw calculations.

intermediates (- 5.32 %). The BRIC countries have gained mostly in capital goods (9.64 %), with the gain being similar in magnitude to the decline in OECD countries. The BRIC countries' gains in market share in consumer goods amounted to 5.21 %, and 4.94 % for intermediates. Finally, the second biggest winners in terms of increasing market share are the EU-12 countries, which have seen gains ranging from 5.98 % in the category of mixed goods to 3.18 % in consumer goods.

Thus, a marked shift occurred in this period within Europe, from EU-15 to EU-12 countries as suppliers of intermediate products. However, the EU-12 countries started from a relatively low level of exports. It is interesting to note that these gains and losses were of a similar magnitude. Simultaneously, there was a significant reorientation towards the BRIC countries at the expense of the advanced OECD countries. Thus one observes a reorientation of sourcing structures within the EU as well as in extra-EU import patterns.

The geographical pattern of EU-27 exports has also changed over the last 10 years. EU-27 export shares to the EU-15, advanced OECD countries and Asia declined, while EU-27 export shares increased to the EU-12, BRIC and the 'rest of world'. These patterns can with a few exceptions also be found for individual EU-27 countries. Considering the EU-27 change in geographical export structure across the product categories, one finds that exports to the EU-15 declined much more for capital goods and for the mixed category of products. The export shares increased for these product categories to the BRIC countries and the 'rest of world'. The changes are most similar across product categories with respect to the EU-12, the advanced OECD countries and Asia.

These shifts in market shares can be related to changes in relative unit values reflecting emerging cost advantages or quality upgrading. This issue is analysed by means of changes in unit value ratios and market shares between 1999 and 2008 ([35]). The analysis shows that the EU-12 countries have been successfully upgrading the quality of goods exported to the EU-27 markets. A similar pattern is found for BRIC countries, though with less pronounced quality upgrading. These patterns are similar across product categories and seem to be more pronounced in high-technology industries in general (cf. Figure 2.1).

An analogous exercise on the exporter side reveals that, within the EU-27 countries, France and the United Kingdom in particular have been losing export shares, defined as exports of the particular country divided by total EU-27 exports ([36]).

2.2.3. Revealed comparative advantages in trade in intermediates

The patterns described above point towards the countries or groups of countries which tend to specialise in the production of intermediates relative to other product categories. It is, however, not easy to discern from the descriptive analysis alone whether particular countries or groups of countries have tended to specialise in the provision of intermediate inputs compared to others and to what extent this has changed over time. This section sheds light on this issue by using a measure of revealed comparative advantages (see Box 2.1) at the level of end-use categories and groups of countries.

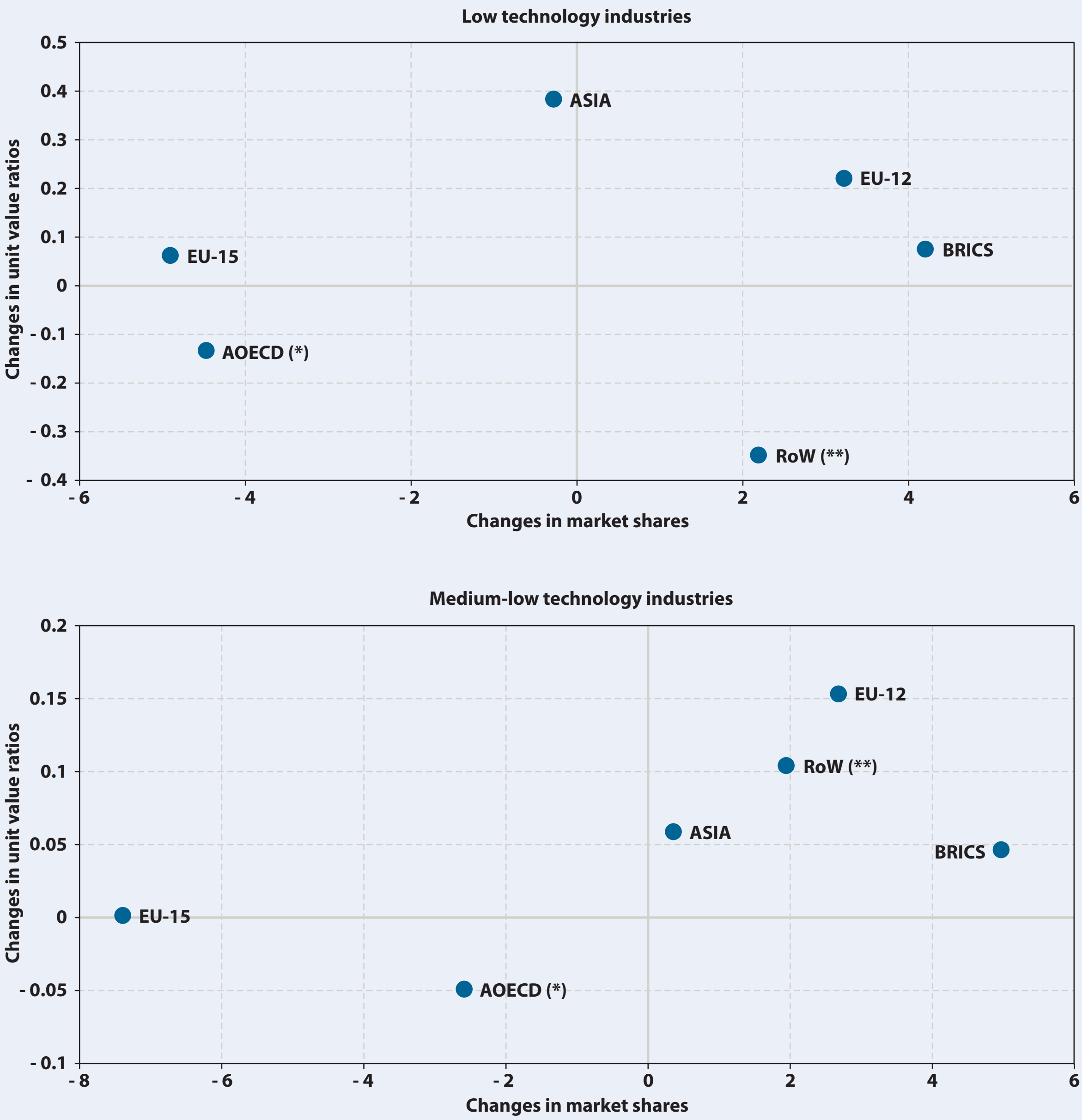
Table 2.5: Changes in export and import shares by end-use category and sourcing region for EU-27, 1999–2008 (in percentage points)

	EU-15	EU-12	Adv. OECD	Asia	BRIC	Rest of world
			Imports			
Intermediates	- 4.57	3.87	- 5.32	- 0.81	4.94	1.89
Consumer goods	- 3.06	3.18	- 1.93	- 2.49	5.21	- 0.90
Capital goods	- 5.31	4.22	- 9.52	- 0.23	9.64	1.20
Mixed category	- 5.87	5.98	- 2.16	- 0.46	0.67	1.84
			Exports			
Intermediates	- 5.06	3.90	- 3.42	- 0.62	3.09	2.11
Consumer goods	- 3.86	3.82	- 2.86	- 0.06	2.46	0.50
Capital goods	- 10.95	4.59	- 3.95	0.02	6.11	4.17
Not classified	- 14.50	3.98	- 1.38	0.49	4.75	6.66

Source: Eurostat Comext, wiiw calculations.

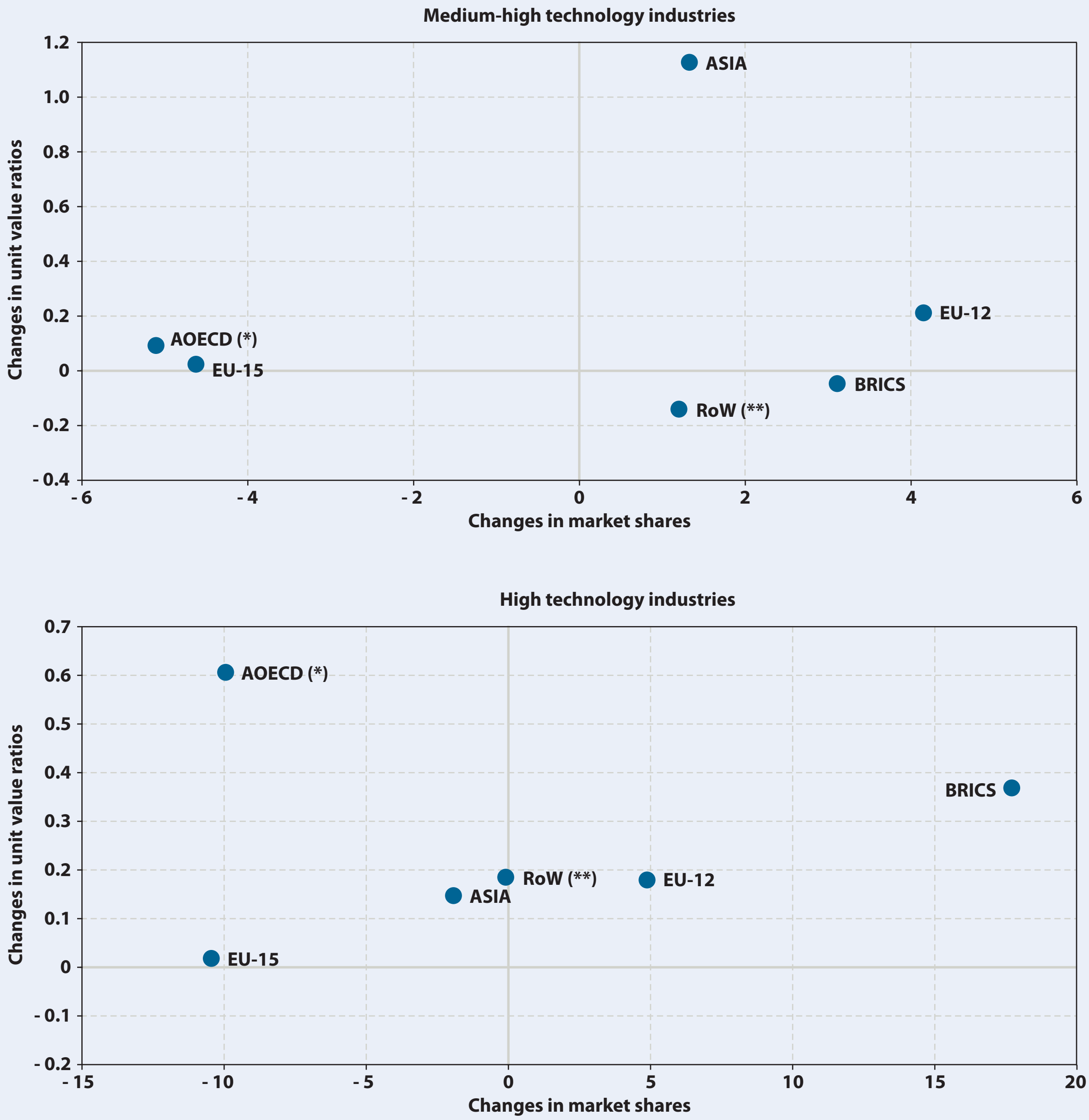
([35]) See the annex for a detailed explanation of the methodology.
([36]) The details of the analyses are available in the background study for the chapter.

Figure 2.1: Changes in market shares and unit value ratios for intermediates by industry groups, 1999–2008



(*) Advanced OECD countries.
(**) Rest of world.
Source: Eurostat Comext, wiiw calculations.

Figure 2.1: Changes in market shares and unit value ratios for intermediates by industry groups, 1999–2008



(*) Advanced OECD countries.
(**) Rest of world.
Source: Eurostat Comext, wiiw calculations.

Box 2.1: Measuring revealed comparative advantages

In the literature, various measures of revealed comparative advantages (RCA) have been proposed, early examples being Balassa (1965) and Vollrath (1991). Greenaway and Milner (1993) provide good discussions of the measures used in the literature. Vollrath's third measure of revealed competitiveness is used here:

$$RCA_j^c = \ln \frac{X_j^c / \sum_k X_j^k}{\sum_n X_n^c / \sum_{k,n} X_n^k} - \ln \frac{M_j^c / \sum_k M_j^k}{\sum_n M_n^c / \sum_{k,n} M_n^k}$$

where X and M denotes exports and imports respectively and j denotes an index for the product category under consideration and c is an index for country. The first term denotes the relative export advantage, which is analogous to the Balassa index, and the second term denotes the relative import advantage. The index ranges from minus infinity to plus infinity and is symmetric around zero. A positive value reveals a comparative advantage. One accounts for double counting by excluding the respective country in the aggregates over countries and the particular product categories in the product aggregates. The index was calculated for a group of 40 countries comprising a significant part of world trade.

Table 2.6 reports the results of this analysis for all countries included in the exercise. Looking at the figures for 2007, it is interesting to note that the set of countries with a comparative disadvantage is rather heterogeneous. With respect to the EU-27, this set includes advanced economies such as Germany, Denmark, and Italy on the one hand and EU-12 countries, e.g. Slovakia, Hungary, Poland, Slovenia and the Czech Republic on the other hand. This should, however, not be interpreted as a comparative disadvantage or advantage with respect to factor endowments or productivities, but rather reflects the structure of national industries or within-industry specialisation.

Many of the countries which have a revealed comparative disadvantage in intermediates show a strong comparative advantage in other categories: for example, Cyprus, Hungary, Lithuania, Poland, Romania, Slovakia and Slovenia have a comparative advantage in consumer goods. In all cases, the group of other advanced countries shows a positive index for intermediates, but a negative one for consumer goods, contrary to the pattern discussed above. With respect to the BRIC countries, these — with the exception of Russia — seem to have a comparative advantage in producing consumer goods, thus being relatively large importers of intermediates in producing final goods. The exception is Russia, for which primary goods are included. With respect to the group of other advanced countries, they all seem to have a comparative disadvantage, whereas they have comparative advantages in exports of consumer goods, though there have been some shifts over time.

Table 2.6: Revealed comparative advantage index, 1999 and 2007

	Intermediates		Consumer goods		Capital goods	
	1999	2007	1999	2007	1999	2007
EU-27	- 0.061	- 0.028	0.138	0.024	0.088	0.164
EU-15						
Belgium	- 0.09	- 0.05	0.15	0.20	- 0.21	- 0.29
Denmark	- 0.35	- 0.14	0.57	0.41	- 0.09	- 0.16
Germany	0.12	- 0.13	- 0.60	- 0.37	0.42	0.51
Ireland	0.11	0.19	0.40	0.06	- 0.24	0.00
Greece	- 0.03	- 0.02	0.81	0.34	- 1.73	- 1.27
Spain	- 0.40	- 0.20	0.43	0.26	- 0.53	- 0.54
France	- 0.15	- 0.06	0.01	- 0.01	0.09	0.02
Italy	- 0.41	- 0.26	0.65	0.30	0.07	0.27
Luxembourg	1.11	1.16	- 0.40	- 0.49	- 1.00	- 0.58
Netherlands	- 0.29	- 0.20	0.30	0.17	- 0.02	0.19
Austria	0.31	0.07	- 0.26	- 0.23	- 0.16	0.08
Portugal	- 0.43	- 0.15	0.81	0.36	- 0.87	- 0.54
Finland	0.10	- 0.01	- 1.22	- 1.12	0.51	0.61
Sweden	0.01	- 0.01	- 0.36	- 0.30	0.19	0.11
United Kingdom	0.13	0.20	- 0.27	- 0.29	0.04	- 0.14
EU-12						
Bulgaria	- 0.45	- 0.01	1.18	0.48	- 1.21	- 1.22
Czech Republic	0.09	- 0.20	- 0.08	- 0.11	- 0.50	0.04
Estonia	0.34	0.47	0.15	0.05	- 0.66	- 0.65
Cyprus	- 1.24	- 0.45	1.18	0.54	- 0.76	- 0.15
Latvia	0.88	0.84	- 0.02	0.02	- 1.65	- 1.01
Lithuania	- 0.32	- 0.05	0.57	0.35	- 1.29	- 0.85
Hungary	- 0.50	- 0.42	0.58	0.21	- 0.06	0.27
Malta	0.14	0.72	0.28	- 0.13	- 0.37	- 0.65
Poland	- 0.32	- 0.11	0.91	0.67	- 0.78	- 0.80
Romania	- 0.78	- 0.06	1.35	0.54	- 1.04	- 0.89
Slovenia	- 0.10	- 0.04	0.62	0.44	- 0.72	- 0.56
Slovakia	- 0.43	- 0.77	0.15	0.46	- 0.63	- 0.57
Other advanced economies						
Australia	1.08	1.13	- 0.15	- 0.27	- 1.93	- 1.91
Canada	0.37	0.76	- 0.17	- 0.57	- 0.48	- 0.55
Japan	0.19	0.14	- 1.51	- 1.67	0.85	0.67
USA	0.49	0.31	- 0.85	- 0.84	0.13	0.15
BRIC countries						
Brazil	0.13	- 0.14	0.78	0.81	- 0.76	- 0.34
China	- 1.61	- 1.19	3.07	2.42	- 0.41	0.10
India	- 1.23	- 0.77	2.91	1.99	- 1.23	- 1.49
Russia	1.36	1.78	- 2.28	- 2.11	- 1.76	- 2.16
Other						
Indonesia	- 0.11	0.37	1.41	0.93	- 1.39	- 1.35
Mexico	- 0.69	- 0.47	0.93	0.66	0.12	0.08
South Korea	- 0.95	- 0.62	0.67	- 0.69	0.52	0.61
Turkey	- 1.01	- 0.95	2.40	1.63	- 1.46	- 0.65

Note: EU-27 includes intra-EU trade.
Source: UN Comtrade, wiiw calculations.

2.2.4. Two-way trade in intermediate products

The analysis so far might have hidden the fact that there is — as in total trade — a lot of two-way trade taking place, i.e. countries being both exporters and importers of intermediates as well as in other product categories. The analysis below takes a closer look at the magnitude of this phenomenon and how it has evolved over time. This analysis is performed by applying the Grubel-Lloyd index at the level of product categories (see Box 2.2 for technical details).

Box 2.2: Measuring two-way trade

To measure two-way trade the common method is the Grubel-Lloyd index (Grubel and Lloyd, 1975). The analyses in this study use a version of this index correcting for trade imbalances (see Greenaway et al., 1994) which is calculated as:

$$RCA_j^c = \ln \frac{X_j^c / \sum_k X_j^k}{\sum_n X_n^c / \sum_{k,n} X_n^k} - \ln \frac{M_j^c / \sum_k M_j^k}{\sum_n M_n^c / \sum_{k,n} M_n^k}$$

This index is used for product categories and country groups based at the CN 8-digit level. The index ranges from 0 to 1 and can be interpreted as the share of two-way trade in total trade of this category. Whenever an export or import value is reported but no corresponding import or export value in the partner country, this is set to zero though it is not possible to know whether the value is missing and consequently should be positive or zero. The alternative to skip those observations would result in higher two-way trade indices but the same conclusions would hold.

Generally, the index tends to be higher for consumer and capital goods compared to intermediate products. Taking country averages, the index in 2008 is 0.35 for intermediates, 0.40 for consumer goods and 0.39 for capital goods. However, there seems to be no clear pattern, although countries with a high index value in one category also tend to have higher values for other product categories. This may be due to country-specific factors such as country size and income per capita being the most important determinants of intra-industry trade. A more striking fact is the large variation across countries. This is shown graphically in Figure 2.2 for intermediate goods trade, which also indicates changes in the index between 1999 and 2008.

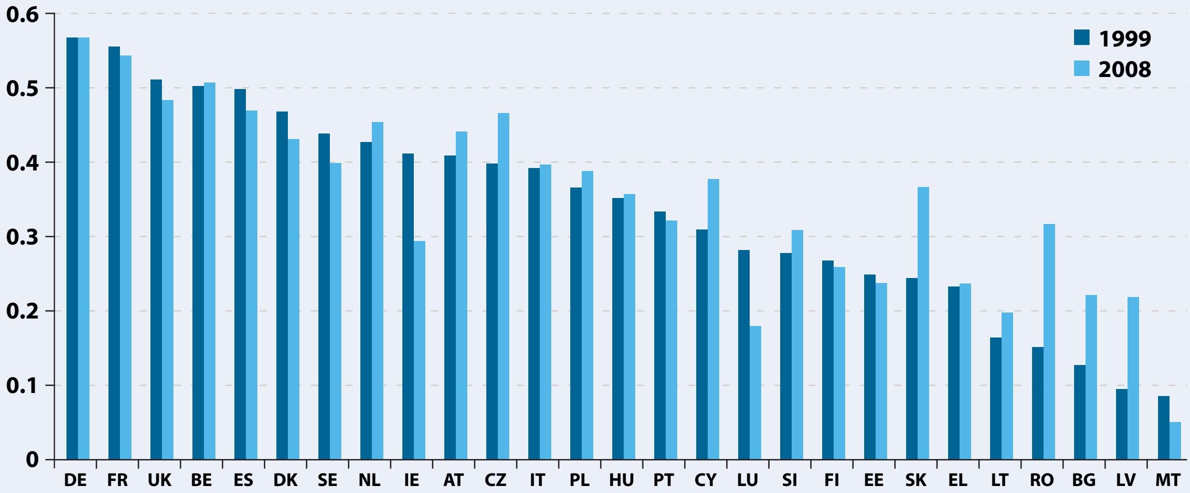
The share of two-way trade in intermediates ranges from more than 50 % in Germany and France to less than 10 % in Malta. As expected, larger and more developed countries in terms of per capita income tend to have a higher index. Interestingly, the index decreased for a number of countries between 1999 and 2008. This was the case for France, the United Kingdom, Spain, Denmark, Sweden, Ireland, Portugal, Luxembourg and Estonia. But there are also a number of countries for which two-way trade increased. This was particularly the case in countries where two-way trade was low in 1999. Two-way trade increased particularly strongly for Latvia, Bulgaria, Romania and Slovakia and to a lesser extent for the Czech Republic ([37]).

Thus, despite its potentially different nature, there is also a considerable amount of two-way trade occurring in intermediates trade, blurring the distinction between typical producer and user countries of intermediates still further (Stehrer et. al., 2010).

Intra-EU trade in intermediate goods is more characterised by two-way trade than extra-EU trade. Two-way trade in intermediates increased for trade with all regions except the countries constituting the 'rest of world', for which it decreased slightly. Two-way trade with the EU-12 increased by a third between 1999 and 2008, which may reflect stronger interlinkages between industries in the EU-15 and EU-12.

([37]) For a detailed comparison to other product categories, changes over time and industry-specific results see Stehrer et al. (2010).

Figure 2.2: Two-way trade in intermediates, 1999 and 2008

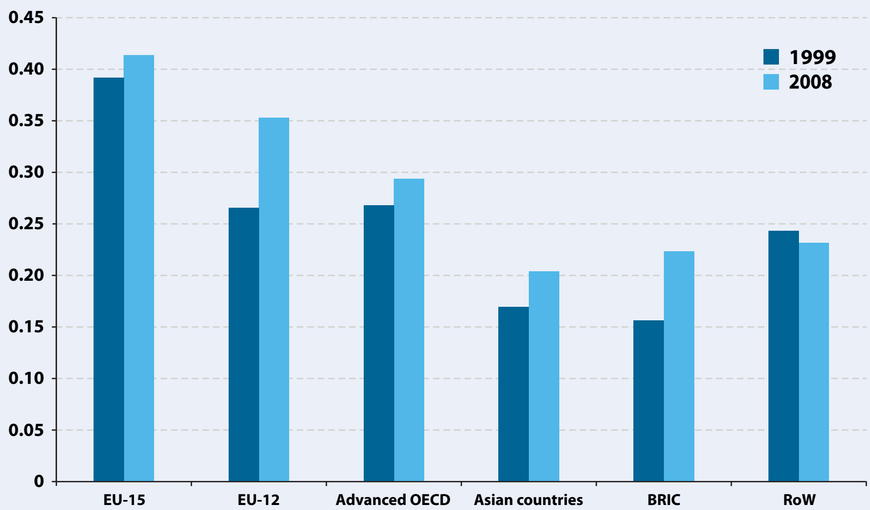


Note: Figures based on CGLI measure.
Source: Eurostat Comext, wiiw calculations.

2.3. Manufacturing supply chains and services

The analysis in the previous section is based on detailed trade data providing information on which products or product groups are traded between different countries. This does not however reveal anything about the industry using a particular product. A semi-conductor or light bulb might be used in different industries as intermediates. The question is to what extent particular industries are users of intermediates in general, and to what extent the structure of intermediate inputs is differentiated across industries and countries. On top of this, one might wonder about the extent to which these intermediate inputs are imported or sourced domestically, which is also a concern of this section and relates to the discussion of imported intermediates above. It then leads naturally to considering the structure of

Figure 2.3: EU-27 two-way trade in intermediates by region, 1999 and 2008



Note: Figures based on CGLI measure.
Source: Eurostat Comext, wiiw calculations.

inputs, either sourced domestically or internationally, for a particular product. This will also be shown in this section, namely in the case study on the Nokia N95. The analysis will show that there are considerable linkages between the manufacturing and service sectors which are in most cases increasing over time, particularly when considering both direct and indirect linkages. A second result is that the share of imported intermediates has grown over time. This implies that despite increasing interlinkages across industries, the domestic multiplier effects are roughly constant or even falling slightly.

2.3.1. Interlinkages between manufacturing and services

On the one hand, manufacturing industries use service inputs, i.e. act as clients of the service sector and hence create a 'pull' effect, by demanding service inputs as intermediates. On the other hand, manufacturing industries sell products to the services sector, i.e. provide products and hence create a 'push' effect ([38]). The pull effect is measured by the share of service inputs in manufacturing industries which are classified below by technology categories. Service inputs include both market and non-market services and represent direct service components embodied in manufacturing. The push effect is captured by the share of material inputs in services, detailed below by service categories ([39]).

Overall, high-tech industries received the largest share of service inputs in 2005, hence creating the largest pull effect. The average for all countries is 24.4 %. The second-largest share was held by low-tech industries (23 %), followed by medium-high-tech industries with 22 %. Medium-low-tech industries required slightly fewer service inputs, at 17 %. These figures hide large differences across countries. The EU-12 and Portugal had smaller service shares across all manufacturing industries, with the sole exception of Hungary, which had a relatively higher service input share in medium-low-tech industries.

There are large differences between countries, and these are most pronounced for the medium-high-tech industries. The differences range from 7 % of service inputs in Slovakia to 70 % in Ireland. When studying changes in the size of the shares between 1995 and 2005, service input shares increased in low-technology industries in almost all countries, which might be interpreted as outsourcing to upgrade production. In high-technology industries as well as in medium-high-tech industries, many countries saw service input shares increase, though less so in the latter category. Service input shares decreased in most countries only in medium-low-tech industries. Differences among countries are again large. Interestingly, the EU-12 display decreasing service input shares in all four technology categories, which is surprising. Slovakia is an exception, in that low-technology service input shares and especially medium-low-tech service input shares increased. This is surprising, given the generally lower shares of services in total manufacturing inputs in those countries.

Studying the push effect of manufacturing reveals that material inputs account for an average of 33 % in trade and hotels and in community services, creating the largest push effects in these service industries. The share is smaller in business services, at 22 %, and also in transport services (16 %). Generally, the differences between countries are not pronounced, with larger differences being found in business services. Interestingly, the EU-12 are among the countries with relatively large input shares, especially in business services and community services. Material input shares declined between 1995 and 2005 in all service categories and among all countries. Variations are less marked; Poland is the only country where material input shares increased in three service industries. Overall, it seems that the push factor of manufacturing on services is slightly larger than the direct pull factor. However, while the former declined over the last 10 years, the pull effect increased substantially.

2.3.2. Imports of intermediate inputs by industry

This section takes a closer look at the structure and changes in imported versus domestically sourced intermediates. Specifically, patterns of imported intermediate inputs by user industry will be analysed with a focus on cross-industry and cross-country differences. First, the developments over time for the aggregate manufacturing and services respectively are analysed. The aggregates are then broken down into different types of manufacturing and services industries.

The analysis is based on Eurostat's symmetric input-output tables, product by product, which are computed for the total economy, the domestic economy and for imports. This enables the role of imports in the economy to be investigated in more detail.

Import shares increased among all manufacturing industries and almost all countries between 1995 and 2005, with only very few exceptions (see Figure 2.4 below). The figure presents the ratio of imported to domestic intermediates in 1995 and 2005 for the Member States for which data is available. The largest shares of imported intermediates are found in the smaller Member States, reflecting their smaller size and lesser ability to produce all necessary intermediates domestically.

([38]) This terminology follows European Commission (2009), p. 79.
([39]) For details on the classification of material and service inputs see Timmer et al. (2008).

Even though import shares of intermediates increased in most countries for service industries between 1995 and 2005, it was less pronounced than for manufacturing (see Figure 2.5). In fact, import shares decreased by some 5 % in Irish service industries between 1995 and 2005.

Moving to less aggregated industries, Table 2.7 presents the share of intermediate imports in total intermediate inputs. Data are only available for the benchmark years 1995, 2000 and 2005.

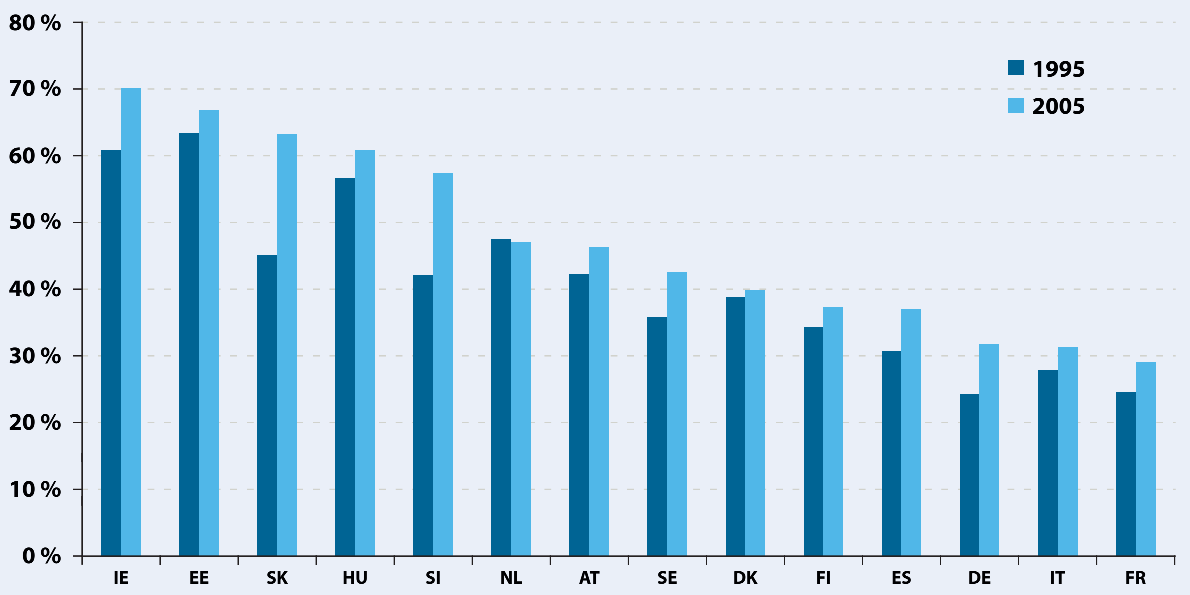
Taking the shares of imported intermediates in total intermediates in four types of manufacturing industries first, data show that imported intermediates are most significant in high-tech industries, where they account on average for 55 % of total inputs in 2005. Imports still account for 50 % of all intermediates in medium-high-tech industries and 48 % in medium-low-tech industries. Low-tech industries require substantially fewer imports, amounting to some 30 % of intermediates on average. Interestingly, the new Member States Estonia, Slovakia, Hungary and Slovenia, and also Ireland, and to some extent Austria, show the largest import shares in almost all technology categories. This may be due to the fact that they are all small open economies and also due to the new Member States' increased need for imported intermediates, as they are not able to source all necessary supplies of inputs domestically. The differences among countries are most pronounced for high-technology industries. Imported intermediates amount to 94 % in Estonia, 89 % in Hungary, 85 % in Ireland and 76 % in Slovakia in the upper range, and 29 % in France and 33 % in Germany in the lower range.

The largest increase occurred in the medium-low-tech industries. The most pronounced import share increases for all four technology categories were in Slovenia and Slovakia. However, import shares also rose in the EU-15 countries. There were above-average increases in Austria, Ireland, Germany, Sweden and Spain.

Analysing the share of imported intermediates in total intermediates in four service categories yields a different picture. Import shares are much smaller in service industries than in manufacturing industries, since fewer services are traded internationally. The services sector also has more SMEs than the manufacturing sector. The shares are about 17 % for trade and hotels, and 16 % for business services and community services. The share of imported intermediate goods is larger for transport services, at 26 %. It is interesting to note that the share of SMEs is smaller in these service industries than in others. In addition, differences among countries are small, with Italy displaying the lowest import shares and Ireland the highest. Import shares increased in most countries between 1995 and 2005, though there was much variation and no common picture. Import shares in business services decreased for three new Member States (Hungary, Estonia, Slovakia).

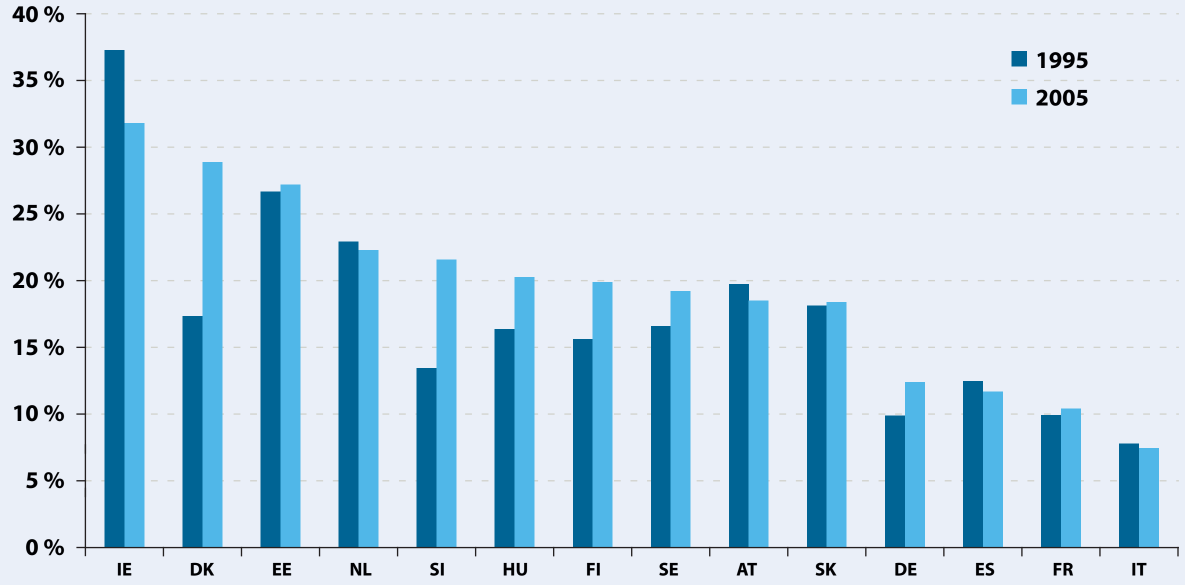
Output multipliers and their changes over time can be used to study changes in inter-industry linkages across sectors. By using output multipliers, both direct and

Figure 2.4: Ratio of imported to domestic inputs in EU manufacturing industries, 1995 and 2005 (in %)



Source: Eurostat input-output tables, wiiw calculations.

Figure 2.5: Ratio of imported to domestic inputs in EU services industries, 1995 and 2005 (in %)



Source: Eurostat input-output tables, wiiw calculations.

indirect effects are taken into account. It is, however, necessary to distinguish carefully between the effects of changes in interlinkages — which can be studied by analysing total multiplies — and the effects of a change in the share of imported intermediates by calculating domestic multipliers only. Total output multipliers are calculated from input-output tables which include imports of intermediate goods, while domestic multipliers are based on the domestic input-output tables which do not include imports. The fact that a significant share of intermediates is sourced from abroad therefore implies that the domestic multipliers evolve differently from total multipliers. For the domestic multipliers, one would expect an increase due to an overall increase in linkages across industries, whereas the fact that intermediates are sourced from abroad would work in the other direction. In a recent study, the European Commission (2009) reports the average of multipliers over 22 countries at the product level and highlights important differences when considering the total and the domestic multipliers. This is done by showing that the sectors with the highest total multipliers and domestic multipliers do not coincide. A similar exercise was undertaken by Stehrer et al. (2010) for three EU-15 countries (Austria, Germany, Spain). The most important finding was that the domestic multipliers are between 20 % and 40 % lower compared to the total multipliers on average. This difference even widened over the periods considered. The total multipliers were increasing in most countries, pointing towards increasing interlinkages, whereas the domestic multipliers were roughly constant or even slightly declining, indicating that imports of intermediates have been increasing over time.

2.3.3. Case study: the Nokia N95 mobile phone

The standard level of trade analysis is usually undertaken by sector, industry, product group or labour skill-groups, as in Sections 2 and 3 above. Global trade and globalisation of economic activities, however, occur at a much finer level of aggregation — at the level of tasks (see for example Grossman and Rossi-Hansberg (2008) for a theoretical approach). Stages of production that used to be performed by the same company in the same geographic location are now fragmented around the world. The various stages are either owned and controlled by one manufacturer, or owned and controlled by independent suppliers. This forms the system of global supply chains — increasingly not only for goods, but also for services. Services have become increasingly involved in international trade due to digitalisation.

A supply chain refers to the global flows of intermediate goods/services — both provided in-house and purchased from outside, unaffiliated, companies — involved in providing a good/service for final consumption. In each step, the vendor employs inputs, conducts its own value-adding activities and transfers its output to the other participants in the supply chain. The sum of all value-adding activities equals the final retail price before any applicable taxes. Figure 2.6 represents

Table 2.7: Shares of imported intermediates (in %)

	Low-tech industries			Medium-low tech			Medium-high tech			High-tech		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Belgium	37.5	41.2	.	46.7	51.4	.	59.4	57.9	.	58.8	57.7	.
Denmark	23.0	28.2	30.2	44.1	42.7	40.2	42.7	43.9	44.1	45.9	49.5	44.0
Germany	20.4	23.6	22.5	28.5	37.4	42.2	24.5	29.0	29.2	23.4	30.7	33.1
Estonia	41.6	45.7	44.5	65.3	52.8	61.8	56.4	61.8	66.8	90.5	95.9	93.5
Ireland	40.7	48.6	58.9	57.2	57.7	51.0	64.7	88.4	85.7	81.1	90.2	85.1
Spain	17.0	21.9	19.1	32.0	39.1	38.2	38.2	48.5	46.1	35.5	39.2	45.1
France	14.2	17.0	16.3	30.4	38.5	41.4	26.3	28.6	28.8	28.0	32.8	29.4
Italy	19.4	20.2	20.8	29.7	35.2	38.5	27.2	29.3	31.2	35.5	38.8	34.7
Lithuania	.	36.4	24.0	.	54.6	46.9	.	79.2	74.0	.	53.0	42.9
Hungary	29.5	39.1	32.3	47.0	57.7	54.6	68.6	69.6	67.3	82.4	90.7	89.2
Netherlands	39.2	38.2	34.3	55.8	58.7	60.4	46.0	46.7	44.4	48.9	51.7	49.0
Austria	26.6	33.3	33.2	39.6	51.5	49.2	51.3	58.1	55.9	52.3	57.8	47.4
Poland	.	19.8	20.3	.	36.7	40.7	.	35.7	42.1	.	41.0	49.3
Romania	.	21.7	23.0	.	30.8	34.4	.	31.0	32.9	.	40.8	51.0
Slovenia	32.5	43.2	43.9	35.4	51.0	61.4	51.1	64.7	61.7	49.5	56.9	62.4
Slovakia	24.4	42.6	44.7	42.5	55.9	62.2	59.8	78.1	70.1	53.6	75.4	75.8
Finland	16.2	18.4	18.5	30.4	36.1	41.3	37.4	37.3	40.2	53.8	44.2	49.5
Sweden	19.7	21.7	23.9	40.4	47.0	52.6	40.8	42.1	42.6	43.1	45.5	51.0
UK	23.4	.	.	25.6	.	.	32.1	.	.	38.2	.	.
	Trade and hotels (GH)			**Transport services (I)**			**Business services (JK)**			**Community services (LP)**		
	1995	**2000**	**2005**	**1995**	**2000**	**2005**	**1995**	**2000**	**2005**	**1995**	**2000**	**2005**
Belgium	19.6	26.2	.	23.2	29.6	.	14.6	19.9	.	16.8	17.5	.
Denmark	11.9	20.6	22.6	40.3	59.2	61.8	4.6	10.5	14.1	12.5	15.9	17.6
Germany	8.7	10.9	10.0	13.6	18.0	17.2	6.7	10.4	10.2	11.0	15.2	12.9
Estonia	23.1	20.1	22.3	37.4	39.9	35.7	25.8	22.0	21.9	20.9	31.2	28.8
Ireland	43.4	30.7	25.4	43.9	38.9	36.4	32.1	56.6	47.0	30.2	34.9	18.7
Spain	6.4	4.1	7.8	19.7	17.9	16.5	8.1	9.8	9.1	15.8	17.0	13.2
France	9.4	10.8	10.8	12.5	11.0	11.9	8.0	8.3	7.5	8.9	11.4	11.5
Italy	6.2	6.3	5.9	9.5	10.2	9.0	10.3	9.8	9.0	5.4	5.9	6.1
Lithuania	.	22.4	15.0	.	29.5	23.6	.	17.3	13.0	.	21.5	13.8
Hungary	12.6	22.5	19.3	16.6	28.0	31.7	22.6	22.1	15.3	14.0	17.0	15.0
Netherlands	27.6	26.3	24.2	31.3	33.7	33.6	15.3	14.6	18.6	17.7	15.5	13.8
Austria	15.6	16.4	18.9	32.0	29.8	25.9	14.8	11.4	13.0	16.9	16.1	16.4
Poland	.	10.7	11.4	.	14.6	15.7	.	6.3	7.4	.	6.5	8.5
Romania	.	24.0	19.6	.	20.0	18.6	.	21.8	23.3	.	34.2	32.8
Slovenia	9.7	11.0	19.6	17.0	25.2	28.0	12.9	16.6	16.3	14.5	17.5	22.4
Slovakia	14.0	16.3	13.3	26.8	43.7	26.7	19.1	12.6	15.7	12.9	13.2	18.3
Finland	13.8	17.9	20.0	21.2	21.4	25.1	13.5	14.6	16.9	14.1	17.2	18.1
Sweden	20.2	25.1	22.8	21.4	21.1	24.3	12.7	15.2	15.8	12.7	14.5	13.9
UK	12.8	.	.	15.1	.	.	10.2	.	.	14.5	.	.

Source: Eurostat input-output tables, wiiw calculations.

a stylised supply chain for the Nokia N95. In the case of tangible components, there are typically four to eight layers between Nokia and the extraction of metals and minerals from the earth's crust (Nokia, 2009a). All components embed intangible assets in some form, and conform to one or more industry standards. In the case of intangible components — licensed and purchased embedded and standalone software — the flows cannot be readily mapped in a similar manner, but there are typically fewer layers. The actors in the supply chain of the N95 are categorised into five groups in the figure: mines and refiners, component vendors and sub-assemblers, software and technology providers and licensers, the actual phone assembly by Nokia, or by an original equipment manufacturer (OEM), as well as wholesale and retail distribution by telecommunication network operators and/or by general traders. Unlike some of its competitors, Nokia maintained significant in-house manufacturing and assembly capacity and thus relied less on OEMs ([40]). In the case of the N95, all final assembly was done by Nokia itself. It did not use providers of electronic manufacturing/assembly services (EMSs) or outsource this task.

2.3.3.1. *Who captures value — where the value is created?*

Since gross domestic product (GDP) can be measured as the sum of the values added by all organisations in a particular country, it is often interesting to know where within the supply chain the value capturing takes place. This is not an easy task, as companies are reluctant to reveal the geography of their operations even at the level of the firm, let alone at the level of a specific offering. It is nevertheless possible to do some calculations that are fairly accurate at least as far as broader regions are concerned. The geographical allocations of the country of final sales and final assembly depend on the individual case. For instance, in the case of an N95 assembled in Salo, Finland, destined for the German market, 2.1 % would go to Finland and 14.5 % to Germany. The outcome would be different in the case of assembly in Beijing, China, destined for the US market. An average was calculated for all potential combinations of assembly locations and destination markets. The average is presented in Figure 2.7 ([41]).

The best estimate is that, on average, overall, 55 % of the value added of the Nokia N95 is captured in the EU-27. This is a remarkably large share for a truly global product. Even in the case of final assembly in China and final sales in the US, the EU-27 captured 51 % of the value added — despite the fact that the phone was 'made in China'. While final assembly is obviously the main step in the physical incarnation of the product, this stage only commands 2 % of the overall value added. On the other hand, the distribution channel and particularly its final retail loop capture a large share of the value added — worth many times more than the final assembly. Taking into account the value added tax or sales tax, the value added received by the country of final sales is even bigger.

How is it possible that the EU-27 can capture so much of the value from a seemingly minor role? The simple reason is that Europe was dominant in the branding, development, design and management of the N95 and related processes. To uncover these geographical connections often requires some detective work. Take, for example, the case of the N95's main processor and Texas Instruments (US). The hardware design was made in Dallas (US) and in Nice (France). Much of the software design and its integration to hardware were of Indian origin. Besides Dallas, the processor was also manufactured in Japan. A single component might be imported and exported several times, at least if the 'in transit' status is not determined appropriately. Even if it is, imports and exports are measured in gross value terms, although the value added at any given location may be small.

The information and communication technologies (ICT) sector and the N95 handset take into account a specific industry and a specific case while looking at the whole industrial landscape. However, they represent the electronics industry as a whole quite well and lead the way in global industrial transformation. Many industries are following suit. On the other hand, there are industries where unbundling of production has been the rule for decades, but localisation decisions differ from those observed in electronics.

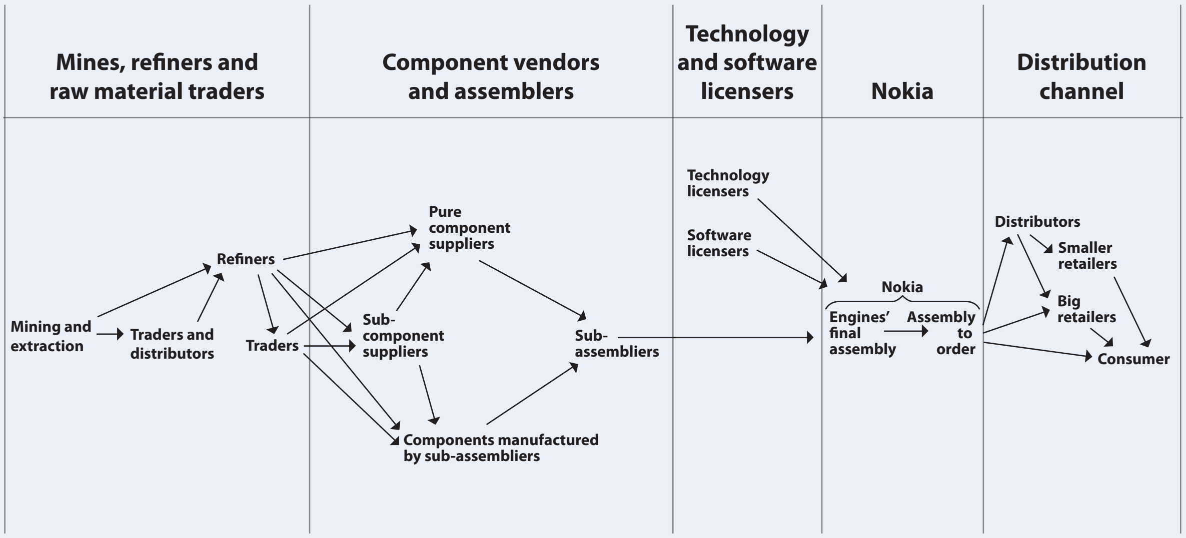
The most notable example is the automobile industry, where outsourcing and separation of different stages of production have proceeded quite far. Advanced ICT has facilitated outsourcing offshore, but much of the production has remained regional rather than becoming global. The simple reason is transportation costs. ICT helps to coordinate the activities of international supply chains, but intercontinental shipping of some auto parts is costly compared to electronics components.

Hence there are regional clusters or hubs specialising in auto parts within a reasonable distance from the final assembly. Nevertheless, the same logic applies; manufacturing that was originally done by the same company in the same factory is today dispersed into a

([40]) In 2007 Nokia outsourced 20 % of its total manufacturing volume (including all models) of mobile device engines (Nokia 20-F report, 2007, p. 36).

([41]) In 2007, the basic principle of Nokia was that smartphones for the European market were manufactured in Europe and correspondingly smartphones for the Asian market were manufactured in Asia. According to the available information, smartphones for the US market are mainly manufactured in Asia. Thus using these three as guidelines, potential combinations are: assembled in EU and sold in EU; assembled in EU and sold in other countries; assembled in Asia and sold in Asia; assembled in Asia and sold in North America; assembled in Asia and sold in other countries.

Figure 2.6: The stylised supply chain of the Nokia N95 mobile phone



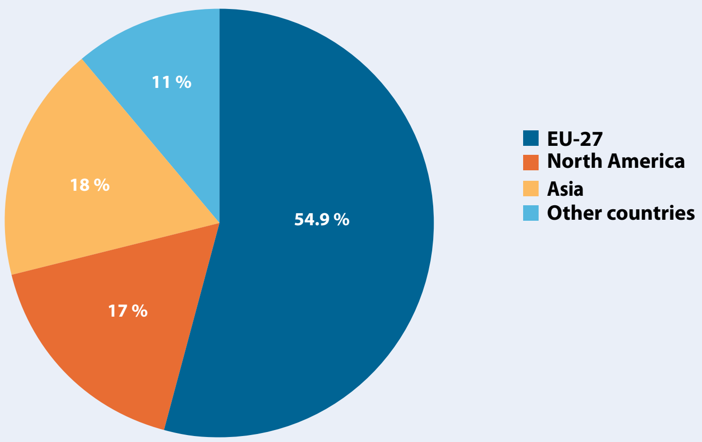
Source: ETLA database.

network of hundreds of suppliers and subcontractors to achieve advantages through economies of scale and specialisation.

The current economic crisis has spurred a discussion about the way in which global supply chains are affected. Has some of the offshore production been brought back onshore to its original location, or will it be? There are arguments for and against this scenario. While the need to seek more cost-advantageous locations has probably only increased for some producers, the crisis has revealed the vulnerability and unpredictability of production chains for others. The net effect is likely to be relatively small.

Unbundling and trade in tasks will most likely expand in services as a consequence of digitalisation. More and more services are becoming tradable once digitally transformed. Firms — both in manufacturing and services — will grow their offshore outsourcing of services to a much greater extent than ever happened in manufacturing. In addition to manufacturing, other tasks such as product development have also been transferred to low-cost countries.

Figure 2.7: The value added breakdown by regions taking into account the value added created in the country of final sales



Source: ETLA database.

2.4. The role of intermediates in the trade collapse in the EU-27: cause, effect or both

The trade collapse following the financial market turbulence of September 2008 which peaked in the winter months of 2008/09 was in many respects unprecedented. The trade slump was even steeper than in the Great Depression (Eichengreen and O'Rourke, 2009), and it occurred on a global scale with an extraordinarily high degree of synchronisation (Araújo and Martins, 2009; Araújo, 2009). Moreover, the decline in global trade in real terms was much more pronounced than that of real GDP. This also reflects a change in the structure of global trade, which is increasingly characterised by vertical specialisation across countries, i.e. countries are not necessarily specialised in the production of goods, but in certain stages of production of particular goods. Vertical specialisation implies that countries produce and export large amounts of intermediate products, parts and components in particular, which are then further processed or assembled in other parts of the world.

Hence, before a country exports a final product, a series of related trade flows of intermediate goods (including imports of primary, semi-finished goods and parts and components) will already have taken place. If, as was the case during the crisis, demand declines in many parts of the world, this affects not only the trade flows of finished goods, but also related trade flows in semi-finished goods and parts and components. By this mechanism, trade in intermediate goods increases the sensitivity of trade with respect to changes in the business cycle. The increasing role of international supply chains and consequent vertical specialisation led to a significant increase in the income elasticity of trade that is well documented in the literature (e.g. Cheung and Guichard, 2009; Freund, 2009). For the EU-15, this elasticity was 1.95 during the period 1961 to 1984, which means that global trade changed by 1.95 % when world GDP changed by 1 %. The elasticity increased to 2.45 % in the period 1985 to 2009.

In 2009, however, global trade took a stronger blow than suggested by the long-term elasticity of trade, as the decline in real global trade outstripped the decline of GDP by a factor of 5 (IMF, 2009). Various explanations for the disproportionate trade collapse of 2008–09 have been suggested, including increased trade costs due to the credit crunch (Escaith and Gonguet, 2009), protectionist tendencies by major trading partners (Evenett, 2009) and a composition effect, i.e. the industries most involved in international trade were hit harder by the decline in global demand.

What has happened to intermediate goods and in particular to parts and components — a subgroup that accounts for approximately 30 % of the EU-27 trade in intermediates — during the crisis is interesting per se, given their important role in international supply chains. Parts and components are of particular interest because they are the goods category most closely associated with the notion of international intra-industry vertical supply chains in the actual debate. They are therefore those most likely to be influenced by potential structural changes that may have occurred during the crisis due to the sourcing decisions of companies operating globally. This section analyses in more detail the development of the EU-27 export and import of parts and components using monthly trade data.

2.4.1. The impact of the crisis on trade flows by end-use categories

The first step in the analysis of the impact of the crisis on trade flows is to compare the decline in various end-use categories, including parts and components, with that of overall trade. Looking first at the development of aggregate exports during the crisis, Figure 2.8 reveals that export volumes declined sharply between October 2008 and January 2009, when the index of aggregate exports reached its trough at a level of 77 % compared to the September 2008 volume, i.e. a decline of 23 % in real values. The start and the intensity of the trade collapse were similar on the import side, but the decline was somewhat more extended, lasting until April 2009, when the volume index reached its low at 80 %. Hence, during the peak of the crisis, the export decline of 24 % was larger than the decline in imports, which amounted to 20 % in real terms.

Differences are also observable for the initial recovery phase discernible on the export side, starting in February/March 2009 and — setting aside the seasonal drop in August — lasting until October 2009, the last available observation for this analysis. In contrast, for imports, no real recovery can be detected before September 2009, so that one year after the outbreak of the crisis, the index level of exports was 4 percentage points above the import level, despite the initially stronger drop in export volumes. These differences in the recovery of trade volumes largely reflect differences in the overall recovery from the crisis, which appears to be more sluggish in the EU-27 than in other regions, particularly Asia and China.

Against this background, the most outstanding point that emerges from Figure 2.8 is that parts and components actually registered the most pronounced drop in trade volumes both on the export and on the import side, followed by capital goods. For example, in January 2009, imported parts and components stood at about 62 % of their September 2008 volume level, and remained at a very low level until September 2009, when they began to recover. Both on the export and on the import side, EU-27 trade in parts and components remained depressed at around 75 % of its September 2008 level at the end of the observation period. In contrast, the trade volume of consumption goods fell less sharply than other goods categories.

2.4.2. The share of parts and components in overall trade declined due to the crisis

The more than proportionate decline in the trade of parts and components led to a decline in the share of these goods categories when pre-crisis and post-crisis averages are compared ([42]). More precisely, for exports, the share of trade in parts and components decreased by 2.3 percentage points, from 17 % to 14,7 %. For imports, the relative decline amounted to 1.1 percentage points, from 15.5 % to 14.4 %. But the fact that parts and components were the most strongly hit goods category of EU-27 trade makes them particularly important for explaining the trade collapse ([43]).

One explanation for the strong decline in parts and components trade could be a change in the structure of trade with respect to trade in parts and components, i.e. a partial reversal of the trend towards ever-deeper and more complex forms of vertical specialisation. Such a trend reversal may have been triggered by a less favourable international environment, with the higher cost of trade finance and potentially protectionist policies implemented by trading partners. Another explanation for the strong decline in parts and components trade, which may be a rival as well as a complementary factor, is again a composition effect, similar to that mentioned above. According to this hypothesis, the trade slump was strongest in trade in parts and components because important industries in world trade which are also intensive in parts and components trade, such as the automobile industry, were relatively harder hit by the shock in global demand than other industries. The causality in this hypothesis is assumed to run from industries to shares in parts and components in total manufacturing trade. If the composition effect drives the strong downward movement of trade in parts and components, the stronger decline in this product category should vanish at the level of individual industries. On the other hand, if international supply linkages were partly disrupted as a consequence of the crisis, as suggested by the first explanation, the share of this category in total trade should have declined both at the total manufacturing level and for individual industries.

2.4.3. Parts and components trade and trade collapse across industries

This section takes a closer look at the share of parts and components trade in individual industries. Figures 2.9 and 2.10 present the shares of parts and components trade in individual industries for exports and imports on the vertical axes, and the industry-specific index of the trade decline on the horizontal axes. The horizontal axes show development between September 2008 and the month displaying the lowest value after September 2008. The series is constructed as an index with the level in September 2008 equal to 100. The lines crossing the data point ‘total manufacturing’ indicate the shares of parts in components trade and the index of trade decline for total manufacturing for comparison, respectively.

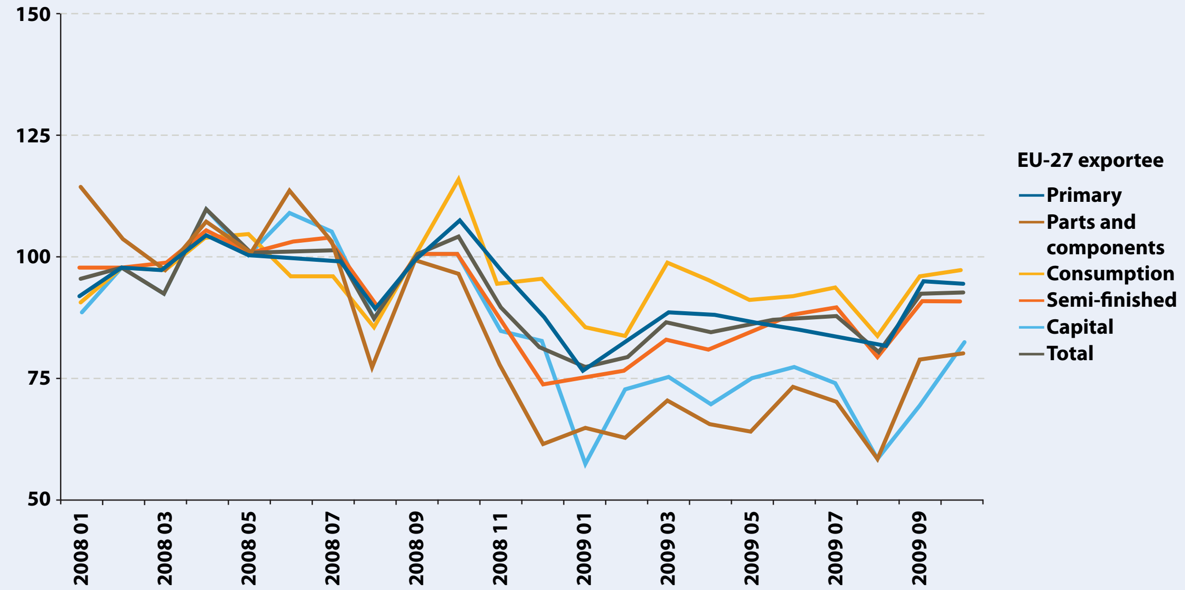
These figures show that vertical specialisation, as measured by parts and components trade, plays an important role in roughly half of manufacturing industries, mainly those with medium- and high-tech intensity. Industries with a high degree of vertical specialisation are found above the vertical line through ‘total manufacturing’. The highest degree of vertical specialisation in EU-27 exports is found in the electrical machinery industry (NACE 31), with 57 % of exported goods constituting trade in parts and components, followed by the machinery and equipment industry (NACE 29), with a share of 39 % in parts and components trade (see Figure 2.9). In the transport equipment (NACE 35) and automotive industry (NACE 34), parts and components account for 36 % and 34 % of industry exports respectively. The industry ranking by share of parts and components imports looks very similar, despite some differences.

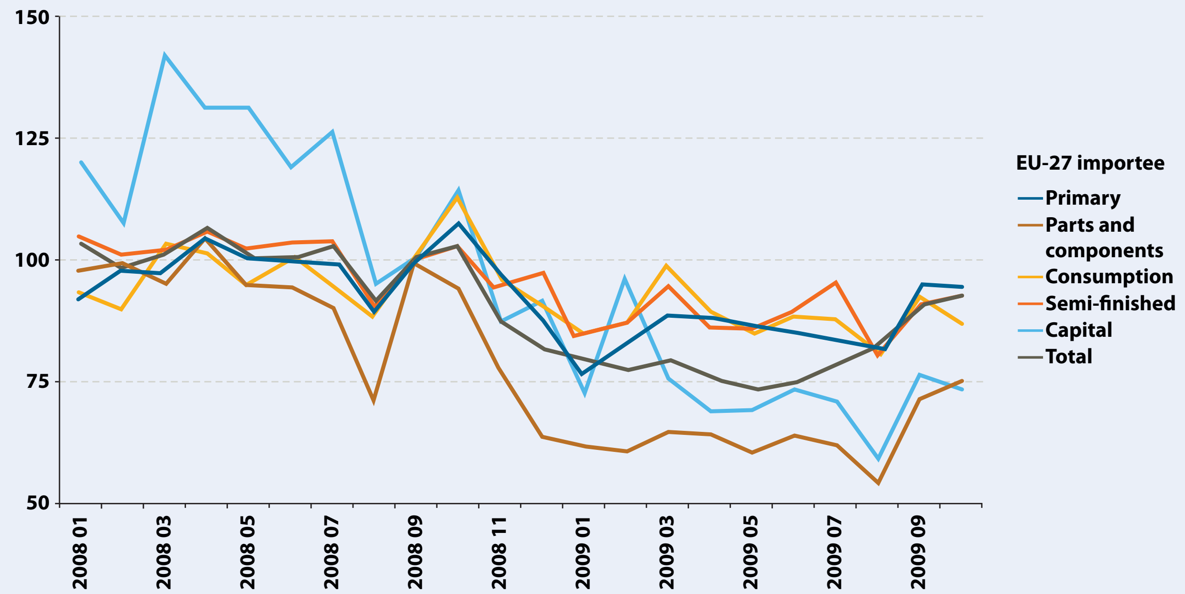
While the electrical machinery industry (NACE 31) has the highest share of parts and components in imports, with 55 %, it is followed by transportation equipment, with 45 % (see Figure 2.10). The machinery and equipment industry, the radio and television industry (NACE 32) and the automotive industry also have relatively high shares of parts and components in imports (see Figure 2.10). So, despite some differences in the precise ranking, the importance of parts and components is very similar on both the export and import side, with the five industries mentioned being those with the highest degree of vertical specialisation.

([42]) Pre-crisis averages are calculated for January 2008 to September 2008 and post-crisis averages for the period October 2008 to October 2009.

([43]) Note that the more than proportionate decline of parts and components is not the result of the multiplicative effect that trade in intermediates introduces into the trade statistics.

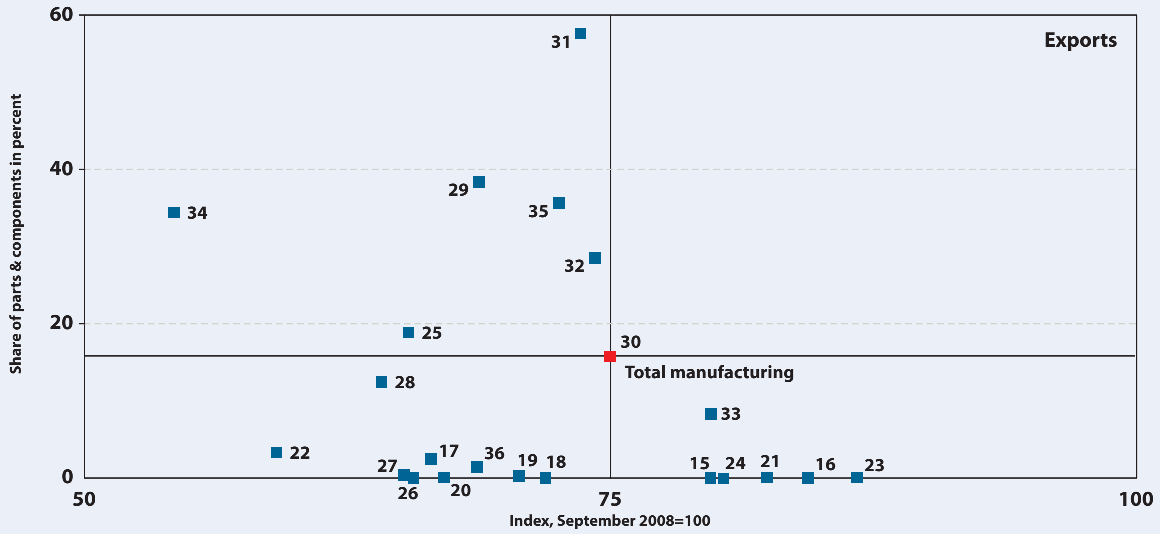
Figure 2.8: Development of EU-27 exports and imports by end-use categories during the crisis (trade volumes, September 2008 = 100)





Source: Comext, wiiw-calculations.

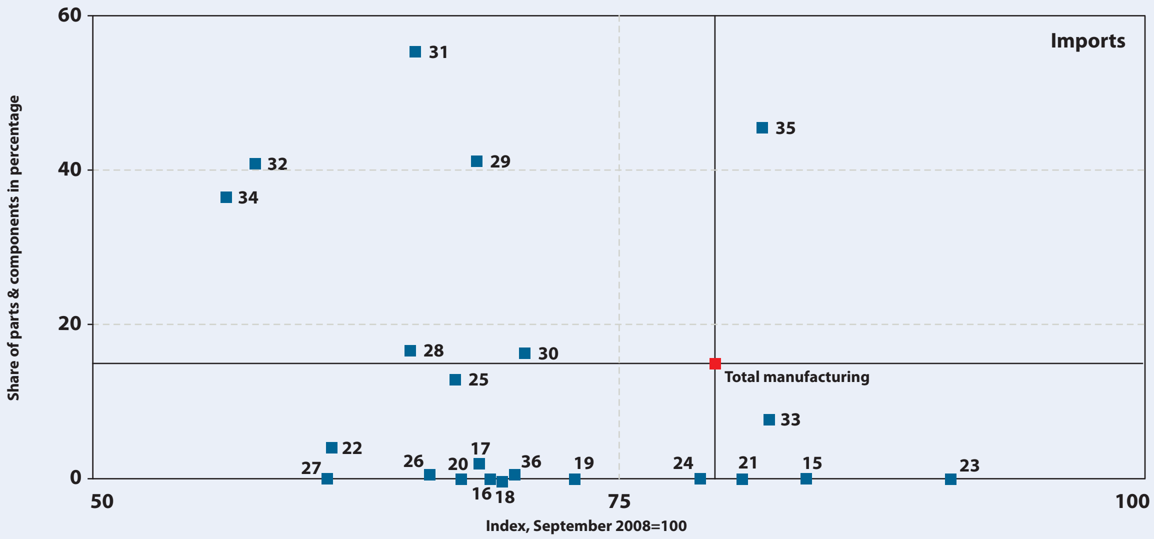
Figure 2.9: Index of real export values against share of parts and components trade of individual industries



Note: The horizontal and vertical axes through 'total manufacturing' refer to the shares and index of total manufacturing. Industries to the left (right) show a stronger (less strong) decline in trade compared to total manufacturing; the index refers to the lowest value after the crisis and thus might differ across industries. Industries above (below) show a higher (lower) share of trade in parts and components compared to total manufacturing.

Source: Comext, wiiw-calculations. August 2009 values neglected due to seasonal fluctuations. The total trade index for the individual industries and the entire manufacturing sector is the index corresponding to the post September 2008 monthly low.

Figure 2.10: Index of real import values against share of parts and components trade of individual industries



Note: The horizontal and vertical axes through 'total manufacturing' refer to the shares and index of total manufacturing. Industries to the left (right) show a stronger (less strong) decline in trade compared to total manufacturing; the index refers to the lowest value after the crisis and thus might differ across industries. Industries above (below) show a higher (lower) share of trade in parts and components compared to total manufacturing.

Source: Comext, wiiw-calculations. August 2009 values neglected due to seasonal fluctuations. The total trade index for the individual industries and the entire manufacturing sector is the index corresponding to the post September 2008 monthly low.

The composition effect hypothesis could serve as a plausible explanation for the strong decline in parts and components trade only if those industries with a high share of parts and components trade suffered from a more than proportionate slump. As indicated above, Figures 2.9 and 2.10 show graphically the relationship between each industry's share of parts and components in total EU-27 export and imports (vertical axis) and the severity of the trade decline that the respective industry suffered (horizontal axis). The industries' positions along these dimensions are shown relative to the entire manufacturing sector (NACE 15–36). The severity of the trade decline of each industry is measured by its index of real trade value at the time of its post-crisis monthly low.

September 2008 values serve as the base month. Consequently, a low index number indicates a strong decline in the real export or import value. Therefore, industries that experienced a strong decline relative to manufacturing are found on the left hand side in Figures 2.9 and 2.10 while industries that fared relatively well, such as the chemical industry (NACE 23), are found on the right hand side. The index numbers on the horizontal axes are related to the share of parts and components in the same industry, which are shown on the vertical axis. The figures show that there is indeed a large degree of variation in the growth performance of individual sectors (see dispersion along the horizontal axis). Focusing first on industries with the most pronounced declines of real trade values, the exports and imports of the automotive industry (NACE 34) experienced the strongest declines, amounting to about 45 % of its September 2008 level [44]. In line with the composition effect hypothesis, the automotive industry is also among the industries with the highest share in parts and components trade. Though developments in the automotive industry were devastating, other industries singled out as having high shares in the parts and components trade did not perform as badly. Nevertheless, the machinery and equipment industry (NACE 29) experienced a decline in real trade values, clearly above the average, as did the imports attributed to the electrical machinery industry (NACE 31) and the radio and television industry (NACE 32). The same is, however, true for a series of other industries with hardly any trade in parts and components such as publishing and printing (NACE 22), rubber and plastics (NACE 25), mineral products (NACE 26) and basic metals industry (NACE 27). Moreover, the transport equipment industry (NACE 35) registered a below-average decline on the import side.

Thus, Figures 2.9 and 2.10 indicate only a very weak negative correlation between the industries' decline in exports and imports respectively during the crisis. The share of parts and components trade lends limited support to the composition effect as the principal explanation for the strong decline in the parts and components trade and the related loss in the relative importance of this goods category in overall exports and imports.

Moreover, Figure 2.11 shows that the crisis also led to a decline in the share of parts and components in overall EU-27 trade in almost all industries where vertical supply chains play a major role, such as the electrical machinery industry (NACE 31), the mechanical equipment industry (NACE 29) and the motor vehicles industry (NACE 34).

This picture supports the hypothesis that some of the established international supply chains were disrupted. This could be the result of changes in the sourcing strategies of multinational corporations, such as shifting to domestic suppliers or bringing back onshore activities that were previously offshore. With respect to the decline in the share of parts and components at industry level in overall EU-27 trade, a third factor, inventory adjustments, may explain developments. While inventories may certainly influence developments of trade values in intermediate goods in the short term, they are unlikely to be the major factor, because trends towards just-in-time delivery for production reduce the impact of inventory adjustments on developments of exports and imports. Moreover, trends for semi-finished goods do not show the same patterns as parts and components; this also supports the case of potential change in the structure of trade with respect to trade in parts and components.

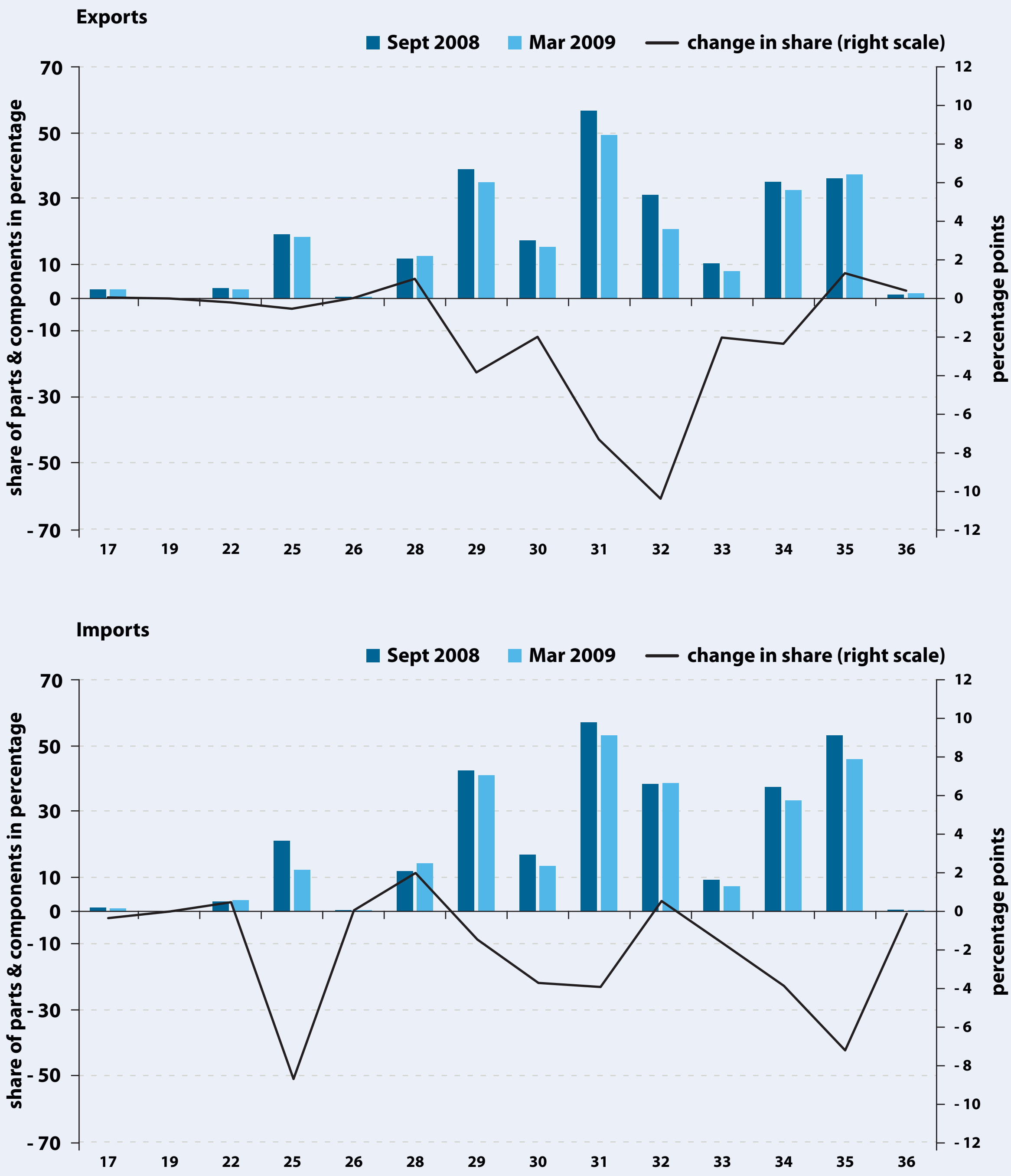
2.5. Summary and conclusions

The analyses of trade in intermediates point towards their relative importance compared to other product categories and their dynamics over time. The share of intermediate imports in total EU-27 trade amounts to around 55 % of total trade. Trade in intermediates is not too distinct from trade in other product categories despite its relative importance and its nature.

The study shows that the shares of imported intermediates in total trade are rather stable for each industry, and that there is a high correlation of these shares across countries at industry level. This suggests that specialisation patterns might play an important role in explaining cross-country differences and changes over time. The analyses showed that there has been a general trend towards increasing shares of trade in intermediates over time. The slightly larger increase in trade in intermediates as compared to other product categories is mostly due to a shift towards more knowledge-intensive industries in which imports of intermediates are more important than in other industries.

[44] Since Figures 2.9 and 2.10 measure the industries' total export and import indices, the trade declines are equal to 100 minus the respective index number.

Figure 2.11: Index of real export values against share of parts and components trade of individual industries — Decline from September 2008 to post-crisis industry low



Source: Eurostat Comext, wiiw calculations.

Some important changes in intermediates trade have occurred over the last decade with respect to the geographical structure of trade. Considering EU-27 imports first, a common trend is that the EU-15 countries, the advanced OECD countries and the Asian countries have lost market shares in all product categories, whereas the EU-12 countries and the BRIC countries have gained market shares. A striking aspect is that these shifts can be observed across all industry categories. In particular, import shares from BRIC countries increased relatively strongly in high-tech industries at the expense of EU-15 and advanced OECD countries, whereas the EU-12 gained mostly in high-tech consumer goods. The shifts are similar for other industry categories, but less pronounced. A similar pattern can be observed for EU-27 exports, with rising export shares observed for EU-12 and BRIC countries.

Overall, the analysis suggests that the pattern of trade in intermediates and its change over time tend not to be too different from other product categories, despite its more complex role as an input in the production process. As such, there seems to be no requirement for specific or distinct policies with respect to different product categories. The findings are suggestive of the importance of the international supply of products used in production processes which have to be taken into account in any bilateral policy measures. A further finding is that the industry dimension, i.e. specialisation patterns, shapes general patterns and volumes of trade in intermediates for individual countries. In some cases, the results indicate that trade in intermediates might serve as an important vehicle for successful trade integration into world markets, and may allow countries to overcome adverse initial specialisation patterns, thus allowing for dynamic shifts in comparative advantage structures through learning effects. Countries such as China (but also others) show particularly dynamic patterns in higher-tech industries or products, not only with respect to consumer goods, but also to intermediate products.

The analyses show that most countries are both exporters and importers (i.e. the share of two-way trade is quite high) even at detailed industry levels. Smaller emerging economies, i.e, the EU-12, are relatively more specialised in trade in intermediates as compared to other economies. Again, these specialisation patterns can be found both in imports and exports.

By using EU domestic and import symmetric input-output tables, analyses of the share of imported intermediate inputs in total intermediate inputs by industry were performed. The analyses were undertaken for both manufacturing and services industries. Imported intermediates are most important for high-technology manufacturing industries with an import share of about 55 %. Imports of intermediates are also important in medium-high-tech industries, where the import share amounts to 50 % and to 48 % in medium-low-tech industries, but less so in low-tech industries, where only some 30 % of input goods are imported. Again, there are quite substantial country differences indicating larger shares for small economies. These country differences seem to be more pronounced in high-tech industries. These shares, with a few exceptions, rose over the period from 1995 to 2005. Regarding service industries, imports generally play a much less important role, ranging from around 16 % in trade and hotels to about 26 % in transport services. Differences across countries for services industries are smaller compared to manufacturing industries.

The analyses indicate an increase of the linkages between industries and countries over time. The increase in inter-industry linkages means that an industry facing an increase in demand requires more inputs from other industries to satisfy that demand than before. The increased industry linkages between countries mean that more of an industry's demand for inputs is satisfied from suppliers in another country than before. Calculations of output multipliers from the input-output tables show that there is an increase in the total output multipliers for the EU-15 economies, but a decrease for EU-12 economies, thus pointing to stronger inter-industry linkages for the former set of countries. When looking at domestic multipliers, the former group shows more or less constant multipliers, implying that increased imports of intermediates are the triggers for increased linkages in terms of multiplier effects.

Given the complexity of the production process and its international relations, aggregated trade data might not be the best source of information when aiming at a detailed analysis of supply chains at the level of firms or even products. In this case, detailed information about the unbundled supply chains in one particular case — Nokia N95 mobile phone — has been used to address these questions in more detail. It turns out that, on average, Europe captured 55 % of the total value added. The N95 was assembled both in Europe and China. When the device was assembled and sold in Europe, Europe's share of the value rose to 68 %. Even when it was assembled in Beijing and sold in the US market, Europe captured as much as 51 % of the value. The final assembly, although important, represents only a fraction of the overall value added of a high-tech product such as the mobile phone. The capture of value is largely detached from the physical flows of goods within the supply chain. Major parts of the value are attributed to design, R & D, branding, marketing and distribution and management of these functions. The estimates based on trade statistics and national accounts tend to give a somewhat biased and inadequate picture of how value added spreads geographically. The only way to shed some light on the issue, given the availability of statistical data, is to conduct case studies. The black box needs to be opened to understand the very nature and consequences of production unbundling. The case study shows that an analysis which takes service flows into account and uses value added-based information comes up with strikingly different conclusions on global trade flows to analyses which use gross values of flows of goods. This suggests that concerted efforts should be made to develop value added-based trade statistics. The current system was developed for the 'old paradigm' globalisation, where trade and specialisation in the international economy were based on comparative advantages of sectors. In order to dig deeper into the consequences of global trade in tasks, value added-based data on trade flows are needed.

Finally, when analysing the impact of the crisis on EU-27 trade flows, a series of explanations has been offered for the trade collapse in the winter months of 2008/09. The increasing role of trade in intermediates plays a central role in most of them. A first reason for this is the stylised fact that the larger share of trade in intermediates caused the income elasticity of trade to increase, which was reconfirmed here for EU-15 trade. One of the major results of the analysis is that parts and components were also the goods category worst affected by the crisis, standing at about 62 % of its September 2008 volume at the peak of the crisis. As a result, the relative importance of parts and components in EU-27 trade declined, with the post-crisis share of parts and components in EU exports and EU imports falling by 2 % and 1 % respectively. This decline appears to be rather small, but when individual industries are considered, the changes become more pronounced for those with a high share of parts and components trade, reaching 7 percentage points for the share of parts and components in EU-27 exports in the electrical machinery industry. This result supports the hypothesis that some of the international supply chains established in the course of globalisation were negatively affected because of changes in the sourcing strategies of multinational firms in reaction to a less friendly trading environment.

The results of the analysis of the parts and components trade also revealed that a composition effect is not the major explanation for the very pronounced slump in parts and components exports and imports of the EU-27. So, while the composition effect and possibly also inventory adjustments may have contributed to the more than proportionate decline in the exports and imports of parts and components, they seem to be insufficient to fully account for the changes seen. In any case, the severe decline in trade in parts and components is one of the elements explaining why the trade slump was even more pronounced than suggested by long-term income elasticity of trade. By viewing the recovery of trade flows, a rapid upturn in EU-27 trade could be expected if the strong decline in parts and components trade were primarily driven by the inventory cycle, as empty stocks have to be refilled. There is, however, a risk that the disruption of existing supply chains, caused by the financial crisis, may have a dampening effect on trade during the recovery.

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Annex

Data and classifications

Trade statistics

The analysis is firstly based on the EU Comext trade database which provides data at the detailed Common Nomenclature (CN) 8-digit level. The analysis is restricted to the period 1999–2008. This database provides information on export and imports at the detailed CN 8-digit product level with all other countries in the world as partner countries. The CN 8-digit nomenclature includes about 11 500 product codes on average per year for which data on both values and quantities (in kilograms) of imports and exports are available. The information on the quantities traded is later on used to calculate unit values or unit value ratios. One important aspect is that the CN 8-digit classification is slightly changed every year. Thus an average of about 500 product codes are replaced per year, although the overall number of products in the nomenclature is roughly constant. Whenever these changes in classification pose some problems, these are circumvented by aggregating the data to the CN 6-digit level which corresponds to the HS 6-digit classification for which the revisions are less problematic. For the detailed product-level data, correspondences exist to NACE industries (at the 2- and 3-digit levels) and to end-use categories known as 'broad economic categories' (BEC) classification as provided by the UN. Table A.1 shows the list of BEC categories. At the 1-digit level there are seven categories classified, which are broken down into primary goods and processed goods in the case of the first three 1-digit product categories, parts and accessories as a subgroup of capital goods and transport equipment goods. Passenger motor cars are included in this last category. At the 3-digit level, parts of the groupings are further classified, according to whether the products are mainly used by industry or for household consumption. This more detailed classification of products allows one to aggregate up to somewhat higher aggregates to consider trade in intermediates, in final consumer goods and in capital goods separately. There are, however, various different ways in which this aggregation can be done and various suggestions are made in the literature. This study follows the definitions suggested by the OECD, as shown in Table A.3 (see Miroudot et al. (2009) for an example ([45])). The table provides evidence that this classification is not a one-to-one correspondence as many products might be used by households for final consumption as well as by industries as inputs in the production process. The most important example of this might be passenger cars, which are therefore not classified. Together with motor spirits (BEC 321), this category is, however, reported separately.

Note that this is a rather broad definition of trade in intermediate products, as it also includes primary products (111, 21, 31) as intermediates. An example would be milk produced in country A and exported to country B for the production of cheese ([46]). This broad definition is used in most parts of the study; however, whenever it is advantageous, a more narrow definition is used, by separating single BEC codes or groups of these.

An additional aspect concerns the detailed list of partner countries. As it is not possible to show the relevant figures for all partner countries, it is necessary to build country groups. The country groups considered are listed in Table A.2.

The EU-15 includes all countries that have been members of the EU since 1995, and the EU-12 includes all countries that joined in 2004 or later (thus this group includes all central and east European countries together with Cyprus and Malta). The EU-15 and EU-12 together are denoted the EU-27. There is also a set of advanced OECD countries not included in the EU-15 or EU-12 (Australia, Canada, Iceland, Japan, New Zealand, Norway, Switzerland, US), a group of Asian countries (including Hong Kong, Indonesia, Macau, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, Vietnam), the BRIC countries (Brazil, Russia, India, China) and finally a 'rest of world' (RoW) category.

In some cases, trade data from UN Comtrade at the detailed HS 6 product level are used. There is also a correspondence to BEC categories for these data. This database allows the inclusion of other countries as reporter countries in the analysis.

Data from input-output tables

The analysis in Section 3 is based on the EU KLEMS data, which distinguish intermediates input by energy, material and services. These data are based on the respective use of tables for each country and allow inclusion of 19 countries in the analysis. Here, the focus is mainly on the inputs of services in manufacturing and on material inputs in services. One should note that this analysis is based on nominal values. Total and domestic input-output tables provided by Eurostat are used to calculate the share of imported intermediates by industry. See

([45]) Examples for slightly different classifications are Gaulier et al. (2007) or Frensch and Wittich (2009).

([46]) There are many definitions of supply chains. All of them share this broad view as expressed in the following statement: 'Entire network of entities, directly or indirectly interlinked and interdependent in serving the same consumer or customer. It comprises of vendors that supply raw material, producers who convert the material into products, warehouses that store, distribution centres that deliver to the retailers, and retailers who bring the product to the ultimate user.' (http://www.businessdictionary.com/definition/supply-chain.html).

Table A.1: BEC classification

1-digit	Description	2-digit	Description	3-digit	Description	
1	Food and beverages	11	Primary	111	Mainly for industry	Intermediates
				112	Mainly for household consumption	Consumption
		12	Processed	121	Mainly for industry	Intermediates
				122	Mainly for household consumption	Consumption
2	Industrial supplies n.e.s.	21	Primary			Intermediates
		22	Processed			Intermediates
3	Fuels and lubricants	31	Primary			Intermediates
		32	Processed	321	Motor spirit	Not classified
				322	Other	Not classified
4	Capital goods (except transport equipment) and parts and accessories thereof	41	Capital goods			Capital goods
		42	Parts and accessories			Intermediates
5	Transport equipment and parts and accessories thereof	51	Passenger motor cars			Not classified
		52	Other	521	Industrial	Capital goods
				522	Non-Industrial	Consumption
		53	Parts and accessories			Intermediates
6	Consumer goods n.e.s	61	Durable			Consumption
		62	Semi-durable			Consumption
		63	Non-durable			Consumption
7	Goods n.e.s					Consumption

Eurostat (2008) for a detailed outline of the compilation of European supply and use and symmetric input output tables. The manufacturing industries are grouped into four groups which are listed in Table A.3.

Monthly trade statistics

The analysis of the trade collapse (Section 4) builds on detailed (CN 8-digit level) monthly trade data for the EU-27 from the Comext database, which provides the same level of detail as the yearly trade data described above. However, this section opted for a more refined categorisation of end-uses, which is more relevant for the analysis of the trade collapse. In particular, the analyses in Section 4 follow the approach in Gaulier et al. (2007) and separate the broad category of intermediates of the OECD classification into (i) primary goods, (ii) semi-finished goods and (iii) parts and components (P & C). The two groups of final goods — capital goods and consumption goods — are treated separately in line with OECD guidelines. Another important difference in this classification is that product groups for passenger cars (BEC category 51) are subsumed under consumption goods (instead of the catch-all group of category 'not classified' or 'mixed'). This finer split-up of intermediates is motivated by the fact that — though all intermediate goods enter the production process — the various categories of intermediates reacted very differently during the crisis. Location and sourcing decisions for primary goods are probably quite different to those for parts and components, which also include a high share of inter-company trade of multinationals. The analysis of trade in parts and components which, in contrast to primary and semi-finished goods, include a high share of technologically sophisticated goods may in general be a more appropriate proxy for vertical specialisation within particular industries ([47]).

Table A.2: Country groupings

EU-15	Old Member States
EU-12	New Member States
AOECD	Advanced OECD
ASIA	Asia
BRICS	BRICs
RoW	Rest of world

([47]) Trade statistics as used here, in fact, only allow intra-industry vertical specialisation to be revealed because products are always allocated to the industry that typically produces this product and not to the industry where it is used for production purposes.

Table A.3: Industry classification

NACE	Description	Group
15	Manufacture of food products and beverages	Low
16	Manufacture of tobacco products	Low
17	Manufacture of textiles	Low
18	Manufacture of wearing apparel; dressing and dyeing of fur	Low
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	Low
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Low
21	Manufacture of pulp, paper and paper products	Low
22	Publishing, printing and reproduction of recorded media	Low
23	Manufacture of coke, refined petroleum products and nuclear fuel	Medium low
24	Manufacture of chemicals and chemical products	Medium high
25	Manufacture of rubber and plastic products	Medium low
26	Manufacture of other non-metallic mineral products	Medium low
27	Manufacture of basic metals	Medium low
28	Manufacture of fabricated metal products, except machinery and equipment	Medium low
29	Manufacture of machinery and equipment n.e.c.	Medium high
30	Manufacture of office machinery and computers	High
31	Manufacture of electrical machinery and apparatus n.e.c.	Medium high
32	Manufacture of radio, television and communication equipment and apparatus	High
33	Manufacture of medical, precision and optical instruments, watches and clocks	High
34	Manufacture of motor vehicles, trailers and semi-trailers	Medium high
35	Manufacture of other transport equipment	Medium high
36	Manufacture of furniture; manufacturing n.e.c.	Low

Note: The classification of industries in technology intensities is based on Hatzichronoglou (1997) and Loschky (1998).

Calculations of unit value ratios

The value of exports to the EU-27 of commodity i by country c in year t is denoted by v_{it}^{c} and the quantity (measured in tons) by q_{it}^{c}, and the export unit value is defined as

$$u_{it}^{c} = \frac{v_{it}^{c}}{q_{it}^{c}}$$

The unit values of country c's exports to the EU are then compared to the unit values of total EU imports (from the world, including intra-EU trade) by calculating the logs of the unit value ratios

$$r_{it}^{c} = \ln \frac{u_{it}^{c}}{u_{it}^{EU-27}}$$

Here, $u_{it}^{EU-27} = \sum_c v_{it}^{c} \Big/ \sum_c q_{it}^{c}$ denotes the unit value of total EU imports for a particular commodity i in year t. Taking the logarithm ensures a symmetric aggregation across products for ratios larger and smaller than 1 (see below). In logs, the ratio is thus larger (smaller) than zero if the export unit value of country c is larger (smaller) than the unit value of total EU imports. The unit value ratios to the level of product categories and industry groups are aggregated. This is done by constructing a weighted sum of the unit value ratios r_{it}^{c} across the products belonging to a particular industry group j and product group k. The weight used for a particular commodity i in such an aggregation is the share of its export value in the industry's or product group's exports of country c. Denoting the set of commodities i belonging to an aggregate j,k by $i \in I(j,k)$ the weights are calculated as

$$w_{it}^{c} = \frac{v_{it}^{c}}{\sum_{k \in I(j,k)} v_{(j,k)t}^{c}}$$

The unit value ratio for a particular aggregate j,k is then

$$r_{(j,k),t}^{c} = \sum_{i \in I(j,k)} w_{it}^{c} r_{it}^{c}$$

This measure can be interpreted analogously to the unit value ratios for a particular commodity as mentioned above. Since this exercise is performed for groups of partner countries (i.e. countries exporting to the EU-27), index c has to be interpreted as a group of partner countries (Asian countries, BRIC countries, etc.).

The market shares of a particular country (group) c in EU-27 markets (or individual countries or country groups) is defined as

$$m^{c}_{(j,k),t} = \frac{v^{c}_{(j,k),t}}{v^{EU-27}_{(j,k),t}}$$

i.e. the export values from country c of product category (j,k) relative to total import values of the EU-27.

For the EU-27's exports a similar exercise is performed. However, one has to keep in mind that using the EU Comext database does not allow use of total exports to the world (from all countries) as a unit for comparison as this dataset provides information on exports and imports of EU-27 countries only, thus excluding trade flows between non EU members. Consequently, the unit value ratios for exports is defined as

$$r^{c}_{it} = \ln \frac{u^{c}_{it}}{u^{EU-27}_{it}}$$

where u^{c}_{it} denotes the unit value of exports for country c being a member of the EU-27 and u^{EU-27}_{it} denotes the unit value of total EU-27 exports to the world. Export shares are defined as the share of country c's exports to the world in total EU-27 exports in the respective product and industry categories.

Table A.4: Change in import values and import shares by end-use categories

	Index 1999 = 1				Change in import shares (in percentage points)			
	Intermediates	Consumer goods	Capital goods	Not classified	Intermediates	Consumer goods	Capital goods	Not classified
Belgium	1.92	2.32	1.70	1.95	- 1.64	3.67	- 1.93	- 0.10
Bulgaria	5.04	5.18	5.26	4.31	- 0.17	0.45	0.85	- 1.13
Czech Republic	3.55	3.58	3.28	3.14	1.10	0.45	- 1.22	- 0.33
Denmark	1.77	1.85	1.69	1.71	- 0.04	1.12	- 0.92	- 0.16
Germany	1.92	1.42	1.59	1.20	6.79	- 3.63	- 1.12	- 2.04
Estonia	3.16	2.97	2.68	7.48	- 1.29	- 2.03	- 3.13	6.45
Ireland	1.09	1.84	1.16	1.12	- 6.12	8.42	- 1.76	- 0.54
Greece	1.77	2.14	1.51	1.49	- 0.50	5.60	- 3.75	- 1.35
Spain	2.09	2.33	1.47	1.31	3.98	3.92	- 4.60	- 3.29
France	1.59	1.65	0.99	1.59	4.23	2.90	- 7.63	0.50
Italy	1.67	1.80	1.30	1.30	2.50	2.58	- 3.23	- 1.85
Cyprus	3.09	2.31	1.99	4.11	5.64	- 5.12	- 4.67	4.15
Latvia	3.91	3.55	3.34	5.41	1.66	- 1.69	- 2.40	2.42
Lithuania	3.87	3.78	4.45	7.69	- 3.10	- 2.26	1.46	3.91
Luxembourg	1.98	1.46	3.00	1.96	- 2.44	- 6.77	9.76	- 0.55
Hungary	2.35	2.51	2.75	3.56	- 3.37	0.15	1.93	1.29
Malta	1.06	1.48	1.15	1.20	- 5.77	5.71	- 0.08	0.14
Netherlands	1.98	1.78	1.90	1.33	2.57	- 1.19	0.22	- 1.61
Austria	1.90	1.67	1.60	1.59	3.81	- 1.25	- 1.88	- 0.68
Poland	3.09	3.08	2.89	3.21	0.74	0.16	- 1.14	0.24
Portugal	1.45	1.54	1.25	1.00	1.99	2.55	- 1.83	- 2.70
Romania	4.87	5.65	6.67	35.18	- 8.44	0.06	3.32	5.06
Slovenia	2.69	2.41	2.40	3.09	1.38	- 1.49	- 1.48	1.58
Slovakia	5.02	4.64	4.41	5.23	2.04	- 0.80	- 1.59	0.34
Finland	1.83	1.91	1.80	2.50	- 1.31	0.36	- 0.87	1.83
Sweden	1.84	1.87	1.58	1.38	2.27	1.25	- 2.07	- 1.45
United Kingdom	1.27	1.58	1.19	1.17	- 1.73	4.59	- 1.90	- 0.96
EU-27	1.85	1.82	1.55	1.49	2.75	0.74	- 2.38	- 1.12

Source: Eurostat Comext, wiiw calculations.

Table A.5: Change in export values and export shares by end-use categories

	Index 1999 = 1				Change in import shares (in percentage points)			
	Intermediates	Consumer goods	Capital goods	Not classified	Intermediates	Consumer goods	Capital goods	Not classified
Belgium	2.01	2.26	1.68	1.33	1.77	3.59	- 1.69	- 3.67
Bulgaria	4.92	2.78	5.17	8.69	8.75	- 12.87	1.53	2.58
Czech Republic	3.60	3.80	5.91	3.67	- 5.77	- 0.70	7.14	- 0.67
Denmark	1.91	1.48	1.45	2.82	5.92	- 3.85	- 2.74	0.67
Germany	1.96	2.11	1.88	1.65	0.89	1.45	- 0.51	- 1.83
Estonia	3.70	2.57	3.63	119.95	0.10	- 9.13	- 0.20	9.22
Ireland	1.28	2.16	0.94	0.21	- 3.68	11.37	- 7.35	- 0.34
Greece	2.09	1.27	2.50	0.70	10.07	- 12.32	3.06	- 0.81
Spain	1.97	1.97	1.63	1.39	3.81	1.84	- 1.44	- 4.21
France	1.41	1.52	1.00	1.18	3.44	3.38	- 6.12	- 0.69
Italy	1.76	1.43	1.59	1.75	3.80	- 3.68	- 0.37	0.24
Cyprus	2.49	1.91	2.33	19.82	3.27	- 8.68	0.35	5.06
Latvia	3.54	3.72	10.04	6.09	- 7.34	- 2.00	8.20	1.14
Lithuania	6.66	3.69	12.36	11.46	3.31	- 15.33	5.96	6.06
Luxembourg	1.62	1.32	6.77	1.96	- 18.67	- 6.48	25.42	- 0.28
Hungary	2.65	2.54	4.09	3.65	- 5.44	- 3.26	7.34	1.36
Malta	0.96	0.99	1.06	14.09	- 2.11	0.17	0.59	1.34
Netherlands	2.35	1.90	2.09	2.05	4.01	- 2.89	- 0.91	- 0.20
Austria	1.98	2.10	2.34	1.62	- 1.99	0.48	2.71	- 1.21
Poland	4.88	3.81	4.90	6.40	3.10	- 5.80	0.83	1.86
Portugal	1.78	1.13	1.90	0.89	9.77	- 8.12	2.69	- 4.34
Romania	5.35	2.04	7.18	13.26	12.52	- 22.99	5.33	5.14
Slovenia	2.84	2.22	3.51	3.85	0.27	- 6.16	2.49	3.41
Slovakia	4.30	6.72	5.65	5.59	- 8.59	5.85	1.13	1.61
Finland	1.36	1.93	1.68	2.66	- 6.91	1.50	2.96	2.45
Sweden	1.60	1.71	1.30	1.67	1.83	1.44	- 3.74	0.47
United Kingdom	1.24	1.36	0.87	1.52	1.84	2.69	- 6.52	2.00
EU-27	1.87	1.84	1.64	1.69	1.99	0.46	- 1.94	- 0.51

Source: Eurostat Comext, wiiw calculations.

CHAPTER 3

Foreign Corporate R & D and Innovation in the European Union

3.1. Introduction

The internationalisation or globalisation of economic activity is one of the most significant changes the world economy has experienced over the last 30 years. Firms have considerably expanded their business through exports and foreign direct investment (FDI). A strong impetus for this expansion came from the opening of new markets in China, India and other emerging economies and the economic integration of the former communist countries in central and eastern Europe into the world economy.

Globalisation does not only change trade and FDI flows. It also opens up access to new knowledge, and it shapes and transforms the innovation processes of firms. It poses new requirements in terms of the knowledge needed to compete on domestic and international markets. To meet these requirements, an increasing number of firms, in particular large multinational enterprises (MNEs), locate research, development and innovation activities outside their home countries. This is what has become known as the internationalisation of corporate R & D and innovation (Narula and Zanfei, 2005; OECD, 2008; Dunning and Lundan, 2009).

The aim of this chapter is to study the internationalisation of R & D and innovation for the European Union. Section 2 of the chapter gives a brief overview of the motives of firms when they internationalise R & D and innovation. Section 3 looks at R & D and innovation activities of foreign-owned firms in the EU by sector, country and technology. Section 4 examines the activities of EU firms outside the European Union. Sections 5 and 6 investigate whether — and how — foreign-owned and domestically owned firms differ in their innovation behaviour. Section 7 investigates how both groups transform innovation into productivity and employment growth. Section 8 draws conclusions from the analysis.

3.2. Motives of firms when they internationalise R & D and innovation activities

The decision of a firm to go abroad with R & D and other innovation activities is a trade-off between the benefits of doing R & D and innovation at various locations and the costs associated with the decentralised organisation of R & D and innovation.

Benefits of doing R & D and innovation abroad are related to the generation and acquisition of new knowledge which is not available in the home country. The literature describes two principal strategies which emerge from this knowledge motive (von Zedtwitz and Gassmann, 2002; Cantwell and Mudambi, 2005; Narula and Zanfei, 2005): first, overseas R & D and innovation seek to create localised, market-oriented knowledge which helps firms to adapt existing technologies and products to foreign markets and to boost the overall revenue they generate from these assets ('asset-exploiting' strategy). R & D and innovation often follow other economic activity, in particular production and sales, to locations abroad and are in most cases an extension of existing overseas production and marketing activities. As a result, countries with strong economic ties in foreign trade and FDI are also integrated in corporate R & D and innovation. Second, R & D and innovation activities of MNEs abroad focus on creating the kind of technological and scientific knowledge that may find application in the whole enterprise group. This is known as the 'asset-augmenting' strategy. Research suggests that asset-exploiting strategies still prevail, although asset augmenting is gaining in importance (le Bas and Sierra, 2002).

Another important motive for overseas R & D and innovation activities — besides a lack of knowledge — are capacity bottlenecks in the home country. In a number of cases, firms move abroad because they cannot find enough research staff at their headquarters location.

The internationalisation of R & D and innovation has also been fuelled by cross-border mergers and acquisitions.

Cost differences between countries, in contrast, seem to be less important for R & D and innovation than for production, and only relevant for certain locations. Evidence from innovation surveys and econometric studies shows cost advantages having only a modest influence compared to other locational advantages (Thursby and Thursby, 2006; Kinkel and Maloca, 2008; Belderbos et al., 2009; European Commission JRC IPTS, 2009b).

The internationalisation of R & D and innovation can create advantages for enterprises; such advantages are not however cost-free. The costs of internationalisation (Gersbach and Schmutzler, 2006; Sanna-Randaccio and Veugelers, 2007) comprise first of all the foregone benefits of R & D centralisation, including economies of scale and scope from specialisation and a tighter control over core technologies. Second, additional costs arise from higher coordination efforts and the cost of transferring knowledge within the MNE. Despite its public-good characteristics, transferring knowledge is an expensive process because of its 'tacit', localised and context-related nature. Third, concentrating innovation activity in the home country is favoured by various linkages between the firm and the host country innovation system. Patel and Pavitt (1999) and Narula (2002) point out that many firms are strongly embedded in their home country innovation system, with ties that include formal R & D cooperation schemes with domestic universities and research centres, and informal networks that have grown from doing business together in the past. Informal networks between firms may also evolve from staff undergoing joint training at universities and research centres and from labour mobility.

It is also important to consider the influence of differences across technologies and sectors. The knowledge bases of technologies and sectors differ in their degree of tacitness, their cumulativeness, appropriability and spatial concentration, or the degree to which they draw on and refer to knowledge external to the firm (Marsili, 2001; Malerba, 2005a,b). These differences translate into different degrees of internationalisation of R & D and innovation at the sectoral and technology levels. A high degree of tacitness, for example, makes it more difficult and expensive to transfer knowledge between the parent company and the affiliate. This may reduce intra-firm knowledge transfer, but may also call for a more decentralised organisation of R & D and innovation, because many tasks can only be done at the affiliate.

3.3. Mapping the internationalisation of R & D and innovation activities in the EU

3.3.1. Internationalisation at the EU-27 level

The analysis starts by examining the degree of internationalisation and characteristics of foreign-owned R & D and innovation activity in the EU Member States. R & D and innovation in firms is a multifaceted process that cannot really be described or measured by reference to a single data source. It is therefore important to look at a variety of data sources to capture different aspects of innovation behaviour (see Annex 'Measuring the internationalisation of R & D and innovation').

Patent data from the European Patent Office (EPO) is a rich source for surveying the innovation activities of foreign-owned firms in the EU as well as cross-border links between EU Member States and countries outside the EU. Patent documents include the location of the applicant and the location of the inventor of a particular patent. By comparing the two, one can derive a measure for the foreign ownership of patent inventions in a particular country. The share of foreign-owned patents in all patent applications of a country will be used as an indicator for the internationalisation of R & D and innovation in that country.

The data reveal that the internationalisation of R & D and innovation has increased considerably in the EU. The share of foreign-owned patents in all patent inventions in the EU-27 at the EPO ([48]) climbed from about 10 % in 1990 to around 17 % in the years 2002 to 2007. This upward trend is even more striking in terms of absolute numbers: the total number of foreign-owned patents rose from 2 772 in 1990 to 9 677 in 2005, an increase of 249 %. Domestically owned patent inventions, by contrast, increased by 88 % in the same period.

Despite a rising degree of internationalisation, foreign-owned patents are still an exception. Patents owned by domestic applicants — individuals, firms, universities or other organisations — still account for the bulk of R & D and innovation in the EU. The data give no indication of any substitution or crowding-out of domestic by foreign-based activity.

Figure 3.1 further distinguishes between patent inventions owned by applicants located in EU-27 countries (intra EU), in other European countries (other Europe) and in countries outside Europe (extra Europe in Figure 3.1). Between 1990 and 1998, internationalisation increased steadily in all three groups. Since 1998, there has been a diverging development between the three

([48]) EPO Patstats database, October 2009 edition.

groups. First, the share of foreign-owned patent inventions with applicants from outside Europe stagnated at between 6 % and 7 %. Second, the share of 'other Europe' and in particular intra-EU ownership continued to increase, at least until 2002, reflecting R & D and innovation integration and exploitation of single market opportunities as well as efforts to support the emergence of a European research area.

Later, around 2002 (after peaking at almost half of all foreign-owned patents invented in the EU-27), the share of intra-EU applicants began to lose ground. As a consequence, the overall degree of internationalisation of innovation and R & D in the European Union has remained fairly stable over more recent years, as measured by cross-border patent ownership.

3.3.2. Trends at the country level

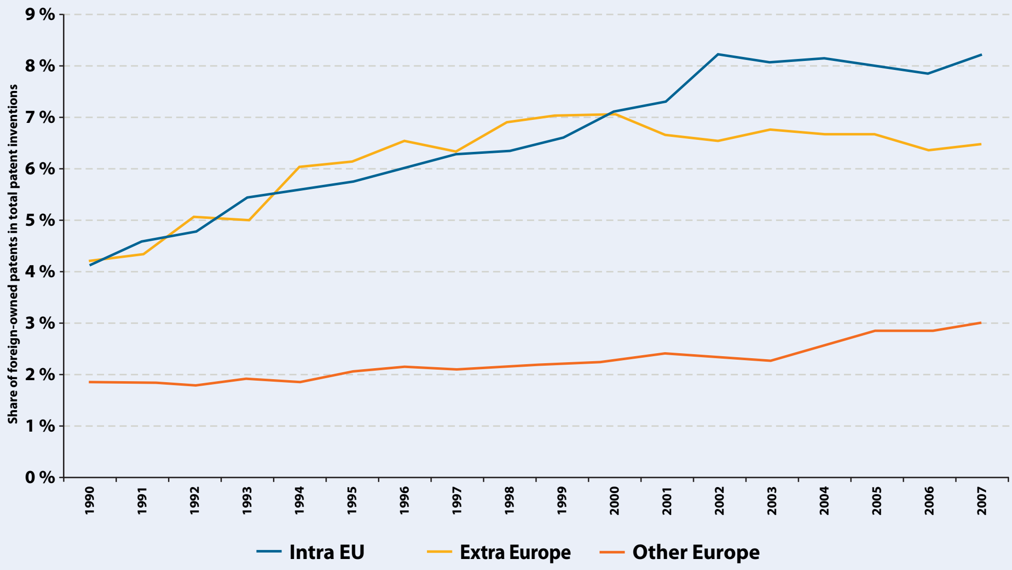
The increasing internationalisation of R & D and innovation is also reflected in R & D expenditure. Figure 3.2 shows — as an example — R & D expenditure by overseas subsidiaries of US multinationals in millions of US dollars for the period 2001–07.

US MNEs devote substantial resources to R & D activities abroad, particularly in the EU-27. Expenditure has increased considerably since 2001 in all EU countries depicted in Figure 3.2 (except for France, for which there is a relative stagnation in that period). The EU and its single market consistently attracted more than 60 % of all US overseas R & D expenditure from 2001 to 2007, followed by Canada (with a much smaller share of around 10 %). R & D expenditure of US MNEs in Brazil, Russia, India and China (referred to as BRICs) is still at a low level, but is growing fast. R & D in Japan and South Korea, by contrast, is stagnating or increasing only slightly.

The upward internationalisation trends can also be observed in data on R & D expenditure by foreign-owned affiliates, provided by the OECD FATS database and Eurostat. Sweden is the country with the longest time series in these databases. The share of foreign-owned affiliates in the Swedish manufacturing sector increased from 14.5 % (1990) to 40 % in 2007. The share of foreign-owned affiliates in manufacturing sector R & D expenditure also expanded in large countries such as France (1994:15.4 %; 2007: 21.1 %). Upward internationalisation trends are the general rule for all countries for which data are available.

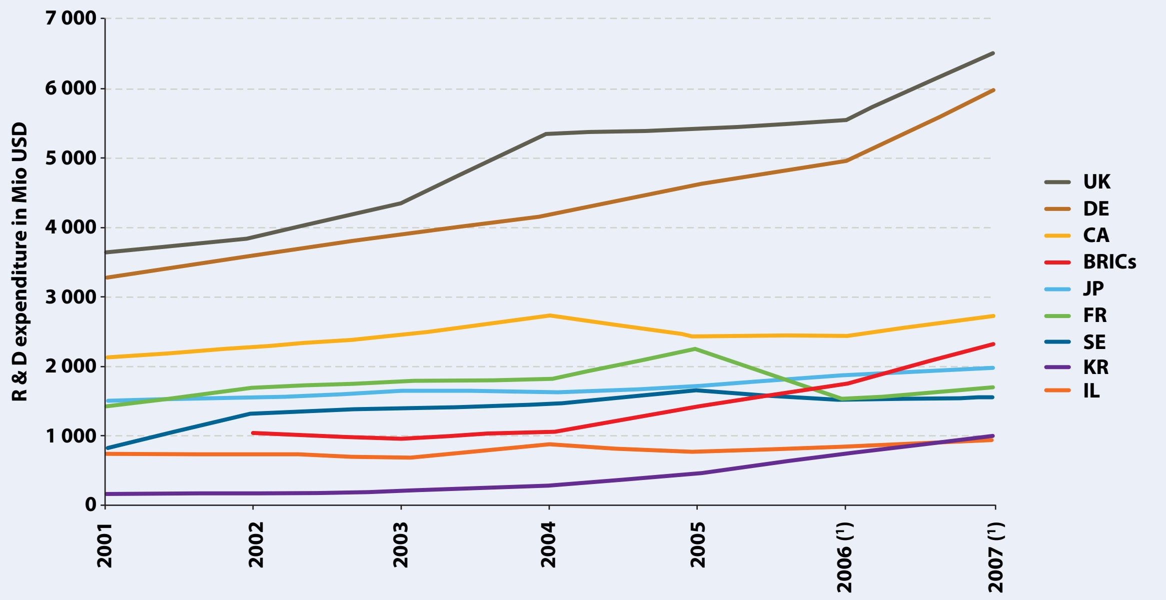
The upward trend is confirmed by patent data. Both datasets — R & D expenditure and patent data — indicate that small and medium EU countries tend to have a higher degree of internationalisation of R & D and innovation (as is the case for trade and FDI). Figure 3.3 illustrates the relationship between size and the degree of internationalisation by comparing the absolute number of patent inventions (horizontal axis) with the share of foreign-owned patent inventions (vertical axis).

Figure 3.1: Share of foreign-owned patents in all domestic patent inventions in the EU-27 by country groups, 1990–2007, EPO



Source: European Patent Office, ZEW/AIT calculations.

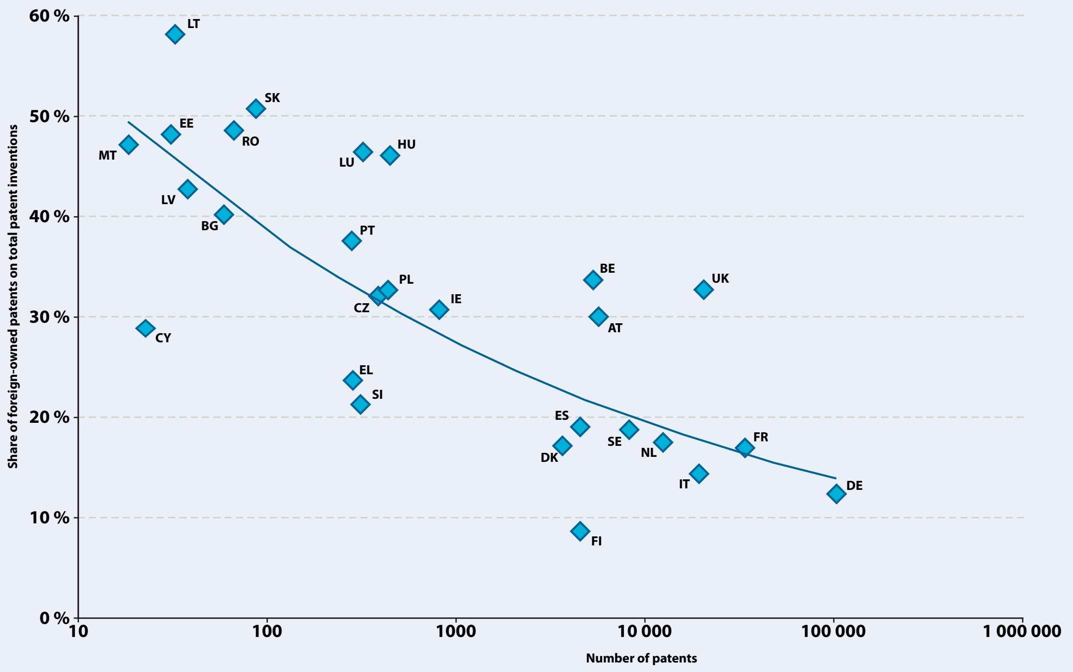
Figure 3.2: R & D expenditure of overseas subsidiaries of US multinational firms, 2001–07 (million USD)



(¹) Only majority-owned affiliates; KR: South Korea; IL: Israel; CA: Canada; BRICs: Brazil, Russia, India, China.
Source: OECD FATS database, US Department of Commerce, ZEW/AIT calculations.

The countries with the highest share of foreign-owned patent inventions in the EU according to Figure 3.3 all have a comparatively small absolute number of patent inventions: Malta, the Baltic states, Romania, Bulgaria, Slovakia and Luxembourg. Large EU countries such as Germany, France

Figure 3.3: Share of foreign-owned patent inventions and total number of patent inventions by country, 2003–07, EPO



Source: European Patent Office, ZEW/AIT calculations.

or Italy, by contrast, exhibit moderate levels of internationalisation.

But there are also exceptions to this rule. The United Kingdom has a considerably higher share of foreign-owned patent inventions than other countries of comparable size. This is due to Japanese and US multinationals which have chosen the UK as their main location in the EU. The UK is also the EU country with the largest inward FDI stock of all EU Member States in absolute terms.

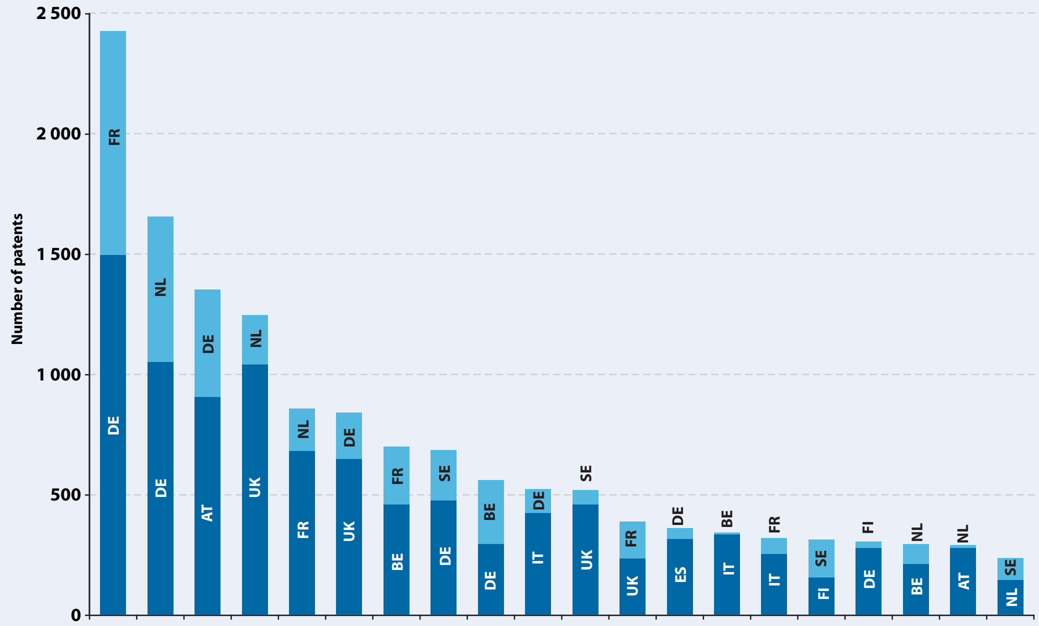
Other positive outliers are Austria and Belgium. Their high level of internationalisation can be explained in part by their proximity to a large neighbouring country. Research has identified geographical and cultural proximity (including a common language) as factors that promote R & D internationalisation between two countries (Guellec and van Pottelsberghe de la Potterie, 2001; Eden and Miller, 2004, Picci, 2010). Finland, by contrast, is the EU country with the lowest degree of internationalisation (more than 90 % of the impressive number of patents granted in the country in 2003–07 are the result of Finnish organisations' R & D and innovation efforts). This correlates with a comparatively small stock of inward FDI and R & D expenditure by foreign-owned affiliates in Finland.

Similar cross-country internationalisation patterns can be observed for R & D expenditure by foreign-owned affiliates for the countries for which data are available (see Table 1 in the annex). Smaller EU countries and the United Kingdom have high shares of foreign R & D expenditure, while other large Member States exhibit low levels. Finland is also the least internationalised country in terms of R & D expenditure by foreign-owned affiliates. Countries with a high share of foreign-controlled R & D expenditure include Austria, the Czech Republic, Hungary, Ireland and Slovakia. (In these five countries, foreign-owned affiliates account for the majority of total manufacturing R & D expenditure.)

As observed (see Figure 3.1 above), intra EU-27 cross-border R & D and innovation activities account for about half of all foreign-owned patents in the EU-27 and contributed in large measure to the overall performance and internationalisation dynamics in the European Union. Figure 3.4 shows the 20 most important country pairs in terms of the absolute number of cross-border patents in the European Union. The values in Figure 3.4 are bidirectional; the value of a country pair A/B includes both patents invented in country B and applied for by country A, and patents invented in country A and applied for by country B.

With almost 2 500 foreign-owned patents, Germany/France is the most important country pair within the EU. Almost two thirds of these patents are German and have a French applicant; the other third consist of French patents with a German applicant. The pair ranked second

Figure 3.4: 20 largest country pairs in terms of cross-border ownership in the EU-27, 2003–07, EPO



Note: Numbers refer to the country of invention; in Germany, for example, more than 1 500 patents were applied for by France. In turn, around 900 patents applied for in France have a German applicant.
Source: European Patent Office, ZEW/AIT calculations.

is Germany and the Netherlands — again, the majority of these foreign-owned patents are German. Pair number three also involves Germany, this time together with Austria.

The country pairs reveal some important facts about intra-EU internationalisation. First, 15 of the top 20 country pairs feature Germany, France or the United Kingdom, which are also the three largest countries in terms of patents granted. Second, the dominant pattern in Figure 3.4 links a large and a medium-sized or small country. In almost all cases, the large and the medium or small country are neighbours, share a certain degree of cultural similarity (e.g. a common language) and have a long-standing business relationship indicated by a large mutual stock of FDI.

Medium-sized and small Member States play an important role in intra-EU integration in R & D and innovation. But not all such countries are equally represented. The internationalisation of R & D and innovation within Europe mainly involves R & D and innovation-intensive countries. There are 702 possible country pairs in the EU-27, but only half of them (370) are connected by foreign-owned patent. In 332 cases, there is no relationship. Examples for these 'missing links' are Greece/Austria, Finland/Slovenia, Finland/Netherlands and Belgium/Ireland. Other links, by contrast, are considerably stronger in relative terms than the absolute number of foreign-owned patents between two countries would suggest (see Box 3.1).

Box 3.1: Strong and weak links between EU Member States

The strength of cross-border links in absolute numbers of patents may be distorted by the size and patenting activity levels of different countries. A look at relative numbers is therefore useful to identify country links which are not based solely on the size of the country but on above-average strength of cross-border ownership. This can be done by calculating an index relating the strength of the relationship between two countries to their relative size within Europe in terms of the number of cross-border patents. The notion is similar to that of other specialisation indexes, such as the revealed technological advantage (RTA) index:

$$X_{ai} = \frac{\dfrac{P_{ai}}{\sum_i P_{ai}}}{\dfrac{\sum_a P_{ai}}{\sum_a \sum_i P_{ai}}}$$

Note: P: Number of patents; a: applicant country; i: inventor country.

In addition, the analysis corrects for outliers in two ways. First, countries with less than 50 cross-border patents 'are dropped'. Second, values are not reported for country pairs in which both partners have individually less than 500 cross-border patents in total (third row and third column from the end in Table 3.1). This filter results in 15 applicant countries (Cyprus, Malta and the EU-15 countries, except Greece and Portugal), 19 inventor countries (the Czech Republic, Hungary, Poland, Slovenia, Slovakia and the EU-15, except Luxembourg) and 205 possible country pairs (Table 3.1).

The table shows that there are considerable differences in the strength of the links between two countries: 25 of the 205 pairs have a very strong link with a value greater than 2, indicating that the number of foreign-owned patents between two countries is twice the number that would result from a uniform distribution across EU countries on the basis of their overall number of cross-border patents. Many of these strong country links can be explained by a common language, geographic proximity or a long history of economic integration; examples include links between the Nordic countries or between Austria and Germany, Ireland and the UK, or France and Belgium.

But not all countries which are close in terms of geography or culture have strong ties; the number of foreign-owned patents involving Belgium and the Netherlands, for example, is surprisingly low. In contrast, there are also some surprisingly strong links in Table 3.1, which can hardly be explained by geographic or cultural proximity. These pairs are somewhat idiosyncratic, i.e. firm-specific, results of managerial intentions, strategies and action. Italy, for example, is more important for Belgium as an inventor country in relative terms than France. Finland is the largest applicant country of foreign-owned patents in Portugal in relative terms, as is Germany in Slovenia. The majority of the medium and small countries have at least one 'missing link' (last row and column to the right; there are, for example, no cross-border patents between Austria and Greece or between Finland and Slovenia).

Table 3.1: Relative strength of country pairs in foreign-owned patents, selected EU-27 countries, 2003–07, EPO

		Applicant															No of Patents	Strong links	Missing links
		AT	BE	CY	DE	DK	ES	FI	FR	IE	IT	LU	MT	NL	SE	UK			
Inventor	AT		0.07	2.30	2.37	0.08	0.11	1.49	0.19	0.04	0.60	0.09	0.49	1.01	0.09	0.12	1 431	2	0
	BE	0.10		1.53	0.79	0.78	0.30	0.41	2.29	3.21	0.33	2.43	0.35	0.85	0.12	0.54	1 226	3	0
	CZ	1.08	1.91		1.95			0.35	0.37					0.52	0.10	1.25	100	0	0
	DE	2.17	0.73	0.48		0.74	0.81	0.87	1.50	0.39	1.06	1.18	1.47	0.87	0.75	0.53	4 829	1	0
	DK	0.10	0.14		1.48			4.47	0.19					0.20	1.48	1.64	398	1	0
	ES	0.30	0.57	0.00	1.81	1.07		0.20	1.18	0.20	2.29	0.00	0.00	0.22	0.73	1.92	662	1	3
	FI	0.07	0.31		0.35				0.19					0.22	5.63	2.50	275	2	0
	FR	0.30	1.31	0.30	1.20	0.47	1.41	0.09		0.66	1.59	1.30	0.52	1.22	0.66	0.95	2 540	0	0
	EL	0.00	0.93		2.01			0.21	0.20					0.05	0.12	3.16	57	2	1
	HU	0.55	0.25		1.56			3.34	0.67					0.07	2.31	0.38	196	2	0
	IE	0.04	0.00		0.82			0.21	0.61					0.28	1.64	7.74	73	1	1
	IT	0.52	3.22	0.59	0.96	0.22	1.99	0.29	0.95	1.78		1.30	2.02	0.30	1.16	1.36	1 684	2	0
	NL	0.16	0.81	0.77	1.40	1.39	1.03	0.11	0.67	0.77	0.45	0.10	0.72		0.91	2.32	1 364	1	0
	PL	0.88	0.38		1.55			1.75	0.31					0.68	0.79	2.33	72	1	0
	PT	0.30	0.12		2.50			2.86	0.18					0.11	0.24	0.86	113	2	0
	SE	0.37	0.73	2.93	1.00	5.18	0.46	3.75	0.32	0.83	0.10	0.47	1.45	0.58		1.44	756	3	0
	SI	1.08	0.00		2.80			0.00	0.46					0.12	0.00	1.62	71	1	3
	SK	1.22	0.09		1.64			1.10	0.58					0.03	0.00	0.74	58	0	1
	UK	0.49	0.55	0.15	0.82	0.80	0.28	1.05	0.49	1.33	0.67	0.27	0.25	1.81	1.55		2 894	0	0
Patents		599	1 169	85	4 933	395	168	932	2 932	350	274	458	63	3 554	1 828	1 051		25	9
Strong links		1	1	2	4	1	0	4	1	1	1	1	1	0	2	5	25		
Missing links		1	2	1	0	0	0	1	0	0	0	1	1	0	2	0	9		

Note: Applicant countries are in columns, while inventor countries are in the rows of Table 3.1. A value larger than 1 indicates that the linkage between two countries in terms of foreign-owned patent inventions is stronger than the relative size of the two countries would suggest. A value of 1.91 in the case of Belgium (applicant) and the Czech Republic (inventor) therefore reveals that this relationship has almost twice the strength that could be expected from the relative shares of the two countries.

Source: European Patent Office, ZEW/AIT calculations.

Medium and small Member States in particular tend to have strong links with only a limited number of EU partners (while links to the other EU countries tend to be weak or even non-existent). Links are also often limited to one direction (e.g. the importance of Italy as an inventor country for Belgian applicants is not mirrored by Belgium as an inventor country for Italian applicants).

The majority of intra-EU cross-border patents are owned by organisations located in EU-15 countries. Cross-border patents between the EU-12 and the EU-15 countries and within the EU-12 are still rare. One important exception is patenting activity between Slovakia and the Czech Republic. Germany is both the most important inventor country for the EU-12 in absolute terms and also by far the most important applicant country for foreign-owned patents in the EU-12. Other countries with growing relationships to the EU-12 are Austria, Sweden, the United Kingdom, France and Finland.

R & D expenditure data are sparser but tend to confirm the main patterns found in EU cross-border patents. For example, German multinationals account for 15.6 % of all foreign-owned patents in France between 2003 and 2007. The corresponding share of German subsidiaries in total foreign-controlled R & D expenditure in France between 2003 and 2006 is 16.1 %. The EU-15 were home to more than three quarters of foreign affiliates' R & D expenditure in Slovakia's manufacturing sector in 2007 (Slovakia is the only EU-12 country with comprehensive and up-to-date inward R & D flows). The corresponding figure for Poland in 2006 is at similar level (71.7 %). R & D expenditure by foreign affiliates of EU-15 firms in the EU-12 may suggest a higher degree of R & D and innovation integration that is not yet reflected in the patent data.

EU countries reveal different patterns in terms of inward and outward internationalisation of R & D and innovation, as measured by cross-border patents. Country A inward internationalisation means patents granted in country A and owned by another country. Outward internationalisation, on the other hand, refers to patents owned by country A but granted in another country. Figure 3.5 depicts outward and inward internationalisation measured by the total number of cross-country patents. Three groups of countries can be identified here:

- Inward is stronger than outward internationalisation in the United Kingdom, Austria, Italy, Spain, Portugal, Greece and all EU-12 countries except Cyprus. These countries are more host than home countries for R & D and innovation internationalisation. With the exception of Austria and the UK, internationalisation tends to be low in absolute terms in these countries, which can be explained by a lack of domestic MNEs investing in other countries.

- Outward internationalisation is stronger in the Netherlands, Sweden, Finland, Luxembourg, Ireland and Cyprus. A common feature of these small and medium countries is that they are home to a number of multinational firms which actively pursue internationalisation.

- In Germany, France, Belgium and Denmark, inward and outward flows are about equally proportioned. Countries in this group take different positions depending on the partner. Germany, for example, is a major location for patents held by French, Dutch, Swedish or Finnish multinationals, but is not very active in the last three countries.

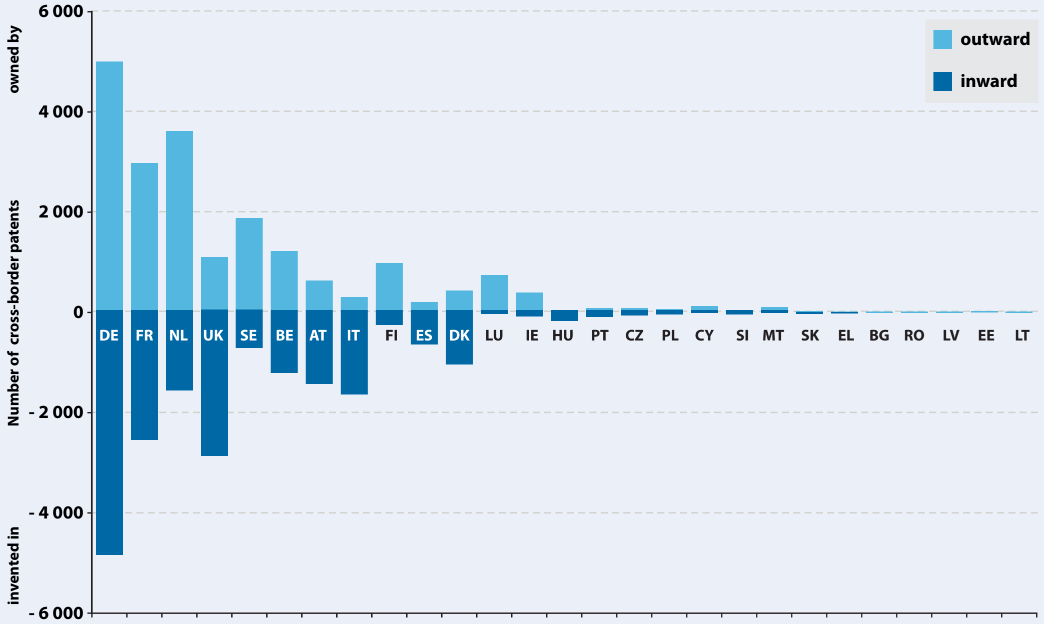
3.3.3. Technologies and sectors

Technology, along with the industrial sector of firms, determines in large measure the level of internationalisation of R & D and innovation. Technologies and sectors differ in their degree of tacitness, their cumulativeness, appropriability, spatial concentration and degree to which they draw on and refer to knowledge external to the firm (Marsili 2001; Malerba 2005a, b).

Technologies do not only differ in the level of internationalisation but also in their absolute size and growth rates. Figure 3.6 sets out the level of internationalisation in 30 different technologies based on patent data. (Patents invented in the EU were assigned to one of 30 technologies, according to their IPC codes, and these 30 technologies were grouped into six broad technology fields — see Dachs et al. (2010) for details). The share of foreign-owned patents in all patents granted in the EU-27 per technology (horizontal axis) is related to growth in the total number of patents in the EU-27 between the periods 1991–95 and 2003–07 (vertical axis). In addition, the size of the circle representing a certain technology illustrates the scale of the technology in terms of the absolute number of patents granted in the EU-27 between 2003 and 2007.

Figure 3.6 confirms that R & D and innovation activities still predominantly take place in the home country, but that there is considerable variation across technologies. The share of foreign-owned patents is, first, lowest (7 %) for 'space technology, weapons' (with the corresponding industries concentrated in a few Member States) and, second, highest (32 %) for 'telecommunication' (a technology characterised by rapid change, a low degree

Figure 3.5: Absolute number of intra-EU cross-border patents by country, 2003–07, EPO



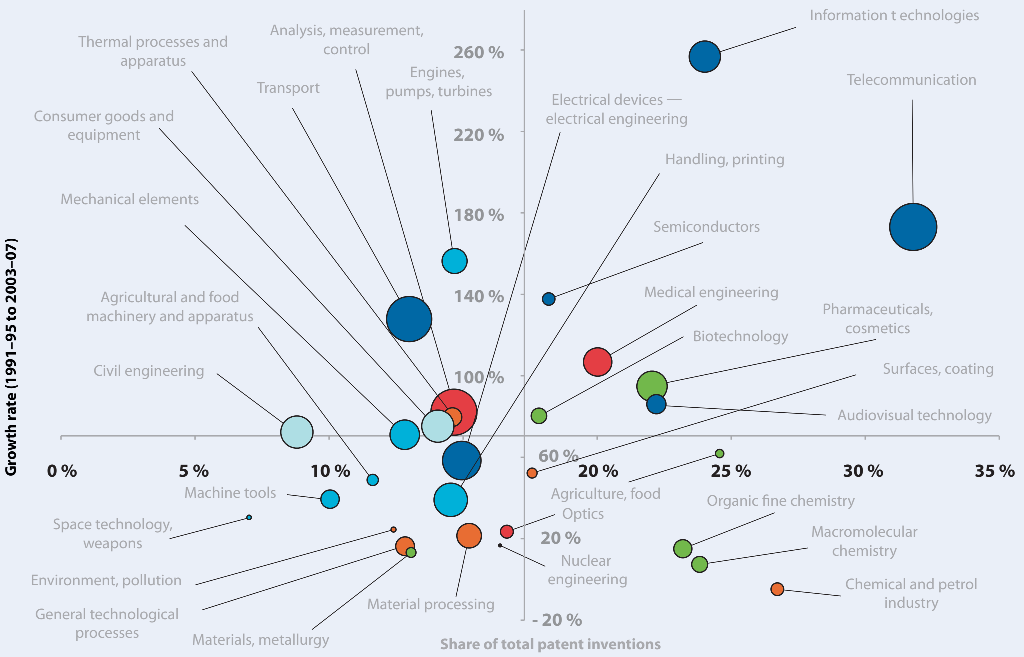
Source: European Patent Office, ZEW/AIT calculations.

of cumulativeness and the leading role of a number of MNEs with R & D and innovation activities distributed over several countries). Third, the majority of the technologies are spread in an intermediate range with limits fixed by the two technologies mentioned previously.

With their high and increasing degree of internationalisation and large number of cross-border patents, 'telecommunication' and 'information technologies' have been two important drivers of the internationalisation of R & D and innovation in the EU. This can also be observed in R & D data. Other technologies with an above-average degree of internationalisation include various chemical technologies and different technologies from the electronics field. But internationalisation is not only about 'high technology'. 'Agriculture and food', where a quarter of all patents are foreign-owned, is also among the most internationalised technologies. This is a technology with a considerable degree of product variation and adaptation to differing consumer tastes in different EU countries, which may require a high degree of decentralisation (Filippaios et al., 2009).

Generally speaking, there is no clear relationship between the growth rate, the absolute size and the level of internationalisation of a particular technology. High and increasing internationalisation is found in 'telecommunication' and 'information technologies', two key technologies at the heart of the Europe 2020 flagship initiative on 'A digital agenda for Europe' (European Commission, 2010b). Technologies in the field 'chemicals, pharmaceuticals' (coloured green in Figure 3.6), by contrast, all have high levels of internationalisation, but differ considerably in growth rates. The same is true of the technological field 'mechanical engineering, machinery' (light blue). Here, different growth rates go along with a common low level of internationalisation.

Figure 3.6: Share of foreign-owned patents (2003–07), growth (1991–95 to 2003–07) and number of patents (2003–07) in the EU-27 by technology (EPO)



Source: European Patent Office, ZEW/AIT calculations.

Box 3.2: Internationalisation in technologies for renewable energy generation

Rising prices for fossil fuels and the global warming threat have placed technologies for renewable energy generation (REG) in the spotlight at Member State and EU levels. The EU is the leader in the development of REG technologies, and this box maps the internationalisation of R & D and innovation in REG cross-cutting technologies, focusing on its specific needs rather than on any traditional technological or sectoral classification.

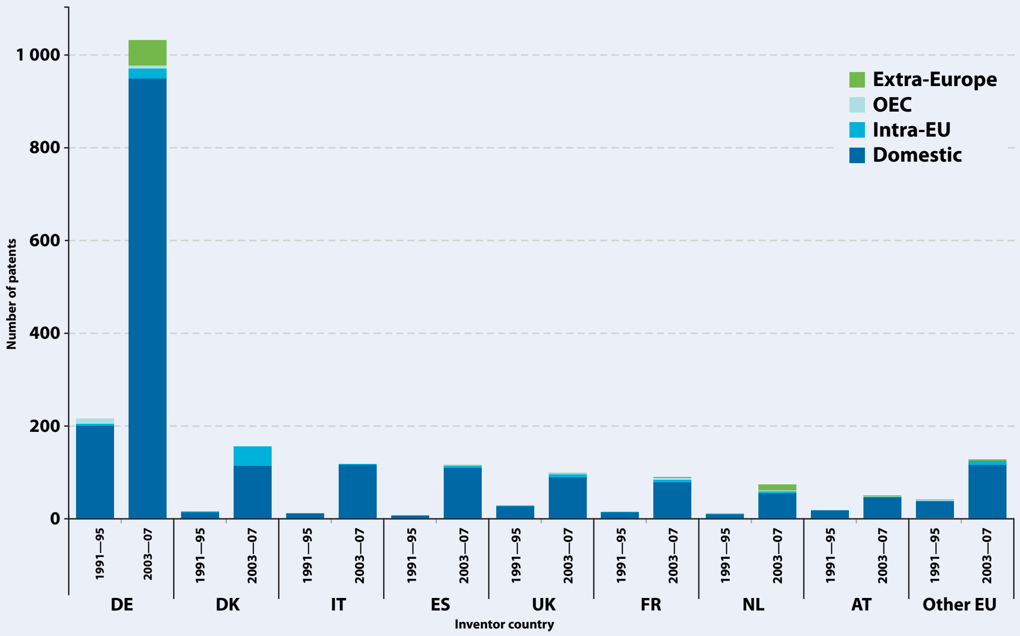
To identify REG in the patent classification, the definition proposed by the OECD (2009b) is followed. This includes the following six technologies: wind power, solar energy, geothermal energy, marine (ocean) energy, biomass energy and waste-to-energy. This gives 2 911 EPO patents for the period 2003–07. REG technologies reveal high growth rates — the number of REG patents in the EU increased by 422 % from 1991–95 to 2003–07. At the same time, REG is still a niche technology, with only 0.9 % of all patents granted in the EU.

According to the OECD (2009c, p. 53), the EU-27 accounts for the majority of worldwide PCT (Patent Cooperation Treaty) patent applications in REG, with a share of around 37 %, followed by the US (20 %) and Japan (19 %). Within the EU-27, research and innovation in REG is concentrated in a small number of countries; only Germany, Denmark and Spain exhibit above-average specialisation in the period 2003–07. Five more countries — Austria, France, Italy, the Netherlands and the United Kingdom — have some role to play in REG. Together, these eight countries account for 92.5 % of all REG patents in the EU. Data on R & D expenditure on REG are very incomplete, but seem to support the finding from patent data that the EU-27 and the aforementioned EU Member States are very well positioned in technologies for renewable energy generation (OECD 2009a).

The level of foreign patent ownership in REG is significantly lower than for other technologies: 89 % of all patents are domestically owned, 6 % owned by organisations from other EU countries, 1 % by other European countries and 5 % by organisations from outside Europe. More than 90 % of the extra-European foreign-owned patents are owned by organisations from the US. Domestically owned and foreign-owned patent inventions in REG increased at a similarly fast pace.

The above-average specialisation of Germany and Denmark in REG may be because these are the only countries in the EU with a noticeable share of foreign-owned patents in REG (see Figure 3.7 below). This indicates that when deciding to internationalise R & D and innovation, firms go primarily to areas that have achieved a critical mass of development and technological leadership, although they may not necessarily have the lowest wages and costs. The example of REG shows that such factors as technological specialisation, favourable market conditions and the availability of specialised knowledge are the main attractors for foreign-owned R & D and innovation.

Figure 3.7: Number of REG patents by inventor country and applicant location, 1991–95 and 2003–07, EPO



Note: Bars show the total number of patents in REG in one country, split between domestic applicants, applicants from other EU countries (intra-EU), applicants from European countries not part of the EU (OEC) and applicants from outside Europe (extra-Europe).
Source: European Patent Office, ZEW/AIT calculations.

Above-average specialisation and technological leadership, however, also create outward R & D and innovation. Denmark predominantly hosts R & D and innovation from German and Spanish firms, while Germany hosts a considerable number of US-owned, but also Danish-owned, patents in REG. REG accounts for about a quarter of all German-owned patents in Denmark, which is a considerable amount given the share of REG in total patent inventions. Spain, the third country with above-average specialisation in REG in the EU, has only a few foreign-owned patents in REG. Spanish firms, however, are very active in Denmark in this field.

Figure 3.8 shows that at technology level too internationalisation of R & D and innovation involves — to a considerable degree — European countries. The importance of extra-European ownership (which is mostly US ownership) is lowest in 'agriculture and food' and 'nuclear engineering', and highest in 'engines, pumps and turbines', 'environment, pollution' and 'information technologies'. It is also interesting to see that the two technologies with the highest level and growth rates of internationalisation — 'telecommunication' and 'information technologies' — have very different positions in terms of the applicant's location. Internationalisation in 'telecommunication' is predominantly intra-EU, while 'information technologies' have a high share (49 %) of patent applicants from outside Europe.

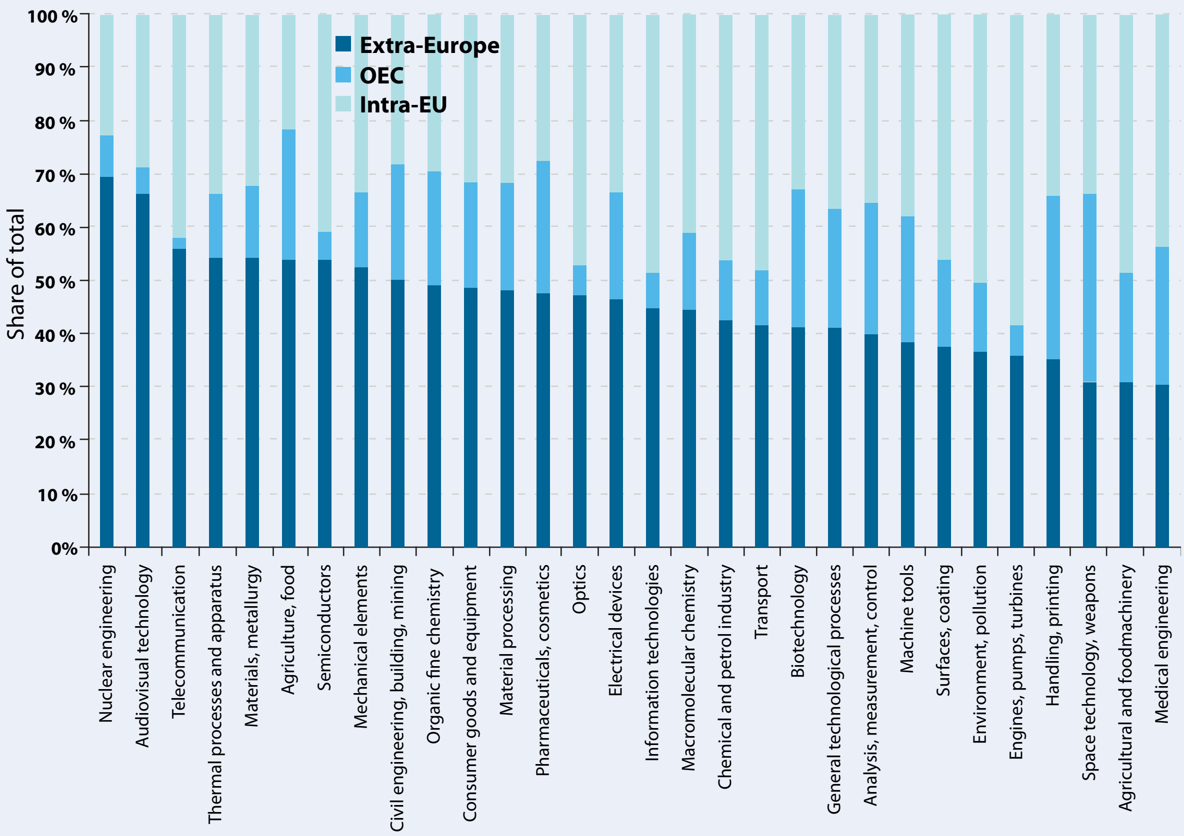
'Telecommunication' and 'information technologies' are at the heart of the EU 2020 flagship initiative on 'A digital agenda for Europe'. Both technologies give a vivid illustration of the power and importance of internationalised R & D and innovation. 'Telecommunication' illustrates the importance of strengthening the internal market and intra-EU flows of R & D and innovation. 'Information technologies' illustrates the importance of extra-EU (from the US in particular) flows of R & D and innovation as the EU seeks to catch up in these technologies.

Patent applicants from other European (non-EU, Switzerland in particular) countries tend to be less important: they are almost non-existent in 'Telecommunication' or 'Audiovisual technology' (technologies for which intra-EU cross-border patents are preponderant), but important in 'Space technology, weapons', 'Handling, printing', 'Medical engineering' and 'Biotechnology' (technologies in which intra-EU cross-border patents are not dominant).

Moving from the technology to the sectoral perspective ([49]) (see Figure 3.9 below), the most internationalised sectors in terms of R & D and innovation are the manufacturers of electronics (NACE Rev. 1.1 Section 32 — this also includes producers of telecommunication equipment), electronic components (NACE 32.1), medical, precision, optical and time measuring instruments (NACE 33), computers and office machinery (NACE 30), food products and beverages (NACE 15) and pharmaceuticals (NACE 24.4). Together, these six sectors account for about two thirds of all foreign-owned patents in the EU-27. In contrast, internationalisation of R & D and innovation is lowest in manufacturing of tobacco products (NACE 16), wood and wood products (NACE 20) and metal products (NACE 28) — all so-called 'low-technology' sectors. This sectoral specialisation corresponds with the observation that FDI is concentrated in technology-intensive industries (Barba Navaretti and Venables, 2004).

A similar overall picture emerges when looking at R & D expenditure by foreign-owned affiliates (see Table 1 in the annex). Foreign-owned affiliates tend to account for a higher share of sectoral R & D expenditures in the chemical and electrical industries, while mechanical

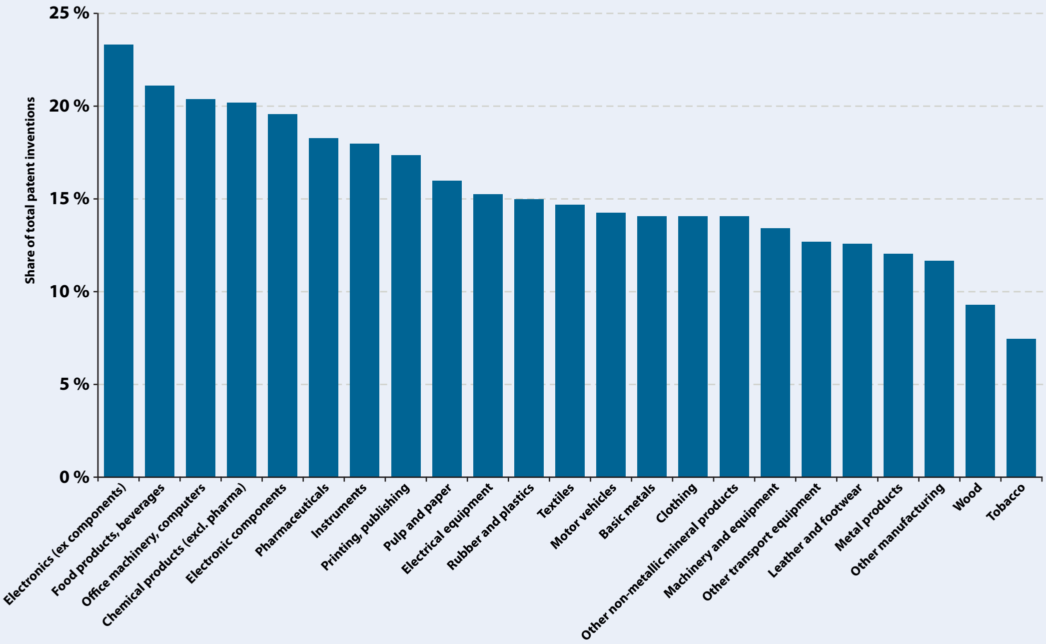
Figure 3.8: Location of applicants for foreign-owned patents by technology, 2003–07, EPO



Note: Intra-EU: applicants from other EU countries; OEC: applicants from European countries not part of the EU; extra-Europe: applicants from outside Europe.
Source: European Patent Office, ZEW/AIT calculations.

([49]) Patents are assigned to sectors using the transformation matrix proposed by Schmoch et al. (2003).

Figure 3.9: Share of foreign-owned patents by industrial sector, 2003–07, EPO



Source: European Patent Office, ZEW/AIT calculations.

industries — including the automotive sector — tend to have lower shares in most countries. A recent study by the European Commission (2010c) shows that for the ICT sector in Europe, above 40 % of all R & D centres belong to companies with headquarters outside Europe. The variation in internationalisation levels in a single sector across different countries, however, is considerable. Sectors may have a high share of foreign-owned affiliates in total R & D expenditure in one country and a low share in another.

From a sectoral perspective, it has to be remembered that the internationalisation of R & D and innovation is not restricted to manufacturing industries. Multinational firms exist in a number of service sectors as well. Examples include the software, finance, business services and transport sectors. The internationalisation of R & D and innovation in services, however, is more difficult to measure than in manufacturing, because firms in a number of service sectors engage in R & D less frequently, and many service innovations cannot be protected by patents.

The OECD FATS database includes data on R & D expenditure by foreign-owned affiliates in some service sectors (see Table 1 in the annex). The figures indicate that in knowledge-intensive services such as finance, insurance or business services, foreign-owned affiliates account for between 16 % (Germany) and 60 % (Ireland) of total R & D expenditure. In trade, repair, hotels and restaurants, the share is considerably higher. Altogether, the degree of internationalisation in service industries seems to be lower than in manufacturing. This finding, however, is tentative due to weak data coverage of the service sector.

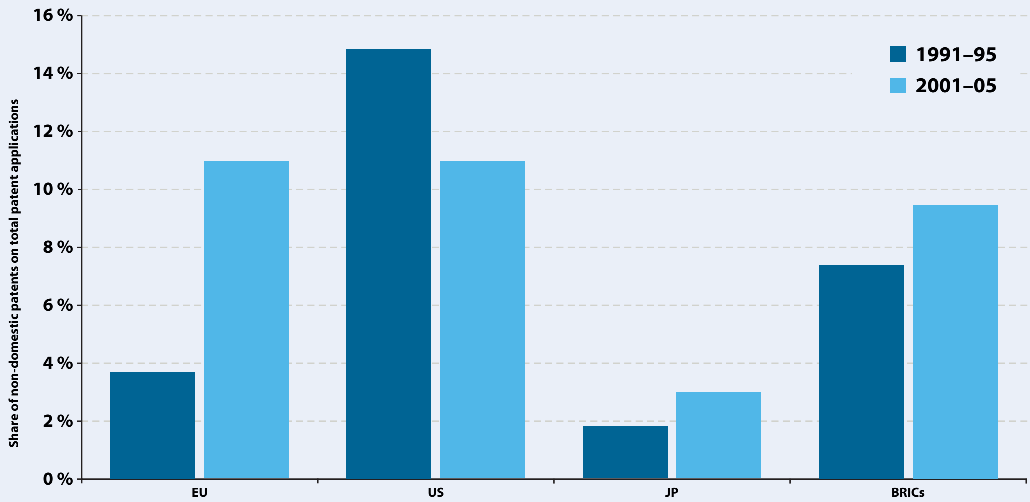
3.4. R & D and innovation activities of EU firms abroad

Outward internationalisation — the degree to which organisations from the EU-27 countries do R & D and innovation outside the EU — is often referred to as 'offshoring', a term suggesting that overseas R & D and innovation substitute for and replace similar activities in the home countries. The economic literature offers a more differentiated view on outward internationalisation, pointing out that overseas R & D and innovation are often complements to and not substitutes for similar activities in the home country. These activities support the use of company assets by adapting existing technologies to foreign markets and generating knowledge not available in the home country (Narula and Zanfei, 2005).

Figure 3.10 shows the share of patents granted abroad compared with total national patent applications, based on triadic patent data ([50]). In all the four areas depicted in Figure 3.10, overseas patents account for a modest

([50]) Triadic patents help to circumvent the so-called 'home office bias' and enable a global comparison to be made. They are patents which have been applied for at all three major patent offices: the EPO, the US Patent and Trademark Office (USPTO) and the Japanese Patent Office (JPO). See annex on 'Measuring the internationalisation of R & D and innovation'.

Figure 3.10: Share of overseas patents in total patent applications (1991–95 and 2001–05)



Note: The European Union is regarded as one geographical entity here. ('Overseas' means patents granted outside the European Union.) The same applies for the BRIC countries.
Source: OECD triadic patent database, ZEW/AIT calculations.

fraction of overall patent applications (around 11 % in the EU and US and around 3 % in Japan, in the period 2001–05).

The share of overseas patents in all patent applications in the BRIC countries is already higher than the corresponding value for Japan. However, the number of BRIC patents granted overseas is still very low. The BRIC countries are still mainly a host country for foreign-owned research and only to a much lesser degree a home country for companies doing R & D and innovation abroad.

The US and the EU appear to have taken different paths from 1990 to 2005. The share of overseas activities of US organisations decreased, while R & D and innovation of EU organisations outside the EU increased considerably. This mirrors the trends in inward internationalisation (observed in Figure 3.1 above). In the early 1990s most of the cross-border patents involving an EU Member State and a non-EU country were granted in the EU and owned by an organisation from outside the EU. Today, the outward dimension, especially with the US as partner country, is of almost equal importance. In the case of some medium-sized Member States, most notably the Netherlands, the outward dimension is clearly dominant. Technologies with higher levels of EU outward R & D activities include semiconductors, macromolecular chemistry, pharmaceuticals, cosmetics and agriculture and food, while technologies such as machine tools or transport exhibit a level of outward R & D internationalisation below the EU average.

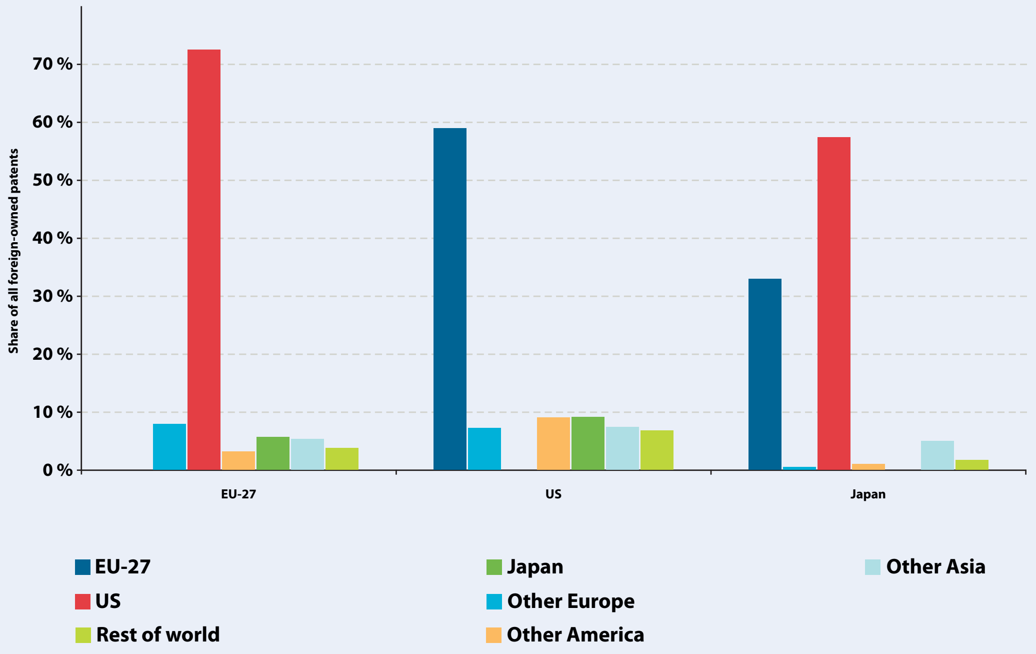
Figure 3.11 splits up the foreign-owned patent applications of the EU, the US and Japan according to the place of residence of the inventor(s) in the following seven areas: EU-27, other Europe, US, other America, Japan, other Asia and the 'rest of world' (ROW).

The data confirm that internationalisation is still predominantly a matter for the EU, the US and Japan. The US is the most important host country for EU overseas patents by far, as is the EU for the US. For Japanese overseas inventions, the US is more important than the EU. Other Asian countries such as China, India or South Korea still play a limited role as host countries of the triadic countries' overseas patents. In relative terms, the US is more active in Asian countries than the EU. These differences, however, are small compared to the scale of the EU–US relationship.

European Patent Office (EPO) data confirm the predominant role of the US for EU outward R & D and innovation activities. Figure 3.12 shows that the US accounts for 60 % of all overseas patents applied for by EU entities at the EPO. This share is virtually unchanged over time. The BRIC share in total EU-27 outward R & D and innovation ([51]) is still small compared to the US, but rising fast. The BRIC countries already account for a larger share of EU overseas patents than Japan or Canada.

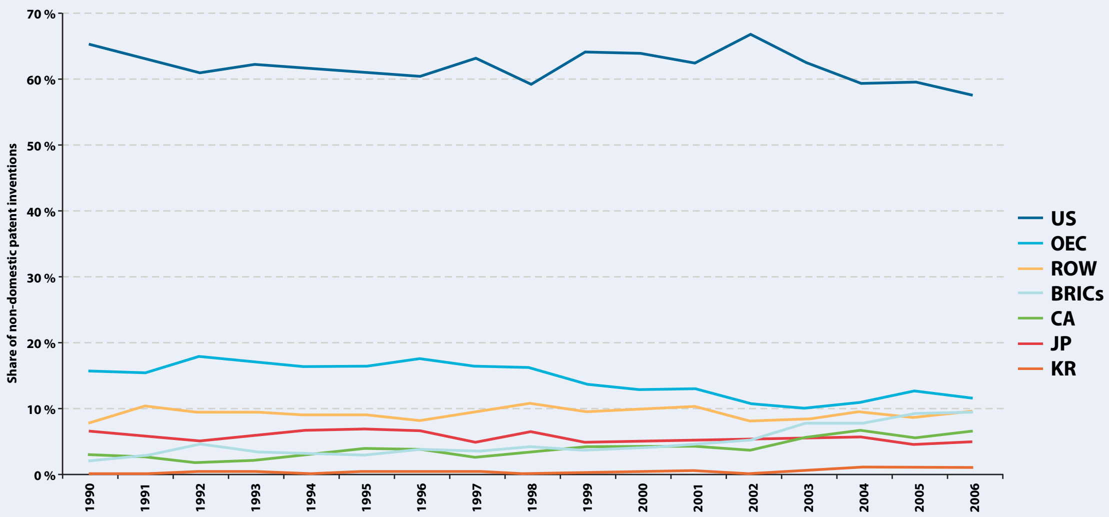
([51]) The BRIC share of EU outward R & D and innovation depicted here should not be confused with the share these countries hold on the world market for certain technologies.

Figure 3.11: Location of overseas patents applied for by the EU-27, the US and Japan (2000–07)



Source: OECD triadic patent database, ZEW/AIT calculations.

Figure 3.12: Location of overseas patents ([52]) applied for by the EU-27, 1990–2006, EPO



Note: KR: South Korea; CA: Canada; BRIC: Brazil, Russia, India, China; OEC: other European countries not member of the EU; RoW: 'rest of world'.
Source: European Patent Office, ZEW/AIT calculations.

([52]) Here, the EU is regarded as a single entity; overseas patents include all patents granted outside the EU-27.

The 2008 EU survey on R & D investment business trends (European Commission JRC IPTS, 2009b) points to similar results. It includes data on R & D investment by 114 European companies, 35 of them having a high, 68 a medium and 27 a low R & D intensity. R & D expenditure data may be more accurate than patent data with respect to shifts of R & D expenditure from manufacturing to the service sector and other R & D activities that do not lead to patents. Just over 20 % of the R & D carried out by these companies was located outside the EU. Almost half of the extra-EU R & D investment is directed to the US and Canada. R & D investment in China (2.7 % of the total) and India (3.5 %) remains relatively insignificant. There are significant differences between firms with high, medium and low R & D intensities. High R & D intensity firms are the most internationalised ones. This higher share is due to the greater importance of the US and Canada, and to a lesser degree India and China, as locations for R & D for the high R & D intensity companies.

Outward internationalisation in R & D and innovation at aggregate or sectoral level may mask a considerable degree of variation at company level. In most countries, in particular large countries, only a minority of firms export or invest abroad (Bernard et al., 2007; Greenaway and Kneller, 2007). The fraction of firms with overseas R & D and innovation activities is even smaller. The European Manufacturing Survey (EMS — see Box 3.3) suggests that the share of firms which go abroad with R & D ('R & D offshoring' in the terminology of the survey) is below 4 % in most of the countries studied. The EMS data confirm that R & D internationalisation strategies are predominantly a matter for large firms. Outward R & D is very rarely found among SMEs. The average size of a firm with R & D offshoring in the sample is 1 602 employees in 2005, compared to 195 in non-offshoring firms. There is also a strong correlation between R & D intensity and R & D internationalisation: higher levels of R & D offshoring firms are found among R & D intensive firms. So the results presented in this section in fact relate to the activities of only a very small number of firms.

EMS and other survey results indicate that lack of knowledge is one of the most important motives for R & D internationalisation. It is therefore not surprising that the United States — still the most advanced country in many technologies — is the most important location of EU R & D and innovation outside the European Union (see Figure 3.12). Besides being a large market, the US offers favourable conditions for R & D and potential spillovers from competitors, suppliers or universities.

All in all, the rising share of innovation and R & D investment in some emerging countries indicates that today's (US–EU) bipolar world may become multipolar in the future, taking in China, India and other countries not yet

Box 3.3: The European Manufacturing Survey: motives for R & D internationalisation

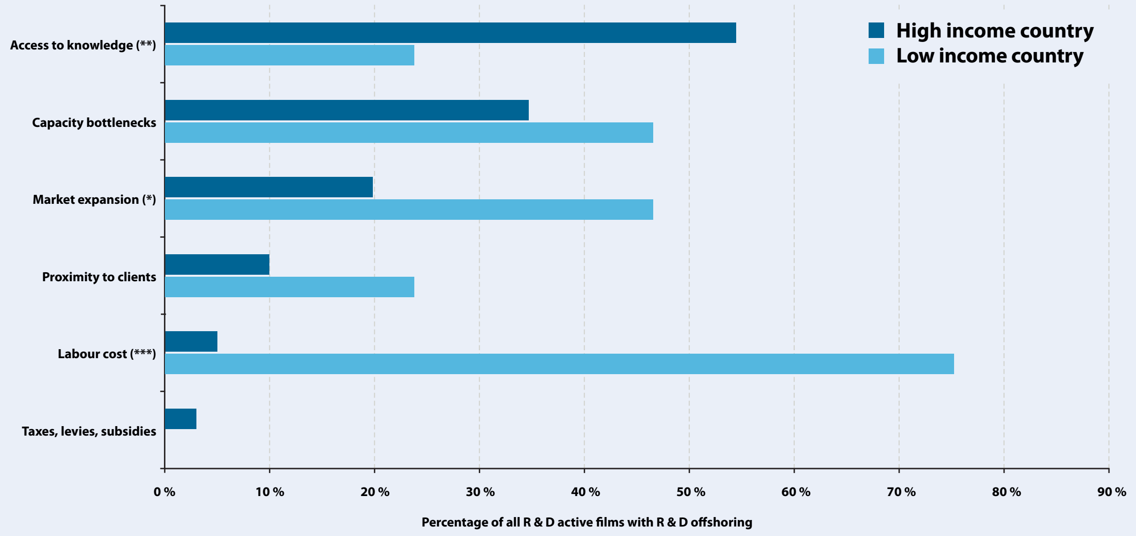
The European Manufacturing Survey (EMS) is a survey on product, process, service and organisational innovation in European manufacturing. It is conducted every three years in 12 European countries by a consortium led by Fraunhofer ISI. The focus is on the introduction of new production technologies, organisational innovation — this includes workplace organisation, but also outsourcing and offshoring — and service innovation in manufacturing.

The sample features 3 120 firms with more than 10 employees from six European countries with a sufficiently large number of firms: Germany (accounting for about half the sample), followed by Switzerland, Austria, Spain, the Netherlands and Slovenia. The largest sector in the sample is the manufacturing of transport equipment, including cars, with a share of around 9 %, followed by electronic and optical equipment (6 %) and the chemical, petroleum and pharmaceutical industry (5 %).

To investigate the motives for R & D internationalisation in more detail, the analysis distinguishes whether a firm is moving its R & D to a high- or low-income country. High-income countries include North America, Japan and the EU-15, while low-income countries comprise the EU-12, South America and the BRIC countries. The two groups of destination countries are clearly associated with different motives and offer different locational advantages (Figure 3.13). R & D offshoring to high-income countries is significantly more often associated with the wish to gain access to knowledge. Labour cost advantages play less of a role in offshoring to high-income countries.

Low-income countries, on the other hand, are associated with advantages from lower labour costs, but also with market expansion and proximity to clients. This indicates that firms identify growing markets mainly in low-income countries, and try to support market development there with R & D facilities. Here then, the internationalisation of R & D is mainly a reaction to growing market shares of emerging countries. There is no significant difference between the two country groups with respect to overcoming capacity bottlenecks in R & D, which is the most frequent motive.

Figure 3.13: Motives for R & D internationalisation and destination country, 2004–06



(***), (**) and (*) denote statistical significance of differences at the 1 %, 5 % and 10 % error level.
Source: European Manufacturing Survey, ZEW/AIT calculations.

well integrated in the international division of labour in science and technology. The BRIC countries, in particular China, have made impressive progress in science and technology (OECD 2007).

The 'Innovation union' flagship initiative recently adopted by the Commission as part of the Europe 2020 strategy aims at increasing the attractiveness of the EU as a location of R & D and innovation investments and at promoting international cooperation on research and innovation (European Commission, 2010a, d). Enhancing Europe's strength in science and technology is the best way to maintain Europe's attractiveness for foreign R & D and innovation. From a European perspective, the EU-15 countries — despite large labour cost differences — still offer considerable locational advantages to firms compared to the BRIC countries, but also to the EU-12. These include access to excellent knowledge and a skilled S & T workforce that helps overcome capacity bottlenecks.

3.5. Performance differences between foreign and domestically owned firms in the EU

Foreign-owned firms account for a considerable share of the R & D and innovation activities in EU Member States. Their share is above average in high-technology sectors and in medium-sized and small countries. From a policy point of view, this raises the question of differences between domestically owned and foreign-owned firms. If there are substantial differences in innovation behaviour between the two groups, countries with a large or small share of foreign ownership may have advantages or disadvantages in innovation and, in the medium term, in growth and employment at the aggregate level.

It is therefore important to understand the characteristics of foreign-owned innovation activity in more detail in order to assess the impact of internationalised innovation and R & D on the EU Member States. This section will investigate whether there are differences between foreign-owned and domestically owned firms in innovation input intensity, innovation output intensity and in cooperation with organisations in the host country.

The analysis is based on data from the Community Innovation Survey (CIS) 2006 (micro-data available in the Eurostat Safe Centre, see Box 3.4 and annex to this chapter). Innovation behaviour is measured by four variables:

- *Innovation input intensity* is defined as the innovation expenditure of the firm in 2006 as a share of turnover in the same year. Innovation expenditure includes internal and external R & D, machinery, equipment and software, other external knowledge and training related to innovation.

- *Innovation output intensity* is measured by the share of turnover generated with products new to the market in the total turnover of the firm. The reference period is 2004–06. Products new to the market are a subset of all product innovations that are new to the firm.

- *Domestic cooperation* includes cooperation with any type of partner outside the enterprise group in the host country. The reference period is 2004–06.

- *Domestic cooperation with science* includes only external cooperation with universities and research centres in the host country. The reference period is 2004–06.

The analysis distinguishes between three types of firms:

- domestically owned non-group firms (DnGF); this type of firm is not affiliated to an enterprise group and is typically a small- or medium-sized firm;

- domestically owned group firms (DGF); this type of firm belongs to a domestic enterprise group, and could be a domestic multinational;

- foreign-owned firms (FOF); this type of firm is domiciled in the country, but owned by a firm or individual from another country.

3.5.1. Descriptive analysis of differences in innovation behaviour between domestic and foreign-owned firms

Descriptive results reveal some important differences between the three groups of firms. Figure 3.14 reports the means of each of the four abovementioned variables for FOFs, DGFs and DnGFs. In addition, it distinguishes between countries in northern, southern and eastern Europe.

FOFs exhibit lower innovation input intensity than both DGFs and DnGFs. Innovation output intensity, on the other hand, is higher in two of the three country groups. There is even more variation in innovation output intensity when looking at the country level. Innovation cooperation is more frequent among DGFs than among FOFs, and more frequent among FOFs than among DnGFs. The same hierarchy can be observed for science cooperation. There is no single country where DnGFs have a higher propensity to cooperate than FOFs. Differences between DGFs and FOFs, however, are considerably smaller than between FOFs and DnGFs.

In addition, descriptive statistics suggest that group membership, besides foreign or domestic ownership, is decisive for differences between the three groups in cooperation behaviour. In many respects, differences between DnGFs and DGFs are greater than between FOFs and DGFs. It can be assumed that FOFs and DGFs, but not DnGFs, share some factors that favour innovation and cooperation. One of these is size. Bearing in mind that DnGFs are considerably smaller than both DGFs and FOFs in the sample — they have fewer than 50 employees on average, compared to a mean of between 100 and 150 for DGFs and FOFs —the gaps in

Box 3.4: The Community Innovation Survey (CIS) 2006

The descriptive and multivariate analysis of this section is based on a sample drawn from the Community Innovation Survey (CIS) 2006. CIS is a survey on innovation behaviour of firms in the Member States of the EU, Norway and Iceland. Eurostat ([53]) provides access to CIS data at company level. The sample used for this analysis includes 315 375 firms (weighted) from 17 European countries. Spain has the largest share of the sample with about 45 %, followed by the Czech Republic and Romania (around 8 % each). Data from Germany, France, Italy and the UK were not available for the analysis.

Some 83 % of the firms in the sample are domestically owned non-group firms (DnGFs), another 11 % are domestically owned group firms (DGFs) and 7 % of the firms are foreign-owned (FOFs).

In the sectoral taxonomy of Peneder (2010), which classifies sectors according to their innovation intensity, 19 % of the firms are from a non-innovation sector. Some 31 % of the firms are from the low innovation sector, 10 % from low–medium innovation and another 22 % from medium innovation sectors. Medium-high and high innovation sectors account for 18 % of the sample. The share of firms in the medium-high and high innovation sectors is considerably larger among foreign-owned firms than among domestically owned firms. In addition, foreign-owned firms are, on average, considerably larger than both domestically owned group and non-group firms. The latter are also smaller than domestically owned group firms.

The vast majority of the foreign-owned firms in the sample — 72 % — are from another EU-15 country. The second largest group are firms from the US. Canadian and Australian firms were added to the US firms. Together, this group accounts for 14 % of all foreign-owned firms. The remaining firms have a parent company from another European, but non-EU, country (6 %), from the EU-12 (4 %), from an Asian country (2 %) or from another country (2 %).

([53]) We thank Sergiu-Valentin Parvan from Eurostat for his support.

cooperation can evidently be explained in many ways by the specific challenges small- and medium-sized firms (SMEs) face in the innovation process rather than by domestic and foreign ownership. Smaller firms, for example, may find it more difficult to raise the resources to maintain cooperation over a longer period of time and are usually less R & D oriented, which may indicate that they lack the capabilities to put the results of the cooperation to good use (see for example Schmidt (2005)).

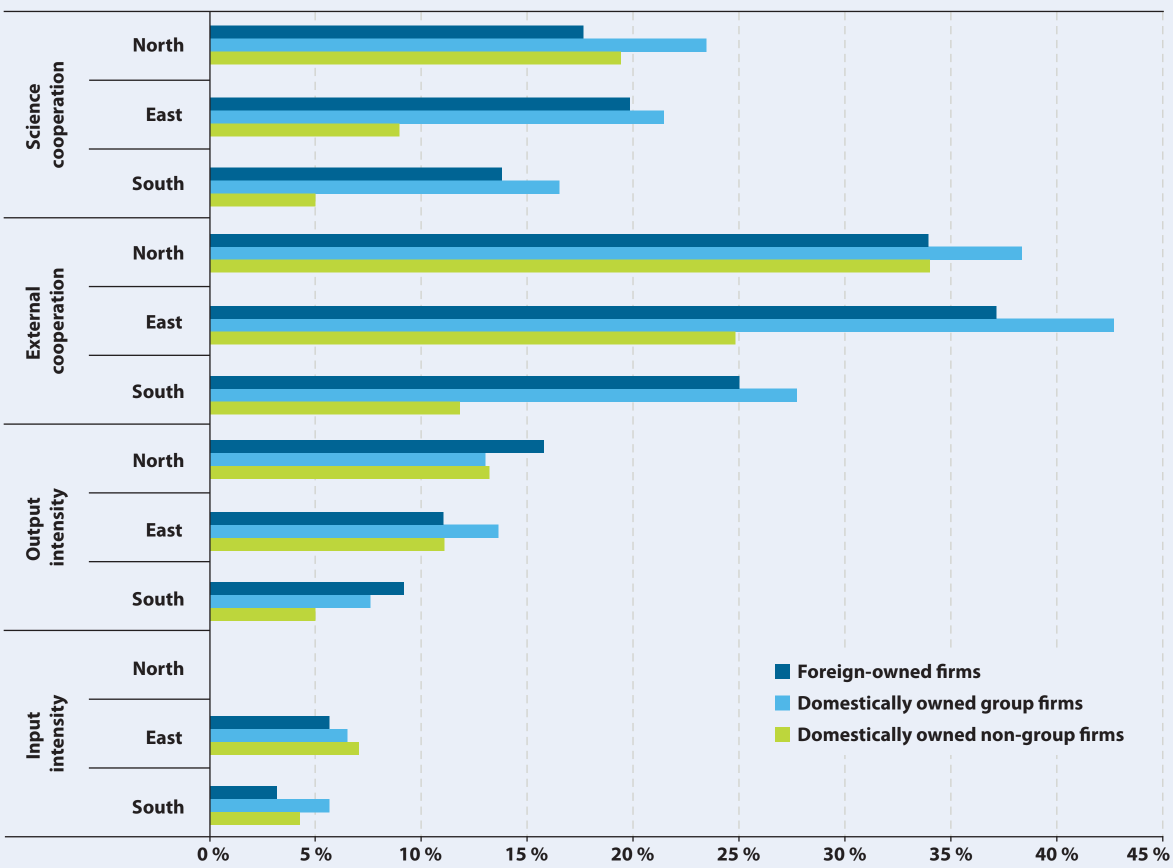
Similar differences between DnGFs, DGFs and FOFs can also be observed for innovation input and output intensity. FOFs are superior in many cases to DnGFs, but perform worse than DGFs, which are themselves domestically owned multinationals in a number of cases.

3.5.2. Innovation behaviour of foreign-owned firms in a multivariate analysis

Descriptive statistics reveal differences between foreign-owned and domestically owned firms, and between group and non-group firms, but are unable to tell whether these differences are related to foreign ownership or to differences between the groups in terms of other variables such as firm size and sector.

In order to disentangle the effects of foreign ownership from other characteristics, four econometric models with the variables of the descriptive analysis as dependent variables are estimated. Independent variables include firm size, international market orientation, R & D orientation, incoming spillovers, public funding, the sector of the firm and country dummies. To account for influences from the sectoral level, the analysis employs a new taxonomy of economic sectors according to their innovation intensity proposed by Peneder (2010).

Figure 3.14: Variables describing innovation behaviour by ownership status and location of the firm, means



Note: North includes Denmark, Finland, Luxembourg and Norway; east includes Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania and Slovakia; south includes Cyprus, Greece, Malta, Portugal and Spain. Data on innovation input are not available for Denmark and Finland, so no value for input intensity is reported for north. Results are adjusted with weights provided by Eurostat.

Source: Eurostat CIS database, ZEW/AIT calculations.

It distinguishes between six sectoral aggregations, which refer to different levels of innovativeness.

The analysis employs a Heckman-selection model with the decision to innovate as selection equation. Innovation input intensity, innovation output intensity, the propensity for external cooperation and the propensity for cooperation with science in the host country are the dependent variables of the function equation.

The results of the regression analysis (see Table 2 in the annex) indicate that performance differences between foreign-owned and domestically owned firms can be explained by company characteristics to a considerable degree. Coefficients for size, sectoral affiliation, R & D activities, received funding or sectoral affiliation are significant in a number of cases (see Table 2 in the annex). The relationship between size and innovation activity, for example, is U-shaped in a number of cases, indicating differing advantages and disadvantages of small and large firms in the innovation process. Small firms are more flexible and can react faster to new technological or market opportunities, while large firms have more internal resources, can spread the risk and uncertainty over more projects and have more potential application areas for a new invention.

After correcting for company characteristics, the results of multivariate analysis confirm that FOFs have a lower innovation input intensity compared to DnGFs, but reap similar or even higher benefits from products new to the firm (the coefficient for innovation output, however, is only significant at the 10 % level). This behaviour of FOFs fits well into the 'asset-exploiting' strategy described in the literature (Cantwell and Mudambi, 2005; Narula and Zanfei, 2005): FOFs benefit from technology received by the parent company to a considerable degree; the FOF can also rely on technological expertise and support from other parts of the group. Hence, innovation input of the FOF can be lower, but innovation output is similar to or even higher than that of a domestically owned firm.

There is a significant positive correlation between foreign ownership and cooperation after checking for company characteristics. FOFs have a higher propensity than DnGFs to cooperate with all types of domestic organisations. The same is true for DGFs. A similar result is found for cooperation with science. This positive and highly significant relationship between foreign ownership and innovation cooperation can be explained by the knowledge requirements of FOFs. A lack of knowledge in the home country is one of the main driving forces for the internationalisation of R & D and innovation. This gives FOFs a strong incentive to enter into cooperation with domestic organisations to gain access to this knowledge. From a policy point of view, a high propensity of foreign-owned firms for domestic cooperation is positive, because cooperation is a main channel for spillovers of knowledge between foreign-owned firms and organisations in the host country.

But there may be other factors that facilitate cooperation and are not accounted for in the regression, because a higher propensity to cooperate is also found in DGFs. The high degree of cooperation between FOFs and the science sector in the host country in particular indicates that asset-exploiting and asset-augmenting strategies are often inseparable (Criscuolo et al., 2005). In addition, joint projects between research organisations and firms have other goals than the creation of new knowledge; the joint supervision of PhD and Master's theses, for example, is a way to recruit new employees (Schartinger et al., 2002).

3.5.3. Innovation behaviour and the home country of foreign-owned firms

Foreign-owned firms are embedded in the corporate culture and standards of their enterprise group and their home countries. Activities abroad are shaped by these factors to a considerable degree (Forsgren, 2008, Chapter 7). The corporate culture of an enterprise group affects the behaviour of the subsidiary, even if its staff and management are mostly locals. Firms with a specific background may find it harder to enter local networks and tap into localised knowledge than firms from a neighbouring country because of the 'liability of foreignness' (Eden and Miller, 2004). It is therefore feasible that not only foreign ownership but also the home country of the FOF matters when it comes to innovation performance.

To analyse differences between foreign-owned firms of different home countries in more detail, a subsample of the CIS 2006 which includes only foreign-owned firms was used (see Box 3.4 for details).

Descriptive statistics provide evidence of differences between FOFs from different home countries (see Figure 3.15). Innovation input intensity of FOFs from 'other' countries is significantly higher than that of any other group in Figure 3.15. This can be explained by the presence of a number of very R & D intensive Israeli firms in the 'other countries' subsample.

Innovation output intensity, by contrast, is higher for firms with an Asian, US, Canadian or Australian parent company or a parent company from another non-European country than for an FOF from another EU-27 country. Science cooperation is more frequently found among US and 'other' firms than among EU-27 and Asian firms.

The differences from descriptive analysis are only partly confirmed by the results of regression analysis (Table 3 in the annex). Regression results show no significant association between innovation input intensity and the home country at the usual significance levels. Thus, the differences observed in the above figure are more likely to be due to different firm sizes, different sectoral affiliations or other factors than to the country of origin.

Innovation output intensity, on the other hand, is significantly lower for FOFs from the EU-27 than for non-EU-27 firms. By further distinguishing between various home countries, it can been seen that this effect is mainly due to Asian and US/Canadian/Australian firms, which are likely to introduce radical innovations in their home markets first and then transfer them to their European subsidiaries. The experience they have gained in their home markets with these new products may explain the performance differences compared with EU-27 firms.

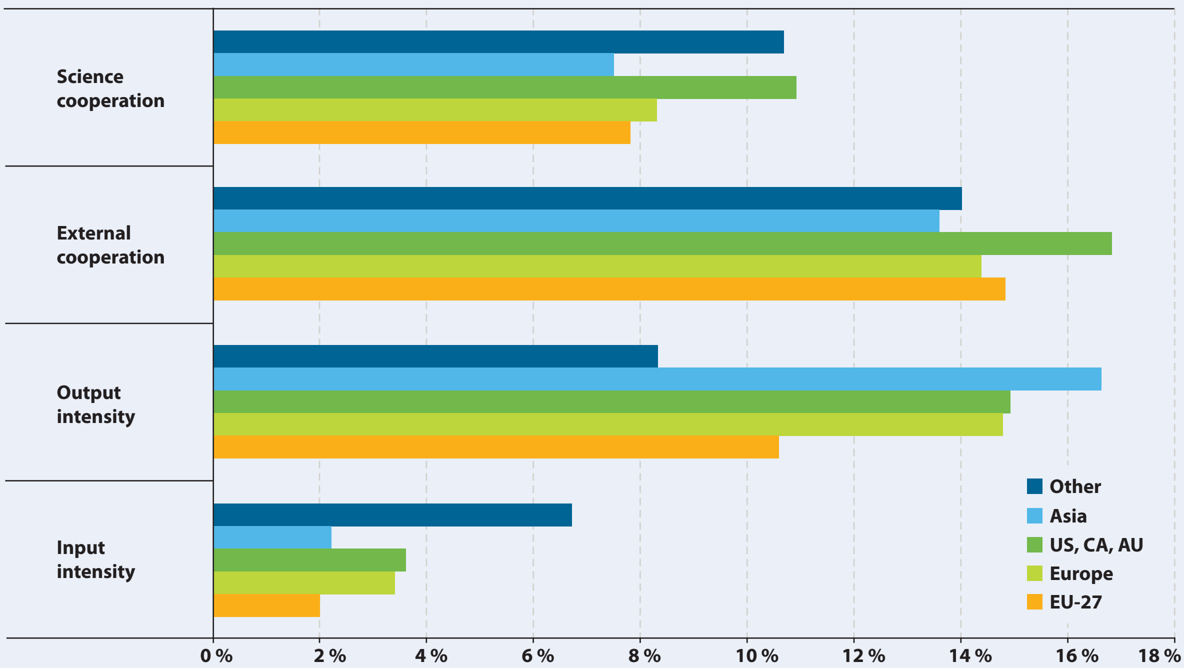
There are no significant results for external cooperation in general. Cooperation with science, in contrast, is negatively associated with Asian ownership at the 5 % error level. This indicates that subsidiaries of Asian groups cooperate significantly less often with universities and research centres than FOFs owned by EU-27 parent companies, after checking for company characteristics. This may be because firms with a very different cultural background find it hard to link to local networks and the host country.

US/Canadian/Australian firms, however, enjoy an advantage over EU-27 firms in science cooperation, as indicated by a significant and positive coefficient. One can only speculate about the reasons for this premium; it may be because US MNEs are still the technological leaders in many areas, in particular in ICT and biotechnologies. US-owned affiliates may therefore be attractive cooperation partners. In addition, the corporate culture of US, Canadian or Australian firms may be more open for science–industry cooperation, and this preference may be transferred to their affiliates in Europe. Differences between EU-27 firms and other home country groups are not significant.

3.6. A dynamic perspective on innovation performance differences between foreign and domestically owned firms

Sections 3.2 to 3.4 have highlighted the long-term shift towards a higher degree of internationalisation in R & D and innovation at the EU-27 level as well as at the country level. The previous section brought out some important differences and similarities in innovation behaviour between domestically owned firms and foreign-owned

Figure 3.15: Innovation input and output intensity and cooperation by country of origin of the foreign-owned firm, means



Note: Figure only includes foreign-owned firms. Results are weighted with weights provided by Eurostat.
Source: Eurostat CIS database, ZEW/AIT calculations.

firms in a cross-section from various European countries. This section complements the preceding ones by making a dynamic analysis of performance differences between foreign-owned and domestically owned firms at the company level.

Given that innovation is key for firms' competitiveness, globalisation raises two questions which are of particular interest from a policy point of view. First, do foreign-owned affiliates persistently differ from domestically owned firms? Or do foreign-owned firms change their innovation behaviour after entering the foreign market and adjust to innovation strategies and to the level of innovation of firms in the host country?

Globalisation increases international competition in the home market. This can stimulate innovation by innovation competition or cooperative innovation activities. Thus, it is interesting to see whether foreign-owned firms become more embedded in domestic networks over time in terms of interacting with domestic customers, suppliers or science institutions.

This section investigates how the innovation behaviour of foreign-owned and domestically owned firms has developed over the last 20 years using a long panel data set. Unfortunately, the dynamic analysis is restricted to foreign-owned and domestically owned firms in Germany, since this is the only country for which a long innovation panel exists. But, as pointed out in Section 3.3, Germany is an important country in the EU regarding the internationalisation of R & D and innovation. The analysis makes use of the Mannheim Innovation Panel (MIP — see Box 3.5 below).

The subsequent subsections first present trends in time series for different indicators. The indicators include the measures for innovation input intensity and innovation output intensity used in the previous section. In addition, innovation input is measured by R & D intensity, which is the share of R & D expenditure in the firm's turnover in 2006. Additional innovation output indicators include the share of firms with process innovation, the share of firms with product innovation and the share of firms which introduced products new to the firm, but not new to the market. Measures for innovation cooperation include cooperation with all domestic partners, with foreign partners, with clients and suppliers and with scientific organisations.

Since differences in innovation behaviour over time between domestically owned and foreign-owned firms can have various causes, panel data regression methods are employed. The econometric analysis makes it possible to gauge the effect of different forms of ownership on the respective innovation indicator and to separate its effect from the impact of other company characteristics, industry and time effects. The econometric analysis checks for firm size, firm age, region, export intensity, creditworthiness (only for innovation input) and innovation intensity (only for innovation output and cooperation). A main advantage of panel data is that they also make it possible to check for unobserved heterogeneity among firms. Random effects probit or tobit models are estimated, depending on the nature of the innovation indicator.

Box 3.5: The Mannheim Innovation Panel (MIP)

The Mannheim Innovation Panel (MIP) is an annual survey carried out by the Centre for European Economic Research (ZEW), infas Institute for Applied Social Sciences and Institute for Systems and Innovation Research (ISI), on behalf of the German Federal Ministry of Education and Research (BMBF). The MIP represents the German contribution to the CIS. In contrast to the CIS, however, the surveys are conducted annually and can be linked over time.

The sample taken from the MIP and used in this section contains 110 324 observations over the years 1992–2008. About two thirds of these observations refer to domestically owned non-group firms (DnGFs). Some 28 % of the firms in the sample belong to domestically owned group firms (DGFs). In total 8 084 observations are from foreign-owned firms, accounting for roughly 7 %. These 8 084 observations can be attributed to 2 305 individual foreign-owned firms.

Around half of the observations come from manufacturing and another 43 % from service industries. Compared to the overall distribution, foreign-owned firms are overrepresented in high-tech manufacturing industries like chemicals, electrical engineering, machinery, vehicles, medical/precision and optical instruments and metals, and in the banking and insurance sector. DnFGs have above-average shares in services, in particular in retail and transport services. The sample also reveals some interesting details about the home country of the foreign-owned firm. Firms from outside Europe and the US are more frequently found in industries like electrical engineering, chemicals and machinery (nearly 40 % of all US subsidiaries belong to these three sectors). The foreign ownership by European firms is spread more across industries. In particular, they own firms belonging to the metal, machinery and chemical industries. Together, these three industries account for 34 %.

In a third step, the section explores the results of a 'quasi experiment' to see whether there is any convergence in innovation behaviour after market entry. For foreign-owned firms which have been created by an acquisition, this experiment asks 'what would the innovation behaviour of the firm have looked like after a certain period if it had not been taken over by the foreign-owned firm'? This part of the analysis identifies firms which were taken over by a foreign-owned MNE, traces their innovation behaviour after the acquisition and compares it to domestically owned firms that have not been taken over, using either random effects probit or tobit models.

3.6.1. Innovation input

Consistent with the findings of the previous section, FOFs show lower innovation input intensity than DGFs and DnGFs over time. This is not true though of every single year.

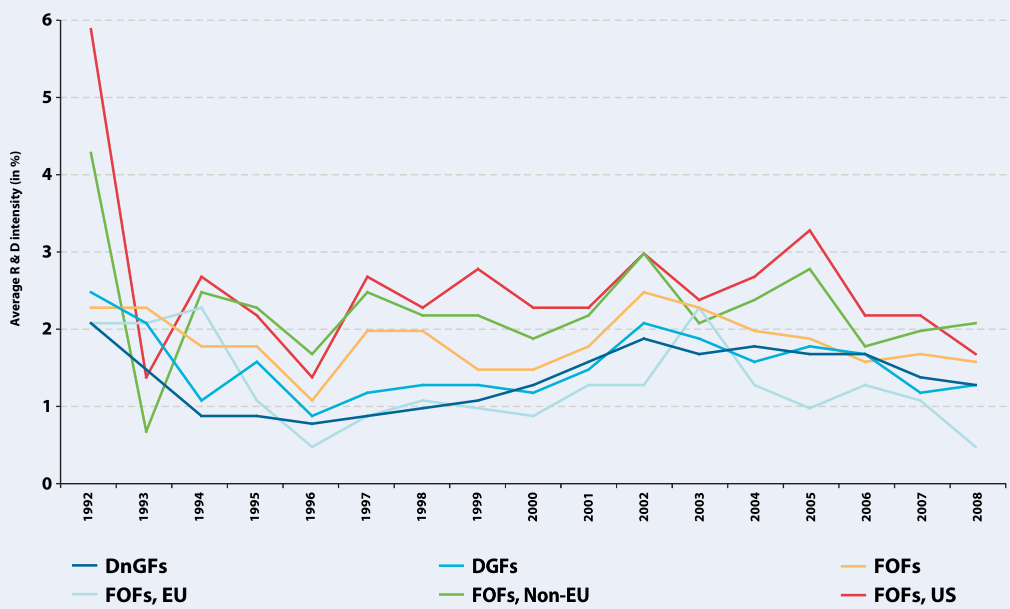
The result is different for R & D intensity. FOFs show the highest R & D intensity among all firms (Figure 3.16). This is mainly driven by FOFs belonging to groups from outside Europe. The time trends for most of the above innovation indicators reveal similar patterns, except for the share of sales of new products and, in part, for innovation expenditure.

These differences in innovation input over time may reflect differing innovation strategies or different ownership-specific advantages on the part of FOFs. On the other hand, since FOFs are typically larger firms that belong to high-tech industries such as chemicals, machinery or electrical engineering, it might not be surprising that FOFs in general and non-European firms in particular outperformed DGFs and DnGFs over the period 1992–2008.

Panel estimations draw a differentiated picture of FOFs' innovation input over the last 20 years (see Table 4 in the annex): FOFs in Germany exhibit on average significantly higher innovation input intensity than DnGFs, but less than DGFs. This result differs from the cross-sectional analysis in the previous chapter, which showed a significantly negative effect of foreign ownership on innovation input intensity after checking for company characteristics.

The fact that FOFs have demonstrated relatively higher innovation input intensities over the last 20 years is mainly due to FOFs belonging to groups from outside Europe. They tend to outperform FOFs from EU countries, which themselves spend significantly less on innovation than DGFs and DnGFs. However, as time goes by, the initial stimulating effect of foreign ownership on innovation intensity fades. That is, there is convergence in innovation intensity at the firm level over time after market entry.

Figure 3.16: R & D intensities by ownership, 1992–2008



Source: ZEW — Mannheim Innovation Panel, ZEW/AIT calculations.

The higher R & D intensity of FOFs is because relatively more FOFs are large firms and belong to technology-intensive industries. Foreign ownership itself does not boost R & D intensity. The finding that FOFs behave in a way similar to DGFs and DnGFs with respect to R & D expenditure is consistent across different home countries of FOFs. The quasi experiment further shows that the R & D intensity of newly born FOFs does not differ from that of domestically owned firms just in the year of the acquisition, but also in the subsequent five years. Only in large upswing phases do FOFs tend to react differently by investing a significantly higher proportion of sales in R & D (Dachs et al., 2010).

3.6.2. Innovation output

The greater innovation efforts of DGFs are only partly reflected in the figures on innovation output. In the last two decades, DGFs have proved to be more likely to introduce new products (either new to the firm or to the market) than FOFs or DnGFs. There are thus grounds for supposing that DGFs pursue a more pronounced strategy geared towards the introduction of product innovations.

Another finding is that the country of origin matters for product innovation strategies. The negative effect that foreign ownership exerts on product innovation, however, is driven mainly by the behaviour of FOFs from other EU countries, which are less likely to introduce new products compared to DGFs, even given the same innovation intensity. This finding indicates a lower innovation productivity of FOFs from EU-27 countries compared to DGFs. Non-EU and US subsidiaries, however, do not significantly differ in their product innovation strategy compared to DGFs.

Over time, both FOFs and DGFs are more successful in generating market novelties than DnGFs. This is partly consistent with the cross-sectional analysis of the previous section, which showed a significant effect on market novelties only for FOFs. Hence, FOFs and DGFs are more likely to be technology leaders. Once again, though, market novelty strategies of FOFs differ with respect to their parents' country of origin. Compared to the results for product innovation, there is — surprisingly — no indication that non-European firms are more strongly oriented towards market novelties. European subsidiaries, though less innovative in terms of introducing product innovations in general, behave in a similar way to DGFs with respect to the introduction of market novelties. This is even more remarkable given their generally lower innovation intensities. It shows that when investing in other EU countries, European firms are more strongly oriented to the introduction of market novelties.

Foreign ownership in general makes for successful market novelties. Compared to DGFs, FOFs have a lower share of sales with new products in general, but not with the more technologically advanced market novelties. This pattern holds true independently of the country of origin. This may well be explained by the higher innovation expenses in particular for market introduction or by better sales channels and networks of the part of firms belonging to a (larger) group. However, this stimulating effect on market novelties seems to work only for more established FOFs, as suggested by the outcome of the quasi experiment. That is, there is no higher innovation success with market novelties in firms that have been acquired by a foreign company in the first five years after the acquisition.

Consistent with this finding, newly established FOFs would seem to have a stronger focus on improving their success with product innovations which are only new to the firm but are not new to the market. More precisely, firms which have been taken over by a foreign company achieve a significantly lower share of sales with new-to-the-firm innovations in the year of takeover. However, they are able to improve their innovation success in the years after the takeover, with the result that there are no longer any differences three or five years after the takeover (Dachs et al., 2010). Thus, convergence again kicks in after market entry.

3.6.3. Innovation cooperation

The dynamic analysis confirms the cross-sectional result from the previous section: both FOFs and DGFs are associated with a significantly higher propensity to cooperate than DnGFs. FOFs, independently of their parent company's country of origin, are more frequently engaged in innovation cooperation.

The dynamic analysis cannot, however, support the view that FOFs in Germany are more likely to cooperate with domestic partners in general and with domestic science organisations in particular compared to German firms in the last 20 years. FOFs prefer foreign firms and suppliers as cooperation partners. Similarly, domestically owned firms prefer domestic partners. The econometric analysis leads one to suppose that the difference is country-induced, rather than a time effect. The finding that FOFs are not significantly more interested in domestic innovation partnerships than national firms is surprising since FOFs could benefit from the host country knowledge. Note that in countries where no such pattern can be observed it is not possible to draw any conclusion as to whether FOFs are not interested in domestic partners because they have similar or fewer market motives and technological capabilities than international operating firms, or whether they find it harder to acquire suitable innovation partners.

3.7. Productivity and job creation of foreign and domestically owned firms

Innovation is not an end in itself, but seeks to improve the firm's competitiveness and performance. Thus, innovation has to be assessed in the light of economic success or, more generally, by its impact on company performance measures (Janz, 2003). More jobs and higher productivity are two major performance measures which are also high on the political agenda. Hence, this section broadens the analysis to take in the effects of innovation on productivity and employment and examines differences between FOFs, DnGFs and DGFs in these respects using CIS data. This gives an insight into how internationalisation changes the productivity and job creation of firms moderated by innovation.

3.7.1. Productivity effects

With respect to productivity, countries can benefit from the presence of FOFs in two ways: directly through higher productivity in foreign-owned firms, and indirectly through productivity increases in domestically owned firms as a result of knowledge spillovers or fiercer competition.

A first important finding with regard to productivity is that FOFs in Europe operate at higher productivity levels than both DnGFs and DGFs (see Table 5 in the annex). In addition, the country of origin does not matter for productivity. Both FOFs from other EU countries and FOFs from outside the EU exhibit a similar productivity lead over DnGFs and DGFs. The productivity advantage of FOFs is in line with the literature, which holds that only the most productive firms go abroad with foreign direct investment (Helpman et al. 2004).

Evidence for higher productivity growth rates of FOFs is mixed. FOFs show slightly higher growth rates than DGFs, but not DnGFs, after controlling for size and other company characteristics. Due to data constraints it is not possible to measure indirect (spillover) effects on the productivity of DGFs and DnGFs. However, the fact that the growth rates are similar for FOFs and domestically owned firms gives at least indirect evidence that domestically owned firms do not fall too far behind foreign-owned firms.

One major channel for strengthening productivity is innovation (see Box A.1 in the annex). Rising innovation activity (measured either as innovation input or as innovation output) has a stimulating effect on productivity levels and productivity growth. This works through product innovation. The innovation-productivity nexus turns out to be similar in DnGFs, DGFs and FOFs from outside the EU. FOFs from another EU country, on the other hand, achieve significantly smaller (but still positive) absolute productivity gains from investing in innovation. However, there are no differences in terms of relative productivity gains (productivity growth).

3.7.2. Employment effects

Employment effects are closely related to productivity effects. If process innovation leads to an increase in productivity, firms are able to produce the same with less input and thus, all other things being equal, at lower unit cost. At the same time, the reduction in unit cost allows the innovative firm to lower its output prices, resulting in higher demand for the product and higher output. The magnitude of this compensating price effect depends on the amount of price reduction, the price elasticity of demand, the degree of competition and the behaviour and relative strength of different agents within the firm (Garcia et al., 2002).

Product innovation, by contrast, affects employment mainly via demand effects. When a new product has successfully been introduced to the market, it creates new demand for the innovating firm. Note that this demand effect can be the result either of market expansion or of business-stealing at the expense of the firm's competitors. In addition to this direct demand effect, there are usually some indirect employment effects. If the new product replaces (partially or totally) the old one, labour demand for the old product will decrease, and the overall effect is ambiguous. However, in the case of complementary demand relationships, the innovation causes the demand for existing products to rise as well. Product innovation may also have productivity effects. The new or improved product may require a change in production methods and input mix, which could either reduce or increase labour requirements (Harrison et al., 2008).

The employment effects of innovation will be examined by reference to a model recently developed by Harrison et al. (2008). This makes it possible to disentangle some of the relationships between employment, prices and production discussed above and establishes a link between employment growth rate and innovation output in terms of sales growth stemming from innovative products. The latter can be directly calculated with CIS data.

The econometric results reveal that employment growth is lower in FOFs, and in DGFs, compared to DnGFs after controlling for country and industry effects. In the service sector, employment growth rates of FOFs are even lower than DGFs. But not all FOFs behave in the same way. In manufacturing, FOFs with a parent company from another European country grow more slowly than North American affiliates. FOFs from European countries, however, tend to perform better than FOFs from the rest of the world.

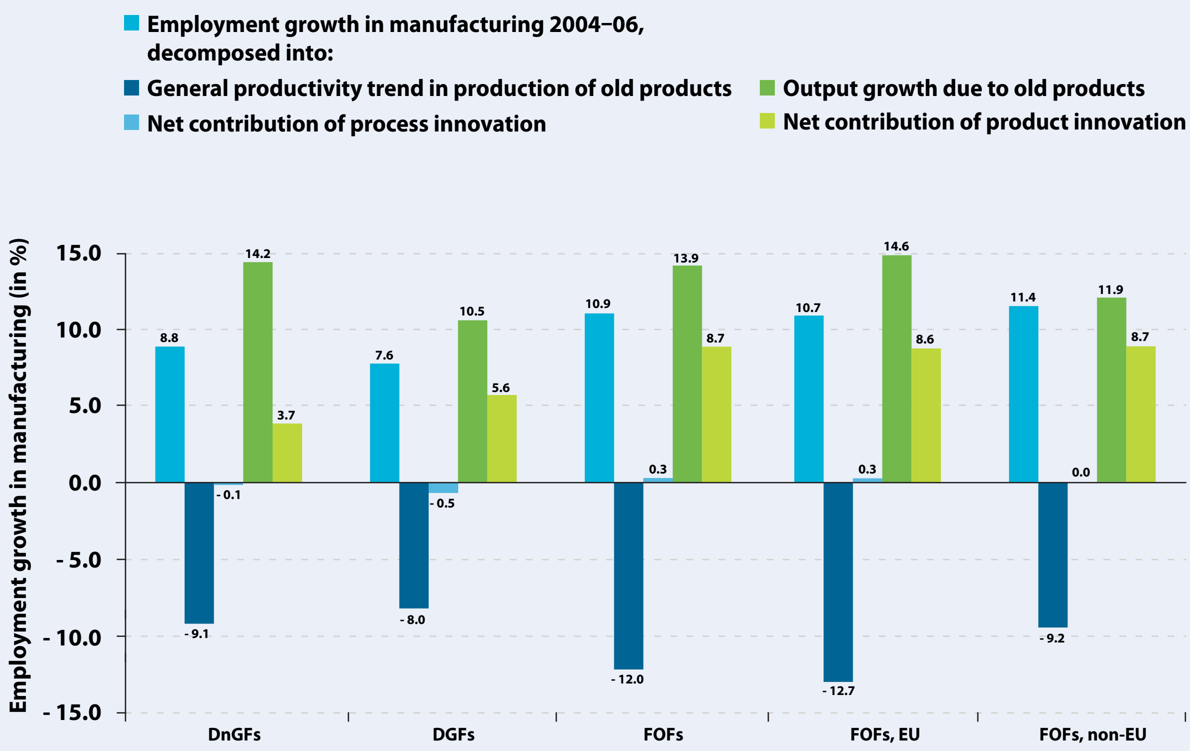
But can these differences between foreign-owned and domestically owned firms be attributed to differences in process and product innovation performance? To answer this question, the average employment growth of each group is separated into four components:

- the change in employment due to a general industry and country-specific productivity trend in the production of old products (productivity gains unrelated to process innovation);
- the net employment contribution made by process innovations related to the production of old products, which is the result of displacement effects brought about by process innovations and the compensatory demand effects responding to cost and price reductions;
- employment change associated with output growth of old products for firms that do not introduce new products or, in other words, the shifting demand for the existing product;
- the net contribution of product innovations on employment for product innovators.

Figure 3.17 shows this detail of employment growth in manufacturing by ownership status for the period 2004–06 based on the regression results ([54]). Similar calculations, not reported here, have been done for the period 2002–04.

Process innovations generally play only a minor role for employment change in all sub-samples. Foreign-owned firms experience a much higher general productivity trend than domestically owned firms, leading to greater job losses. Affiliates from another EU Member State achieve the strongest general productivity gains due to organisational changes, sales of less productive firm components, the acquisition of more productive firms, improved capital endowment and learning or spillover effects.

Figure 3.17: Breakdown of employment growth by ownership, manufacturing, 2004–06



Note: DnGFs: domestically owned non-group firms; DGFs: domestically owned group firms; FOFs: foreign-owned firms; FOFs, EU: foreign-owned firms from an EU country; FOFs, non-EU: foreign-owned firms from a country outside the EU.
Source: CIS 2006, Eurostat, ZEW/AIT calculations.

([54]) Note that this divides up actual average employment growth. This growth rate turned out to be higher in foreign-owned firms, which can be explained by industry and country effects. Ownership itself, all other things being equal, has a significantly negative effect on employment growth. For each group of firms, industry and country effects are captured by the general productivity trend.

These negative employment changes, however, are outweighed in each subsample by the output growth for old products and by the contribution of new products to employment growth. In general, output growth for old products spurs employment more than product innovation for all types of firms. Interestingly, job creation arising from increased demand for existing products is highest for affiliates from another EU Member State, closely followed by domestically owned unaffiliated firms.

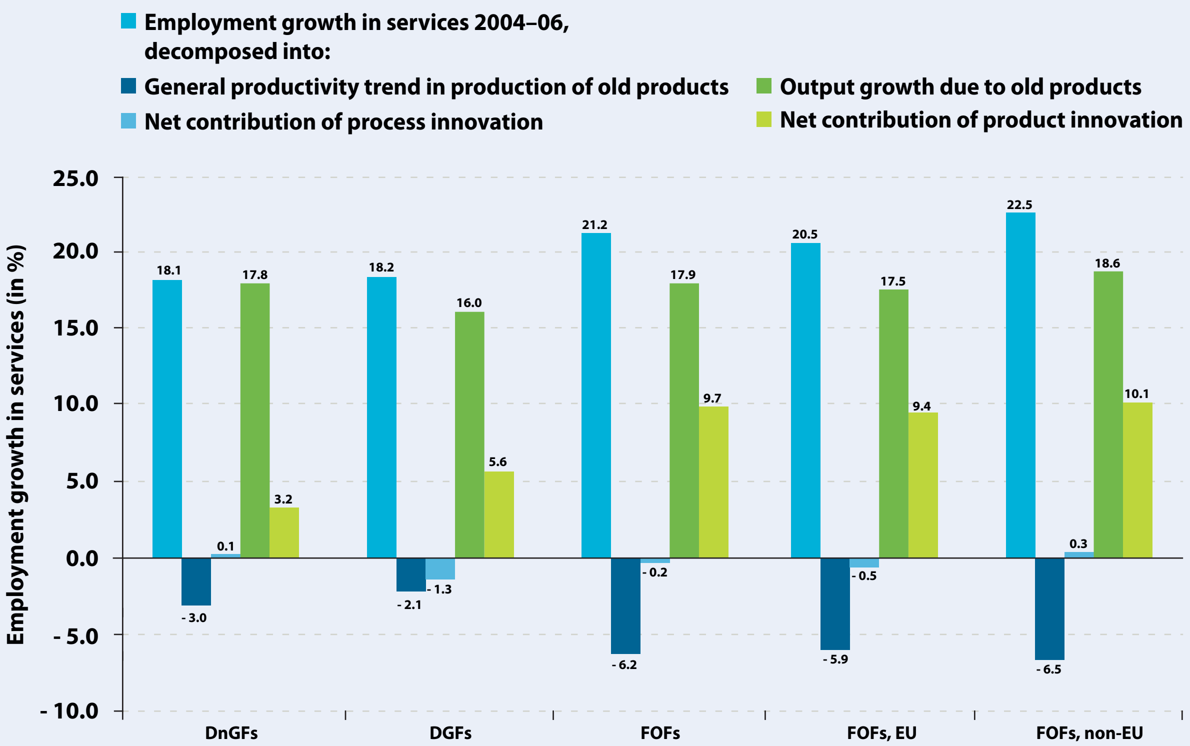
The main difference between foreign-owned and domestically owned firms lies in the contribution of product innovation to employment growth. This is smaller in absolute terms than the contribution of old products in absolute terms. New products, however, play a much stronger role in employment creation in foreign-owned affiliates than in domestically owned unaffiliated firms or firms belonging to a domestic group in both periods. Here, affiliates of EU and non-EU MNEs tend to be similar.

Similar relationships can be observed in services (Figure 3.18). Again, employment growth is driven mainly by shifts in demand for old products, and the effects of product innovation on employment growth, both of which more than compensate job losses resulting from general productivity gains and displacement effects of process innovations. New products make an even greater absolute and relative contribution to employment growth for both non-European and European affiliates.

Both observations accord with the literature (Dunning, 1981; Caves, 1996 (1974); Markusen, 2002). Foreign-owned affiliates have access to superior technology and organisational and management capabilities internal to the multinational firm which domestically owned firms might not have. These capabilities allow foreign-owned firms to enjoy higher productivity gains than the average domestically owned firm.

A second advantage of foreign-owned firms is that they can utilise existing products and technologies of the parent company, and learn from their experience with product innovation in other countries. This may help them to reap higher output growth from new products, which translates into a higher contribution to employment growth.

Figure 3.18: Breakdown of employment growth by ownership, services, 2004–06



Note: DnGFs: domestically owned non-group firms; DGFs: domestically owned group firms; FOFs: foreign-owned firms; FOFs, EU: foreign-owned firms from an EU country; FOFs, non-EU: foreign-owned firms from a country outside the EU.
Source: CIS 2006, Eurostat, ZEW/AIT calculations.

3.8. Summary and policy implications

The above analysis has yielded various insights into the internationalisation of R & D and innovation in the European Union.

The level of internationalisation of R & D and innovation has been on the increase in the EU since 1990. Today, some 17 % of all patents granted in the EU-27 are owned by foreign organisations from inside or outside Europe. Increases in foreign and domestic activities indicate that the two complement one another and satisfy different needs, rather than being substitutes. The Innovation Union Flagship initiative recently adopted by the Commission as part of the Europe 2020 strategy therefore aims at increasing the attractiveness of the EU as a location of R & D and innovation investments and at promoting international cooperation on research and innovation (European Commission, 2010a, d).

Small and medium EU Member States show a higher degree of internationalisation than large countries. There are at least five countries in the EU where foreign-owned firms currently hold more than 50 % of R & D expenditure in manufacturing. Cultural and geographical proximity between countries goes a long way to explaining the internationalisation of R & D and innovation. Despite high levels of internationalisation in the EU-12, the bulk of foreign-owned R & D and innovation activity takes place between EU-15 Member States.

A high share of foreign-owned R & D and innovation activity can be found in technology-intensive sectors, such as electronics, pharmaceuticals, office equipment and the computer industry. Innovation in services is less affected by internationalisation in R & D expenditure than manufacturing.

Outward internationalisation of EU firms has increased as well over the last decade. Today, some 10 % of all EU patent (triadic) applications are based on inventions made outside the EU. The preferred location for overseas R & D and innovation of EU firms is the United States. Similarly, the EU is the preferred location for US firms.

Outward R & D and innovation activities of EU firms in China, India, Brazil or other emerging economies start from low levels but are rising fast. Bearing in mind that overseas R & D activities follow outward foreign direct investment to a considerable degree, the share of the BRIC countries in EU overseas R & D and innovation activities can be expected to rise considerably in the future.

Multivariate analysis reveals that foreign-owned firms (at least from a static perspective) have a lower innovation input intensity than domestically owned firms, but achieve a similar innovation output, which is the key determinant in assessing the contribution these firms make to growth. This confirms that their innovation efforts are based to a considerable degree on technologies, brands and other assets they receive from the parent company or other parts of the enterprise group. A number of differences between foreign-owned and domestically owned firms are due to related firm characteristics — foreign-owned firms are larger, have higher absorptive capacities or operate more often in technology-intensive sectors.

One important finding is that cooperation with domestic partners, in particular domestic universities and research centres, is frequent among foreign-owned firms. The analysis reveals that foreign-owned firms have at least the same propensity to cooperate with external organisations in the host country as domestically owned firms. This seems to indicate that foreign-owned firms are well embedded in the national innovation systems of their host countries. Moreover, if cooperation is viewed as a two-way relationship, it follows that knowledge from foreign-owned firms has the potential to spill over to domestic organisations. Hence, host economies can benefit from the knowledge the foreign-owned subsidiary receives from its enterprise group. Foreign-owned firms therefore can act as agents of international technology diffusion and as bridges between organisations in the host country and foreign sources of knowledge.

Foreign-owned firms show significantly higher productivity levels (measured by sales per employee) than domestically owned firms. The country of origin has no influence on the strength of the effect. Foreign-owned firms also show higher levels of productivity growth, although here the differences with domestically owned firms are considerably smaller and less significant. Productivity growth is mainly related to output growth for old products and the effects of product innovation, but not process innovation. There are no major differences between foreign-owned firms, domestic group enterprises and domestic unaffiliated firms in the way innovation affects productivity levels. Subsidiaries of European MNEs, however, seem to benefit less from innovation expenditure than do subsidiaries of non-European MNEs.

Foreign-owned firms also differ from domestically owned firms in the way they transform new technologies into employment growth. Foreign-owned firms shed more jobs in the wake of general productivity increases; these are, however, overcompensated for by the employment-creating effects of higher sales of old products and product innovation in foreign-owned firms, which are higher than in domestically owned enterprises.

Together, these three effects result in net employment growth, including higher demand for skilled personnel. Overcoming capacity bottlenecks in the home country is indeed one of the main reasons why firms take their R & D and innovation activities abroad. Combining this finding with the fact that foreign-owned firms tend to operate more in technology-intensive industries, foreign-owned R & D and innovation activities in a country may also trigger structural change in the sense of boosting the share of high- and medium-tech industries.

What challenges and opportunities emerge for the EU?

Empirical evidence shows that foreign-owned firms contribute in many ways to a country's innovative capacity and performance. They innovate differently, but not necessarily less intensively than domestically owned firms. Foreign-owned firms have a lower innovation input intensity (after controlling for their main characteristics), but a similar innovation output, which is the key determinant in assessing the growth contribution of these firms.

There is no evidence that the presence of foreign-owned firms is detrimental to national innovation systems, e.g. by siphoning off knowledge resources or crowding out innovation by domestically owned firms.

A survey of current internationalisation policies (Dachs et al., 2010) showed that the principle of non-discrimination is adopted in all EU Member States. There is very little formal discrimination against foreign-owned firms with respect to access to funds or other restrictions of their business activities, as long as they are domiciled in the country. There may, however, be certain de facto preferences in some Member States for domestically owned firms in national innovation programmes.

The analysis in this chapter reveals no evidence in support of negative discrimination against (by limiting the activities of) foreign-owned firms ([55]).

The empirical findings indicate no support for positive discrimination either (e.g. by offering special incentives to foreign-owned firms). The high level of R & D and innovation activities of foreign-owned firms indicates that the EU is an attractive location for these types of activities. Empirical evidence suggests that the decisive factors in attracting R & D and innovation activities of foreign-owned firms are economic stability, high market growth expectations or the excellence of the science sector, IPR protection and the availability of S & T personnel (Cantwell and Mudambi, 2000; Thursby and Thursby, 2006). These factors are often more important than financial incentives, like tax breaks for foreign-owned firms ([56]).

Countries which are successful in attracting and benefiting most from foreign R & D and innovation tend to have stable macroeconomic conditions and policies and dynamic scientific and technology bases. They are also keen to foster capabilities for innovation in both foreign-owned and domestically owned firms. This conclusion is underpinned by the finding that many differences between foreign-owned and domestically owned firms are related to company characteristics such as size, sectoral affiliation and export orientation rather than to foreign ownership as such.

Moreover, R & D and innovation activities of foreign-owned firms are often the last step in their expansion at a certain location and are preceded by investment in production or sales activities. The most appropriate way to encourage R & D-intensive foreign-owned firms is to give them backing throughout their expansion by administrative simplification, matchmaking with domestic partners and other 'after-care' services following market entry (Guimón, 2009).

Policies which strengthen the links and integration of foreign-owned firms into domestic innovation networks, particularly with other firms in the host country, can deliver substantial benefits. Both supplier and user links to foreign-owned firms, as well as pre-competitive cooperation schemes with foreign-owned competitors, can help domestically owned firms to learn from these internationally experienced companies. Learning and technology transfer from foreign-owned firms can contribute in three ways to competitiveness:

- Foreign-owned firms tend to apply more advanced innovation management techniques, including ideas for successfully commercialising new products.
- Foreign-owned firms — with their higher productivity levels — may have technologies that can help domestically owned firms to advance their own production methods and product portfolios.
- Finally, domestically owned firms can use their contacts to foreign-owned firms to learn for their own internationalisation activities, including R & D and innovation internationalisation. Linking domestically owned and foreign-owned firms may also include ways and means of raising the capacities of domestically owned firms to absorb and make use of external knowledge.

([55]) In addition, limiting the activities of foreign-owned firms would violate EU competition law.

([56]) The 2008 EU survey on R & D (European Commission JRC IPTS, 2009b) points to some further differences between firms. High R & D intensity firms appear to give relatively more importance to tax incentives.

There is some evidence that supporting domestically owned firms' outward R & D and innovation activities can be advantageous for a national innovation system. R & D and innovation activities abroad help to gear innovative products to the requirements and preferences of foreign markets, which in turn increases the sales potential of domestic innovations. In addition, foreign R & D and innovation improves access to foreign knowledge sources, which can be used to advance domestic R & D and innovation, e.g. by accessing new research findings or lead markets abroad. So far, there have only been very few national programmes that actively support foreign R & D and innovation by domestically owned firms. This may be because of concerns of knowledge leaking out or of using taxpayers' money to support R & D at foreign locations. Empirical evidence suggests, however, that the internationalisation of firms will strengthen the entire business, i.e. also business activities in the home country (see, for example, Europe Economics (2010), Pfaffermayr (2004)).

It is not possible from today's perspective to fully ascertain the effects of the economic and financial crisis on the internationalisation of R & D and innovation. Innovation and R & D, however, show a high degree of robustness and consistency over time (Filippetti and Archibugi, 2010), which suggests that the crisis will have only minor consequences. Evidence from panel data described above indicates that R & D and other innovation expenditure by both foreign-owned and domestically owned firms is affected in the same way by the business cycle. In a cyclical downward trend, foreign-owned firms tend to keep up their higher R & D investment for a longer time. A high degree of foreign-owned R & D activity in a country may therefore even have a stabilising effect on gross national R & D expenditure in times of crisis.

There are several ways in which the European Commission can help firms to benefit from the internationalisation of R & D and innovation.

At the EU level there could be programmes linking EU partners with non-EU industrial partners in joint R & D and innovation projects. These would indirectly stimulate both inward R & D investment by non-EU firms and active R & D internationalisation of EU firms. It might be beneficial for unaffiliated, small- and medium-sized firms in particular (see SBA, Principle VIII), encouraging investment in research by SMEs and getting them to take part in transnational research activities — which can be achieved in part by getting them actively involved in the seventh RTD framework programme. The analysis has shown that this group cooperates considerably less with domestic partners. There are specific obstacles to cooperation in SMEs, such as a lack of resources and long-term funding of R & D, which are found less frequently in large firms.

In addition, support for SMEs to take their R & D and innovation activities abroad and forge links to specific foreign sources of knowledge may also yield considerable benefits for these firms. Empirical evidence suggests that internationalising innovation may boost the economic performance of the SME in the home country. Foreign-based R & D and the exploitation of innovations in foreign markets help SMEs to significantly increase employment at domestic locations (Rammer and Schmiele, 2008). Large domestic multinational firms do not need support from public policy to intensify their international linkages.

There may be advantages from making the European research area and the framework programme more open to non-EU firms, universities and other organisations. Cooperation between EU and non-EU organisations within the framework programme could strengthen links between Europe and other parts of the world. Linking MNEs more closely to domestic research organisations in joint projects may step up the transfer of knowledge between foreign and domestic partners.

Another channel for knowledge spillovers from foreign-owned firms to the domestic innovation system is staff mobility (see, for example, Kaiser et al. (2008)). Creating a culture that encourages spin-offs by employees of domestic and foreign-owned multinationals can foster growth and create more jobs.

There are some issues related to the internationalisation of R & D and innovation where a pan-European discussion and further comparisons of actual policies in the Member States would be beneficial: one of these is the treatment of non-domiciled foreign-owned firms (with no subsidiary in a Member State) in national funding schemes for R & D and innovation.

The locational advantages of the European Union could be enhanced by removing more barriers to trans-European R & D and innovation activities. One example is the European patent. A single EU patent with centralised application and litigation procedures and a sound application and renewal fee structure could have a stimulating effect on R & D and innovation by foreign-owned firms in particular.

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Annex

Measuring the internationalisation of R & D and innovation

There are at least three approaches to measuring the internationalisation of R & D and innovation activities. Patent data feature the location of the applicant and the location of the inventor of a particular patent. By comparing the two, it is possible to derive a measure for the foreign ownership of domestic patent inventions, which can be used as an indicator for the internationalisation of R & D and innovation (Guellec and van Pottelsberghe de la Potterie, 2004; Belderbos et al., 2009). Patent data are available in great detail for many countries, years and technologies. There are, however, some shortcomings that must be considered (see also the preceding chapter), such as: time lags between application and invention; not all inventions being patentable; differences in the propensity to patent between sectors (with very few patents in the services sector); no indication of its application or economic value; and potential distortions from 'strategic' patenting.

This study employs two types of patent data — that provided by the European Patent Office (EPO) and that on triadic patents which have been applied for at all three major patent offices, the EPO, the US Patent and Trademark office (USPTO) and the Japanese Patent Office (JPO). The number of triadic patents is relatively small, especially in more recent years. However, triadic patents help to circumvent the 'home office' bias in patents which results from the tendency of an inventor to apply at the patent office of her/his home country first. As a consequence of this bias, US inventors are overrepresented at the USPTO, while European inventors dominate the EPO.

Innovation surveys, in particular the Community Innovation Survey (CIS) and the European Manufacturing Survey (EMS), are a second data source employed in this chapter. Innovation surveys provide detailed information on goals, hindering factors, financial inputs and outcomes of corporate innovation processes. This study employs CIS data in the multivariate analysis featuring in Chapters 4, 5 and 6, and EMS data in Chapter 3.

An advantage of innovation survey data is that they cover the whole innovation process, not just R & D, and usually include the service sector. They often include information on various company characteristics, which makes it possible to relate innovation activity to company size, sector and employment structure, etc. Disadvantages of innovation survey data include problems with their scope and definitions (Salazar and Holbrook, 2004) and with data access. This chapter employs firm-level data from the CIS and the EMS.

A third data source is R & D expenditure of foreign affiliates published by national statistical offices. The biggest advantage of data on R & D spending by foreign subsidiaries is that it allows a direct comparison with R & D expenditure at the sectoral or aggregate level. The broad coverage of national R & D surveys makes them highly representative and includes R & D in the service sector. However, a number of countries have not yet extended their R & D surveys to cover the ownership status of the firm, and coverage is still poor at the sectoral level, with respect to outward internationalisation. Data on R & D expenditure by foreign affiliates is presented in Section 3.

Table A.1: Share of R & D expenditure by foreign-owned affiliates in manufacturing and services (most recent year)

	AT	CZ	DE	FI	FR	HU	IE	IT	NL	PL	PT	SE	SK	UK
Year	2004	2007	2007	2006	2007	2004	2005	2007	2001	2007	2007	2007	2007	2007
Total Business Enterprise	44.9	54.7	26.2	17	19.6	73.9	70.3	27.4	19.6	30.7	23.1	35.5	37.5	37.5
Manufacturing	54.5	67.7	27.4	13.5	21.1	58.7	76	24.3	22.2	31.6	39.4	40.3	66.8	..
Food, beverages and tobacco	25.2	64.9	54.9	26.6	36.8	69.8	36.2	14	12.5	..	..	46.4	95.7	42.9
Textiles, wearing apparel, leather, footwear	..	24.9	..	..	18.3	0	34.8	12.4	22.2	..	5	64.8	..	32
Wood and paper products, publishing, printing	41.3	0	..	6.4	29.2	30.8	16.7	..	21.4	..	46.6	27.1	..	23.8
Chemical products	67.3	68.8	35.6	34.6	23.3	40.7	94.5	49.9	26.4	24.2	20	91	74.9	34.6
Drugs and medicines	73.2	87.7	52.8	34.3	21	..	96.3	..	25.7	..	21	..	92.1	34.1
Rubber and plastic products	6.6	58.5	36.5	10.6	11.3	47.4	28.6	17.9	37	..	10	23.4	75.6	42.9
Non-metallic mineral products	11.7	23.1	41.2	41.5	19.4	11.1	24.7	8	40.7	12.2	30.9	78.3	87	51.9
Basic metals	6.3	50.6	21.7	20.8	68.9	78.3	0	..	18.2	22.8	18.8	16.1	..	..
Fabricated metal products	21.7	42.9	22	54	30.9	20	46.3	..	12.7	..	20.3	9.9	62.5	61.9
Total machinery and equipment	..	51.4	29.3	..	28.2	86.4	76	..	9.2	..	57.2	..	..	50.7
Non-electrical machinery and equipment	..	46.7	26	..	35	65.5	63.8	..	7.2	..	39.4	43.3	..	56.8
Machinery and equipment n.e.c.	38.2	47.4	18.7	26.4	35	67.9	62.2	33.2	8	24.8	41.9	45.2	38.3	56.1
Office, accounting and computing machinery	..	0	77.4	..	33.9	0	64.8	..	3.3	..	0	8.1	..	64.6
Electrical machinery and electronic equipment	83.8	57.2	33.5	..	25.7	91.4	83.7	..	31.1	..	69.4	..	69.4	45
Electrical and optical equipment	..	61.3	30.9	..	24.7	83.6	78.3	18.5	27	..	..	..	..	..
Radio, TV and communication equipment	95.3	66.9	34.7	..	24.3	92.4	88.6	..	..	8.1	75.9	..	93.5	55.5
Medical, precision, opt. instruments	18.1	68.4	17	..	21.6	14.3	77.9	..	40.9	..	..	43.7	..	58.6
Motor vehicles	50.3	95.2	14.9	25.4	19.2	96.9	86	..	89.9	..	65.4	50.3	..	89
Other transport equipment	33.6	9.8	81.4	..	2.3	0	0	..	5.6	..	..	7	..	..
Furniture, recycling and manufacturing n.e.c.	..	28.6	28.1	24.8	27.5	0	1.1	24.8	27.3	..	..	6.2	..	..
Electricity, gas and water supply, construction	0	1	..	10.2	..	2.6	0	..	10.8	..	0.3	39.4	..	36.8
Trade, repair, hotels and restaurants	42.9	56.4	..	87.3	..	..	0	67.9	36.9	83.4	..	42.2	..	42.9
Finance, insurance, real estate, business act.	20	35.7	16.4	19.4	..	..	60.1	43.7	16.8	48.9	24.4	20.3	..	..

Source: OECD FATS, ZEW/AIT calculations.

Table A.2: Impact of foreign ownership and domestic group membership on innovation and cooperation behaviour of EU firms

COEFFICIENT	lintens	turnmar	co_dom_ex	co_dom_sci
domgp	- 0.0733 (**) *(0.0320)*	0.0075 *(0.0050)*	0.2627 (***) *(0.0426)*	0.3417 (***) *(0.0518)*
forown	- 0.1505 (***) *(0.0374)*	0.0107 (*) *(0.0056)*	0.1372 (***) *(0.0484)*	0.2736 (***) *(0.0508)*
lemp	- 0.8864 (***) *(0.0523)*	- 0.0177 (**) *(0.0078)*	0.0318 *(0.0726)*	0.0056 *(0.0762)*
lemp2	0.0445 (***) *(0.0049)*	0.0017 (**) *(0.0007)*	0.0117 (*) *(0.0067)*	0.0117 (*) *(0.0065)*
rrdin	0.4960 (***) *(0.0264)*	0.0459 (***) *(0.0041)*	0.5086 (***) *(0.0372)*	0.6099 (***) *(0.0495)*
spill	0.3566 (***) *(0.0485)*	0.0495 (***) *(0.0074)*	0.6778 (***) *(0.0667)*	1.0018 (***) *(0.0849)*
mar_int	- 0.2823 (***) *(0.0541)*	0.0367 (***) *(0.0088)*	- 0.0107 *(0.0612)*	- 0.0280 *(0.0683)*
finsup	0.8309 (***) *(0.0274)*	0.0228 (***) *(0.0044)*	0.5042 (***) *(0.0389)*	0.6738 (***) *(0.0454)*
low	0.2552 (***) *(0.0751)*	0.0332 (***) *(0.0121)*	0.4666 (***) *(0.1038)*	0.3310 (***) *(0.1179)*
med_low	0.6288 (***) *(0.0754)*	0.0259 (**) *(0.0121)*	0.4486 (***) *(0.1014)*	0.2691 (**) *(0.1119)*
med	0.8903 (***) *(0.0730)*	0.0351 (***) *(0.0117)*	0.4959 (***) *(0.0993)*	0.3177 (***) *(0.1102)*
med_high	0.8746 (***) *(0.0739)*	0.0298 (**) *(0.0118)*	0.4988 (***) *(0.0996)*	0.4242 (***) *(0.1111)*
high	1.4314 (***) *(0.0746)*	0.0862 (***) *(0.0119)*	0.6488 (***) *(0.1016)*	0.6317 (***) *(0.1116)*
Constant	- 1.3666 (***) *(0.2805)*	- 0.0388 *(0.0480)*	- 2.3949 (***) *(0.3765)*	- 2.8199 (***) *(0.4880)*
Wald chi2	5 108.10 (***)	858.56 (***)	1 545.60 (***)	952.22 (***)
Observations	78 403	85 456	84 677	84 677
Uncensored observations	20 797	18 484	27 071	27 071

Note: Lintens is the ln of innovation expenditures as percentage of turnover in 2006; turnmar is the share of turnover generated by market novelties in 2006. co_dom_ex is 1 if the enterprise had cooperation agreements during 2004–06 with suppliers, clients or customers, competitors or other firms, consultants, commercial labs, private R & D institutes, universities, government or public research institutes at the national level. Co_dom_sci is 1 if the enterprise had cooperation agreements during 2004–06 with universities, government or public research institutes at national level. Domgp identifies domestically owned group enterprises, forown is 1 if the firm is foreign-owned. Description of the other independent variables (see Dachs et al. (2010)): Size (*lemp*): ln (total number of employees) in the reference year 2006; Size^2 (*lemp2*); Intramural R & D (*rrdin*): 1 if the enterprise is engaged in intramural (in-house) R & D; 0 otherwise; External Spillovers (*spill*): Sum of scores of importance of the following information sources for the innovation process [number between 1 (low) and 3 (high)]: sources from Professional and industry associations, sources from scientific journals, trade/scientific publications and sources from professional conferences, trade fairs, meetings; (rescaled between 0 and 1); International market-orientation (*mar_int*): 1 if a firm exported goods or services during the years 2004–06; 0 otherwise; Public funding (*finsup*): 1 if the firm got public funding for innovation from local or regional authorities, or from central government, or from the EU; 0 otherwise; Sectoral affiliation (*none, low, low_med, med, med_high, high*): taxonomy of economic sectors (six categories) according to their innovation intensity (Peneder 2010); sectors are classified according to cumulativeness of the knowledge base, appropriability conditions, technological opportunity and creative vs. adaptive strategies.

Lintens and turnmar are estimated by Heckman regression; *co_dom_ex* and *co_dom_sci* are estimated by Heckman Probit; (***), (**) and (*) denote statistical significance at the 1 %, 5 % and 10 % test level; standard errors in parentheses; observations cover innovative and non-innovative firms; uncensored observations relate to firms with innovation activities; the test is a Wald test that all coefficients in the regression model (except the constant) are 0.

Country dummies are not reported in the table.

Source: ZEW/AIT calculations, CIS2006, Eurostat

Table A.3: Innovation and cooperation behaviour of FOFs from different home country groups

COEFFICIENT	lintens	turnmar	co_dom_ex	co_dom_sci
asia	0.269	0.0857 (**)	- 0.192	- 0.3840 (**)
	(0.220)	*(0.0423)*	*(0.142)*	*(0.167)*
noneu	0.0418	0.0562	- 0.0290	0.0266
	(0.233)	*(0.0431)*	*(0.140)*	*(0.147)*
usca	- 0.0690	0.0289 (*)	0.0796	0.3010 (**)
	(0.138)	*(0.0166)*	*(0.115)*	*(0.124)*
other	0.534	- 0.0465 (*)	- 0.160	0.119
	(0.329)	*(0.0244)*	*(0.185)*	*(0.198)*
lemp	- 0.9390 (***)	- 0.0503 (*)	- 0.0276	- 0.200
	(0.222)	*(0.0298)*	*(0.184)*	*(0.183)*
lemp2	0.0370 (*)	0.00390	0.0158	0.0252 (*)
	(- 0.0191)	*(0.00255)*	*(0.0145)*	*(0.0136)*
rrdin	0.4870 (***)	0.0307 (**)	0.5100 (***)	0.6000 (***)
	(0.115)	*(0.0138)*	*(0.0724)*	*(0.0879)*
spill	0.0682	0.0183	0.6700 (***)	1.3380 (***)
	(0.236)	*(0.0296)*	*(0.179)*	*(0.187)*
mar_int	- 0.0179	0.0074	- 0.2250 (**)	- 0.125
	(0.168)	*(0.0164)*	*(0.107)*	*(0.110)*
finsup	0.5750 (***)	0.0308 (*)	0.5130 (***)	0.6530 (***)
	(0.118)	*(0.0173)*	*(0.0828)*	*(0.0918)*
low	- 0.111	0.111 (***)	0.449 (**)	0.0371
	(0.369)	*(0.0214)*	*(0.222)*	*(0.260)*
med_low	0.536	0.0622 (***)	0.3810 (*)	- 0.0244
	(0.369)	*(0.0154)*	*(0.218)*	*(0.250)*
med	0.6580 (*)	0.0656 (***)	0.3770 (*)	0.0052
	(0.362)	*(0.0168)*	*(0.215)*	*(0.249)*
med_high	0.8030 (**)	0.0882 (***)	0.5630 (***)	0.4790 (**)
	(0.351)	*(0.0157)*	*(0.209)*	*(0.242)*
high	1.0000 (***)	0.1170 (***)	0.6270 (***)	0.4440 (*)
	(0.364)	*(0.0167)*	*(0.215)*	*(0.245)*
Constant	- 0.318	0.2130 (**)	- 1.9750 (**)	- 1.688
	(0.947)	*(0.0952)*	*(0.786)*	*(1.027)*
Wald chi2	226.74 (***)	158.27 (***)	298.31 (***)	241.45 (***)
Observations	7 782	8 650	8 525	8 525
Uncensored Observations	3 149	2 911	3 892	3 892

Note: Lintens is the ln of innovation expenditures as percentage of turnover in 2006; turnmar is the share of turnover generated by market novelties in 2006. co_dom_ex is 1 if the enterprise had cooperation agreements during 2004–06 with suppliers, clients or customers, competitors or other firms, consultants, commercial labs, private R & D institutes, universities, government or public research institutes at the national level. Co_dom_sci is 1 if the enterprise had cooperation agreements during 2004–06 with universities, government or public research institutes at national level. Domgp identifies domestically owned group enterprises, forown is 1 if the firm is foreign-owned. Description of the other independent variables (see Dachs et al. (2010)): Size (*lemp*): ln (total number of employees) in the reference year 2006; Size^2 (*lemp2*); Intramural R & D (*rrdin*): 1 if the enterprise is engaged in intramural (in-house) R & D; 0 otherwise; External Spillovers (*spill*): Sum of scores of importance of the following information sources for the innovation process [number between 1 (low) and 3 (high)]: sources from Professional and industry associations, sources from scientific journals, trade/scientific publications and sources from professional conferences, trade fairs, meetings; (rescaled between 0 and 1); International market-orientation (*mar_int*): 1 if a firm exported goods or services during the years 2004–06; 0 otherwise; Public funding (*finsup*): 1 if the firm got public funding for innovation from local or regional authorities, or from central government, or from the EU; 0 otherwise; Sectoral affiliation (*none, low, low_med, med, med_high, high*): taxonomy of economic sectors (six categories) according to their innovation intensity (Peneder 2010); sectors are classified according to cumulativeness of the knowledge base, appropriability conditions, technological opportunity and creative vs. adaptive strategies.

Lintens and turnmar are estimated by Heckman regression; *co_dom_ex* and *co_dom_sci* are estimated by Heckman Probit; (***), (**), (*) denote statistical significance at the 1 %, 5 % and 10 % test level; Standard errors in parentheses; observations cover innovative and non-innovative firms; Uncensored observations relate to firms with innovation activities; the test is a Wald test that all coefficients in the regression model (except the constant) are 0.

Country dummies are not reported in the table.

Source: ZEW/AIT calculations, CIS2006, Eurostat.

Table A.4: Impact of foreign ownership and domestic group membership on innovation and cooperation behaviour of EU firms, panel regressions

	Dependent Variable			
	Innovation input intensity	Innovation output intensity	Cooperation with domestic partners	Cooperation with domestic science
Ownership				
DGF	0.972 (***) *(0.198)*	1.452 (**) *(0.666)*	0.029 (**) *(0.015)*	0.011 *(0.007)*
FOF	-	-	-	-
FOFEU	-0.902 *(0.598)*	0.526 *(1.536)*	0.034 *(0.039)*	0.004 *(0.018)*
FOFNONEU	0.171 *(0.706)*	0.620 *(1.763)*	0.042 *(0.042)*	0.034 *(0.023)*
FOFUS	-	-	-	-
FOFROW	-	-	-	-
Innov. Intensity in t-1		1.799 (***) *(0.224)*		
Firm size	1.018 (***) *(0.074)*	-4.608 (***) *(0.772)*	0.079 (***) *(0.005)*	0.040 (***) *(0.003)*
East Germany (0/1)	1.146 (***) *(0.264)*	-1.587 (***) *(0.365)*	0.112 (***) *(0.016)*	0.045 (***) *(0.009)*
Firm age	-1.800 (***) *(0.118)*	0.376 (***) *(0.019)*	-0.018 (**) *(0.007)*	-0.010 (***) *(0.003)*
Export intensity	3.670 (***) *(0.310)*	9.188 (***) *(1.144)*	0.131 (***) *(0.025)*	0.080 (***) *(0.013)*
Creditworthiness	0.431 *(0.417)*	16.180 (***) *(0.549)*		
Constant	-1.877 *(2.532)*	-35.964 (***) *(2.428)*		
Year dummies ([1])	0.000 (***)	0.000 (***)	0.000 (***)	0.000 (***)
Industry dummies ([1])	0.000 (***)	0.000 (***)	0.000 (***)	0.000 (***)
sigma_a	13.372 (***) *(0.116)*	19.351 (***) *(0.414)*		
sigma_e	11.385 (***) *(0.054)*	19.431 (***) *(0.237)*		
rho	0.58	0.498		
LL			-5 160.070	-4 775.694
W: DGF = FOFEU	0.002 (***)	0.543	0.925	0.681
W: DGF = FOFNONEU	0.254	0.634	0.883	0.285

Note: Estimation method: random effects tobit model. ([1]) Year and industry dummies are included but not reported. Reported is only the p-value of a test on joint significance. W: DGF = FOFEU reports the p-value of a test on joint significance of DGF and FOF, EU (H0: not jointly significant). W: DGF = FOFNONEU reports the p-value of a test on the difference between DGF and FOF, non-EU (H0: no significant difference). Sigma_a and sigma_e denotes the standard deviation of the individual fixed/random effects and the idiosyncratic error term, respectively.
(***), (**) and (*) denote statistical significance at the 1 %, 5 % and 10 % test level; standard errors in parentheses; observations cover innovative and non-innovative firms.

Source: ZEW — Mannheim Innovation Panel, ZEW/AIT calculations.

Table A.5: Effects of foreign ownership and innovation on productivity in EU firms

	Traditional approach											
	Productivity level						Productivity growth					
Innovation												
Innovation intensity	0.096 (0.006)	(***)	0.096 (0.006)	(**)	0.106 (0.005)	(***)	0.007 (0.002)	(***)	0.007 (0.002)	(***)	0.010 (0.002)	(***)
Process innov.	-0.058 (0.020)	(**)	-0.058 (0.020)	(**)	-0.058 (0.020)	(**)	-0.058 (0.006)	(**)	0.000 (0.006)		-0.000 (0.006)	(**)
Ownership (reference: DnGF)												
DGF	0.218 (0.015)	(***)	0.219 (0.015)	(***)	0.124 (0.052)	(**)	-0.009 (0.009)		-0.010 (0.009)		-0.035 (0.019)	(*)
FOF	0.383 (0.028)	(***)	-		-		0.009 (0.011)		-		-	
FOFEU	-		0.376 (0.039)	(***)	0.177 (0.089)	(**)	-		0.013 (0.013)		-0.043 (0.041)	
FOFNONEU	-		0.389 (0.034)	(***)	0.319 (0.119)	(**)	-		0.005 (0.010)		-0.063 (0.033)	(*)
*Innovation * Ownership*												
Innovation intensity * DGF	-		-		-0.016 (0.009)		-		-		-0.004 (0.003)	
Innovation intensity * FOFEU	-		-		-0.034 (0.012)	(**)	-		-		-0.009 (0.006)	
Innovation intensity * FOFNONEU	-		-		-0.012 (0.017)		-		-		-0.012 (0.005)	(**)
	CDM model											
	Productivity level						Productivity growth					
Innovation												
Product innovation output	0.491 *(0.021)*	(***)	0.405 *(0.026)*	(***)	0.453 *(0.030)*	(***)	0.034 *(0.007)*	(***)	0.028 *(0.006)*	(***)	0.030 (0.010)	(***)
Process innov.	-0.097 *(0.014)*	(***)	-0.101 *(0.015)*	(***)	-0.105 *(0.014)*	(***)	-0.004 *(0.004)*		-0.002 *(0.005)*		-0.002 (0.005)	
Ownership												
DGF	0.121 *(0.020)*	(***)	0.147 *(0.019)*	(***)	-0.151 *(0.111)*		-0.001 *(0.006)*		0.001 *(0.007)*		0.005 (0.038)	
FOF	0.197 *(0.021)*	(***)	0.231 *(0.022)*	(***)	-0.082 *(0.127)*		0.004 *(0.007)*		0.010 *(0.009)*		-0.033 (0.050)	
*Innovation * Ownership*												
*Product innov. output * DGF*	-		-		-0.082 *(0.030)*	(***)	-		-		0.001 (0.010)	
*Product innov. output * FOF*	-		-		-0.089 *(0.037)*	(***)	-		-		-0.013 (0.014)	

Note: The dependent variable is labour productivity measured by sales per employee and labour productivity growth, respectively. Labour productivity is explained either by innovation input (innovation intensity measured by the innovation expenditures as percentage of turnover; traditional approach) or product innovation output (share of sales with new products; CDM model). Further explanatory variables include process innovation (dummy — yes/no) and a set of dummy variables indicating ownership: DGF (domestically owned group firm), FOF (foreign-owned firm), FOFEU (foreign-owned firm from an EU country), FOFNONEU (foreign-owned firm from a non-EU country). Reference group is DnGF (domestically owned non-group firm). The third estimation further includes interaction terms between innovation input (output) and ownership. Additional control variables (not reported here) include firm size (log. number of employees), physical capital (log. investment per employee), human capital (share of high skilled employees), export intensity, country dummies and industry dummies. The CDM model only reports the final stage. The hypothesis on equal effects of DGF and FOF on productivity growth in the traditional approach is rejected at the 10 % level (p value: 0.093).
(***), (**) and (*) denote statistical significance at the 1 %, 5 % and 10 % test level; standard errors in parentheses; observations cover innovative and non-innovative firms.

Source: CIS 3, Eurostat, ZEW/AIT calculations.

Box A.1: Linking productivity to innovation

There is an enormous amount of work examining the factors underlying productivity and productivity growth. Two different approaches can be distinguished. The traditional approach uses a Cobb-Douglas (CD) production function as its theoretical framework to explain productivity, augmented by knowledge capital as an additional input besides labour and physical capital. Taking logs and assuming constant returns to scale lead to the following estimation equation:

$$q_{it} - l_{it} = a_i + \lambda t + \alpha\left(c_{it} - l_{it}\right) + \gamma k_{it} + \left(\mu - 1\right) l_{it} + u_{it},$$

where l denotes labour, q-l labour productivity, c-l physical capital per employee, k knowledge capital and t exogenous technological change. γ measures how much a firm benefits in terms of a percentage increase in production if it boosts its innovation investment by 1 %. Instead of the productivity level, one can similarly derive the productivity growth. To compare domestically owned firms, the specification will be enhanced by including ownership dummy variables.

The second approach is based on the CDM model by Crepon, Duguet and Mairesse (Crepon et al., 1998). It was developed because the traditional approach does not take into account the fact that not all firms are engaged in innovation, which can lead to biased results. Furthermore, the link between innovation input and innovative outcome remains a black box. The CDM approach is a three-step model consisting of four equations. In the first step, firms decide on the strength of the expected profits whether to engage in innovation activities (selection equation) and on the amount of money to invest in innovation. If the firm opts to innovate, the second step describes the relationship between innovation input and innovation output (knowledge production function, see Pakes and Griliches, 1984). The third step is similar to the traditional approach. An augmented CDM production function is estimated in which productivity results from knowledge capital, now proxied by innovation output, and other explanatory factors. Innovation input is proxied by innovation intensity; the share of sales of new products measures innovation output.

CHAPTER 4

European Competitiveness in Key Enabling Technologies

4.1. Introduction

What products will be demanded in the future, what will producers be able to offer, and which production processes will be available in years to come? These crucial questions are of course impossible to answer and it would be foolhardy to make an attempt: history is full of examples of futile prophecies, guesses and market analyses that over time have proved to be wide of the mark.

It is however possible to say something meaningful about the technologies that will be crucial to the development of a multitude of new products and processes in many different industries and fields of application. Such key enabling technologies are attracting increasing interest, not least in difficult economic times, as they are seen as the route to new and better products and processes, capable of generating economic growth and employment and strengthening the competitiveness of the economy. They are moreover expected to provide significant economic benefits, offering a widening variety of uses in an increasing number of application areas and industries.

The discussion of key enabling technologies is not new. The concept is in fact closely related to the concept of general purpose technologies coined by Bresnahan and Trajtenberg (1995) and further developed notably by Helpman (1998) and Lipsey et al. (2005). The link was already established in the introduction to Bresnahan and Trajtenberg (1995):

> 'Most general purpose technologies play the role of "enabling technologies", opening up new opportunities rather than offering complete, final solutions. For example, the productivity gains associated with the introduction of electric motors in manufacturing were not limited to a reduction in energy costs. The new energy source fostered the more efficient design of factories, taking advantage of the newfound flexibility of electric power.' (Bresnahan and Trajtenberg, op. cit., p. 84)

In 2002 the Commission presented an industrial policy communication (European Commission, 2002) in which it called on the European Union to reinforce its position in certain enabling technologies such as information and communication technologies (ICT), electronics, biotechnology and nanotechnology. This is reflected in the current framework programme for research, technological development and demonstration activities (2007–13), as well as its specific programmes, where key enabling technologies feature prominently. Furthermore, one of the chapters of the *European Competitiveness Report 2007* (European Commission, 2007a) included a survey of existing literature on a number of future key technologies: ICT, microsystems, advanced and smart materials and nano- and biotechnologies. In 2009 the Commission presented a stand-alone communication on key enabling technologies (2009a) accompanied by a working document on the state of play regarding these technologies in Europe (2009 b), both of which are central to this chapter. Two recent strategy communications, on Europe 2020 (2010a) and on a digital agenda for Europe (2010b), have further underlined the importance of key enabling technologies.

There is no universally accepted definition or agreed list of key enabling technologies. For the purpose of this chapter, the definition in European Commission (2009a) will be used.

Moreover, the key enabling technologies examined in this chapter — nanotechnology, industrial biotechnology, advanced materials, micro and nanoelectronics including semiconductors, photonics and advanced manufacturing technologies — are essentially the same as in European Commission (2009a), the only difference being that given the importance of process innovation in industrial competitiveness and the important role of advanced manufacturing as enabler of process innovation, advanced manufacturing technologies have been added and will be considered alongside nanotechnology, industrial biotechnology, advanced materials, micro and nanoelectronics and photonics. Including

Box 4.1: Definition of key enabling technologies (KETs)

KETs are knowledge-intensive and associated with high R & D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment. They enable process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technology leaders in other fields to capitalise on their research efforts (European Commission, 2009a).

advanced manufacturing technologies in the analysis is in line not only with European Commission (2009a) but also with European Commission (2007a).

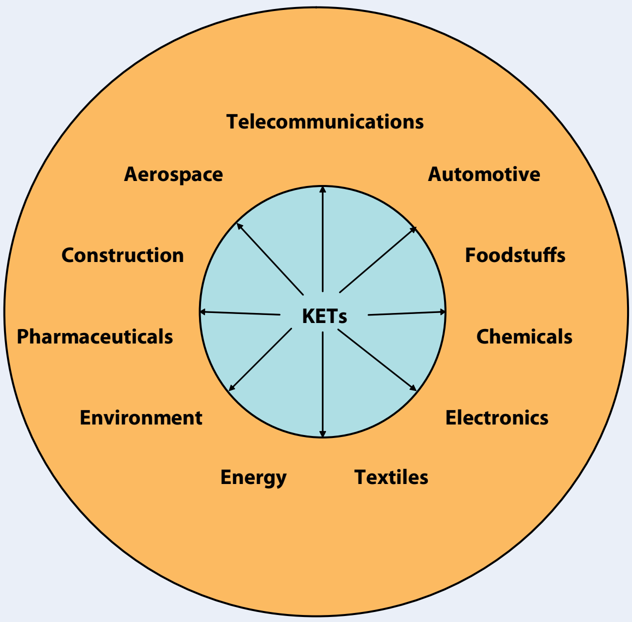
4.2. Applications of key enabling technologies

An important aspect of key enabling technologies which is clearly expressed in the quoted paragraph from Bresnahan and Trajtenberg (1995) but is perhaps less clear from the definition in Box 4.1 is that whilst developing and mastering a key enabling technology is likely to require considerable input of resources (capital, time, labour, R & D), the direct return on that investment tends to be disproportionally small. It is instead the applications it enables that are expected to create jobs, growth and wealth in the economy and boost competitiveness. A number of current and future applications are discussed further in Section 4.5, while existing estimations of market potential are reported in Section 4.6. Europe's competitiveness is assessed in Section 4.7, followed by implications and priorities in Section 4.8.

Figure 4.1 is a schematic representation of the links between key enabling technologies, at the core of the process and interacting with one another, and some of their applications, which is where value, growth and employment are created. In many cases small- and medium-sized enterprises (SMEs) play a vital role, often as part of a cluster, in the development and commercialisation of applications, whereas their role in the development of key enabling technologies is more limited because they lack the necessary resources.

The case of environment applications may serve as an illustration of the links in Figure 4.1. Due to scarce resources and the need to meet climate change targets, the market for eco-friendly technologies is expected to continue to grow faster than the economy as a whole, as it has done in recent years. Key enabling technologies such as nanotechnology for filtering polluted water or used in desalination plants, advanced manufacturing technologies and advanced materials to come up with environmentally friendly building materials and industrial biotechnology are some of the technologies likely to play a role on this expanding market.

Figure 4.1: Key enabling technologies and some areas of application



Source: Adapted from Confindustria (2009).

Given the considerable resources needed to develop key enabling technologies, might it be preferable not to make the investment, wait for them to be developed elsewhere and then either purchase or acquire them through cooperation with external partners? There are at least two arguments against such a 'free-rider' approach. First, developing commercial applications based on key enabling technologies often requires a certain degree of technological competence in order to absorb and apply new knowledge, as well as close interaction between fundamental research and industrial innovation. The need for interaction often manifests itself in the forming of clusters, a topic which is discussed in Section 4.7.7. Second, first-mover advantages are particularly important in the case of path-breaking technologies. First-mover advantages include learning and reputation effects as well as standard-setting and developing innovation-friendly regulation. The issue of first movers is discussed further in Section 4.3 below.

4.3. Key enabling technologies and the economy

The development of a key enabling technology can be regarded as a technological push to the innovation efforts of firms and can be expected to raise the overall level of innovation activities in an economy (Helpman, 1998; Baptista, 1999; van Ark and Piatkowski, 2004). Moreover, research has shown that innovative firms are often more productive and grow faster than other firms, indicating a higher level of competitiveness (Crépon et al., 1998; Griffith et al., 2006; Harrison et al., 2008; Janz et al., 2004). Similarly, greater innovativeness in terms of the degree of novelty and the amount of R & D effort tends to be associated with higher economic performance in terms of productivity and growth (Peters, 2008).

Applying new technologies early and broadly often requires close interaction between the producers and users of these technologies (Fagerberg, 1995; Porter, 1990). Competitiveness effects of new technologies strongly depend on the speed of their diffusion and on the rate at which the opportunities they present are exploited. Being the first to generate new scientific findings is not a sufficient condition for securing economic returns from new technologies. The main challenge for any innovation project, including innovations based on key enabling technologies, is to balance technological opportunities originating from research with user needs, cost-efficient production and the capabilities of business partners (suppliers, distributors, users), without losing sight of the innovative strategies of competitors. As a consequence, innovators use a variety of inputs to orient their innovative activities.

From a macroeconomic point of view, key enabling technologies can increase productivity and wealth through more efficient use of production factors and through structural change. Within a production function environment, their positive productivity effects may be reflected in a higher rate of technical progress. Alternatively, one may model the effect of key enabling technologies as a separate input factor; a stock of new knowledge resulting from R & D. Efforts to develop key enabling technologies result in larger knowledge stocks and increased output. Within a sector-specific production function environment, key enabling technologies are likely to shift sector shares since the output of sectors that produce such technologies and can obtain productivity advantages from them is likely to grow faster. In a dynamic perspective, positive productivity effects from structural change driven by key enabling technologies are likely since technology sectors will experience above-average productivity growth.

Box 4.2: The economics of key enabling technologies

The economic rationale for developing key enabling technologies can be illustrated in the framework of a knowledge-augmented Cobb-Douglas production function:

$Y = T\,C^{\alpha} L^{\beta} M^{\kappa} K^{\gamma}$ where C, L, M and K are the input factors physical capital, labour, material, and knowledge; α, β, κ and γ are their associated partial output elasticities; T is total factor productivity and Y is output in the economy. Developing and mastering key enabling technologies can be expected to have a positive effect on K, T and Y. The effects on C, L, M and the four elasticities will depend on the degree of substitution, efficiency and other factors.

Another way of looking at the introduction of applications of key enabling technologies is in the context of the production frontier of the economy. Developing a key enabling technology will expand the production set so that previously unobtainable output combinations become feasible while previously possible combinations can be obtained at a lower cost, using fewer inputs. It should however be noted that the outward shift of the production frontier associated with the expansion of the production set is unlikely to be a parallel shift: in all likelihood the new equilibrium output will differ in its composition from the old equilibrium.

Key enabling technologies play a crucial part in accelerating technical progress. In general, applying them will enable producers to use labour, capital, energy and other inputs more efficiently. It is important to stress that unlike other drivers of technical progress — diffusion of existing technologies, improving skills through education and training and learning from good practice — key enabling technologies are more likely to result in leaps in efficiency levels, particularly when their use affects many sections of the economy simultaneously. The case of information and communication technologies illustrates the point. The productivity growth generated by them was due mainly to their wide diffusion across many different industries, including sectors with traditionally low technology intensities (in terms of the amount of new technology used in production) such as retail or transportation. In addition, the particularly strong productivity impact of ICT resulted from their network characteristics. Productivity stemmed not only from a firm's own use of ICT but also from the use by business partners (suppliers and customers) since ICT fostered more efficient external business processes. Technologies exerting less significant network effects are likely to result in lower economy-wide productivity gains.

However, ICT have also shown that there may be substantial time lags between the invention and first application and the economic impact of a new technology. For many new technologies the most important applications may not be evident in the early stages of technology development. Potential applications typically emerge from the interaction of suppliers, producers and users of a new technology, through learning by using (Rosenberg, 1982) and from fierce competition among technology producers who are seeking competitive advantages by customising the new technology to the needs of users. More complex technologies tend to generate particularly high returns to adoption (Arthur, 1989).

A preliminary conclusion is therefore that the scale of the effects on productivity from a key enabling technology will depend on: (i) the speed and breadth of its diffusion across sectors and users; (ii) the extent to which its use gives rise to network effects; and (iii) how mature it is, in terms of the various technological applications and innovative solutions developed in its wake.

A second dimension of the macroeconomic importance of key enabling technologies is that they can open up entirely new markets, or at least step up product quality in existing markets. Such industrial change is likely to involve higher levels of input-output relations since entirely new products on new markets and higher-quality products are likely to command higher output prices per unit. Opening up new markets can also help unlock additional demand and new resources for production, thereby increasing net output.

An important issue in this respect is the timing of new markets. Economies able to open up new markets before others could gain a temporary monopoly, as a source of additional income. More importantly, in a dynamic sense such first-mover advantages can translate into positive cumulative effects (Porter, 1990). These cumulative effects may result from network effects among producers, suppliers and users who can learn from each other and leverage economies of scale and scope. In addition, first movers may be able to define global standards, establish global distribution channels and build up a reputation as technology leaders. Follow-up innovations can build on the accumulated knowledge in a specific field of technology. These cumulative effects will also act as entry barriers and can secure a long-term lead in a specific technology.

History abounds with examples of such cumulative technological advantages, e.g. in aircraft, space and defence technologies (USA), microelectronic household applications (Japan) and mechanical engineering (Germany). Cumulative technological advantages can be reinforced by adapting education, innovation, production and policy systems to the specific needs of the leading technology sector. While such adaptations support the further advancement of these technologies, they may also be a source of lock-in effects and path dependence which can make it more difficult to adjust to new upcoming technologies.

4.4. Public policy in support of key enabling technologies and applications

As pointed out above, turning key enabling technologies into commercial applications typically requires close interaction between fundamental research, which is often publicly funded and carried out by universities or research organisations, and industrial innovation and R & D. There is a need for exchange of knowledge between these two sectors and for incentives for researchers in the public sector to engage actively in technology transfer. There is also a need for firms to possess the right technological skills to absorb and apply the new technologies, including the ability to conduct in-house R & D and the organisational skills to manage innovation processes and integrate new technologies into existing business practices. A third need is for an adequate regulatory framework to be developed and adapted in parallel with the technological progress achieved, in order to foster commercialisation of applications. Interaction between the developers of new technologies and the designers of the regulatory framework will facilitate an innovation-oriented regulatory framework. Being the first to introduce such a framework can also generate a competitive advantage.

For these reasons, and because of the first-mover advantage described above, it is vital to put in place a comprehensive and coherent public policy covering all areas from the funding of academic research and industrial R & D projects to cooperation and networking initiatives, public awareness measures, standardisation, promotion of venture capital supply and education and training (OECD, 2009a). Networks and clusters constitute a particularly important aspect of public policy. Clusters are important because they facilitate exchange between different scientific disciplines and fields of technology, as well as interaction among actors from public research and various industries. They also encourage knowledge spillovers and mutual learning, and provide a breeding ground for ventures commercialising new technologies (Enright, 2003; Keeble and Wilkinson, 1999; Sternberg, 1996). The importance of clusters is further discussed in Section 4.7.7.

4.5. Six key enabling technologies: history, current state, applications

This section describes briefly the six technologies that are the focus of this chapter, their current state of development and how they may be applied. It neither represents a complete list of applications nor seeks to distinguish between current and future applications. It does however aim to give an impression of the importance of each technology as a generator of future prosperity and utility.

4.5.1. Nanotechnology

Nanotechnology is a generic term for the design, manufacturing and application of structures, devices and systems for analysis and control on a molecular or atomic scale, defined as 100 nanometres (nm) or smaller. It can involve scaling down materials to a nanolevel ('top-down nanotech') by means of physical techniques such as lithography, cutting, etching, electro-spinning or milling. For instance, this approach has enabled the construction of integrated circuits based on structures of 32 nm in semiconductor production. An alternative approach ('bottom-up nanotech') is to create new materials directly at a nanoscale, typically using physical, chemical and biological methods such as deposition, nanoparticle synthesis or liquid-phase processes. Controlled self-assembly of molecules and their macrostructures based on the manipulation of individual atoms is a predicted extension of the latter approach and is expected to lead to the discovery of completely new dimensions of nanotechnology.

Nanoscale (≤ 100 nm) structures frequently possess electrical and magnetic properties, surface and mechanical properties, stability, chemical processes, biological processes and optical features that differ radically from those of their micro/macroscale counterparts. Similarly, many materials exhibit new characteristics as nanomaterials, adding to the variety of application areas and implying that nanotechnology can have a significant impact in every industry where materials are processed and used. These changes in properties and characteristics are at the heart of the innovative power of nanotechnology.

4.5.1.1. Background and current state

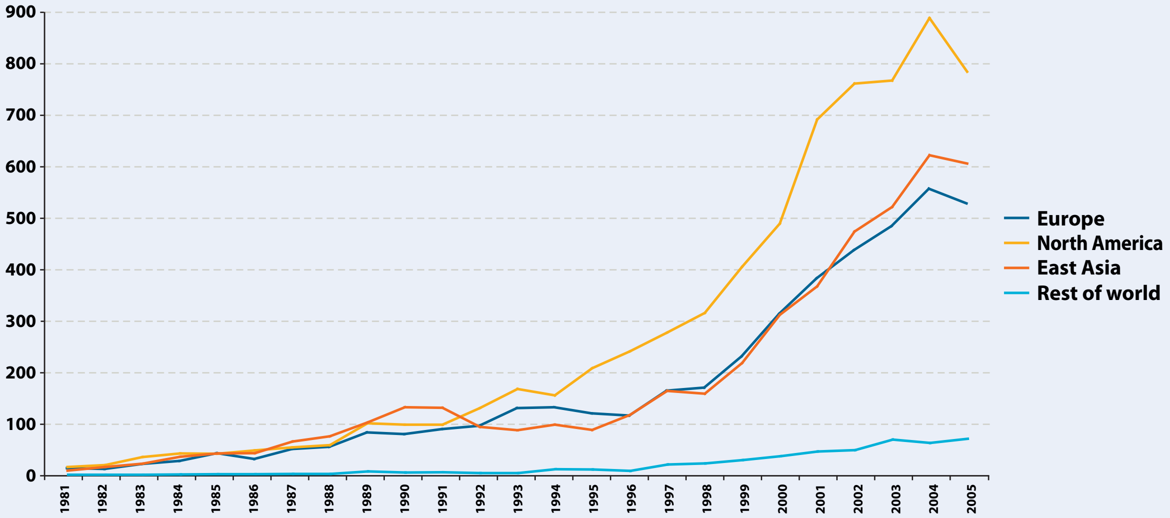
Nanotechnology is a relatively young technology into which systematic research began in the 1960s. The original idea was to construct complex materials and devices out of single atoms (molecular nanotechnology) but since the 1990s all work related to nanostructures is regarded as being part of nanotechnology. Since the mid-1990s, nanotechnology research has been developing an increasing number of industrial applications, illustrated by the fast-growing number of nanotechnology patents (Figure 4.2) and by growing sales of products using nanomaterials or produced with the help of nanotechnological processes.

Figure 4.2 shows how the rapid growth in nanotechnology patents in recent years is attributable to rising numbers of North American, east Asian and European applicants ([57]) whereas the number of patent applications from the rest of the world remains low. The most active applicants from the three leading regions between 2000 and 2007 were Hewlett-Packard (USA; 107 applications), Samsung (South Korea; 169 applications) and Commission à l'énergie atomique (France; 111 applications). Furthermore, Figure 4.2 shows how North America (mainly the USA) has forged ahead since becoming the lead applicant region in 1992. It also shows how in recent years applications from east Asia (mainly Japan and South Korea) have overtaken European applications. This is made even clearer in Figure 4.3, in which the number of patent applications from the three leading regions is related to their GDP levels. It is clear that once the differences in GDP have been accounted for, North American and east Asian application intensities are very similar. European researchers, on the other hand, are falling behind and should, given Europe's GDP, account for 50 % more patent applications in order to match the intensities of their North American and east Asian counterparts.

Within Europe, German applicants account for most nanotechnology patent applications (34 %) at EPO/PCT, followed by France (17 %), the UK (14 %) and the

([57]) In this chapter Europe is defined as all EU Member States plus Albania, Andorra, Bosnia and Herzegovina, Croatia, Iceland, Liechtenstein, Monaco, Montenegro, Norway, San Marino, Serbia, Switzerland and the former Yugoslav Republic of Macedonia; North America as Canada, Mexico and the USA; and east Asia as China, Japan, Singapore, South Korea and Taiwan.

Figure 4.2: Number of nanotechnology patent applications (EPO/PCT) by region of applicant, 1981–2005

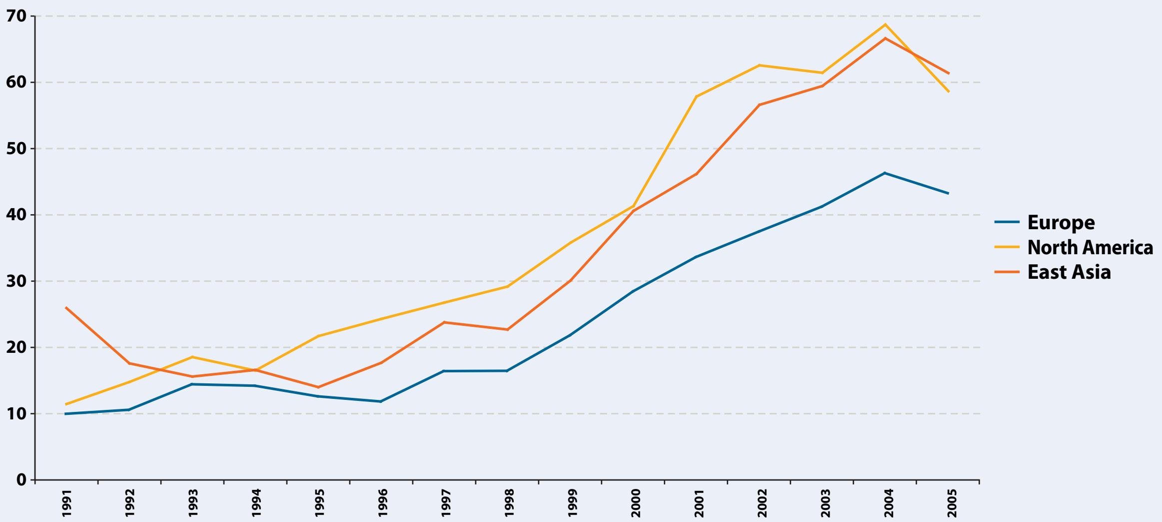


Source: EPO Patstat, background study.

Netherlands (8 %) (Figure 4.4). German applications increased particularly fast from 1997 onwards and are overrepresented (in relation to Europe as a whole) in nanomaterials and nanoanalytics. It is interesting to note that in recent years applications from European countries that are not among the eight countries with the largest number of nanotechnology patent applications have increased markedly, indicating stronger efforts in nanotechnology in those countries.

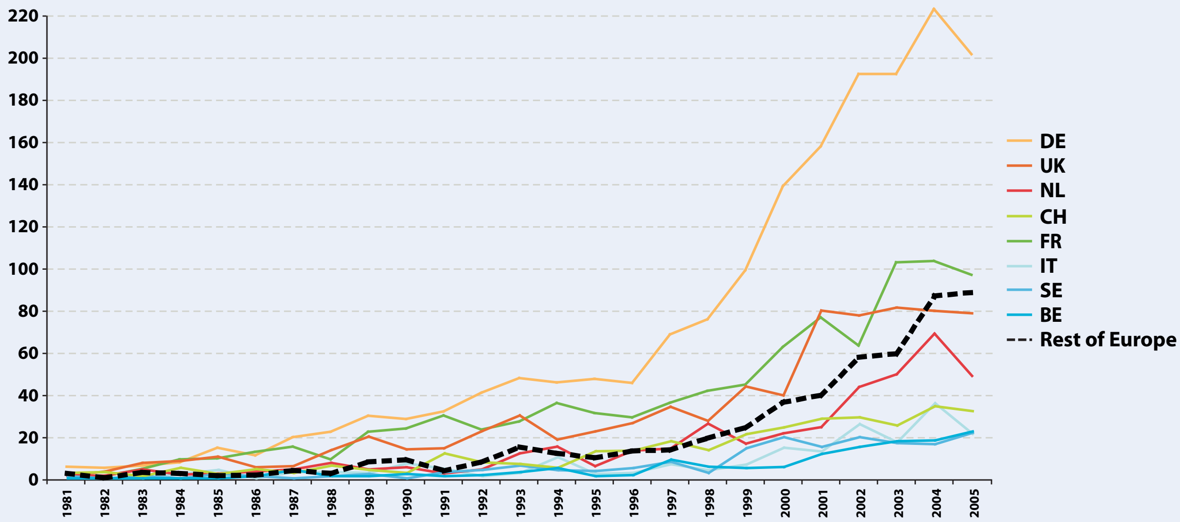
In relation to its GDP, however, Germany is not the main producer of nanotechnology patent applications in Europe. Switzerland (overrepresented in nanoanalytics and nanoelectronics) has by far the highest application intensity, followed by the Netherlands (overrepresented in nanoelectronics and nanomagnetics), with Germany in third place.

Figure 4.3: Nanotechnology patent application intensity (number of EPO/PCT patents per trillion of GDP at constant PPP US dollars), 1991–2005



Source: EPO Patstat, OECD (2009 b); background study.

Figure 4.4: Nanotechnology patent applications (EPO/PCT) by country, 1981–2005



Source: EPO Patstat, background study.

4.5.1.2. Nanotechnology applications

By combining disciplines such as physics, chemistry and biology, nanotechnology applications cover a wide spectrum ranging from materials, electronics and chemicals to process engineering, transportation and medicine. Notwithstanding their enormous potential, most of the nanotechnological products and processes commercialised so far rely on a few nanomaterials such as carbon nanostructures, silver and gold nanoparticles and nanowires, and nanoscale metal oxides (PCAST, 2008). By no means exhaustive, Table 4.1 nevertheless gives a flavour of the wide range of existing and future applications of nanotechnology.

It is evident from the examples in Table 4.1 that nanotechnology applications are relevant in a number of different sectors. It is therefore not surprising that it is the key enabling technology with the most links to other KETs; nanotechnology is in fact strongly linked to all the other five technologies in this chapter.

4.5.2. Micro and nanoelectronics, including semiconductors

Micro and nanoelectronics refers to semiconductor components as well as highly miniaturised electronic subsystems and their integration in larger products and systems. Miniaturisation is the main technological driver, with several benefits in terms of cost reduction, faster propagation over shorter distances and, in the case of nanoelectronics, new and interesting properties at atomic and molecular levels. As pointed out in the previous subsection, semiconductor production has already mastered 32 nm structures in integrated circuits. Technical progress is expected to result in a further reduction of structural widths (BMBF, 2005) and the next step in semiconductor production will be to build 22 nm structures, expected to be achieved in 2011.

Recent advances in miniaturisation have meant that some of the latest microelectronics could in fact be called nanoelectronics as they are measured in nanometres. In a narrow sense though, nanoelectronics can be limited to techniques based on silicon and to a structural width of less than 100 nm, and in many cases nanoelectronics refers to structures so small that inter-atomic interactions and quantum mechanical properties need to be studied extensively (BMBF, 2002).

Table 4.1: Examples of current and future nanotechnology applications, by industry

Industry	Established nanoproducts	Recent market launch	Prototype stage	Concept stage
Chemicals	Nanopowder Nanostructured active agents Nanodispersions	Carbon nanotubes Nano-polymer composites Hybrid composites	Nano porous foams Switchable adhesives Electro-spun nanofibres	Self-healing materials Self-organising composites Molecular machines
Electronics	Silicon electronics Nanoscale transistors Polymer electronics Nanodots/nanowires Spintronics	CNT field emission displays MRAM memories Phase-change memory	MEMS memory CNT data memory CNT inter-connected circuits Nanojoining	Molecular electronics Nanowires for electricity production Spintronic logics Orbitronics
Optics	Ultra-precision optics Anti-reflection layers LED and diode lasers Nanobeam x-ray photochromics	Nanoresolution in microscopes OLED 2D photonic crystals Waveguiding	EUV lithography optics Quantum-dot lasers 3D photonic crystals Electrochromics	All-optical computing Optical meta-materials Data transmission via surface plasmons
Medicine, Pharmaceuticals	Nanoparticles as contrast media Nanoscale drug carriers Nanomembranes for dialysis Nanoscale sunscreens Tissue engineering	Nanostructured hydroxylapatite as bone substitute Quantum-dot markers Nano cancer therapy Nanodentistry Skin-delivered vaccines	Biocompatible implants Selective drug carriers Nanoprobes and nanomarkers for molecular imaging Tissue engineering Antimicrobial planes	Artificial organs through tissue engineering Nano-engineered gels for supporting nerve cell growth Neuro-coupled electronics for active implants
Environmental technologies	Nanostructured catalysts Nanomembranes for sewerage Anti-reflection layers for solar cells	Nano-optimised micro-fuel cells Iron-nanoparticles for groundwater sanitation Nano-titanium oxide for photo catalysis	Large-area polymer solar cells Nanosensorics for environmental monitoring Nano-catalysts for hydrogen generation	Artificial photosynthesis Quantum-dot solar cells Nanoscale rust for cleaning water
Automotive	Nanostructured coatings Nanocoated diesel injectors Nanostructured admixtures for tyres	Nanoparticles as diesel additives Nano-optimised lithium-ion batteries LED headlights Anti-fog surfaces	Thin-film solar cells for car roofs Nano-optimised fuel cells Nano-adhesives in production	Switchable, self-healing coatings Adaptive body shell for lower air resistance
Textiles	Nanoparticles for dirt repellence Nanosilver for antibacterial textiles Nanocontainers for scent impregnation	Nano-titanium oxide for UV protection Aerogels for thermal protection Ceramic nanoparticles for abrasion resistance	Phase-change materials for active thermal regulation Textile-integrated OLEDs Electrically conductive textiles	Textile-integrated sensorics/actorics for control of body functions Textile-integrated digital assistance systems

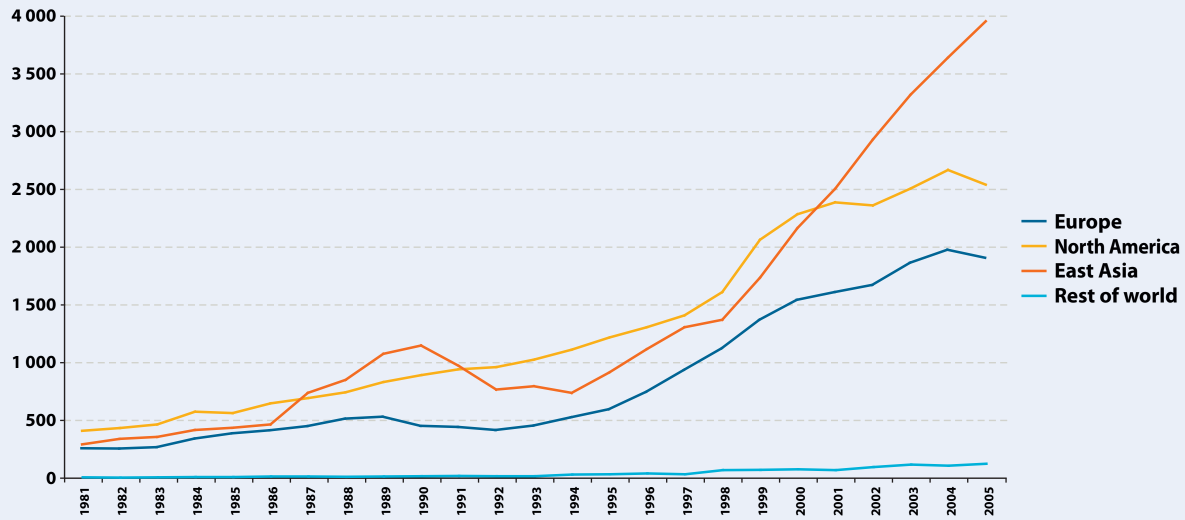
Source: Luther and Bachmann (2009), Gennesys (2009), background study.

4.5.2.1. Background and current state

Although the first computer was invented in the 1940s and the principles behind mobile telephone communication have been known since the 1920s, microelectronics dates back no further than 1958, with the discovery of the integrated circuit (BMBF, 2005). Following the invention in 1971 of the first microprocessor, successive waves of advances in miniaturisation and nanotechnology have led to ever-smaller, cheaper and more effective components and systems. This rapid growth is reflected in the number of patent applications shown in Figure 4.5.

It is clear that east Asian applicants dominate the world market for patents and have done so since 2001, with North America trailing in second place and Europe in third. The number of patent applications from the rest of the world is very limited by comparison. The most active applicants from the three leading regions in the period 2000–07 were Infineon (Germany; 1 525 applications), Tokyo Electronics (Japan; 1 498 applications) and Applied Materials (USA; 1 051 applications). It should however be noted that in east Asia both Matsushita (Japan; 1 392 applications) and Samsung (South Korea; 1 077 applications) made more applications in that period than the leading North American appli-

Figure 4.5: Number of micro and nanoelectronics patent applications (EPO/PCT) by region of applicant, 1981–2005



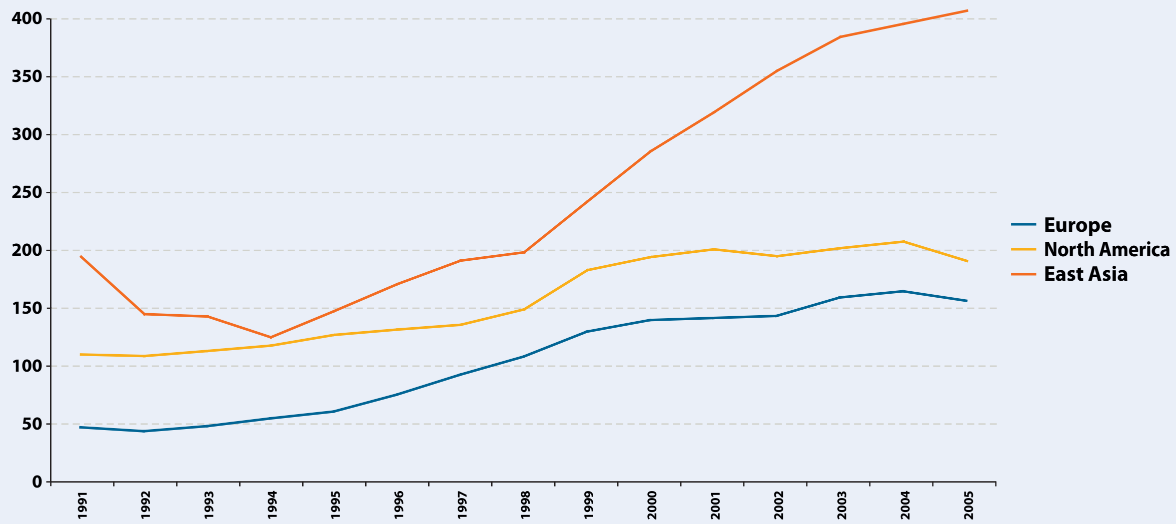
Source: EPO Patstat, background study.

cant. Figure 4.5 also shows how east Asia (mainly Japan and South Korea) has increased its lead since 2001. The dominant position of east Asian applicants is made even clearer when related to GDP (see Figure 4.6). Microelectronic patent application intensities in east Asia are more than twice as high as in North America or Europe, which follow the same stagnating pattern.

The European picture concerning micro and nanoelectronic patent applications is similar to that of nanotechnology (cf. Figure 4.4), except for a more prominent role played by Dutch applicants. Germany again dominates (41 %), followed by France (16 %), with the Netherlands and the UK in third place (12 % and 11 % respectively).

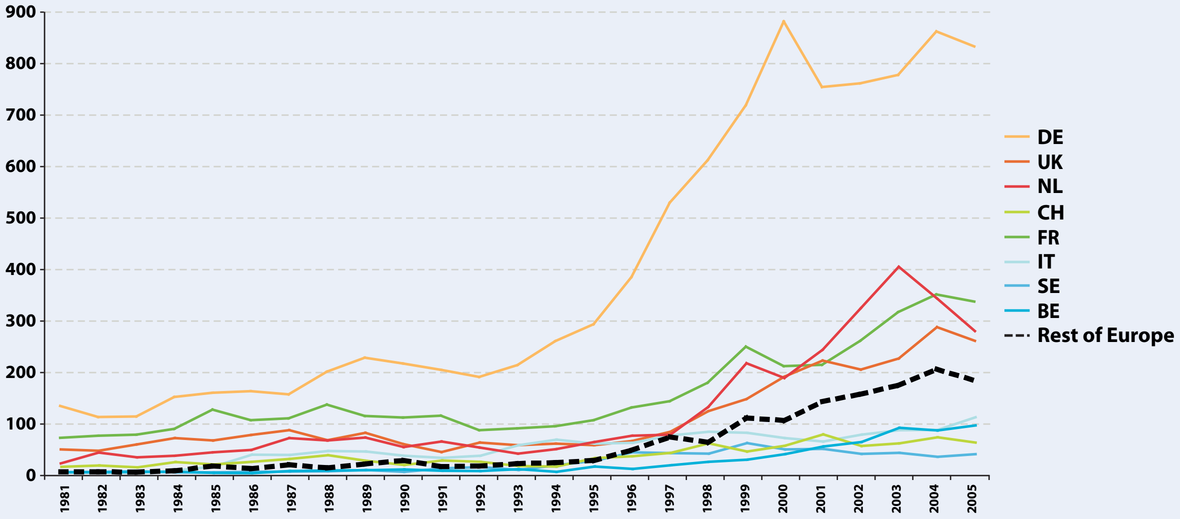
When differences in GDP are taken into consideration, Germany no longer leads in terms of application intensity but is relegated to second place by the Netherlands, which exhibits much stronger application intensities in micro and nanoelectronics than its European peers,

Figure 4.6: Micro and nanoelectronics patent application intensity (number of EPO/PCT patents per trillion of GDP at constant PPP US dollars), 1991–2005



Source: EPO Patstat, OECD (2009 b), background study.

Figure 4.7: Micro and nanoelectronics patent applications (EPO/PCT) by country, 1981–2005



Source: EPO Patstat, background study.

notably in the area of x-ray, where it is overrepresented in comparison with Europe as a whole.

4.5.2.2. *Applications of micro and nanoelectronics including semiconductors*

Traditionally, micro and nanoelectronic components and systems have been applied mainly in the ICT sector, in applications such as memories, displays and processors, as well as products enabling communication between devices or systems. In recent decades advances in miniaturisation have meant that micro and nanoelectronic applications have expanded into new sectors such as the automotive, medical and consumer goods sectors, with products ranging from sensors to toys being based on semiconductors (Confindustria, 2009). This expansion of micro and nanoelectronics into new sectors of application is set to continue.

Micro and nanoelectronic applications are often linked to one or more other key enabling technologies. The closest links are with nanotechnology, photonics and advanced manufacturing technologies.

4.5.3. Industrial biotechnology

Industrial biotechnology, also known as white biotechnology, means the use of microorganisms such as mould, yeast, bacteria and enzymes in industrial processes to produce biochemicals, biomaterials and biofuels. The many products manufactured using biotechnological processes include various chemicals, plastics, biofuels, detergents, vitamins and enzymes. Industrial biotechnology is also used in the final stages of production of textiles, leather and paper (BMBF, 2008). It is distinct from medical ('red') and agricultural ('green') biotechnology.

Industrial biotechnology competes with other production methods, in particular chemical synthesis. It tends to be more environmentally friendly since it uses renewable raw materials such as vegetable oils and starch, and produces less harmful by-products and higher yields, all of which combine to reduce dependence on fossil resources. However, biotechnological processes are not always less energy-intensive; they sometimes need considerably more energy than other processes. Even so, industrial biotechnology presents an opportunity to improve the quality of existing products and develop completely new products which cannot be produced by traditional synthetic methods and processes (OECD, 2009c; OECD, 2009d; OECD, 2010).

4.5.3.1. *Background and current state*

Ancient examples of the practical application of biotechnology — brewing beer, making wine and cheese and baking leavened bread, to name but a few — suggest it was developed in parallel with agriculture. However, it was only thanks to the scientific work of Louis Pasteur and his peers in the 19th and 20th centuries that the processes behind the old techniques could be explained and bettered, and new processes discovered. Modern biotechnology dates back to the early 1970s when recombinant DNA technology was first developed (European Commission, 2007b). Recent advances in genome research and microbiology have enabled more targeted use of molecular biology, for instance in the discovery of enzymes as biocatalysts or using bacteria to produce medical substances (BMBF, 2008). As a result the use of enzymes for the production of foods, detergents, textiles, chemicals, pharmaceuticals and pulp and paper is well established.

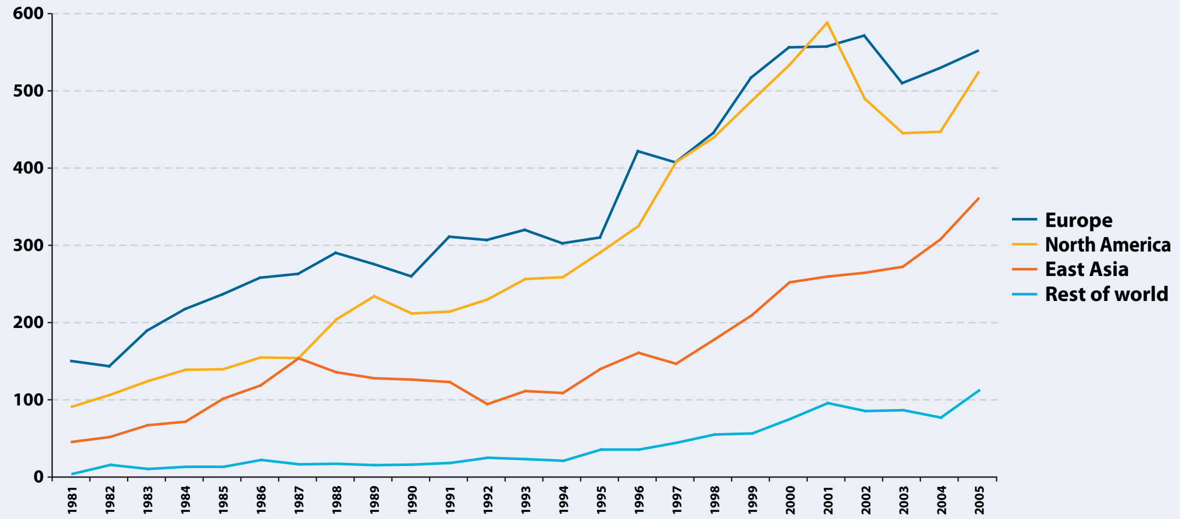
The importance of industrial biotechnology differs across industries. In basic chemicals only 1.5 % is based on biotechnology. In active pharmaceutical ingredients the share of biotechnology sales exceeds 18 % (OECD, 2009d). Biotechnology-based polymers are the most important biomaterials and are produced in quantities estimated at between 300 000 and 600 000 tonnes per year but still represent less than 1 % of total polymer production (European Commission, 2007b; OECD, 2009c). In pulp and paper on the other hand, biotechnological applications account for 10 %, in detergents 30 % and in some food production processes (e.g. some fruit juices) up to 100 % (European Commission, 2007b).

Figure 4.8 shows the increase in biotechnology patent applications from 1981 to 2005 and how European and North American applicants have dominated in the past but suffered from a slowdown in patenting activity in the early years of the new century, allowing east Asian applicants to close the gap to some extent. European and North American applicants account for around 35 % each of all biotechnology applications, with east Asia at 23 % and the remaining 7 % of applications coming from the rest of the world. The three leading biotechnology patent applicants in the period 2000–07 were all European: BASF (Germany; 235 applications), Novozymes (Denmark; 159 applications) and Evonik Degussa (Germany; 136 applications), followed by DuPont and University of California (both US) with 126 and 119 applications respectively. The leading east Asian applicants were all Japanese, led by Matsushita, but in terms of numbers did not come close to the leading European or North American applicants.

Patent application intensities, adjusted for differences in GDP, are depicted in Figure 4.9. It is evident how the slowdown in biotechnology patenting in Europe and North America since 2000/01 has enabled east Asian applicants to reach almost the same application intensities as in North America.

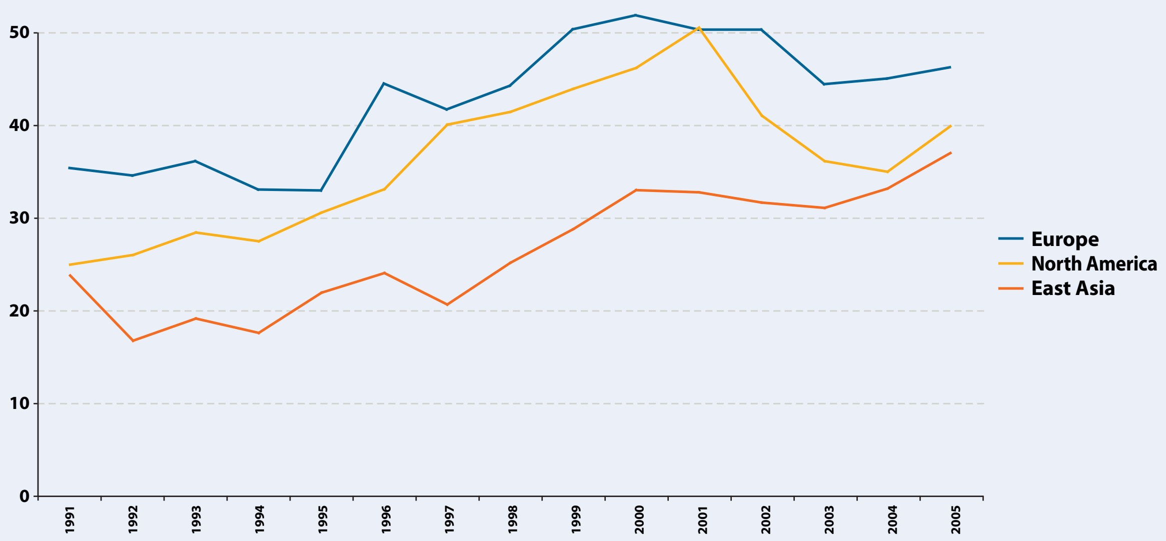
In Europe, most biotechnology patent applications come from German applicants (Figure 4.10), particularly in the area of established biochemicals where German applications are overrepresented in relation to Europe as a whole. Another contributing factor behind Germany's present dominance is that the rate of German biotechnology applications almost doubled in the second half of the 1990s, from around 110 a year to over 200. The UK and France, both of which are overrepresented in applications concerning enzymes, have 12 % each of all European EPO/PCT applications, followed by the Netherlands with 9 % on the back of a particularly high number of applications in fermentation. Applications from European countries that are not among the top eight countries represent around 20 % of all European EPO/PCT applications.

Figure 4.8: Number of biotechnology patent applications (EPO/PCT) by region of applicant, 1981–2005



Source: EPO Patstat, background study.

Figure 4.9: Biotechnology patent application intensity (number of EPO/PCT patents per trillion of GDP at constant PPP US dollars), 1991–2005



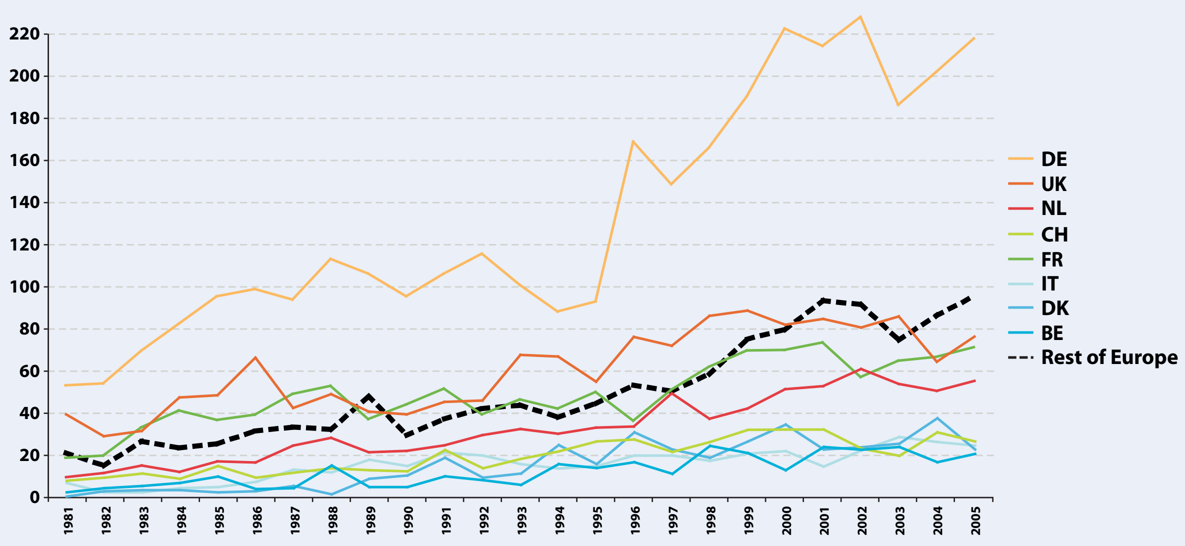
Source: EPO Patstat, OECD (2009 b), background study.

When adjusting the data in Figure 4.10 for GDP differences, however, it emerges that Germany has only the fourth highest patent application intensity in industrial biotechnology, behind Switzerland, Denmark and the Netherlands.

4.5.3.2. Industrial biotechnology applications

Established applications such as using enzymes in the production of foodstuffs, detergents, textiles, chemicals, pharmaceuticals and other products have already been mentioned in the previous subsection, as have fermentation and basic chemicals. More recent applications of industrial biotechnology include the use of waste from farming or forestry for the production of biochemicals and biofuels (Confindustria, 2009). Biopolymers, whether produced from waste or otherwise, are still in

Figure 4.10: Biotechnology patent applications (EPO/PCT) by country, 1981–2005



Source: EPO Patstat, background study.

an early development phase (European Commission, 2007b). Examples include biopolymers based on lactic acid, polyhydroxyalkanoates, bio-propanediol and bio-acrylamide. In biofuels, the bioethanol and biodiesel industries are in a similar state of technological development. Another relatively new application is bioremediation of contaminated water, soil, air and solid waste, using mainly microorganisms to transform contaminations into less harmful substances. Even less developed is the new discipline of synthetic biology using DNA synthesis and genetic engineering. Its potential applications include energy production, bioremediation, smart materials, biomaterials and sensors and detection systems (European Commission, 2007b).

There are close links between many applications of industrial biotechnology and other key enabling technologies, notably nanotechnology and advanced materials.

4.5.4. Photonics

Photonics is the science and technology of generating, detecting and managing light. It is defined in Jahns (2001) as the use of photons as carriers of energy and information, thereby in a way gradually assuming the role previously played by electrical and electronic processes. It is a cross-sectoral technology, bringing together the disciplines of physics, nanotechnology, materials science, biotechnology, chemistry and electrical engineering (European Commission, 2008). With the development in the 1960s of electronics, laser technology and fibre optics, the technological environment for optical communication was created and the term photonics was coined (Jahns, 2001; European Commission, 2008).

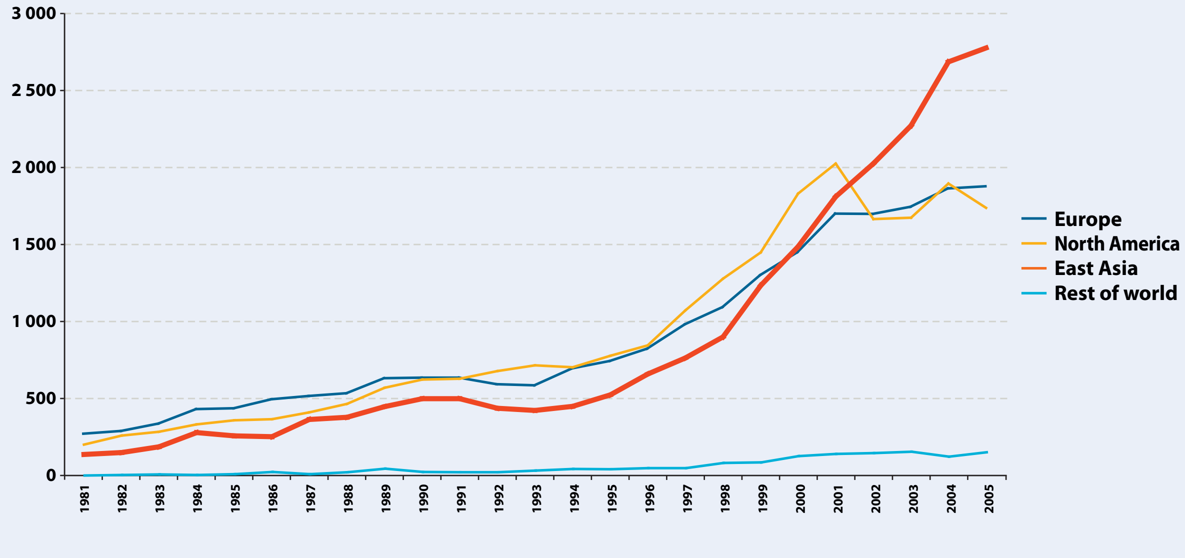
4.5.4.1. Background and current state

Though photonics is a relatively young technology into which systematic research began in the 1960s, its foundation was the discovery by Einstein that light is composed of indivisible, energy-rich elementary units (quanta) which we now call photons. Developments in several other sciences from the 1960s on paved the way for rapid advances in photonics in recent decades, as illustrated by the increasing number of patent applications shown in Figure 4.11. It is interesting to note that until 2001 the three regions from which most photonics patent applications came followed more or less the same pattern and their shares of the total number of applications were very similar, whereas from 2001 to 2005 the numbers levelled out in Europe and North America but continued to rise in east Asia, whose share of total EPO/PCT applications in photonics consequently rose to 42 %, compared to 29 % for Europe and 27 % for North America.

The most active applicants from the three leading regions in the period 2000–07 were Samsung (South Korea; 1 029 applications), Osram and its owners Siemens (Germany; 964 applications), Matsushita (Japan; 750 applications) and 3M (USA; 748 applications).

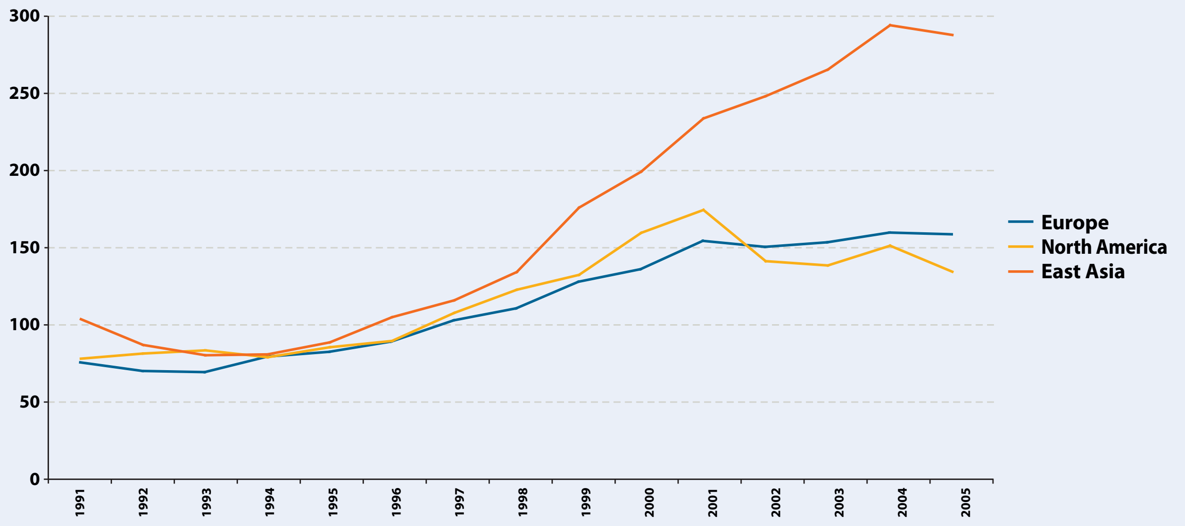
The dominance of east Asian applicants over European and North American applicants is even more striking when differences in GDP are taken into account. Patent applica-

Figure 4.11: Number of photonics patents (EPO/PCT) by region of applicant, 1981–2005



Source: EPO Patstat, background study.

Figure 4.12: Photonics patent application intensity (number of EPO/PCT patents per trillion of GDP at constant PPP US dollars), 1991–2005



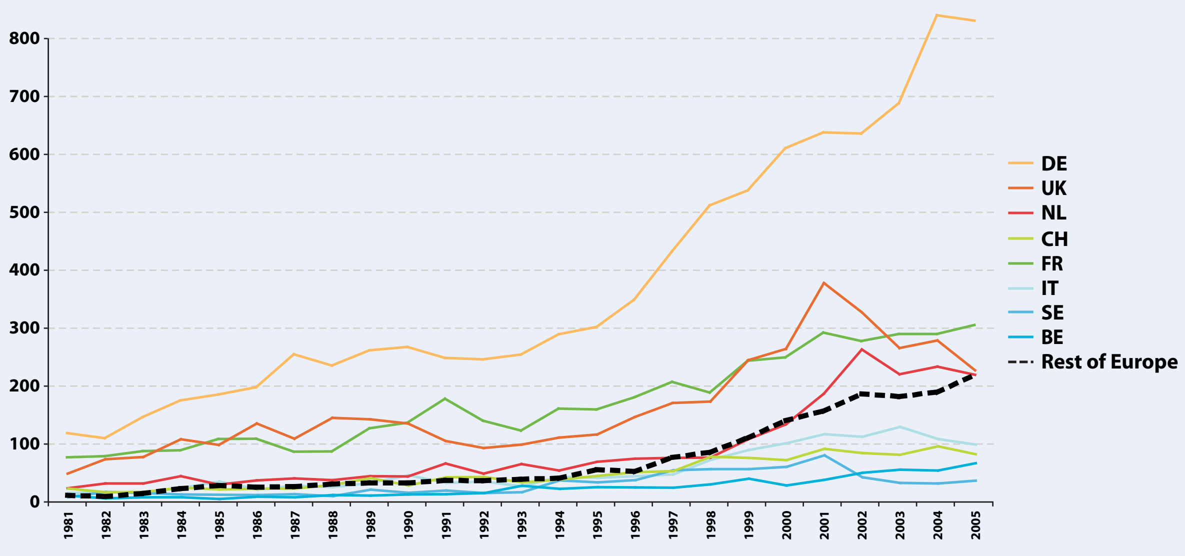
Source: EPO Patstat, OECD (2009 b), background study.

tion intensities are almost twice as high in east Asia (mainly Japan and South Korea) as in Europe and North America.

In Europe as well as globally, Germany has a very strong position in terms of EPO/PCT applications. Figure 4.13 illustrates the dominance of German applicants and how far away it has moved from France, the UK and the Netherlands. However, Germany has only the third highest patenting intensity when GDP is factored in: applicants from the Netherlands and Switzerland submitted around 20 % more patent applications in relation to their GDP than Germany.

In relation to the European average, German patent applications are overrepresented in solar cells, an area where French and UK applicants are underrepresented. The latter are instead overrepresented in laser applications and optical devices (the UK also in lighting). Applicants from the Netherlands are overrepresented in patent applications concerning lighting.

Figure 4.13: Photonics patent applications (EPO/PCT) by country, 1981–2005



Source: EPO Patstat, background study.

4.5.4.2. Photonics applications

By combining disciplines such as physics, nanotechnology, materials science, biotechnology, chemistry and electrical engineering, applications of photonics cover a variety of sectors including information processing, communication, imaging, lighting, displays, manufacturing, life sciences and healthcare and safety and security (European Commission, 2008). Its exceptional properties — which include being focusable, travelling at the speed of light and combining ultra-short pulses with high power — make it a key enabling technology to consider when developing new applications. Photonics can furthermore be considered a green technology insofar as it enables conventional applications (such as lighting, data communication) to be developed more efficiently, or the production of cleaner energy (solar cells). Although by no means exhaustive, Table 4.2 gives an idea of the range of existing and future applications of photonics.

As has been made clear in the preceding subsection, there are close connections between photonics and most other key enabling technologies, in particular nanotechnology, micro and nanoelectronics including semiconductors, biotechnology and advanced manufacturing technologies.

Table 4.2: Examples of current and future photonics applications, by field of industry

Field of technology	Examples of applications	
Production technology	Laser materials processing systems lithography systems (IC, FPD, mask)	Lasers for production technology objective lenses for wafer steppers
Optical measurement and machine vision	Machine vision systems and components Spectrometers and spectrometer modules Binary sensors	Measurement systems for: — semiconductor industry — optical communications — other applications
Medical technology and life sciences	Lenses for eyeglasses and contact lenses Laser systems for medical surgery, therapy and cosmetics Endoscope systems Microscopes and surgical microscopes	Medical imaging systems (only photonics-based systems) Ophthalmic and other *in vivo* diagnostic systems Point of care diagnostic systems Systems for *in vitro* diagnostics, pharmaceutical and biotech R & D
Data communication	Optical transmission, networking and coding systems for core and access networks	Components for optical networking systems
IT: consumer electronics, office automation, printing	Optical disk drives Laser printers and copiers, PODs, fax and MFPs Digital cameras and camcorders Scanners Barcode scanners	Systems for commercial printing Lasers for IT Sensors (CCD, CMOS) Optical computing Terahertz systems in photonics
Lighting	Lamps LEDs	OLEDs
Displays	LCD displays Plasma displays	OLEDs and other displays Projection displays Display glass and liquid crystals
Solar energy	Solar cells (organic and inorganic)	Solar modules (organic and inorganic)
Security, safety and defence photonics	Vision and imaging systems, including periscopic sights Infrared and night vision systems Ranging systems Munition/missile guiding systems	Military space surveillance systems Avionics displays Image sensors Lasers Terahertz systems
Optical systems and components	Optical components and optical glass optical systems ('classical' optical systems)	Optical and optoelectronic systems

Source: Photonics21 (2007), background study, Commission services.

4.5.5. Advanced materials

The meaning of advanced materials has shifted over time and nowadays tends to include materials possessing new and different types of internal structures and exhibiting innovative properties and higher added value, as a result of modifying and improving structures and properties (Moskowitz, 2009). The importance of advanced materials lies in their potential applications in various sectors such as aerospace, construction and healthcare, and the reduction in costs, resource consumption and environmental impact as well as improved performance often associated with the substitution of existing materials. More efficient use of resources and smaller environmental impact are especially important aspects for Europe and other parts of the world where natural resources are scarce (Confindustria, 2009).

4.5.5.1. Background and current state

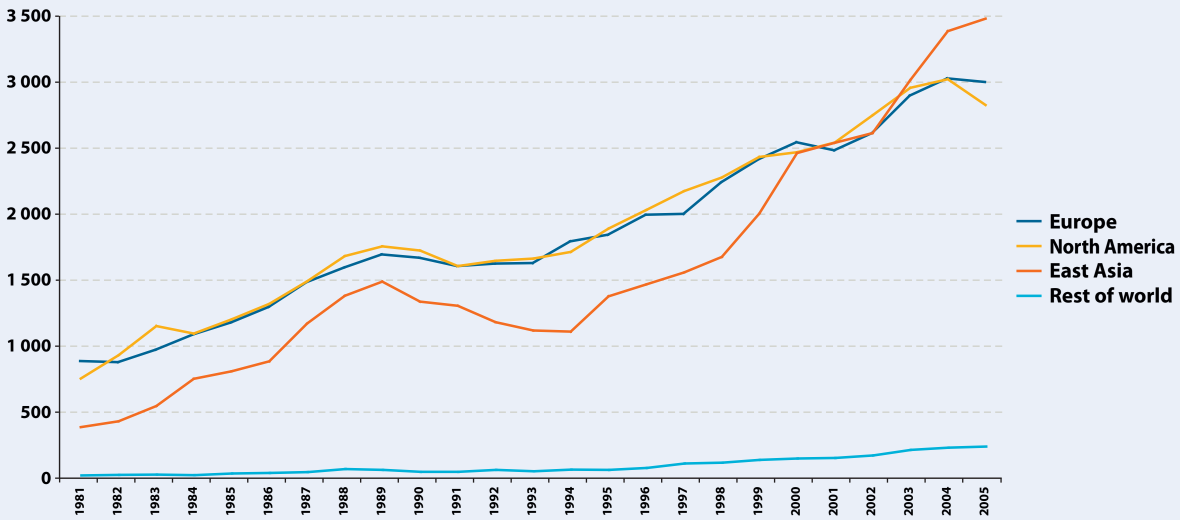
Efforts to improve the material base for the manufacture of goods, allowing for higher product quality and new product characteristics, go back a very long way in human history. In modern times, the focus was initially on improving metals by introducing new alloys with superior performance characteristics (such as steel) and exploring the industrial applicability of new metals (such as aluminium). In addition, a number of innovations took place in the field of non-metallic materials such as glass, ceramics and concrete. In the late 19th century the focus shifted to chemicals and a large number of synthetic materials were invented as a result. In the 20th century the focus shifted again and most efforts went into building up so-called 'macrostructures' or 'superpolymers' by linking together molecular units into super-long chains (e.g. polyethylene, styrene, Teflon) possessing desirable physical and chemical properties (Moskowitz, 2009). The latest shift took place in the late 1970s and involved customisation of the atomic structure of materials by creating, manipulating and reconfiguring molecular or atomic units within a wide range of material categories. Despite the shifts in priorities over time, material innovations still occur along all the lines mentioned above.

The recently renewed interest in advanced materials is due to the latest materials having application rates nearly three times higher than previous generations of materials. It has been estimated that the eight most important materials entering the market in the first seven decades of the 20th century — electrometals, synthetic ammonia, nylon, styrene, etc. — had an average of 2.7 applications per material, whereas the 14 latest advanced materials (including nanocrystals, nanocomposites, nanotubes and organic electronic materials) have on average 8.6 applications per material (Moskowitz, 2009).

Figure 4.14 shows the increase in patent applications in advanced materials in recent decades, illustrating the growing number of applications enabled by continued innovation. The graphs are very similar to those in Figure 4.11 for photonics in the sense that the European and North American numbers are very similar and have stagnated in the early years of the 21st century, whereas east Asian applications have continued to increase and resulted in east Asia becoming the primary source of EPO/PCT patent applications in advanced materials, with 37 % of all applications. Even so, the most active applicants in the period 2000–07 were all European or North American: BASF (Germany; 1 410 applications), DuPont (USA; 1 303 applications), Dow (USA; 1 170 applications), 3M (USA; 1 101 applications), Evonik Degussa (Germany; 885 applications), Arkema (France; 796 applications) and Bayer (Germany; 646 applications). The most active east Asian applicant was Fujifilm (Japan) with 602 EPO/PCT patent applications.

The differences between the three main regions become even more evident when GDP is taken into account, as shown in Figure 4.15 below. It also shows that the increase in the number of European and North American patent applications from 1991 to 2005 was similar to their respective GDP increases, leaving the patent application intensity more or less constant, whereas east Asian applications increased faster than the rate of GDP growth.

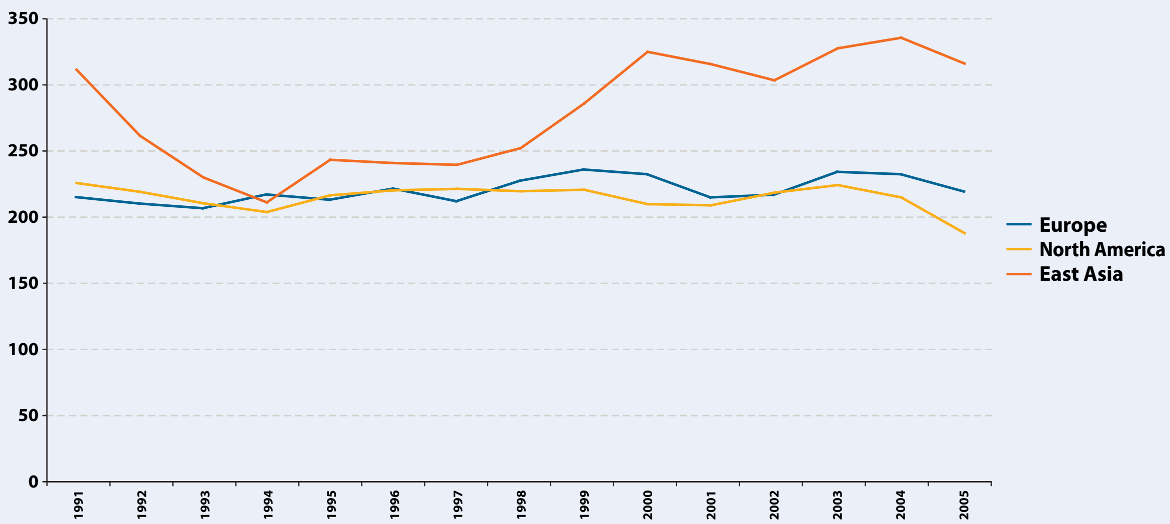
Figure 4.14: Number of advanced materials patent applications (EPO/PCT) by region of applicant, 1981–2005



Source: EPO Patstat, background study.

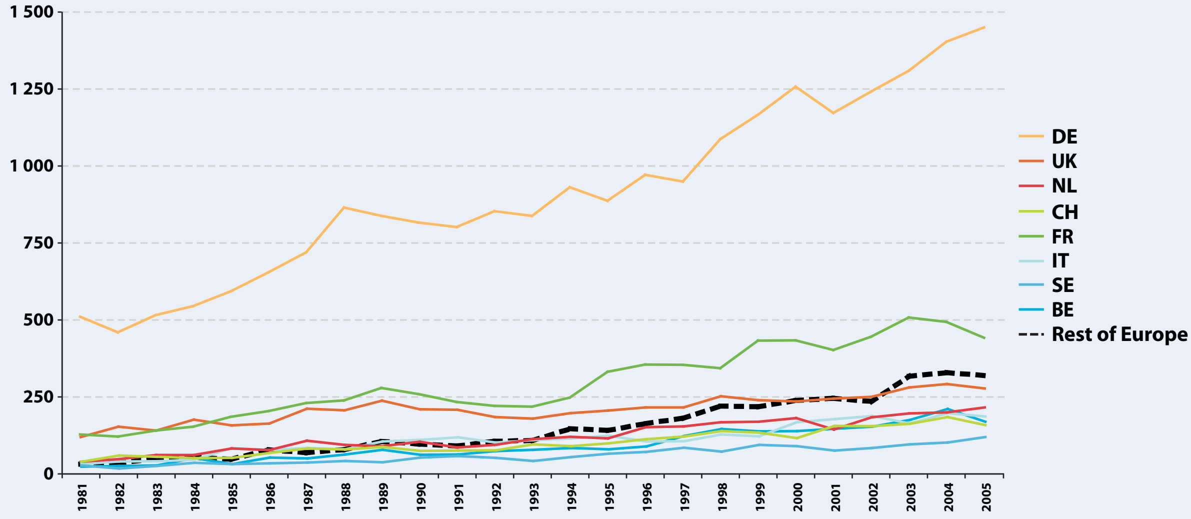
Applicants from Germany account for almost half of all European patent applications in advanced materials and, as Figure 4.16 suggests, Germany strengthened its position in recent decades. In relation to Europe as a whole, German applicants are overrepresented in macroscaled materials. French applicants account for around 14 % of all European applications and are over-represented in high-performance materials, alloys and energy-efficient materials. UK applicants, which tend to submit more applications in layered materials, energy-efficient materials and nanomaterials than the European average, are responsible for 10 % of all European EPO/PCT applications concerning advanced materials.

Figure 4.15: Advanced materials patent application intensity (number of EPO/PCT patents per trillion of GDP at constant PPP US dollars), 1991–2005



Source: EPO Patstat, OECD (2009 b), background study.

Figure 4.16: Advanced materials patent applications (EPO/PCT) by country, 1981–2005



Source: EPO Patstat, background study.

4.5.5.2. *Advanced materials applications*

Advanced materials, being a true general purpose technology, can be applied widely across industries as well as in service sectors such as health, software, architecture and construction, telecommunication and engineering services. Moreover, thanks to recent advances and new priorities, the average number of applications per new advanced material is now three times higher than in previous decades (Moskowitz, 2009).

The most important application areas for advanced materials change over time due to shifting priorities and scientific progress. Right now semiconductors, automotive and aircraft, energy and environment, medicine and health, construction and housing and various process technologies (including mechanical engineering and automation, packaging and logistics, textiles and clothing) are the main application areas. Other major applications are in defence and security.

Turning to future applications, Schumacher et al. (2007) have surveyed technological foresight studies and have concluded that the main priority will be to develop new applications of advanced materials in medicine, ICT and entertainment, textiles and smart materials. Another priority concerns security, where new applications such as nanomaterials and smart materials for protection, identity authentication and alarm systems will be needed. A third priority concerns energy and addresses applications such as solar materials, fuel cells and materials for energy efficiency.

It is clear that advanced materials are essential for the further development of many other key enabling technologies, in particular nanotechnology, micro and nanoelectronics including semiconductors, and photonics.

4.5.6. Advanced manufacturing technologies

Advanced manufacturing technologies comprise all technologies that significantly increase speed, decrease costs or materials consumption and improve operating precision as well as environmental aspects such as waste and pollution from manufacturing processes. They are not a single technology but a combination of different technologies and practices that aim at improving manufacturing processes. Material engineering technologies (including cutting, knitting, turning, forming, pressing, chipping), electronic and computing technologies, measuring technologies (including optical and chemical technologies), transportation technologies and other logistic technologies are some of the many technologies that come together to form advanced manufacturing technologies.

The importance of promoting the development of advanced manufacturing technologies was highlighted in all four scenarios presented in FutMan (2003) and a recently launched US study on the creation of new industries through science, technology and innovation is expected to pay particular attention to advanced manufacturing technologies (STPI, 2010).

4.5.6.1. Background and current state

It could be argued that advanced manufacturing technologies are the oldest key enabling technology known to man, as the never-ending quest to do things in a better way is as old as human civilisation. This quest is usually rewarded in incremental steps, in the form of innovations and method improvements, but disruptive changes do occur from time to time, usually as a result of a new general purpose technology emerging. (Examples include the steam engine, electrical motor, and computing.) Another peculiarity of advanced manufacturing technologies is that progress and innovation stem not only from technology producers but also from the users. In fact, in some specialised manufacturing industries there are no external providers of advanced manufacturing technologies, forcing manufacturing firms to develop on their own the skills needed to advance manufacturing methods.

In recent decades there has been a clear trend away from traditional engineering technologies to the integration of computer technology into manufacturing processes and to enabling the vertical integration of planning, engineering design, control, production and distribution processes. Another trend, automation, allows increasingly complex manufacturing processes to be performed without any manual intervention. Robotics, automation technologies and computer-integrated manufacturing are the keywords in this context.

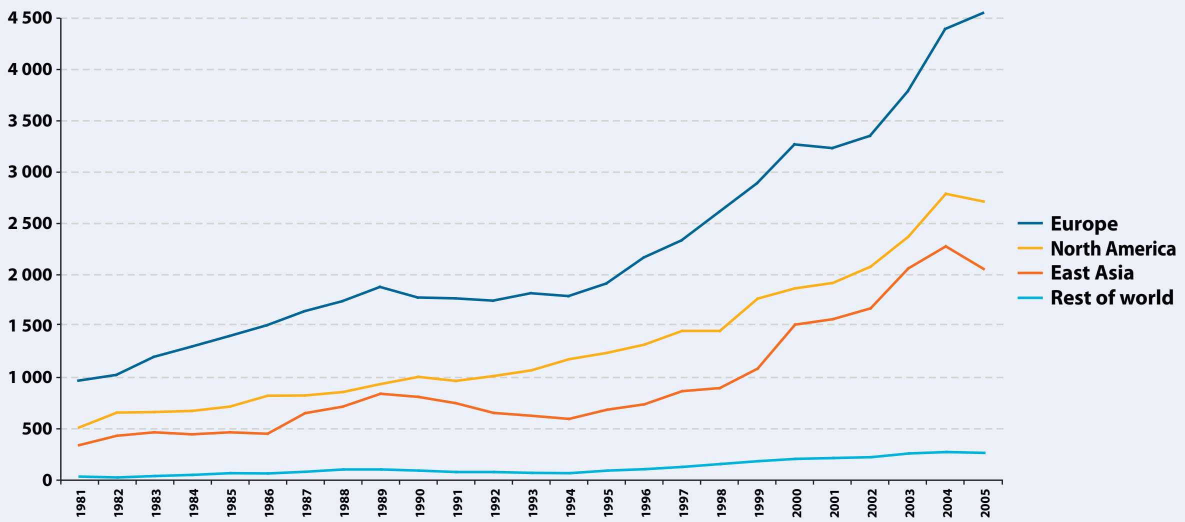
Figure 4.17 shows the number of EPO/PCT patent applications over time from Europe, North America, east Asia and the rest of the world. The increase in patent applications in all three main regions over the last three decades reflects the growing importance manufacturing firms attach to advanced manufacturing technologies and the opportunities that advances in other fields have offered in recent years.

It is also clear from Figure 4.17 that European applicants dominate, representing nearly half of all EPO/PCT applications. North American applications represent less than 30 % of the total and east Asian applications around 20 %. The four leading EPO/PCT applicants in the world in the period 2000–07 were all from Europe: Siemens (Germany; 1 847 applications), Robert Bosch (Germany; 1 348 applications), Continental (Germany; 635 applications) and Endress+Hauser (Switzerland; 589 applications), followed by Fanuc (Japan; 574 applications) and Honeywell (USA; 573 applications).

Europe is where most EPO/PCT applications originate even after differences in GDP have been factored in, as Figure 4.18 illustrates. The application intensities of North America and east Asia are very similar, whereas the European application intensity has always been more than 50 % higher.

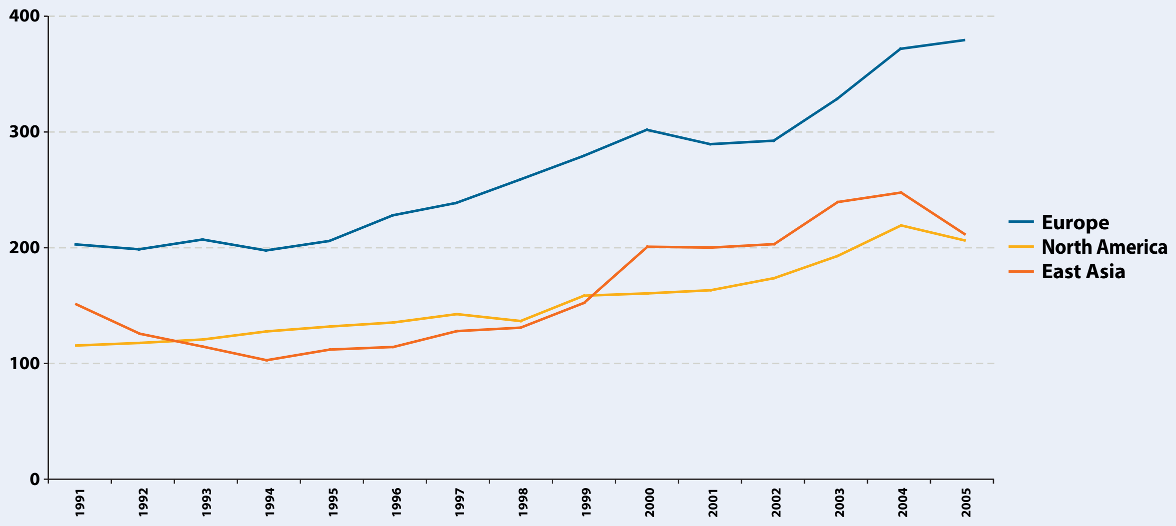
Germany is by far the most active European country in terms of EPO/PCT applications, with almost half of all European patent applications in advanced manufacturing technologies, due mainly to Germany's strong performance in tools, measuring and control. As Figure 4.19 shows, there was a particularly strong increase in German patent applications from 1993 to 2000, and again from 2002 onwards, which was not replicated in other European countries. French applicants account for 14 %

Figure 4.17: Number of advanced manufacturing technology patent applications (EPO/PCT) by region of applicant, 1981–2005



Source: EPO Patstat, background study.

Figure 4.18: Advanced manufacturing technology patent application intensity (number of EPO/PCT patents per trillion of GDP at constant PPP US dollars), 1991–2005



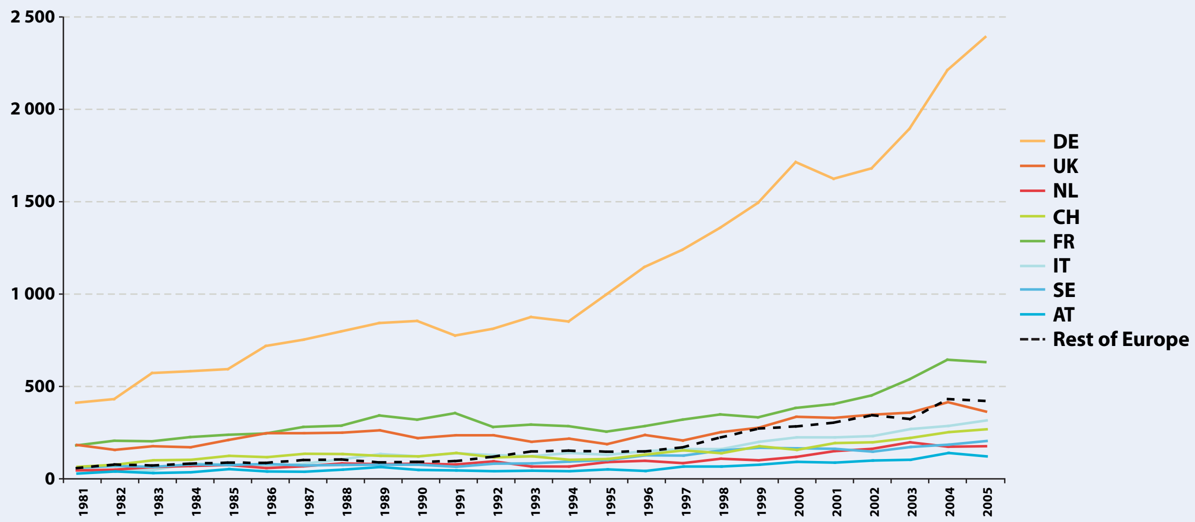
Source: EPO Patstat, OECD (2009 b), background study.

and UK applicants for 10 % of all European patent applications. When adjusted for differences in GDP the application intensities of Germany and Switzerland are very similar, the Swiss intensity being slightly higher.

4.5.6.2. *Applications of advanced manufacturing technologies*

Given the current focus on increased automation and integration of computers, it is natural that most applications of advanced manufacturing technologies are in robotics, computer-assisted design and computer-integrated manufacturing. Furthermore, robots are expected to become much more flexible and easy to use over the next few years, paving the way for a new era of robotics, improving the quality of life by delivering efficient services and, in so doing, combating an expected shortage of skilled labour of up to 6 million people by 2020. In addition, high labour costs are a particularly compelling reason for European manufacturing firms

Figure 4.19: Advanced manufacturing patent applications (EPO/PCT) by country, 1981–2005



Source: EPO Patstat, background study.

to use robots more in the interest of productivity and competitiveness. The miniaturisation of robotic technologies and the development of sophisticated sensors are important trends in this context as they will enable robots to be used in small-batch production facilities. Similarly, new developments in robotic technologies mean that they can assist in operations under hazardous conditions, for example in space, deep sea or mining and mineral extraction.

Another feature of applications of advanced manufacturing technologies is the emergence of multifunctional 'platform technologies' with a range of manufacturing applications. These include technologies such as plastic electronics, silicon design, renewable chemicals and carbon fibre composites capable of replacing various metals. Such platform technologies offer the potential for substantial economic opportunities.

Advanced manufacturing technologies are linked to most other key enabling technologies. In particular, progress made in advanced materials, microelectronics, biotechnology and nanotechnology will profoundly affect manufacturing and help manufacturers master the challenges ahead (FutMan, 2003), while STPI (2010) refers specifically to photonics, nanomaterials and industrial biotechnology as having a crucial impact on advanced manufacturing technologies.

4.6. Market potentials

Estimating market potentials is notoriously risky, even in the case of established products on stable markets. For key enabling technologies it is even more difficult as the technologies and products for which market potentials are estimated often do not yet exist on the market. Most of the potential applications are at a pre-commercial or even conceptual stage, driven by technological opportunities rather than the likely preferences of users. Demand is largely unknown and it may well be that there will be no market at all for some of the concepts. Historical experience with new technologies shows that many of the most important application areas were not envisaged at the early stages of technological development but emerged later through interaction of users and producers, and sometimes just by chance.

Furthermore, products based on key enabling technologies often serve as inputs into more complex products. For instance, nanomaterials may be used in a wide variety of manufactured products from different industries. Semiconductors can be applied to a range of instruments, machinery and equipment. Biotechnologically produced enzymes may be found in a number of food or chemical products. New photonic applications such as OLED displays can be used in electronic, automotive and telecommunication devices. Advanced materials and advanced manufacturing technologies can be used to produce virtually any kind of commodity. As a consequence market potential estimates will vary depending on the underlying definition of key enabling technologies (as there is no universally accepted definition or agreed list) and also depending on which sections of a value added chain are considered.

All this complicates any attempts to predict future market development and often results in poor forecasts. Instead of trying to do this, the background study contains several detailed compilations of existing estimations of future market volumes (of which there are many, not always pointing in the same direction). The results in terms of current and future market sizes as well as implied annual growth rates are set out in Table 4.3. (More detailed tables can be found in the background study.)

Bearing in mind the above caveats, as well as the fact that the six technologies in Table 4.3 have no intrinsic market value unless they can be commercialised in the form of marketable products for which there will be a demand, it is possible to get a rough idea of the size of the current and future market for applications of key enabling technologies by adding the volumes of the six technologies. (Some market volumes are likely to be

Table 4.3: Estimated global market potentials of key enabling technologies

	Current market size (around 2006–08; USD)		Expected size in 2015 (around 2012–15; USD)		Expected compound annual growth rate	
	lower bound	upper bound	lower bound	upper bound	lower bound	upper bound
Nanotechnology	12 bn	150 bn	27 bn	3 100 bn	16 %	46 %
Micro and nanoelectronics	250 bn		300 bn	350 bn	5 %	13 %
Industrial biotechnology	90 bn		125 bn	150 bn	6 %	9 %
Photonics	230 bn		480 bn		8 %	
Advanced materials	100 bn		150 bn		6 %	
Advanced manufacturing technologies	150 bn		200 bn		5 %	

Source: Background study, Confindustria (2009).

counted twice, for instance the market for nanomaterial applications.) Such an exercise results in a current market volume of USD 830 billion to USD 970 billion which is projected to grow to between USD 1.3 trillion and USD 4.4 trillion around 2015. The spread of the latter interval reflects genuine uncertainty and is predominantly due to widely differing expectations about the future market for nanotechnology applications, which in a cautious scenario is expected to more than double from USD 12 billion to USD 27 billion and in the most optimistic scenario to grow by 2 000 %, from USD 150 billion to USD 3 100 billion. These differences reflect not only different levels of optimism and uncertainty but also the lack of definitions of key enabling technologies. A case in point is the lower estimate of the current market volume for nanotechnology applications, which is clearly based on a much more restrictive definition of nanotechnology than the higher estimate of USD 150 billion.

It is interesting to note that only two markets, for nanotechnology and photonics applications, are expected to outperform the overall market for goods. In the case of advanced materials and advanced manufacturing technologies, the market for applications is expected to grow by 5 % to 6 % per year, similar to the expected medium-term growth rate for the goods market as a whole, and in a conservative scenario this also applies to industrial biotechnology and micro and nanoelectronics including semiconductors. At least as regards advanced materials and advanced manufacturing technologies, substitution effects may be part of the explanation for the seemingly low growth rates.

Market volumes and growing demand should not however be the main drivers for a policy on key enabling technologies. Growth in market volumes for a particular technology says little about the effects on macroeconomic net growth. Although key enabling technologies make it possible to develop entirely new applications in many fields of manufacturing and help to establish new markets, many of the new applications will result in demand shifts between sectors and markets and cause declining demand in sectors less affected by such technologies. Policies should therefore focus on stimulating the productivity and innovation impacts of key enabling technologies, even though such impacts are difficult to quantify. Productivity impacts tend to be higher the faster the technologies diffuse across industries and the higher the number of different industries in which they are applied. Innovation impacts can be manifold and are not limited to technology producers. Key enabling technologies can stimulate product and process innovation in several sectors, including innovative applications beyond the horizon of technology producers. Exploiting the innovative potential of key enabling technologies often requires close interaction between their producers and users, taking into account the specific needs of those users. Examples of indirect innovation effects of key enabling technologies range from medicine to environmental technologies.

4.7. European competitiveness by subsector

Analysing Europe's international competitiveness in key enabling technologies is not a straightforward exercise as there are no data on sales, costs, prices or profitability for the type of pre-market products, or in some cases mere concepts or not even conceptualised ideas, with which this chapter deals. One possible approach to take is to base the competitiveness analysis on patent data, using patent applications within a particular technology as a proxy for the competitiveness of an applicant in that technology. However, using patent data for analysis is potentially more problematic than using such data for illustration purposes, as in Section 4.5. Potential pitfalls range from definition problems — assigning classification codes to the right technology, making sure that no relevant classification code is left unassigned while keeping to a minimum the number of cases in which classification codes are assigned to more than one technology — via the skewed value distribution of patents (few patents are valuable and most are economically irrelevant) to the fundamental question of whether the number of patent applications is a good proxy for competitiveness or not. An illustration of the latter question is given in PCAST (2010), which notes that even though the USA is the world's leading producer of nanotechnology patents, in terms of scientific publications in the field of nanotechnology it has been second to the EU since 1995 and has recently been surpassed by China as well.

The arguments for and against patent analysis are set out in the background study, which also contains an explanation of the methodology used to assign patent classification codes to technologies, as well as several examples of the effect on results of using data on patent applications made at the European Patent Office (EPO), the US Patent and Trademark Office or the Japanese Patent Office or filed at all three patent offices jointly.

The analysis in this section will be based on applications made at the EPO or under the Patent Cooperation Treaty (here referred to as EPO/PCT applications), bearing in mind that the data are probably biased in favour of European applicants and therefore likely to exaggerate Europe's strengths. EPO/PCT applications are, however, preferred as they are likely to represent greater economic value since they are more expensive than applications made at a single patent office.

As illustrated in Figures 4.2, 4.5, 4.8, 4.11, 4.14 and 4.17, patent applications from Europe have generally increased in tandem with applications from the rest of the world, enabling Europe to more or less hold on to its share of overall applications in each of the six technologies. As Figure 4.20 shows, the European share of all EPO/PCT applications is particularly high in advanced manufacturing technologies and industrial biotechnology but lower in micro and nanoelectronics owing to a preponderance of applications from east Asia in recent years.

Across all six technologies, German applicants make the single most important contribution to the European share, with more than 43 % of all European applications being made by German applicants, followed by France (15 %) and the UK (11 %).

Assuming that the shares indicated in Figure 4.20 remain stable at their 2005 levels and that they can serve as proxies for market share, combining them with the global market volume estimations in Table 4.3 gives a rough idea of the expected contribution of the technologies to the European economy around 2015. In the conservative scenario in Table 4.3, the market for European products applying key enabling technologies could be worth USD 400 billion, or 31 % of the USD 1.3 trillion world market. In the more optimistic scenario the market value for Europe would be considerably higher, at USD 1.2 trillion, or 27 % of the world market of USD 4.4 trillion.

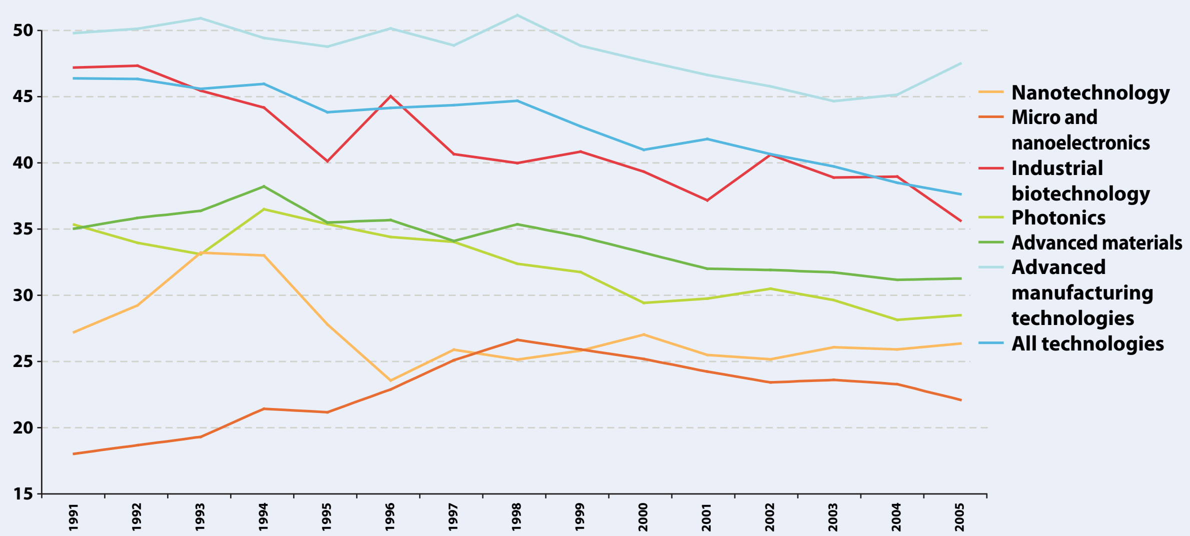
In the following subsections patent analysis and cluster analysis will be used to explore each of the six technologies in greater detail.

4.7.1. Nanotechnology

European applicants accounted for one in four EPO/PCT nanotechnology patent applications in 2005, compared to 39 % for North America and 30 % for east Asia. These aggregate figures can be subdivided into nanostructures, nanomagnetics, nanoanalytics, nano-optics, nanomaterials, nanoelectronics and nanobiotechnology. The share of EPO/PCT applications for each of these fields is shown in Figure 4.21, for the three main regions and for the rest of the world. It is clear that in most of the fields North America accounts for more applications than Europe or east Asia. Europe's strength is in nanobiotechnology and its weakest fields are nanoanalytics and nano-optics. In all seven fields Europe is behind one or both of the other main regions in terms of EPO/PCT applications.

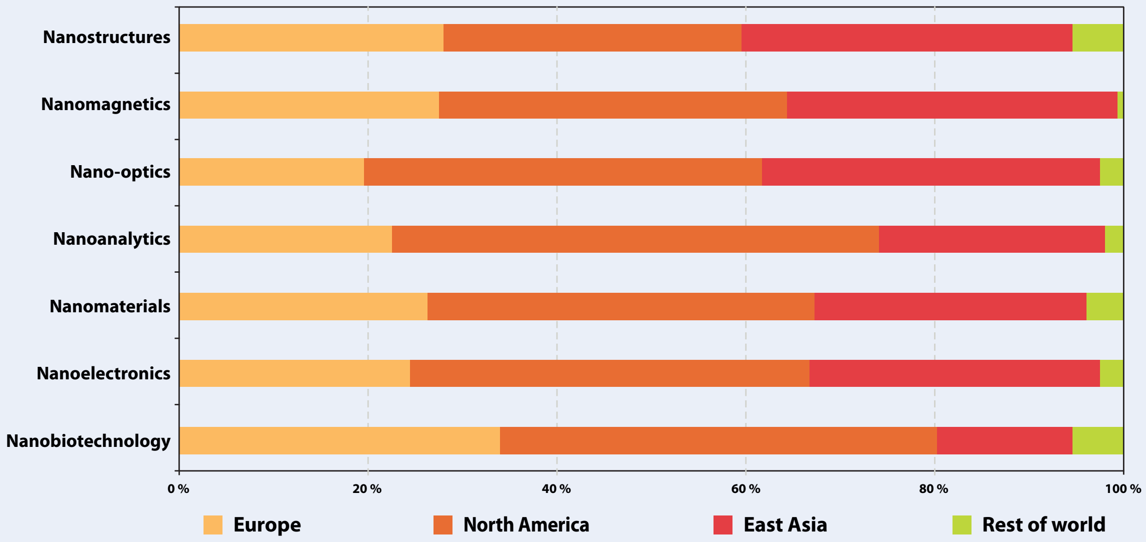
In Europe there are more than 240 nanotechnology research centres and around 800 companies specialising in nanotechnology research (Afsset, 2008; Conseil économique et social, 2008). Both figures are slightly higher than the corresponding US numbers. In terms of its research base Europe has a particularly strong position in nanomaterials, nano-optics and nanobiotechnology, whereas its position in nanoelectronics, nanoanalytics and nanomagnetics is less prominent. In 2008 public funding for European nanotechnology research amounted to USD 2.6 billion, ahead of the US (USD 1.9 billion) and comparable to east Asia (USD 2.8 billion), but private investment in nanotechnology research fell short in Europe, at USD 1.7 billion compared to USD 2.7 billion to 2.8 billion in the US and east Asia (Confindustria, 2009; PCAST, 2010).

Figure 4.20: European share (%) of total patent applications (EPO/PCT), 1991–2005



Source: EPO Patstat, background study.

Figure 4.21: Composition of nanotechnology patent applications (EPO/PCT) in 2005



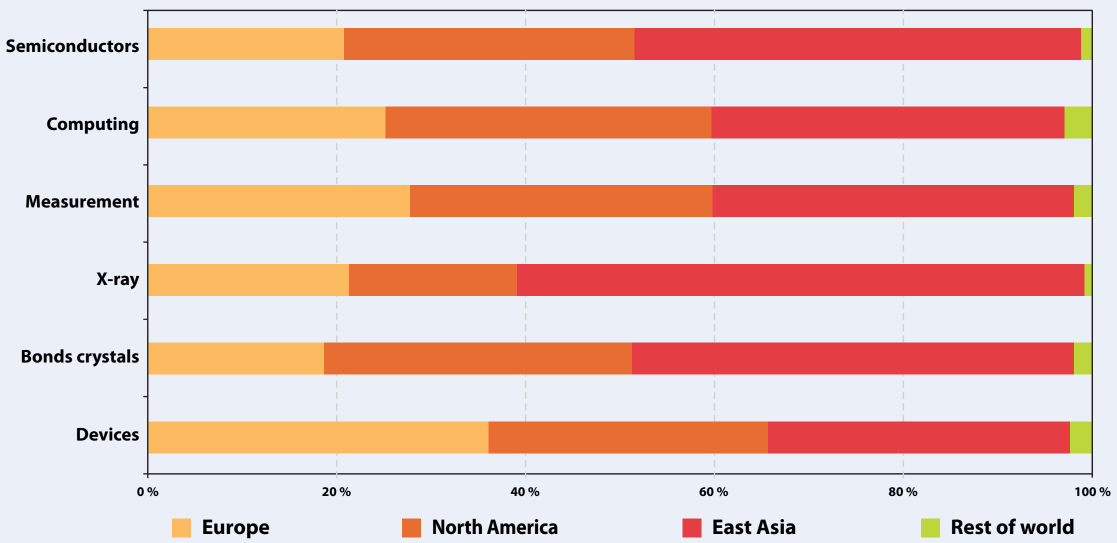
Source: EPO Patstat, background study.

4.7.2. Micro and nanoelectronics, including semiconductors

In 2005, European applicants accounted for 22 % of all EPO/PCT patent applications in micro and nanoelectronics, compared to 30 % for North America and 46 % for east Asia. The applications can be divided into semiconductors, computing, measurement, x-ray, bonds and crystals and electronic devices. The market volume for semiconductors is far greater than the market volume of the other five segments combined.

As Figure 4.22 demonstrates, European applicants dominate the market for devices patents but are weaker in bonds/crystals and semiconductors. It is striking that east Asian applicants made almost half of all EPO/PCT applications in the important semiconductor field.

Figure 4.22: Composition of patent applications (EPO/PCT) in micro and nanoelectronics including semiconductors in 2005 (in %)



Source: EPO Patstat, background study.

Returning to the aggregate level, Europe attracted only 10 % of overall investment in micro and nanoelectronics in 2007, compared to 48 % in east Asia (Confindustria, 2009).

4.7.3. Industrial biotechnology

Industrial biotechnology is one of the key enabling technologies in which Europe is ahead of North America and east Asia in terms of patent applications. In 2005, Europeans submitted the highest share of EPO/PCT patent applications in industrial biotechnnology (36 %), followed by North American (34 %) and east Asian (23 %) applicants. Europeans are in fact world leaders in the production of enzymes and in fermentation: around 80 of the most important enzyme producers are located in Europe, with only 20 in North America (Confindustria, 2009).

The competitiveness of the entire European biotechnology industry was the subject of a chapter in the *European Competitiveness Report 2001* (European Commission, 2001). In the present chapter, however, the interest lies only in industrial biotechnology, which in turn can be divided into enzymes, fermentation processes, other enzyme-using processes and established biochemicals except enzymes (such as organic acids, vitamins and proteins).

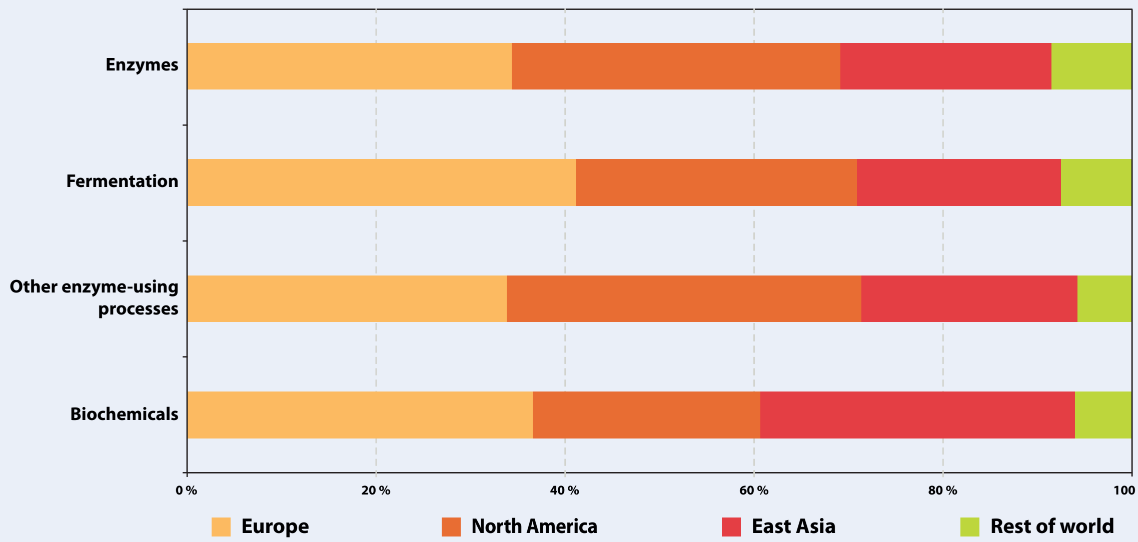
Figure 4.23 confirms Europe's strong position in all four fields, notably in fermentation. In enzymes and other enzyme-using processes North American applicants are about as active as their European counterparts.

4.7.4. Photonics

As in the case of micro and nanoelectronics, photonics is a key enabling technology in which east Asia has left Europe and North America behind in terms of patent applications. In 2005 European applicants accounted for 29 % of all EPO/PCT applications in photonics, North American applicants for 27 % and east Asian applicants for 42 %. Even so, European producers maintain a strong position in many photonics applications such as data communication, healthcare, lighting (including inorganic and organic LEDs), solar cells, safety and security and laser-assisted manufacturing. It is estimated that there are around 5 000 photonics companies in the EU, mostly SMEs, employing around 300 000 people directly (Photonics21). In addition, the jobs of more than 2 million employees in the EU manufacturing sector depend directly on photonics products.

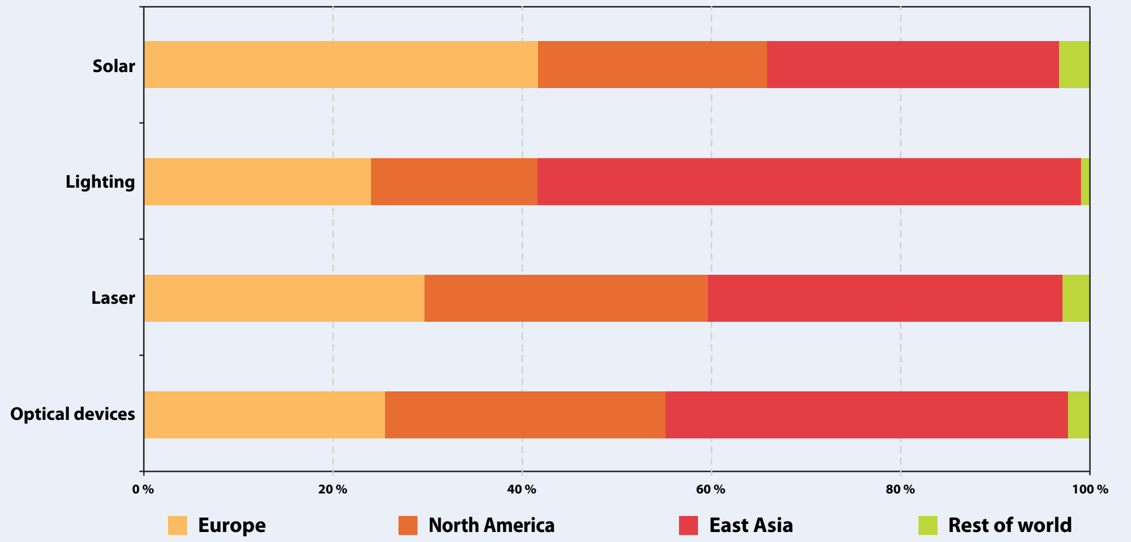
Photonics can be categorised as solar technology, lighting, laser and optical devices. Figure 4.24 shows the shares of EPO/PCT patent applications in each category, and it is clear that European applicants are strongest in solar technology. The largest field in photonics, however, is optical devices, where Europe is underrepresented in terms of patent applications.

Figure 4.23: Composition of industrial biotechnology patent applications (EPO/PCT) in 2005



Source: EPO Patstat, background study.

Figure 4.24: Composition of patent applications in photonics (EPO/PCT) in 2005



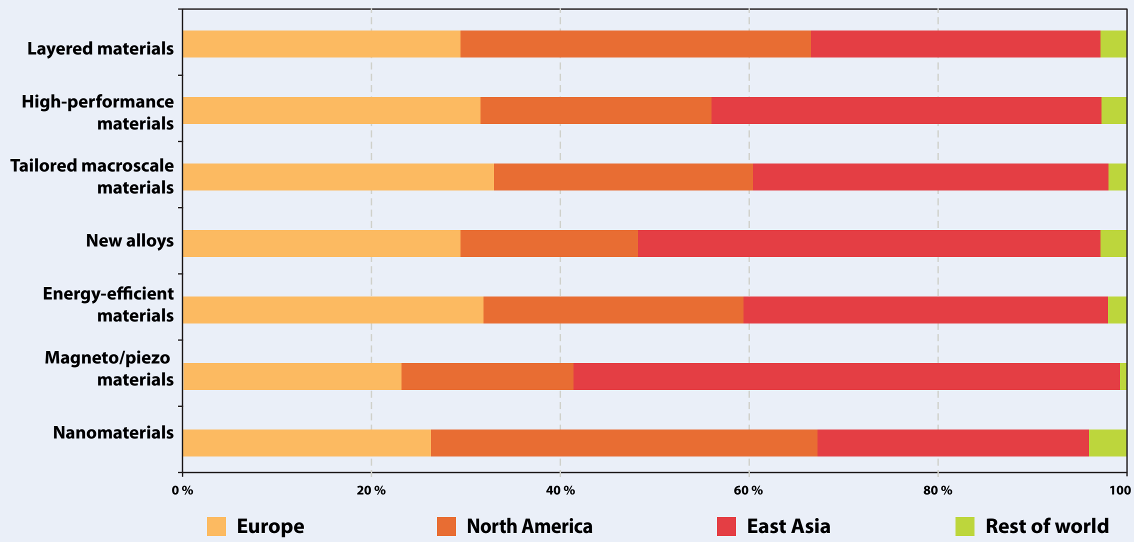
Source: EPO Patstat, background study.

4.7.5. Advanced materials

Despite a very strong research base in advanced materials, and public research spending to the tune of EUR 44 billion a year (around 75 % higher than USA or Japan), European patent applications in advanced materials have lost momentum in recent years and represented 31 % of all EPO/PCT applications in this field in 2005. North American applications have also petered out and stood at 30 % of the total in 2005, whereas east Asian applications have continued to increase and had reached 37 % by 2005.

Advanced materials can be divided into layered materials, high-performance materials, tailored macroscaled materials, new alloys, energy-efficient materials, magneto and piezo materials and nanomaterials. Though currently quite modest, the latter category is expected to grow faster than any other category of advanced materials in the medium term.

Figure 4.25: Composition of patent applications in advanced materials (EPO/PCT) in 2005



Source: EPO Patstat, background study.

Figure 4.25 demonstrates that Europe is relatively strong in tailored macroscaled materials and in energy-efficient materials, albeit in both cases with a smaller share than east Asia. In magneto and piezo materials, on the other hand, European applicants appear to be falling behind. In all seven fields Europe is behind one or both of the other main regions in terms of EPO/PCT applications.

4.7.6. Advanced manufacturing technologies

Europe is the world leader in advanced manufacturing technologies and in 2005 accounted for almost half of all EPO/PCT applications, followed by North America with around 30 % of all applications and east Asia with around 20 %.

Advanced manufacturing technologies can be subdivided into robotics, measuring, controlling industrial processes, regulating industrial processes, machine tools and computer-integrated manufacturing. Figure 4.26 illustrates how European applicants account for most EPO/PCT applications in all six categories, representing around half the applications in machine tools and in measuring industrial processes. After Europe, east Asian applicants are particularly strong in robotics, and North American applicants in computer-integrated manufacturing.

4.7.7. Cluster analysis

As a complement to the patent data analysis on which preceding subsections are based, the background study also contains 10 case studies of clusters. For each key enabling technology except advanced manufacturing technologies, a cluster in the EU and a cluster outside Europe have been analysed and compared. The results are summarised in Table 4.4.

4.8. Implications

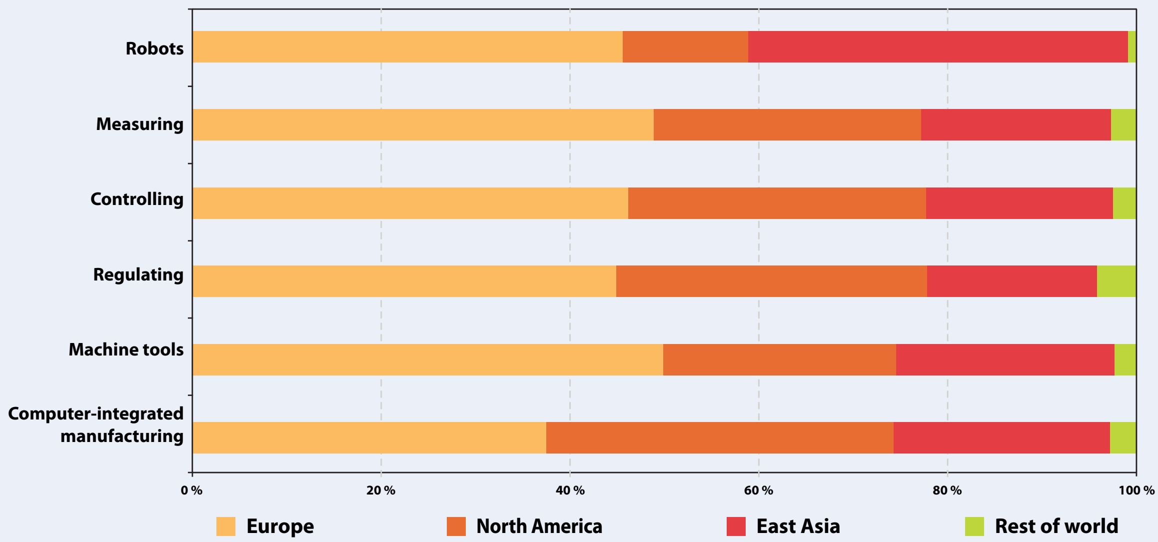
Europe is an important source of technological progress in all six technologies considered in this chapter. It is the world leader in advanced manufacturing technologies, holds a top position in industrial biotechnology, has been able to maintain a strong position in advanced materials and is also building a strong position in photonics despite a rapid increase in technology output in east Asia. In nanotechnology and micro and nanoelectronics, Europe contributes less than North America and east Asia.

4.8.1. Existing priorities

The European Union and its Member States have recognised the importance of key enabling technologies and, in many cases, adopted strategies for them in the medium to long term. There is, however, a lack of coordination between Member States.

France was the first Member State to publish a strategy for key technologies. Since 1995 it has published, every five years, strategy documents covering the next five years. The current strategy ('Technologies clés 2010') is

Figure 4.26: Composition of patent applications in advanced manufacturing (EPO/PCT), 2005



Source: EPO Patstat, background study.

Table 4.4: Main results of cluster analysis

Technologies	EU cluster	Non-EU cluster	Main findings
Nanotechnology	North Rhine-Westphalia (NRW)	Kyoto	Both clusters are relatively young. Both focus on integrating nanotechnology with other sciences. Kyoto is better than NRW at private financing, commercialisation of results, lead or anchor firms and entrepreneurial spirit.
Micro and nano-electronics including semiconductors	Grenoble	Ottawa	Stronger cluster identity in Grenoble than Ottawa. Strong research base in both. Stronger government incentives (e.g. tax credits) in Ottawa than Grenoble.
Industrial biotechnology	Cambridge	San Francisco Bay area	Both clusters developed spontaneously and are now mature. Bay area firms more commercially oriented than Cambridge, which is more closely linked to universities.
Photonics	Berlin-Brandenburg (OpTecBB)	Quebec	OpTecBB geographically more concentrated, financially better equipped and with stronger cluster identity than Quebec. Stronger government incentives (e.g. tax credits), greater dynamism, more access to venture capital in Quebec.
Advanced materials	Wallonia (Plastiwin)	Changsha, China	Both clusters are young and both have a number of large firms. Stronger government role in Changsha. Cluster leads or anchors in Plastiwin are the larger firms, in Changsha universities.

in the process of being replaced by a new strategy running until 2015.

Germany launched its high-tech strategy in 2006 with nanotechnology, biotechnology, microsystems technology, ICT, optical technologies, material technologies, production technologies and innovative services identified as key technologies (BMBF, 2006).

In the United Kingdom, a strategy document published in 2008 listed advanced materials, biosciences, electronics, photonics and electrical systems, nanotechnology, high-value manufacturing and ICT as key technologies (Technology Strategy Board, 2008).

At EU level, following last year's communication (European Commission, 2009a), a high-level group has been set up with the task of developing a shared longer-term strategy and action plan on the key enabling technologies identified in the communication. Furthermore, a study has been launched comparing the policies in different countries. The present chapter should be seen in the same context.

The priorities of the EU regarding key enabling technologies have also manifested themselves in other ways: the action plan for Europe on nanosciences and nanotechnology 2005–09, which is being succeeded by a new action plan for the period 2010–15; the strategy for Europe on life sciences and biotechnology; and the European nanoelectronics initiative advisory council (ENIAC) founded by the EU, its Member States and industry to take forward European research in nanoelectronics. As already pointed out, the framework programme for research, technological development and demonstration activities also reflects the priorities of the EU in the area of key enabling technologies.

4.8.2. Future directions

All in all, Europe is neither losing nor gaining ground in the six technologies, judging by its share of EPO/PCT patent applications and bearing in mind that patents are less relevant than future commercial applications based on the technologies. In all cases Europe is confronted with increasing competition from east Asia, which in the past decade has made considerable progress, whereas North America's share in global technology output has gradually diminished.

Europe's position tends to be stronger in chemicals-related fields than in technology areas linked to electronics. Another European peculiarity is the importance of the automotive sector as a source of technological progress in some key enabling technologies (micro and nanoelectronics, photonics, advanced manufacturing technologies) due to the high degree of technological competence in this particular industry in Europe.

Public research plays a more prominent role in Europe than elsewhere, although in some technologies (industrial biotechnology, nanotechnology) North America reports an even greater share of public research in total patent output. Dedicated technology start-ups are less significant in Europe compared to North America, but more prevalent than in east Asia.

The critical role of key enabling technologies for manufacturing calls for attention, regardless of the current technological competitiveness. A mix of generic measures and technology-specific interventions is most likely to accelerate the development, diffusion and use of key enabling technologies and increase their impact on the wider economy:

- Since key enabling technologies are research-driven it is essential to maintain a strong research base. Funding basic research with a long-term view is a key policy task. Basic research funding in key enabling technologies needs to strike a balance between setting thematic priorities (in order to obtain a critical mass of knowledge and promote cooperation among researchers working on similar subjects) and providing free space for explorative research into entirely new areas.

- Because these are technologies originating at the frontier between scientific research and industrial applications, the exchange between both groups of knowledge producers is essential as well. In particular, incentives need to be in place at public research institutions for actively engaging in technology transfer. This includes proper intellectual property management, promotion of spin-offs, acknowledging the importance of technology transfer in evaluations and funding and offering linkage programmes such as researcher mobility programmes.

- Industrial R & D on key enabling technologies is characterised by high knowledge spillovers and high technological uncertainty. There is a case for public co-funding of business enterprise R & D, as long as state aid rules are respected and case-by-case assessment criteria fulfilled. R & D programmes should follow a long-term perspective, align technology priorities with thematic priorities of basic research programmes and include incentives for cooperative R & D.

- Although key enabling technologies are characterised by particularly high investment in R & D and high technological and market risks, a generally favourable framework for innovation and commercialisation of new technologies can also be helpful. Policy measures that stimulate start-ups, including a culture of entrepreneurship and risk-taking, can be important, as can a favourable financial environment, including tax incentives for R & D and investment in new technologies.

- Key enabling technology actors should be encouraged to build up networks for joint technology development, particularly in areas requiring a high degree of cross-disciplinary and cross-technology fertilisation. Networking could take place at different geographical levels: global networks of the leading organisations from research and industry where appropriate, regional networks (clusters) to spur technology development wherever close and frequent cooperation among actors is needed. Clusters can be particularly helpful for linking R & D and commercial applications.

- Maintaining a competitive manufacturing base within each technology is critical in order to make full use of their productivity and innovation impact. While pure technology development could be spatially separated from production, direct interaction between R & D, manufacture and application in user industries is needed for creating new fields of application and developing efficient production facilities for new technologies.

- Boosting education and training in these technologies is essential in order to ensure a supply of skilled personnel. Strengthening cross-disciplinary education is a main challenge in that context. A likely shortage of skilled labour should be tackled through education and/or immigration policies.

- An active venture capital market is important for commercialising research results in key enabling technologies through spin-offs and other types of start-ups. Above all, venture capital needs a supportive regulatory environment. If private venture capital markets in Europe are not fully capable of providing sufficient funds for start-up and early-stage financing, public programmes may have to fill the gaps.

- Addressing barriers to the adoption of new technologies is another important task. Extensive experience has been gained in promoting the rapid and broad diffusion of, for example, advanced manufacturing technologies (Baptista, 1999; Link and Kapur, 1994; Arvanitis and Hollenstein, 1997; Shapira and Youtie, 1998). These findings stress the need for consultancy, skills and training, access to external funding as well as cooperation and mutual learning among SMEs.

- There is also a need to acknowledge the role of lead firms and lead markets in the commercialisation of key enabling technologies. Early incorporation of large, globally active companies can help match research with global market prospects and thereby link technological advances to market needs. Venture capitalists can also play a part in this process.

- Balancing health, environment and safety issues against innovation incentives is a major challenge for regulation of key enabling technologies. Involving all the main stakeholders and focusing on legislation that is flexible enough to adjust to technological progress within each technology is a promising approach.

- In order fully to leverage the potential of key enabling technologies to increase productivity and wealth, an integrated, coordinated approach is required, linking actors from regional, national and international levels as well as from different policy domains, including research, innovation, education, competition, industry, taxation, health and environment.

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CHAPTER 5

Innovation and Competitiveness of the Creative Industries in the EU

5.1. Introduction

Broadly speaking, the creative industries comprise activities 'at the crossroads between arts, business and technology' and produce 'symbolic products with a heavy reliance on intellectual property' (Unctad, 2004, p. 4). In European countries, the term 'creative industries' was first introduced by the UK's Department of Culture, Media and Sport (DCMS) in 1998, to denote 'those industries that have their origin in individual creativity, skill and talent and that have a potential for wealth and job creation through the generation and exploitation of intellectual property' (DCMS, 1998, 2001). The significant size of the creative industries and the fast rate at which it has grown over the last two decades has aroused considerable interest among policymakers at national, regional, and international levels, in particular among those concerned with urban planning, regional development, labour market and education policies and, more recently, innovation policy (Caves, 2000; Hesmondhalgh, 2007; Landry, 2000; Stoneman, 2010; Miles and Green, 2008).

While the term 'creative industries' has been commonly used in EU countries for more than a decade, in the US the focus has been more on creative knowledge workers or the 'creative class' as it is labelled by Florida (2002). Creative workers such as engineers, scientists, architects, artists and writers generate ideas and knowledge and are seen as the driving force behind regional growth. Creative industries do not have a monopoly on creative occupations: creative workers can also be found in other skill-intensive manufacturing or business services activities. In the related literature, the growth effects of creative industries and the creative workforce and their role in the wider economy are subjects of intensive debate.

The growth of the creative industries is driven by various trends (Unctad, 2008): reduced working time (more leisure), improved education, and growing real income have all triggered changes in preferences, resulting in increased demand for goods and services with creative, cultural and artistic content. Areas like film, music, performing arts and lifestyle products are the predictable beneficiaries of these trends, all of which have direct consequences for the overall contribution of the sector to national employment and GDP. In addition, new technologies — especially innovations in information and communication technologies (ICT) — have had a massive impact on many creative industry segments and contributed to the rapid growth of software and multimedia services. ICT and the Internet are leading to new forms of distribution, more choices for consumers and a more efficient production process. However, they have also initiated the profound ongoing restructuring of the traditional publishing and media industry. Furthermore, firms in the creative industries are increasingly being regarded not merely as users of new technologies that trigger demand for innovative solutions, but also as a source of innovative ideas and services (e.g. images, design, symbols).

While there is a widespread perception that creative industries comprise a highly diverse set of economic activities, they are also often seen to have a number of common characteristics. Most of the firms are small (employing fewer than 10 people) and most of the workers are highly skilled self-employed professionals. In addition, many people within the creative industries work part time and/or have temporary contracts. Creative industries also often feature a high degree of networking, an intensive supply chain and other inter-firm linkages, and are concentrated in major cities, in many cases organised in regional clusters. Regional authorities can play an important role as facilitators and catalysts of such clusters in order to boost their competitiveness.

The main objective of this report is to provide a comprehensive picture of the innovation performance and competitiveness of the creative industries, along with their relative size and economic performance in the EU-27 countries. In doing so, it explores the growth drivers of the creative industries as well as their economic impact on the wider economy. This impact (Chartrand, 1984;

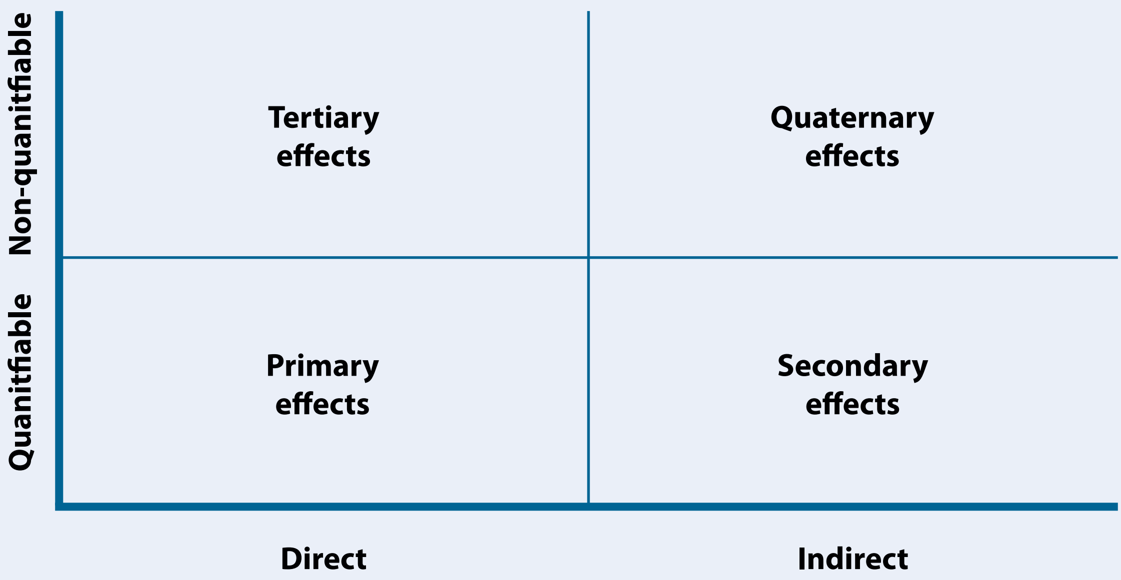
Heng and Choo, 2003; Potts and Cunningham, 2008) is summarised in Figure 5.1 The study looks at four main types of impact: primary, secondary, tertiary and quaternary.

The 'primary' economic impact of the creative industries refers to their direct contribution to the economy — usually in terms of employment and some output measure, such as value added or exports. 'Secondary' economic impact involves spillovers into the wider economy as a result of economic activity in the creative industries. For instance, those creative industry segments that produce intermediate inputs for other sectors rather than final products (such as graphics and design) are expected to profit from enterprises' growing efforts to establish dedicated brands and enhance brand recognition. Secondary impacts can be assessed by investigating how important the creative industries are in stimulating (i) regional growth through regional spillovers and (ii) demand in other sectors of the economy through sectoral spillovers. 'Tertiary' economic impact, meanwhile, embraces the direct, but less quantifiable, contributions of the creative industries to innovation. It addresses the question of how innovative the creative industries are and how they make other sectors innovative. This report touches only briefly on the 'quaternary' economic impact of the creative industries, examining such aspects as the creative industries' role in improving quality of life, maintaining and/or restoring a sense of cultural identity and realising a wide range of other societal objectives. These indirect and non-quantifiable contributions of the creative industries are referred to only in the policy conclusions. Finally, the last section explores the scope and opportunities for policy intervention.

This four-part framework, where the three first elements are of an economic nature, provides a basis on which to answer a number of questions about competitiveness and innovation in the creative industries:

- What is the relative size of the sector and its evolution over time in terms of employment, value added and exports?
- How and to what extent is the current recession affecting the creative industries?
- What do the different creative industries have in common? How do they differ?
- To what extent are creative industries and the creative workforce spatially clustered and what are the underlying factors?
- How innovative are firms in the selected creative industries in terms of technological innovations as compared to firms in other industries? Which sources of knowledge and innovation partners are most relevant for the innovation process?
- What characterises urban areas and regions with a high population share of creative individuals? Do these regions exhibit high levels of growth?
- To what extent do creative industries contribute to innovation in the wider economy? What contribution do design innovations make to firms in non-creative industries?

Figure 5.1: Economic impacts of the creative industries: structure of the report



Source: WIFO (2010), based on Chartrand (1984).

- What is the role of government in supporting and promoting the creative industries?

This study complements the work undertaken by Power and Nielsén (2010) and KEA (2006) in a number of ways. First, different concepts of creativity (i.e. both creative industries and the creative workforce) are considered, and different data sources are used (EU labour force survey at the individual level, structural business statistics and the firm-level Amadeus database). Second, new evidence is provided on the growth effects of the creative industries at regional level, as well as on the drivers of the creative industries.

5.2. Stylised facts on the creative industries in the EU

5.2.1. Definition of the creative industries

Creative industries 'have their origin in individual creativity, skill and talent and have a potential for wealth and job creation through the generation and exploitation of intellectual property' (UK Department of Culture, Media and Sport (DCMS), 1998). As noted by Cunningham (2001), the 'creative industries' concept embraced activities from the new economy era that were not included in the 'art', 'media' or 'culture' concepts. While creative industries link creative content to job and wealth creation, cultural industries are not first and foremost defined by their business value. According to Unesco, cultural activities correspond 'to those activities, goods and services, which at the time they are considered as a specific attribute, use or purpose, embody or convey cultural expressions, irrespective of the commercial value they may have' ([58]). Dealing with creative industries is therefore not exactly the same as dealing with cultural industries. Cultural industries are considered by some as an 'adjunct' of the creative sectors and vice versa. While the scope here is limited to creative industries, the broader perspective taken by the European Commission Green Paper (European Commission, 2010) includes both creative and cultural industries, therefore reconciling both economic and cultural objectives.

In practice, the sectors encompassed in these two concepts are quite similar. Creative industries include business market services that are not usually considered 'cultural' such as architecture, advertising, design, fashion and software services. Also, creative industries, as defined by DCMS, do not include non-profit activities. If one takes a statistical approach and sums up the various subsectors included in these different concepts, the aggregates are very similar. In practice, economic policy rationales tend to dominate in the case of creative industries while cultural policies tend to prevail for cultural industries. Indeed, the survey of policies in the 27 Member States reveals that cultural objectives rank below economic policy rationales when they deal with creative industries.

The statistical definition of 'the creative industries' applied here is based on the definition developed by the UK Department of Culture, Media and Sport (DCMS). A number of reasons led to using this definition. The DCMS definition enjoys a first-mover advantage; it is well known and broadly acknowledged worldwide. Moreover, the statistical definition of an industry will always remain ill-defined if its conceptual foundations are too broad.

In future, the work of Eurostat will serve the purpose of sharing commonly agreed definitions. A network of several European statistical systems (ESSnet-culture) was set up in 2009 at Eurostat ([59]) to further coordinate the harmonisation of statistics on cultural and creative activities.

Once translated into industrial classifications NACE Rev. 2 and NACE Rev. 1.1, the primary impact of creative industries (their share in the EU economy) can be estimated. The exact choice of sectors is detailed in Table 5.1 (NACE Rev. 2) below and in Table A.1 (NACE Rev. 1.1) in the appendix. As will be explained later, the definitions are most sensitive to whether software is included or not, as this sector greatly influences the growth of creative industries.

([58]) http://portal.unesco.org/culture/en/ev.php-URL_ID=33232&URL_DO=DO_TOPIC&URL_SECTION=201.html

([59]) http://ec.europa.eu/culture/our-policy-development/doc1577_en.htm

Table 5.1: Definition of the creative industries (according to NACE Rev. 2)

	NACE Rev. 2	Description	Proportion of code taken
Information services	J58	Publishing activities (publishing of books, periodicals and software publishing), motion pictures, video and television programme production	1.00
		Sound recording and music publishing activities	1.00
	J60	Programming and broadcasting activities	1.00
	J62	Computer programming, consultancy and related activities	1.00
Business services	M711	Architectural and engineering activities and related technical consultancy	0.25
	M731	Advertising	1.00
	M741	Specialised design activities	1.00
	M742	Photographic activities	0.25
	M743	Translation and interpretation activities	1.00
Art and entertainment	R90	Creative, arts and entertainment activities	1.00

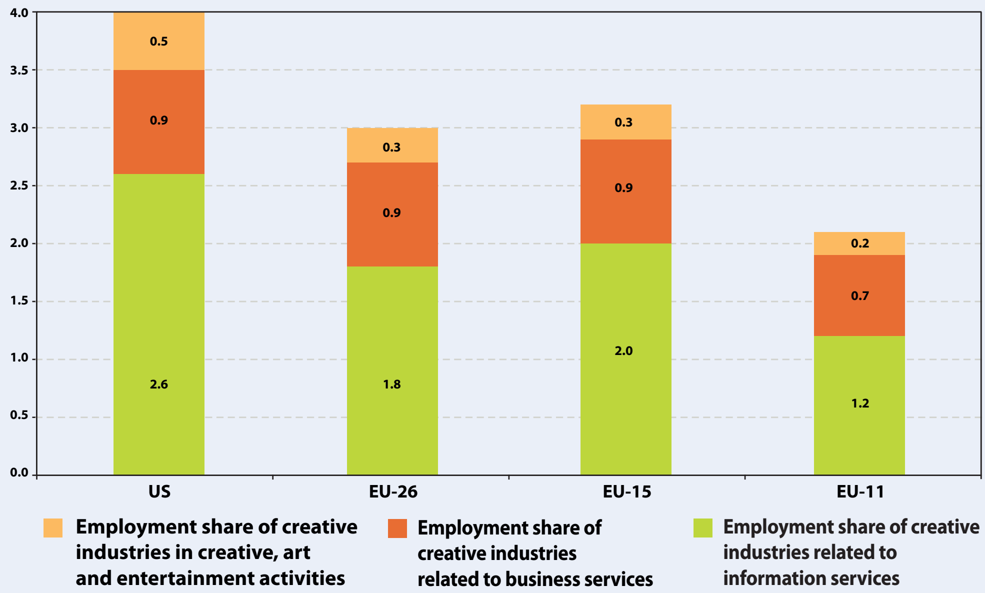
Source: Söndermann (2009), Wilkinson (2007), p. 33.

5.2.2. Size and evolution of the creative industries in the EU

The creative industries account for 3.0 % of total employment (2008) and 3.3 % of GDP (2006). The number of employees in the creative industries in the EU-27 was 6.7 million in 2008 (based on NACE Rev. 2). The corresponding employment shares for the EU-15 and EU-11 (EU-12 excluding Malta) are 3.2 % and 2.0 %, respectively (Figure 5.2). In terms of exports, creative goods account for 4.3 % of the EU-27's external exports.

Figure 5.2 also shows that, in the EU-26, creative industries related to information services accounted for the bulk of total employment in the creative industries in 2008 (62 %, or 1.8 % of all EU-26 employment) ([60]).

Figure 5.2: Employment share of the creative industries in the EU and USA in 2008 (in %)



Note: The EU-11 and EU-26 respectively represent the most recent countries that joined the EU and all the EU Member States except Malta in both cases. Data for the EU are based on NACE Rev. 2. US data are based on NAICS. Employment in architecture and photographic activities is weighted by 0.25.
Source: Eurostat structural business statistics, New Cronos, US Bureau of Labour Statistics.

([60]) The EU-26 is defined as EU-27 excluding Malta.

Creative industries in professional services represented 29 % of total employment and the remaining group — creative, arts and entertainment activities — accounted for 10 %. In the US, the employment share of the creative industries was 4.0 % in 2008, based on BLS data and a very similar definition of the creative industries (Figure 5.2). The employment share of the creative industries is sensitive to the definition applied. When both architecture and photographic activities are fully incorporated into the classification of industries, it amounts to 3.9 % in the EU-26, 4.2 % in the EU-15 and 4.7 % in the US. The reason for the difference in the size of the employment share of the creative industries between the US and EU lies in their disparate structure: the US has a larger share of audiovisual and computer software sector activities as compared to both the EU-15 and the EU-27.

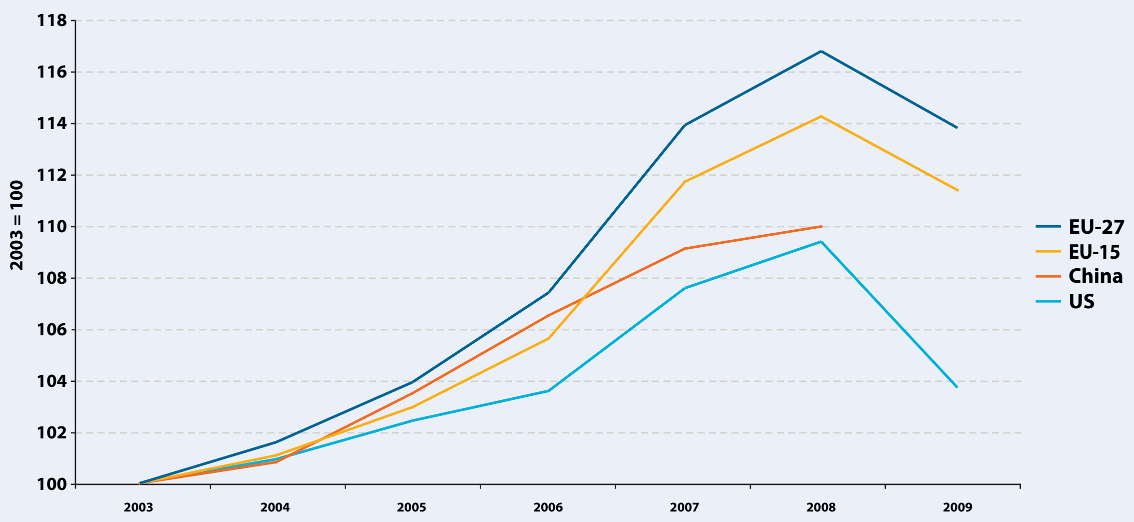
Between 2000 and 2007, employment in the creative industries grew by an average of 3.5 % per annum, compared to 1 % in the overall EU-27 economy. In the US and China the creative industries also grew quickly, averaging employment growth rates of 1.8 % and 1.9 % per annum respectively (Figure 5.3).

However, employment growth in the creative industries varied greatly from one subsector to another. While software consulting and supply showed the highest employment growth of all sub-industries (+ 5.4 % on average since 2000), publishing did not grow much at all (Figure 5.4). The audiovisual sector (including media, arts and entertainment) and architecture also grew faster than overall employment in the EU-27. In the US the fastest-growing creative industries are architectural and engineering services, computer services, radio and television, broadcasting and Internet publishing, independent artists and performing arts (excluding spectator sports).

The source of employment growth in the creative industries is concentrated in a handful of subsectors. A breakdown of the figures shows that software consulting and supply accounts for more than half the employment growth in creative industries in the EU-27 in the period 2000–07 (Figure A.1 in the appendix). As can be seen, advertising is most sensitive to variations in the business cycle. Recent research for the UK also suggests that the rapid growth of the creative industries varies greatly from one firm to another. In particular, NESTA analysis with the Economic Research Institute of Northern Ireland (ERINI) and Aston University suggests that just 7.5 % of 'high-growth' businesses accounted for the overall employment growth in the creative industries in 2005–08. Software, computer games and electronic publishing companies accounted for 45.3 % of all these high-growth creative businesses.

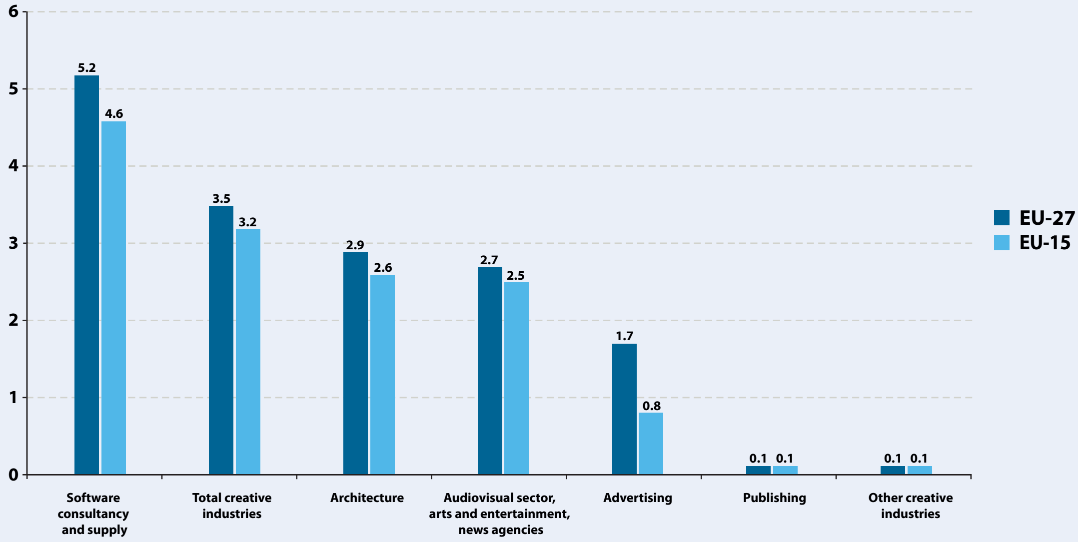
The short-term structural business statistics allow for a more detailed examination of the creative industries' growth by subgroup at the NACE Rev. 2 level. The data for the EU-27 suggest that this strong growth is

Figure 5.3: Evolution of employment in the creative industries



Note: For the EU-15 and the EU-27, data are extrapolated from 2008 onwards based on short-term business statistics containing information on the evolution of labour input for publishing, motion pictures, video and television programme production, sound recording and music publishing activities, programming and broadcasting activities, computer programming, consulting and related activities. Employment data for architectural and engineering activities, technical testing and analysis and advertising and market research are interpolated based on the evolution of turnover in constant prices and an output elasticity of 0.5.
Source: Eurostat structural business statistics, New Cronos, US Bureau of Labour Statistics, Chinese statistical yearbook (various issues).

Figure 5.4: Average annual employment growth of the creative industries in the EU by subsector, 2000–07 (in %)



Source: Eurostat structural business statistics, New Cronos.

not limited to software consulting and supply; it also includes activities in motion pictures, video and television programme production, sound recording and music publishing, which averaged an employment growth rate of 1.9 % per year between 2000 and 2008. However, employment in programming and broadcasting activities increased by less than the average of the creative industries at large.

With respect to the structure of the creative industries classified in NACE Rev. 2, it can be seen that in the EU-27 the largest subsector is computer programming and consulting, accounting for 37 % of total employment in the creative industries in 2008. Advertising services is also an important sector, with 15 % in the same year. The employment share of activities in motion pictures, video and television production, sound recording and music publishing activities was 6.2 %. Specialised design activities — introduced in NACE Rev. 2 for the first time — account for 2.5 % (Table A.2 in the appendix). Programming and broadcasting activities have a share of 3.3 %.

The increasing importance of the creative economy also becomes evident when its growth is measured in terms of creative occupations. 'Creative occupations' is a broader concept than 'creative industries'. It embraces the professions that are 'creative' in essence, no matter whether they belong to the so-called 'creative industries'. Table 5.2 details the occupations considered 'creative': engineers, architects, writers, creative and performing artists and artistic and entertainment professionals, etc. These 'knowledge workers' produce intangible assets such as ideas, knowledge and information that increase firms' value added. A large number of creative occupations are embedded outside the creative industries. In the EU-15 in 2008, 62 % of creative occupations were in sectors other than information and communication services, professional, scientific, and technical activities and the arts, entertainment and recreation.

Calculations based on the EU labour force survey for the EU-15 show that the core creative occupations grew by an average of 3.1 % per year between 2002 and 2008 (see Table 5.2). The corresponding employment share of the core creative occupations increased from 6.6 % to 7.7 % of persons employed in the EU-15 during the same period (Table 5.2). The highest employment growth can be observed for artistic and entertainment professionals — averaging 5.7 % per year — followed by social science and related professionals (5.0 %), mathematical and statistical professionals (4.0 %), computing professionals (3.2 %) and engineers and architects (3.2 %). Similar trends can be observed through an aggregate of new Member States.

5.2.3. Drivers of the creative industries

A number of demand and supply factors have contributed to the rise of the creative industries. Key drivers of the creative economy include innovation, information and communication technologies, talent and skills. Other factors include wealth (i.e. GDP per capita), leisure time and disposable household income, macroeco-

Table 5.2: Evolution of the core creative occupations between 2002 and 2008

		EU-15			EU-7		
		Persons employed (in 1 000s)		Average annual growth rate	Persons employed (in 1 000s)		Average annual growth rate
		2002	2008	%	2002	2008	%
211	Physicists, chemists and related professionals	260	287	1.6	23	31	4.7
212	Mathematicians, statisticians and related professionals	37	47	4.0	8	8	1.7
213	Computing professionals	1 528	1 845	3.2	84	124	6.8
214	Architects, engineers and related professionals	3 088	3 724	3.2	186	219	2.8
221	Life science professionals	332	298	- 1.8	25	33	4.8
222	Health professionals	1 769	1 978	1.9	129	150	2.6
243	Archivists, librarians and related information professionals	198	193	- 0.5	24	29	3.3
244	Social science and related professionals	1 057	1 413	5.0	98	116	2.9
245	Writers and creative or performing artists	1 016	1 175	2.5	73	85	2.7
347+521	Artistic, entertainment and sports assoc.	897	1 250	5.7	46	60	4.5
	total creative occupations	10 183	12 211	3.1	695	856	3.5
	employment share of the creative occupations	6.6	7.7		5.2	6.0	

Note: The EU-7 includes CY, CZ, EE, HU, LT, LV and SK. In the individual anonymised data of the EU labour force survey for SI, PL and BG there is no information on ISCO 88 at the 3-digit level. ISCO corresponds to International Standard Classification of Occupations. In addition, for RO there is no data on ISCO 88 at the 3-digit level before 2005. Creative occupations include physical, mathematical and engineering science professionals, life science professionals, health professionals (except nursing), archivists, librarians and related information professionals, social science and related professionals, writers and creative or performing artists, artistic, entertainment and sports associate professionals and fashion and other models.

Source: EU labour force survey, WIFO calculations.

nomic performance and the initial level of the creative industry in the economy.

Well-educated and skilled workers are the key resource in the creative economy. Indeed, evidence based on the EU labour force survey of 22 EU countries shows that the workforce in the creative industries has the highest proportion of persons with tertiary education (the International Standard Classification of Education — ISCED levels 5 and 6). In the EU-22 in 2008, information services (NACE Rev. 2 J, of which the associated creative industries account for more than 70 % of industry employment) is the sector of the EU economy with the third-largest share of workers with tertiary education (behind the education sector and professional, scientific and technical activities), boasting more than 50 % compared to 26 % for the total EU economy [61]. Similarly, creative, arts and entertainment activities and the business-led creative industries (such as architecture, advertising and design) are characterised by significantly higher skill intensity than the rest of the economy. In the EU-22 in 2008, professional, scientific and technical activities and arts, entertainment and recreation (of which the associated creative industries represent a significant part) had a tertiary education share of 57 % and 35 % respectively.

Other supply-side factors include the rapid advance of digital technologies, the globalisation of networks and the deregulation of media. The Internet has created new distribution channels and business models. For instance, the rise in online advertising has changed the entire advertising industry, leading to declining sales for traditional advertising media. In four out of 15 EU countries, the share of online advertising is already about 20 % or more (IAB Europe, 2009). A recent study on the European software industry revealed that the rapid growth of online advertising is being driven by the growth of the worldwide online population, broadband access development and an increase in time spent online (Pierre Audoin Consultants SAS (PAC), 2009). A recent JRC-IPTS study on videogames yields similar results (De Prato et al., 2010). The shift to digitisation and the increase in broadband access have decreased the cost of media distribution, in particular for recorded music and films. In recent years, digital distribution of recorded music and other media via the Internet has created a whole new business model (Stoneman, 2010). Global

([61]) Calculations are based on the EU labour force survey of 2008 where all numbers are weighted to reflect the total population of persons employed.

digital music sales are growing rapidly, whereas physical music sales have fallen in the last five years (IFPI, 2009). Recent unpublished data show that in the UK revenues from digital sales outstripped physical sales for the first time in 2009.

Correlations based on aggregate country data find a strong relationship between broadband penetration and the size of the creative industries (with a correlation of 0.80 for 27 EU countries in 2008). In addition, there is a significant correlation between the increase in broadband penetration and the increase in the employment share of creative industries across Member States. However, the EU-15 is lagging behind both the US and Japan in digital music distribution. In the EU-15 the share of digital music in retail sales is estimated at 12 % for 2009, compared to 33 % in the US and 19 % in Japan according to the International Federation of Phonographic Industries (IFPI). Similarly, the EU is well behind the US in both online advertising and the deployment of ultra-high broadband (IAB Europe, 2009).

The demand-side factors include the increase in available leisure time and disposable household income (Andari et al., 2007). Available empirical evidence for nine EU countries reveals that spending on cultural services increased from 1.0 % to 1.3 % of GDP between 1999 and 2005 ([62]). It is worth noting that cultural services include licence fees for television equipment and subscriptions to television networks. Similarly, household spending on communication increased steadily due to rising expenditure on Internet connection services. In 2005, spending on cultural services surpassed traditional media (i.e. books and newspapers) in the same eight countries. Between 1998 and 2005 there was even a decline in household consumption of these products, further indicating that Internet media are replacing traditional media. Similar trends can be observed in the structure of US household consumption spending (Beyers, 2008).

Another explanation of the fast growth of the creative industries in the EU is that a number of less advanced EU countries are starting to catch up with the more developed Member States. In fact, empirical evidence shows that EU countries with a low initial employment share in creative industries exhibited a significantly stronger increase in the same employment share between 2000 and 2007 (with a correlation of - 0.45). This relationship remains robust and highly significant when software consultancy and supply is excluded from the creative industries. Macroeconomic growth also explains the rapid increase in the overall share of the creative industries. EU countries with high growth rates experienced a higher-than-average increase in their employment share in creative industries.

Besides, creative industries are very dependent on business cycles. There are various reasons why creative industries have been affected more severely by the recession than other sectors. First, falling consumer spending is expected to have a large impact on those industries that sell a large portion of their output to final demand (i.e. end-users), such as arts and entertainment and the audiovisual sector. It is well known that decreases in consumer spending have a high impact on creative goods and services characterised by high income elasticity, such as opera tickets and other luxury items. Second, creative industries are affected indirectly as a result of intensive supply-chain linkages to other sectors. This particularly concerns creative industries that have a large number of business-to-business transactions with industries that are badly affected by recession.

Available evidence for the EU-27 shows that, in each of the creative industries, turnover (in current prices) and labour decreased in 2009 for the first time in the last 10 years. (More information on the turnover evolution from 2000 to 2009 is available in the background report.) Advertising saw the strongest decrease between 2008 and 2009 (approximately 12.4 %, see Table 5.3). It is obvious that the decline was caused by intensive supply-chain linkages to other sectors of the economy that have been hit hardest. Most firms cut their advertising budgets during the recessionary period. Publishing turnover decreased by 6.8 %, while computer programming/consulting and architecture were less affected (a 5.0 % decline).

The number of employees (measured by the labour index) also decreased, with the exception of computer programming and consulting, where employment was stable in 2009. The explanation for this procyclical behaviour lies in the labour hoarding of skilled workers. For the arts, entertainment and recreation sector there is no information on turnover on a regular basis. Available evidence for France suggests that the output (in current prices) of this sector decreased only moderately, showing declines of between 3.7 % for performing arts and 5.0 % for artistic creation. Turnover in the operation of arts facilities even increased between 2008 and 2009 (Table A.3 in the appendix).

5.2.4. Industry and labour market characteristics

Creative industries are dominated by a large number of micro firms (with nine or fewer employees, including one-person firms). Based on the Eurostat structural business statistics data for the EU-22, 95 % of the 1.2 million firms in the core creative industries employ fewer

([62]) The nine EU countries are Belgium, Greece, Spain, France, Italy, Luxembourg, the Netherlands, Portugal and the United Kingdom.

Table 5.3: Annual change in turnover in current prices and labour input in 2008 and 2009 (in %)

	EU-15		EU-27	
	Change in turnover in current prices in %			
	2008	2009	2008	2009
Total services (except retail trade and repair)	5.2	- 9.8	5.5	- 9.9
Publishing activities	0.6	- 6.7	0.9	- 6.8
Motion picture, video and television programme production, sound recording and music publishing activities	4.4	- 3.9	4.3	- 3.9
Programming and broadcasting activities	0.7	- 7.0	1.6	- 8.2
Computer programming, consultancy and related activities	4.4	- 5.5	4.9	- 5.0
Architectural and engineering activities; technical testing	7.1	- 5.5	7.7	- 5.0
Advertising and market research	0.6	- 12.6	2.6	- 12.4
	Change in labour input in %			
	2008	2009	2008	2009
Total services (except retail trade and repair)	1.3	- 3.2	1.7	- 3.3
Publishing activities	0.0	- 4.0	0.2	- 3.2
Motion picture, video and television programme production, sound recording and music publishing activities	1.4	- 3.5	0.8	- 5.7
Programming and broadcasting activities	0.6	- 0.9	0.4	- 3.5
Computer programming, consultancy and related activities	4.3	0.1	4.5	0.3

Source: Eurostat structural business statistics, New Cronos.

than 10 people (Table 5.4). This share is much higher than that of manufacturing industries (80 %). However, the share of micro firms is similar to that of all business services except advertising, which has a higher share of these small enterprises. Overall, a large share of small firms is a common characteristic of the creative industry and shared by most sub-industries. Furthermore, the majority (58 %) of businesses in the creative industry consist of self-employed people (Table 5.4). The share of self-employed people in all businesses is even higher in the culture and recreation sector (63 %) and advertising (67 %). When the employment distribution is considered, the findings again indicate the predominance of micro firms. Such firms account for 35 % of all employment in the creative industries in the EU-22. This is similar to the corresponding share in all business services. Furthermore, the self-employment rate in creative industries is about 13 % — much higher than the aggregate self-employment rate (excluding agricultural employment).

In creative industries, labour costs account for a high percentage of value added, indicating that production is both labour- and human capital-intensive. Creative industries also differ in their average labour productivity and part-time ratio as compared to all business services. In particular, software consultancy and supply industries have the highest level of labour productivity of all the business services considered.

It is often argued that the different creative industries are so intertwined that they can be viewed as a single sector. Indeed, available evidence based on detailed input-output tables (at the 3-digit level) shows strong supply-chain linkages among the different creative industries. First and quite obviously, there are strong

Table 5.4: Size distribution of employment and firms in creative industries in the EU-22, 2007

	Size distribution of firms		Size distribution of employment	
Firm size (persons employed)	Number of firms	%	Number of persons employed	%
Zero	669 170	58	658 921	13
Between 1 and 4	376 537	32	752 344	15
Between 5 and 9	56 479	5	386 023	8
10 or more	58 961	5	3 267 222	65
Total	1 161 148	100	5 064 510	100

Note: Creative industries are restricted to publishing, software consultancy and supply, architecture, advertising, motion picture and video activities, radio and television activities, arts and entertainment and news agencies. For architecture, all numbers are weighted by 0.25. The EU-22 refers to BG, CZ, DK, DE, EE, ES, FR, IT, CY, LV, LT, LU, HU, NL, AT, PT, RO, SI, SK, FI, SE and UK. The data refers to 2007 or the latest available year. For 221 and 223 the split into the three smallest size classes is based on additional data sources.

Source: Eurostat structural business statistics, WIFO calculations.

supply-chain linkages between publishing and advertising. Second, it is well known that advertising is one of the two main sources of revenue of the traditional media industry and online advertising, besides consumer and end-use spending. Picard (2009) suggests that book publishers rely on contract writers, editors, printers and binders and distribution services. Magazine publishers engage independent writers, photographers and printing and distribution firms. These interactions require ongoing contacts and coordination, and often lead service firms and individuals to establish themselves near those who require their services. Such interactions and processes have historically produced self-generating media clusters and a high degree of path dependency.

The supply-chain linkages among different creative industries can be described based on Danish supply-and-use tables, which are available at the 3-digit level for 2005. For advertising, the share of intermediate inputs supplied by publishing is 48 % (Figure A.2 in the appendix). The second most important suppliers of advertising are recreational and cultural industries belonging to the market sector (i.e. excluding non-market firms such as museums and libraries). They contribute 17 % of all domestic inputs in advertising. This is clearly related to the close integration between advertising and the audiovisual sector. However, there are surprisingly few linkages between software consultancy and supply on the one hand and the remaining creative industries on the other hand.

Table 5.5 shows the EU-15 labour-market characteristics of creative workers, defined by creative occupations based on the European labour force survey for 2008. Here the focus is on occupations that are most prevalent in the creative industries. These characteristics include percentages of creative workers with tertiary education (ISCED levels 5 and 6), self-employed individuals, creative workers with temporary contracts, part-time workers, creative workers at micro firms and multiple job holders ([63]).

The different creative occupations share a number of common characteristics. First, for creative occupations in the EU-15, the proportion of employees with tertiary education is 78 % against 24 % for workers in non-creative occupations. The proportion of employees with tertiary education ranges from 42 % for artistic, entertainment and sports associate professionals to 65 % for writers and creative/performing artists and over 80 % for physical, mathematical and engineering science professionals. Another common characteristic of creative occupations is a higher self-employment rate. In the

Table 5.5: Labour market characteristics of creative occupations in EU-15, 2008 (in %)

Creative occupations	ISCO 88	Tertiary education	Self-employment rate	Temporary contracts	Part time	Working in micro-firms	Multiple job holders
				EU-15			
Physicists, chemists and related professionals	211	87	7	13	7	11	3
Mathematicians, statisticians and related professionals	212	81	11	15	7	11	6
Computing professionals	213	70	10	8	7	9	3
Architects, engineers and related professionals	214	85	19	7	7	12	3
Life science professionals	221	91	10	14	10	15	4
Health professionals	222	95	40	14	14	26	8
Archivists, librarians and related information professionals	243	78	3	12	31	22	6
Social science and related professionals	244	86	16	15	30	14	8
Writers and creative or performing artists	245	65	44	13	26	14	10
Artistic, entertainment and sports associate professionals and fashion	347	42	38	14	30	24	9
Creative occupations		78	24	11	16	16	6
Non-creative occupations		24	15	12	21	26	4

Note: All numbers are weighted in order to reflect total population.

Source: EU labour force survey, 2008.

([63]) Based on the EU labour force survey, micro firms can only be defined as firms with 10 or fewer persons employed, instead of nine or fewer persons employed based on the Eurostat structural business statistics.

EU-15, the self-employment rate is 9 percentage points higher for workers in creative occupations than for those in non-creative occupations. Artists and writers tend to work fewer hours, as indicated by the part-time ratio. Furthermore, 6 % of creative professionals hold multiple jobs, compared to 4 % for those in non-creative occupations. Among writers and performing artists, nearly one in 10 is a multiple job holder. Overall, non-standard forms of employment such as self-employment, part-time employment and employment in multiple jobs are more prevalent among creative occupations than among non-creative occupations. However, the creative occupations are highly heterogeneous themselves, with wide variations between physical, mathematical and engineering science professionals on the one hand and writers and creative/performing artists on the other.

5.2.5. Trade in creative industry goods and services

Sectoral competitiveness is invariably and closely related to trade performance. But it is important to highlight that the EU, and its Member States, have chosen to preserve their capacity to define and implement policies for the purpose of preserving cultural diversity when joining the General Agreement on Trade in Services (GATS). The question of trade is therefore not a straightforward one. While a number of studies, policy documents in particular, point at the growing importance of trade in creative industry products, and the sound export performance of the creative industries, this issue has until now almost never been studied in a thorough way. This is mainly due to the limitations of trade statistical data. Notable exceptions are the contributions of Disdier et al. (2010) on cultural goods and the Unctad report (2008) on the creative economy. Services play a large part in the creative industries, but services are by nature less tradable than goods. This may explain why creative industry trade issues are seldom analysed. They are nevertheless quite dynamic. Unfortunately, the coverage of services in trade statistics leaves a lot to be desired. For this reason, evidence is limited to a small number of EU countries as far as trade in services is concerned while the geographical coverage of trade in creative industries' goods is more exhaustive.

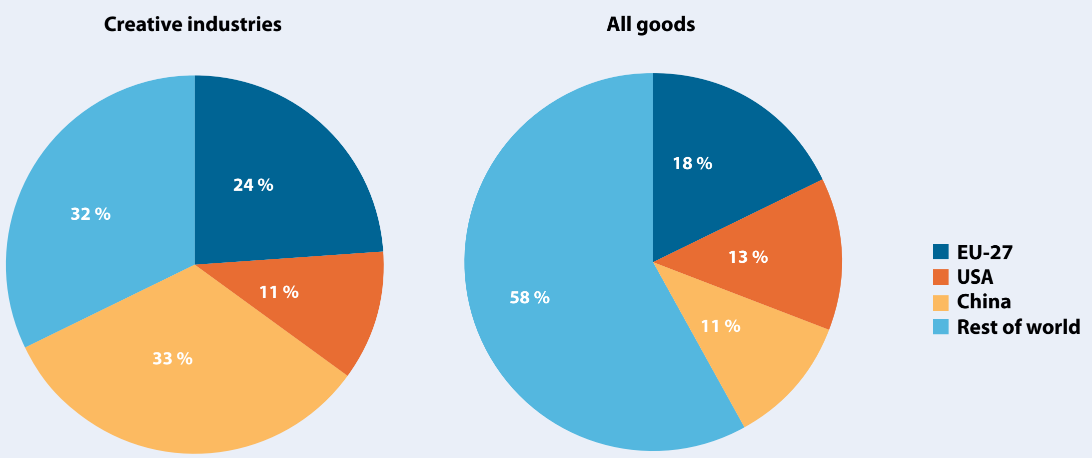
5.2.5.1. Trade in creative industry goods

Breakdown by region

The share of creative industries' goods in total world exports was 3.6 % on average during the years 2000–05 (based on the Unctad global databank) but its growth dynamics were lower than for total export goods. Its share fluctuated between 3.7 % and 3.8 % until 2003 and declined to 3.3 % in 2005. This indicates that trade in creative industries' goods did not grow as much as global trade at that time. World exports of creative industries' goods grew at an average annual rate of only 1.7 % between 2000 and 2005, reaching a value of approximately EUR 270 billion in 2005.

In 2005, three economic regions accounted for two thirds of the world's exports of creative goods (the exports within the regions not being taken into account): a third from China, almost a quarter from the EU-27 and 11 % from the US.

Figure 5.5: Exports breakdown of creative industries' goods and exports of all goods, excluding intra-regional trade (2005) (in %)



Source: Unctad global databank on world trade in creative products (left panel), UN Comtrade (right panel), WIFO calculations.

Breakdown by creative domains

When the focus is on the types of creative goods exported by region, more heterogeneity in the structure of exports can be observed (Figure 5.6 and Table 5.6).

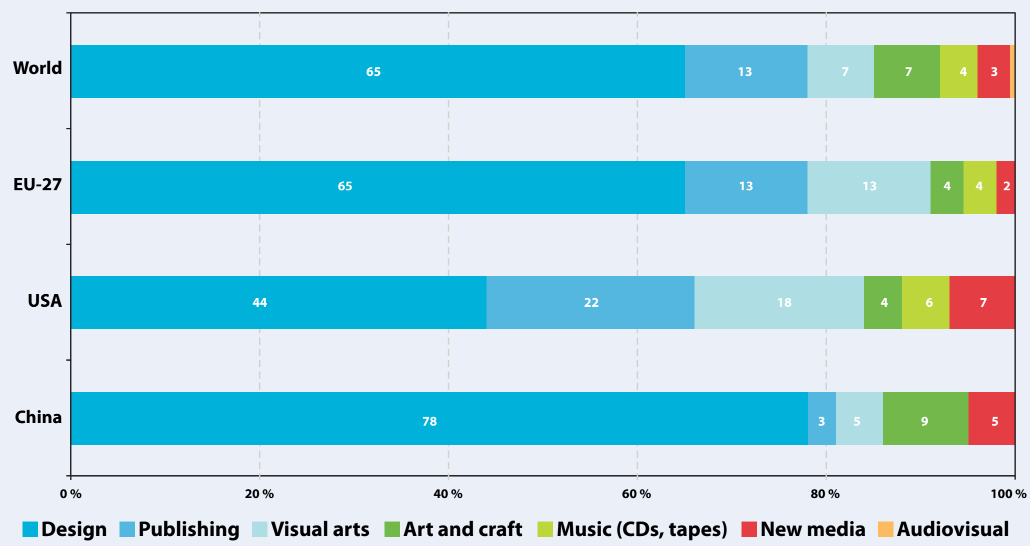
World: In 2005, two thirds of world exports in creative industries' goods were classified as design, followed by publishing with only 13 %. Strikingly, the sectors that account for the lowest share of world exports — music (4 %), audiovisuals (0.2 %) and new media (4 %) — are also the ones with the highest growth between 2000 and 2005 (9.4 %, 5.7 % and 5.2 % respectively). This trend is in line with the change of consumer habits towards increased media/new media consumption highlighted in Section 5.2.3 on 'Drivers of creative industries'. It is worth noticing that at this level of aggregation (world trade in creative industries' domains) the structure of exports remains relatively stable over time.

EU: Apart from design, which dominates (65 % of exports), publishing and visual arts carry considerable weight in EU exports of creative industries' goods (each with 13 %). The fastest-growing creative industries' goods exports in 2000–05 were new media (8.7 % growth). When one looks at intraregional trade in the EU, the most dynamic sectors were music (16.2 % growth) and audiovisual (15.1 % growth).

China: With a share of 78 %, design goods dominate Chinese exports even more than they do globally, while publishing goods make up only 3 % of China's extraterritorial export volume. With a relative export share of 9 %, arts and crafts products account for a non-negligible share of China's total creative industries' products. In fact China is the leading exporter of arts and crafts products worldwide (Unctad, 2008). These findings are quite intuitive and emphasise the role of common languages and cultural norms in creative industries' trade. For instance, prevailing cultural and linguistic differences between China and the western hemisphere make it almost impossible for the Chinese publishing and music industries to compete in world trade. When it comes to the fastest-growing sectors, China significantly outpaces other regions in terms of new media exports. The observed average annual growth of creative industries' trade reached an impressive 42.6 % in 2000–05 (Table 5.6).

The US: The US was specialised in publishing and the visual arts in 2005, which come in at 22 % and 18 % respectively; they hold a comparatively large share in new media (7 %), but a distinctly lower relative share in design (44 %). In the US, only the music sector saw an increase in the volume of creative industries' goods in 2000–05.

Figure 5.6: Share of creative industries' domains in export of creative industries' goods (2005) by region



Note: Intraregional trade is not included. The share of audiovisuals in exports of creative industries' goods accounts for 0.2 % of world exports, 0.1 % of both US and extra-EU-27 exports and 0.003 % of Chinese extraterritorial exports (i.e. only USD 3 out of every USD 1 000 worth of export earnings are derived from audiovisuals). The share of music exports from China is negligible.
Source: Unctad global databank on world trade in creative products, WIFO calculations.

Table 5.6: Average annual growth in exports of creative industries' goods (2000–05) by domains

	World	EU-27 (extra)	EU-27 (intra)	USA	China (gross)
All creative industries	1.7 %	1.0 %	3.4 %	- 1.7 %	3.4 %
Arts and crafts	- 0.5 %	- 3.2 %	2.6 %	- 3.4 %	- 1.4 %
Audiovisuals	5.7 %	- 1.2 %	15.1 %	- 9.6 %	- 17.0 %
Design	2.0 %	1.2 %	2.8 %	- 1.3 %	3.1 %
Music (CDs, tapes)	9.4 %	0.7 %	16.2 %	2.2 %	- 2.1 %
New media	5.2 %	8.7 %	- 0.2 %	- 0.1 %	41.6 %
Publishing	- 0.3 %	0.9 %	2.1 %	- 3.8 %	6.5 %
Visual arts	- 0.1 %	0.7 %	- 0.6 %	- 1.4 %	- 1.3 %

Source: Unctad global databank on world trade in creative products, WIFO calculations.

Revealed comparative advantages

In 2005, the EU had a revealed comparative advantage in creative industries' exports for 13 out of 25 products. This means that the share of EU creative industry exports in total exports is higher than the share of creative industry exports in total exports in the world ([64]). As can be seen in Figure A.3 (in the appendix), a number of products even increased their revealed comparative advantage in 2000–05. The individual products that most improved their position were digital records (new media) and antiques. The publishing types of creative goods also enhanced their comparative advantage. In particular, the EU turned its former disadvantage in newspapers into an advantage. Interestingly, the EU still does not have a revealed comparative advantage in the fast-growing video games sector, but has nonetheless made considerable progress. Conversely, its competitive position in interior design deteriorated until the corresponding RCA index eventually became negative, indicating a revealed comparative disadvantage for this good. The ability of the EU to compete in arts and crafts goods was already low at the outset (2000), and had fallen further behind by 2005. A similar trend is observable for the visual arts, with the notable exception of antiques. Though the EU mostly retains its power to compete in design goods, its competitiveness there has definitely been eroded.

5.2.5.2. Trade in creative industry services

Consistent evidence on trade in creative industries' services is only available for 11 EU Member States. This group of countries increased its aggregate exports of creative industries' services by nearly 60 % between 2000 and 2005, while the increase in imports of creative industries' services was less than 1 % a year. Evidence derived from this limited group of countries strongly suggests that the great dynamics in trade of creative industries' services differs from the sluggish trend in trade of creative industries' goods. As of 2005, the sample of 11 countries was still a net importer of creative industries' services, but it certainly managed to improve its trade balance for creative industries' services to a considerable degree.

The group of 11 EU countries advanced its international competitiveness in architectural, engineering and other technical services. This finding is relevant in economic terms since this creative industries' service category also forms the top service category of the sample under review. As of 2005 its share came to 30 % of total creative industries services. With a share of 24 %, royalties and licence fees ranked second, which underlines the need to develop and enforce regulatory framework conditions that are responsive to the challenges of the digital age.

Since the internal market is an opportunity to boost intraregional trade in creative industries' services, it is important to evaluate the current cross-border trade and the potential barriers. Another indicator of service trade is the percentage of firms carrying out cross-border trade. In the selected western EU countries, the percentage of firms ranges between 8.9 % in architecture and 23.1 % in software consultancy (Table 5.8). The corresponding share for advertising is 16.3 %. The sample of eastern EU countries shows similar shares except for software consultancy and supply.

Given the low share of exporters among service firms it is worth investigating the main barriers to export (such as taxation issues and language and cultural barriers). Table A.4 (in the appendix) provides an overview of a number of potential barriers to service exports characterised by the degree of importance: somewhat, fairly, very and not important. All business service firms, exporting or non-exporting, were questioned. The greatest barriers are said to be 'difficulties in identifying potential clients abroad', 'lack of international standards for services' and 'language and cultural barriers', while 'insurance, guarantee systems, etc. issues' and 'taxation issues' are less important.

([64]) The revealed comparative advantage formula is available in the statistical annex of this report.

Table 5.7: Trade in creative industries' services in 11 EU countries, key figures

	Export of creative industries' services		Import of creative industries' services	
	Share in total creative industries' services (2005)	Average annual change (2000–05)	Share in total creative industries' services (2005)	Average annual change (2000–05)
Total creative industries services	100 %	9.5	100 %	0.6
Royalties and licence fees	24 %	9.8	24 %	1.1
Advertising, market research and public opinion polling services	16 %	10.3	17 %	1.8
Architectural, engineering and other technical services	30 %	12.2	21 %	1.2
Audiovisual and related services	3 %	5.8	9 %	- 5.3
Research and development services	21 %	7.7	17 %	6.7
Personal, cultural and recreational services	6 %	4.0	11 %	- 4.9

Note: The 11 EU countries are the Czech Republic, Germany, Spain, Italy, Latvia, Poland, Portugal, Romania, Slovenia, Finland and Sweden.
Source: Unctad global databank on world trade in creative products, WIFO calculations.

5.2.6. Evidence on the urban specialisation of the creative industries

A major characteristic of creative industry firms is their geographical clustering. Firms that produce creative goods and services are located in close proximity. A large number of empirical studies show that the creative industries and creative professionals (also referred to as the 'creative class') are highly concentrated in metropolitan and urban areas. For a recent contribution see Power and Nielsén (2010) at the NUTS 2 level for the EU countries. (NUTS 2 correponds to the Nomenclature of Territorial Units for Statistics, representing basic regions for the application of regional policies.) Calculations at NUTS 2 level for several EU countries reveal that the regional difference in the share of creative industries within countries is greater than the difference between EU countries, as indicated by the coefficient of variation. The same holds when the share of creative occupations is used to calculate the coefficient of variation between regions and industries.

Table 5.8: Share of enterprises carrying out cross-border trade, 2004

	EU-West	EU-East
Software consultancy and supply	23.1	17.4
Architectural and engineering activities	8.9	8.7
Advertising	16.3	15.2
All NACE branches — Total	13.0	12.4

Note: EU-West includes Denmark, Ireland, Spain, Italy, Luxembourg, Portugal and Sweden. EU-East includes Bulgaria, the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Romania, Slovenia and Slovakia.
Source: Eurostat structural business statistics, WIFO calculations.

Figure A.4 in the appendix gives a first indication of the urban specialisation of the creative industries in the EU-27, based on the Amadeus database where specialisation is measured as the location quotient in 2006 ([65]). The evidence shows that cities have far higher concentrations of creative industry activity than does the national economy. In particular, Ljubljana, Warsaw, Bratislava, Prague, Vienna, Sofia, Rome, Copenhagen and Lisbon all have a location quotient of 2.0 or higher. Unpublished results show that the location quotient does not vary much when the spatial unit is defined as the core city or the metropolitan unit, except in the cases of London and Paris, where the location quotients are much higher.

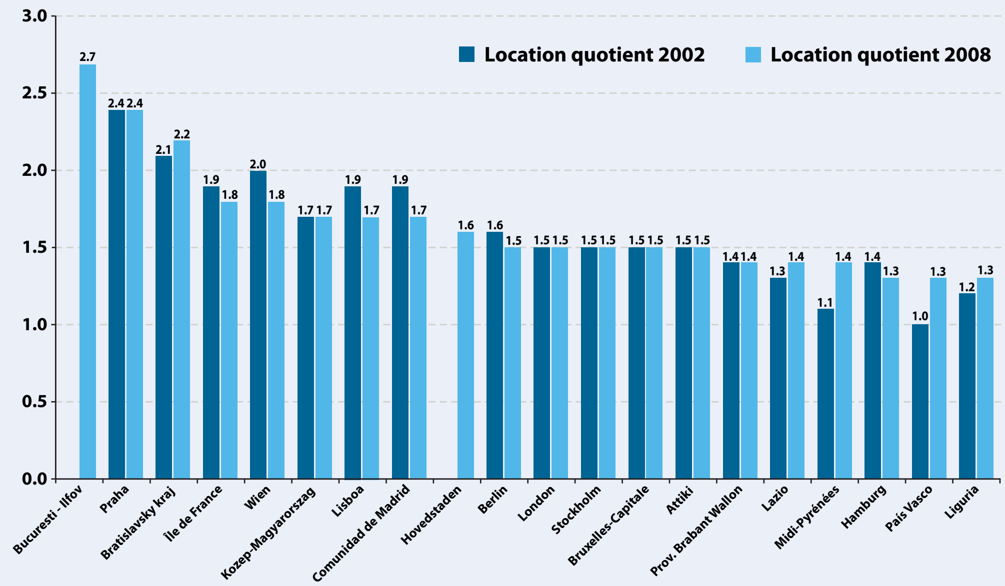
A similar picture emerges when the location quotient is based on the occupational measure. Figure 5.7 shows the location quotient based on creative occupations at NUTS 1 and 2 levels for the 17 EU countries for which data is available.

The findings show that 17 out of 20 NUTS regions with the highest share of creative occupations are capital regions or semi-capital regions. Again, Bucharest, Bratislava and Prague have location quotients for creative occupations of 2.0 or more.

The finding that creative industries and creative workers are concentrated in urban areas is consistent with the related literature. A recent study conducted for the European Cluster Observatory also shows a high degree of urban clustering (Power and Nielsén, 2010). In particular, the authors find that large urban areas and capital city

([65]) The location quotient indicates whether and to what extent the share of creative industries (creative occupations alternatively) exceeds the national average. A location quotient of 1 indicates that the employment share of the creative industries in the given area is identical to that of the national economy. A quotient greater than 1 means that the creative industries are more prevalent in a given area than in the national economy.

Figure 5.7: Location quotient of creative occupations, 2002 and 2008



Note: Location quotients are calculated at NUTS 1 or 2 levels for the following countries: AT, BE, CZ, DK, DE, EL, ES, FI, FR, HU, IE, IT, PT, RO, SE, SK and UK. It is not possible to calculate the location quotient of creative occupations for SI, PL and BG because there is no information on ISCO 88 at the 3-digit level in the EU labour force survey microdata. In addition, there is no regional information for EE, LT, LU, LV and NL. See Table 1 for the definition of creative occupations. All numbers are weighted to reflect national population weights.

Source: EU labour force survey, 2002 and 2008.

regions dominate the creative and cultural industries. Furthermore, empirical evidence for North America and the EU suggests that urban concentration is uneven across the different creative industries and among the different creative occupations. For Sweden, Hanson (2007) finds a higher degree of spatial concentration of 'bohemians' (artists, writers, etc.) as compared to all creative workers (Hanson, 2007). For the EU countries, Power and Nielsén (2010) find that sub-industries with the highest urban concentration include (i) reproduction of computer media, sound recording and video recording, (ii) publishing of software and sound recordings, (iii) motion picture and video production and distribution and (iv) news agency activities. Similarly, evidence at regional level for the UK shows that the highest urban concentrations can be found for video, film and photography, music, visual and performing arts and radio and TV, with London location quotients of about 2.7, 2.4 and 3.1, respectively (De Propris et al., 2009). London also shows the highest urban concentration of advertising, designer fashion and publishing as compared to the creative industries at large. The remaining creative industries are more evenly distributed across the British regions.

Using metropolitan data for the US for the year 2001, Schoales (2006) finds that independent artists, writers and performers and jobs in motion picture and video production, distribution and postproduction show the highest level of spatial concentration of all industrial activities and services except hotel casinos. The author suggests that these industries are very cluster-dependent because of an inherently rapid pace of product innovation.

Table 5.9 presents evidence on the degree of spatial specialisation for selected creative occupations based on the EU labour force survey for 2008.

Table 5.9: Location quotient of core creative occupations in urban, rural and intermediate populated areas, EU-14 and EU-7, 2008

		EU-14			EU-7		
		Densely populated area	Inter-mediate area	Thinly populated area	Densely populated area	Inter-mediate area	Thinly populated area
	Share of creative occupations	9.6	6.2	4.5	7.2	4.6	2.5
	Total creative occupations	1.25	0.81	0.59	1.53	0.98	0.53
211	Physicists, chemists and related professionals	1.27	0.82	0.52	1.49	1.03	0.55
212	Mathematicians, statisticians and related professionals	1.57	0.46	0.23	2.09	0.63	0.20
213	Computing professionals	1.30	0.78	0.47	1.71	0.91	0.40
214	Architects, engineers and related professionals	1.20	0.91	0.57	1.51	1.01	0.55
221	Life science professionals	1.11	0.80	1.01	1.16	1.15	0.79
222	Health professionals	1.25	0.79	0.63	1.31	1.17	0.65
243	Archivists, librarians and related information professionals	1.27	0.61	0.84	1.46	1.16	0.52
244	Social science and related professionals	1.23	0.82	0.64	1.52	1.00	0.54
245	Writers and creative or performing artists	1.36	0.65	0.53	1.86	0.72	0.36
347	Artistic, entertainment and sports associate professionals	1.28	0.73	0.63	1.53	0.75	0.64
521	Fashion and other models (1)	1.18	0.58	1.18	1.16	2.28	0.30

Note: EU-14 refers to AT, BE, DE, DK, EL, ES, FI, FR, IT, LU, NL, PT, SE and UK. EU-7 refers CY, CZ, EE, HU LT, LV and SK. All numbers are weighted to reflect national population weights. Densely populated areas are defined as local areas with a density superior to 500 inhabitants per km2, where the total population for the set is at least 50 000 inhabitants. Intermediate areas have a density of 100 inhabitants per km2 with a total population for the set of at least 50 000 inhabitants. Thinly populated areas contain areas that belong to neither types (see EU labour force survey user guide).

(1) In some cases, the number of observations is less than 50. The number of observations is sometimes fewer than 50 for 'Fashion and other models'.

Source: EU labour force survey 2008.

In the EU-14 (EU-15 excluding Ireland) the difference in location quotient between rural and urban areas is greatest for mathematical and statistical professionals, writers, creative/performing artists and computing professionals. For artistic, entertainment and sport occupations, the rural-urban gap is close to that of all creative occupations.

Based on Dutch urban areas and very long time series, Deinema and Kloosterman (2009) find that the arts show the highest degree of spatial concentration, followed by publishing, as compared to advertising, architecture and broadcasting. The magnitude of spatial concentration not only lasts for a long time, but also seems to be reinforced over a long period of time. In other words, some creative industries display a very high degree of path dependence. Calculations based on EU data also show that the spatial pattern in the location of creative industries is highly persistent over time.

There are several reasons why creative industries are concentrated in urban areas. The main factors are: (i) importance of specific local labour markets and tacit knowledge; (ii) spillovers from one specific creative industry to another; (iii) firms' access to dedicated infrastructure and collective resources; (iv) project-based work; (v) synergistic benefits of collective learning; and (vi) development of associated services, infrastructure and supportive government policies (Lorenzen and Frederiksen, 2008; Malmberg and Maskell, 2002). Local labour markets are particularly relevant for the creative industries. Creative industry firms locate near one another in order to take advantage of a common pool of labour, knowledge and ideas. Lorenzen and Frederiksen (2008) mention the high degree of mobility and labour flows between different creative industry firms. In addition, there are a significant number of multiple job holders (e.g. a film director involved in advertisement production). Localisation helps to decrease transaction costs due to the temporary and flexible nature of projects. The second point concerns knowledge spillovers. Typically, agglomeration economies related to knowledge spillovers are usually more pronounced in skill-intensive industries, as is the case for creative industries. The size, density and compactness of urban centres foster interpersonal interaction, creating greater opportunities for enhanced information flows. As a result, cities have historically been the places where much innovation has occurred (Bettencourt et al., 2007). Another reason is firms' access to infrastructure — such as music schools and opera houses — and collective resources (e.g. universities). Furthermore, clustering in the creative industries is also related to the fact that the work is often project-based with many face-to-face contacts due to high levels of uncertainty, instability and project complexity, as well as short product cycles (Lorenzen and Frederiksen, 2008).

Evidence on interrelations between different creative industries can be obtained by investigating co-location patterns. Advertising businesses tend to favour highly centralised downtown locations in order to be close to national newspapers and television stations (Grabher, 2002). The media industry often manifests itself as a specialised form of cluster designed to produce media content, such as motion pictures, television programmes/videos, broadcasts, audio recordings, books, newspapers, magazines, games, photography and designs, websites and mobile content (Picard, 2009). Wu (2005) suggests that multimedia firms (i.e. firms that provide Internet content) appear to settle in places where the traditional media sector (e.g. the film and music industry, entertainment) and the software industry are already in place.

There are also significant relations between the media industry and music and theatrical performance and festivals, sport and entertainment activities, information and communication technologies (computers, software, telecommunications) and hardware manufacturers (television and radio receivers, set-top boxes, game consoles, DVD players, etc.) (Picard, 2009).

Currid and Williams (2010) find that several cultural subsectors show strong co-location patterns. Using highly disaggregated data for Los Angeles and New York, the authors find correlation coefficients across districts of 0.75 and higher for (i) performing arts and music, (ii) music and film, (iii) art and design, and (iv) art and film. The co-location patterns are explained by cultural infrastructure.

Not only are creative industries as a whole heavily concentrated in urban areas but the degree of urban concentration also depends on the type of creative industry. A very high degree of spatial concentration can be found in film, music and other arts. The tendency of the music industry to agglomerate in urban areas can be explained by the fact that the music industry is very often a highly localised cultural product industry that draws on a local creative background and cultural forms (Power and Hallencreutz, 2002; Hesmondhalgh, 1996). Another reason is that the national subsidiaries of major international record companies are also located in major cities. Within such music clusters, new project partners (e.g. art direction, media and event firms) can be easily found, which reduces transaction costs (Maskell and Lorenzen, 2004; STEP, 2003).

Given the degree of urban concentration in creative industries, it is natural to ask to what extent this is linked to factors such as population size, GDP per capita and availability of human capital. It is obvious that size matters. Large cities have a large number of consumers with a high disposable income for spending on luxury goods and a significant amount of leisure time. The next step, therefore, is to explore the statistical relationship between the concentration of creative industries in cities and the size and wealth of the population of those cities. The data on metropolitan population, GDP per capita in PPS and the tertiary share are obtained from the urban audit statistics and refer to 2006 or the latest available year. The location quotient is calculated based on the Amadeus database and refers to 2006.

OLS (ordinary least squares) estimation results indicate that population size and human capital are the most important factors that affect the spatial concentration of creative industries in different urban areas in the EU. In particular, the larger the population of a European city or metropolitan area, the larger will be its share of creative industries relative to the national average. However, the elasticity of the 0.26 location quotient with respect to population size indicates that the degree of urban specialisation of the creative industries rises less than proportionally with an increase in population size. The significance of population is related to the fact that many cities have too few inhabitants to constitute sufficient consumer demand for the specialised services that creative industries offer. The elasticity for the tertiary graduate share indicates that the degree of urban specialisation of the creative industries rises proportionally with the tertiary education share. However, in general, causality can go both ways. For instance, the employment share of creative industries does not only depend on a significant proportion of highly skilled labour: cities that offer a significant output of creative and cultural products as compared to the national average also tend to attract more highly skilled workers. GDP per capita is only significant at the 10 % level. The location quotient of capital cities is not significantly higher than that of non-capital cities. Other factors, such as past population growth and the share of foreign-born people, are not significant. Belonging to a capital city is not significantly related to the location quotient once cities' GDP per capita and human capital population size are controlled for.

5.3. Growth effects and the wider role of the creative industries

5.3.1. Relationship between the size of creative industries and regional growth

There is an ongoing debate about the effects of creative occupations and creative industries on regional growth in the EU and the US. Florida (2002, 2004) suggests that creative people are key drivers of urban and regional growth. This 'creative class' hypothesis has received much attention among scholars, policymakers, urban planners and civic leaders. In particular, the creative class hypothesis links urban growth with the knowledge economy. According to Mellander and Florida (2009) the creative workforce can have an indirect impact on regional growth through its positive impact on high-tech employment, innovation and entrepreneurship.

In recent years there have been numerous studies testing Florida's hypothesis using more rigorous econometric methods. So far, empirical evidence on the growth effects of the creative class hypothesis and/or the creative industries is mixed and controversial. However, the results based on regional data for EU countries tend to be more optimistic about the growth effects of the creative industries (Piergiovanni et al. (2009) for Italy; Stam et al., 2008; Marlet and Van Workens (2007) and Oort et al. (2009) for the Netherlands; Falck et al. (2009) and Möller and Tubadji (2009), both based on German regional data; Boschma and Fritsch (2009), for two EU countries; and Chantelot (2008), based on French data). Andersen (2010) validates Florida's theories with regard to larger Nordic city regions. Although these studies show positive results, it is difficult to generalise from the findings since they differ widely in their scope: they are based on different sample periods and countries, different definitions of the creative occupations and on different model specifications and estimation techniques.

Much of the controversy concerns how to define and measure the creative class. The major critical point is that there is no clear distinction between the creative class and people with high educational attainment, since no high-skill occupations have been excluded from the creative class (Markusen, 2006). In fact, a number of empirical studies find a high degree of correlation between human capital (measured as the share of working-age population with tertiary education) and the creative class. Using Swedish regional data, Hansen (2007) shows that this correlation is 0.94. He captures the latter in terms of educational attainment levels. For the US, Glaeser (2005) finds a 0.75 correlation between the share of college graduates and the creative class. Based on regional data (at the NUTS 1 and 2 levels) drawn from the EU labour force survey from 2008, the correlation between the share of creative occupations and the share of workers with tertiary education is 0.8. This indicates that the creative class is little different from the group that have received tertiary education (which often is the source of measurement of human capital) and raises serious doubts about how much the creative class concept introduced by Florida (2002) adds to the theory of human capital. From an empirical point of view, the high degree of multicollinearity makes it impossible to sort out the individual effects of the two explanatory variables.

Given the high degree of correlation between human capital and the creative class, it is not surprising that only a few studies come to the conclusion that the creative class measures explain growth better than human capital (Marlet and Van Workens (2007) for the Dutch regions; Möller and Tubadji (2009) for German regions). In a study of the 50 most important cities in the Netherlands, Marlet and Van Woerkens (2007) find that both the creative class concept and education are significant. More importantly, the professional categories which make up the creative class are better indicators for predicting economic growth than human capital. In contrast, the 'bohemian index' is not a useful indicator for explaining the differences in economic performance among Dutch cities. In an influential study, based on US metropolitan data, Glaeser (2005) finds that the creative class becomes an insignificant factor of urban growth when human capital is included. Similar findings are obtained by Hoyman and Faricy (2009) based on US data. Rausch and Negrey (2006) also find that the concentration of creative class workers is insignificant in explaining metropolitan output growth after controlling for educational attainment.

Some studies do not even find that creative occupations have a direct effect on growth, even when human capital is not controlled for (Beckstead et al., 2008; Donegan et al., 2008; Rausch and Negrey, 2006; Beyers, 2010). Few studies investigate whether creative occupations are a significant driver of growth not only in urban but also in rural areas. An exception is the study by McGranahan and Wojan (2007), who find that both urban and rural areas with higher levels of creative occupations are associated with higher rates of total employment growth. Overall, the literature suggests that the creative class is important, but is not the dominant driver of metropolitan economic growth. Human capital and innovation are more important. An interesting result is obtained by Chantelot (2008) based on French urban data, namely that the growth effects of creative occupations are greater in metropolitan areas than in medium-sized cities.

Table A.5 in the appendix provides ONS estimates of the relationship between the employment share of creative industries and the average annual change in GDP per capita in purchasing power parities between 2002 and

2007. Alternatively, the real growth rate of regional GDP at market prices between 2002 and 2006 is used. The underlying data are at NUTS 2 regional level and drawn from the New Cronos regional database, combined with the employment share of the creative industries drawn from the Amadeus database, also at NUTS 2 level. All explanatory variables refer to 2002. Three specifications are provided. The first includes the initial log level of GDP per capita, the employment share of creative industries and the dummy variable for capital city regions. The second specification adds the investment ratio and the third includes the share of working age population with tertiary education as well.

The results show that the employment share of the creative industries in the initial year has a positive and highly significant impact on the average annual growth rate of regional GDP per capita in the next five years. This indicates that regions with a high employment share of creative industries grow faster than other regions (column i). The coefficient of 0.15 indicates that an increase in the employment share of the creative industries by 1 percentage point raises the average annual growth rate by 0.15 percentage points ([66]).

The coefficient of the share of creative industries remains positive and significant when the investment ratio is included in the regression equation. However, the coefficient of the employment share of the creative industries drops considerably when human capital is included in the regional growth equation as indicated by column (iii). Furthermore, the standard error of the coefficient on the employment share of creative industries is enlarged due to multicollinearity between the share of creative industries and the share of workers with tertiary education ([67]). Wald test statistics of joint significance indicate that both the employment share of creative industries and human capital are jointly significant at the 5 % level. Looking at the magnitude of the effects, one can see that human capital is more important than the share of the creative industries in explaining regional growth ([68]). The finding that human capital is one of the main drivers of regional economic growth is consistent with the literature (e.g. Glaeser et al., 2000).

As expected, lagged GDP per capita is significantly negative. The coefficient indicates that the speed of convergence is about 1 % per year, which is in line with earlier studies. The dummy variable for the capital city region is significantly negative, indicating that these regions exhibit, other things being equal, lower growth rates of GDP per capita.

When the growth rate is measured as real growth of GDP per capita in euro (rather than in current PPS), both human capital and the share of the creative industries are seen to have a positive and significant impact, as indicated by the Wald test statistic (lower panel of Table A.5 in the appendix). This means that the estimation results are not sensitive as to whether GDP is measured in euro or in PPS.

To sum up, the key result in this section is that the initial share of the creative industries has a positive and significant effect on the growth rate of GDP per capita at regional level in 10 EU countries. The positive growth effect of the creative industries remains robust even when allowing for general human capital. This means that the real growth rate increases when other firms from the creative industries decide to locate nearby. The positive growth effects could be related to the fact that the resulting increased concentration of creative industry firms within a region facilitates knowledge spillovers. It appears that aggregate growth depends on the industrial structure and/or the concentration of specific industries, and this result is consistent with Peneder (2003), who finds that aggregate growth is significantly positively related to technology-led and skill-intensive industries based on a sample of OECD countries.

5.3.2. Supply-chain linkages between creative industries and the rest of the economy

One way of investigating the wider effects of the creative industries is to look at the importance of creative goods and services as an intermediate input factor in other sectors. These supply-chain relationships may be an important factor for productivity gains and innovation. Innovation effects might reflect the direct provision of innovative services in the case of advertising companies, say, that are developing new brands for their clients, or design consultancies that are offering customers product design services. Knowledge spillovers may also occur if creative working practices 'rub off' onto their business clients in an unremunerated way. A second mechanism under consideration is the possibility that the creative industries support local innovation systems through channels — including knowledge spillovers — that operate specifically at the local level. These mechanisms are not necessarily mutually exclusive.

Business-to-business (B2B) transactions account for the majority of creative industry sales. The official UK supply and use tables show that around 60 % of creative products supplied to the UK economy are used as intermedi-

(66) However, the three variables (i.e. initial GDP per capita, employment share of the creative industries and the dummy variable for capital cities) in the basic equation explain only a small proportion of the variations in growth rates across European NUTS 2 regions, as indicated by the low *R* squared of 0.08.

(67) The correlation between the two variables is 0.44.

(68) In particular, an increase of one standard deviation in the tertiary graduates' share leads to an increase in the growth rate of 0.5 percentage points (= 0.057*0.084*100), whereas an increase in the employment share of creative industries by one standard deviation raise the average annual growth rate by 0.2 percentage points (0.11*0.017*100).

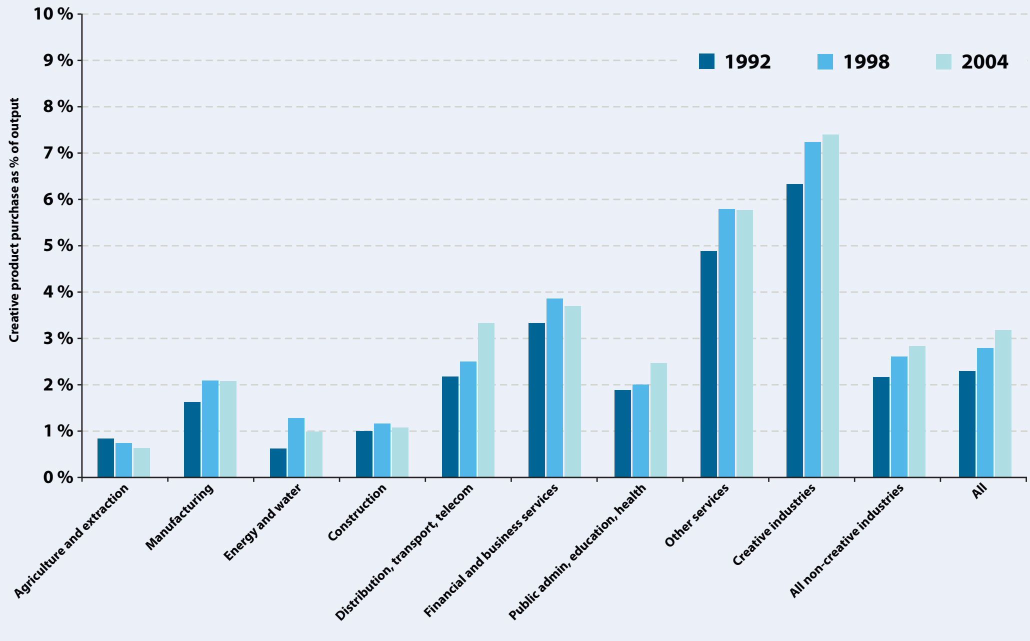
ate inputs for other industries (including other creative industries (Experian, 2007). B2B demand is particularly important for advertising, architecture, software and fashion products (Figure A.5 in the appendix). For the latter two industries, notable growth can be observed over time. Architecture and software products also stimulate investment — adding to the future productive capacity of the UK economy (Figure A.6 in the appendix). Other creative products — the arts, radio and TV and film — are primarily consumption goods.

Evidence based on structural business data for 12 EU countries in 2004 also shows that B2B transactions dominate in software architecture and advertising with a turnover share of 80 % or more in software and 93 % in advertising. Households account for 3 % to 6 % depending on the subsector. The public sector accounts for the remaining part.

Industry purchases of creative products accounted for around 6 % of overall intermediate purchases by UK industries in 2004 and were equivalent to around 3 % of total gross industry output (Figure 5.8). These 'forward' supply chain linkages from the UK's creative industries appear to be stronger for certain services sectors than they are for manufacturing. Purchases of creative products were particularly important among the creative industries themselves: creative product purchases made up over 8 % of total gross output and accounted for 19 % of intermediate purchases by the creative industries.

Calculations based on input-output tables for Denmark lead to similar findings (69). Figure A.7 in the appendix shows the 20 largest industry users of creative inputs among 121 Danish industries at the 3-digit level. Again, the creative industries themselves are the largest supplier, with a creative intermediate input share of 37 %. The real estate sector acquires 22 % of its input from the creative industries (mainly inputs from publishing and software consultancy and supply). Among the manufacturing industries, manufacturers of tobacco and beverages have the highest share of creative intermediate input due to their extensive use of advertising services. The education sector also has one of the highest usage rates of creative input (over 10 %), which is due to its close integration with the audiovisual sector. In addition, wholesale and retail trade have a higher than average rate of usage of creative inputs. Unpublished results show that advertising and software consulting have supply-chain linkages with all of the 116 non-creative industries.

Figure 5.8: UK industry purchases of UK creative products, 1992–2004



Source: ONS UK input-output supply and use tables, used in Experian (2007).

(69) *Statistics Denmark* provides a detailed input-output table (121 x 121 product industry matrix). For most EU countries official input-output tables are only available at the 2-digit level.

5.4. The role of innovation in the creative industries — The role of the creative industries in innovation

The links between the creative industries and innovation are manifold. First, the innovation performance of the creative industries is above average ([70]), although often underrated due to the mostly non-technological nature of these activities (Stam et al. (2008) for the Netherlands; Bakhshi et al. (2008) and Bakhshi and McVittie (2009), both for the UK; Müller et al. (2009) for Austria). Creative industries' innovations rely on R & D inputs, and may not even promote the primary generation of new knowledge. Rather, innovations are driven by acts of creativity and cooperative efforts (Potts, 2009).

Second, this specific innovation behaviour of creative industries' firms helps increase their dynamic capabilities and thus helps disseminate new technologies. Creative industry firms tend to make use of a large network of weak, heterogeneous relationships that ensure easy access to and fast absorption of new knowledge — an observation which fits in well with the evolutionary/systemic view of innovation. Knowledge and technology transfer is also driven by a strong functional or regional (business-to-business) network structure (Potts et, 2008).

Third, the dynamic development of the creative industries is closely tied to technological progress and innovations in some key technologies developed elsewhere. Current means of mass (re)production, mass consumption and commercialisation of artistic/creative content have been made possible mostly by technological advances in the fields of information and communication technology (Cunningham et al., 2004). In fact, creative industries are intense users of ICT innovations in particular, as well as other new technologies. For instance, digital technologies and compression methods for audio and video signals that allow efficient storage and rapid transmission with little loss of quality have created new, low-cost means of sales distribution. Such a development accelerates the diffusion of technological innovations from the supply side (Müller et al., 2009). Lastly, consumer habits, particularly those of young buyers with considerable affinity for technology, play a crucial role from the demand side (for the role of consumers see Hartley (2008)).

New data from the fifth UK innovation survey suggest that the creative industries have higher levels of product, process and wider innovation activities than other sectors ([71]). For example, 32 % of creative industry businesses introduced product innovations in the three years to 2007 (compared to 21 % in other industries) and 16 % introduced new process innovations (compared to 11 % outside the creative industries). The differences are greater when considering new-to-market, as opposed to new-to-firm, innovations: here, proportionately twice as many creative businesses were product innovative (14 %, compared to 7 % in the rest of the economy) and process innovative (6 %, compared to 3 % in other sectors). As many as 40 % of creative industry firms introduced wider innovations in the three years prior to 2007 (that is, they made changes to their corporate strategies, management techniques, organisational structure or marketing methods), compared to 29 % in other sectors.

Furthermore, new evidence based on the Community Innovation Survey (CIS) 2006 for 19 EU countries also shows that creative industry firms are more innovative than firms belonging to non-creative industries ([72]). However, this innovativeness varies greatly from one industry to another. Most notably, it is very high in software consulting and supply, a little lower in architecture and close to average in advertising and publishing. In particular, for the seven EU-15 countries for which data are available, half of the software firms introduced new or significantly improved services and/or goods, while for other services the share was 12.7 %. There are similar findings for the remaining EU countries. The difference in innovativeness is even more pronounced when market novelties are considered: 36 % of west European (EU west includes Denmark, Ireland, Spain, Italy, Luxembourg, Portugal and Sweden) software firms were innovative in the three-year period 2004–06, compared to only 4.6 % of other service industries.

Compared to non-creative service industries, the architecture and advertising industries also have a higher percentage of firms introducing new or significantly improved services — although the difference is less pronounced than in the case of the software industry. Firms in the publishing sector are no more innovative than other manufacturing industries. Turning to process innovations, software firms again show a higher proportion of innovation than firms in the non-creative services. For the remaining creative industries the evidence is not

([70]) A recent IPTS report supports this statement on the innovation performance of creative industries and in particular the quite outstanding one of the software sector. The report indicates that, from 2002 to 2007, business expenditures in R & D (BERD) increased by 40 % and employment of researchers by 56 % in the computer services and software sector (NACE Rev. 1.1 sector 72). See Turlea 2010.

([71]) This survey covers the period 2005–07 with a sample size of 14 870 firms. Traditionally, not all of the 4-digit SIC codes that define the creative industries have been covered by the sample frame, but the statistical authorities have in recent years made particular efforts to address this. Advertising, architecture, arts and antiques, designer fashion, most of publishing (except news agency activities) and most parts of video, film and photography, software, computer games and electronic publishing are included. Radio and TV and all firms in artistic and literary creation and operation of arts facilities — which are part of the music, visual, and performing arts sector — are excluded.

([72]) However, in CIS data for the 19 EU countries, coverage of the creative industries is limited to publishing, software consultancy and supply, architecture and advertising, unlike the CIS data for the UK, which also includes arts and antiques, designer fashion and most parts of video, film and photography, software, computer games and electronic publishing.

clear-cut. While publishing shows a higher share of firms with new production processes, architecture and advertising exhibit a similar proportion of innovators.

There is a similar pattern when different innovation-input activities (i.e. R & D and non-R & D innovation activities) are considered. Evidence based on the CIS 2006 survey for the UK suggests that creative industry businesses tend to engage in more innovation-related activities, undertake more R & D, invest in more training and spend more on design than firms in other sectors (Figure A.9 in the appendix). Descriptive evidence based on CIS 2006 data for 17 EU countries shows that software and architectural services have a significantly higher share of firms conducting R & D (47 % and 27 %, respectively) compared to 6 % for other services (based on seven EU-15 countries). More generally, innovation activities in the creative industries are much broader than just R & D investment. The evidence shows that creative industry firms tend to engage more in training activities related to innovation and the acquisition of external expertise and new machinery as compared to firms outside the creative industries. This also holds for advertising and publishing.

Creative industry firms are not only more innovative in general but are also early adopters of Internet and e-business practices. Evidence based on the e-business w@tch survey 2005 of seven EU countries shows that more than 30 % of creative industry firms had adopted e-business activities by 2000 or earlier, compared to 17 % for the remaining industries. More importantly, the majority of technological innovations (90 % of innovations in the publishing industry, for instance) are enabled by ICT.

Following the system of innovation literature, the ability of firms and industries to generate innovations depends not only on the performance of individual firms but also on their interaction and organisation. There are many additional players, including other firms (suppliers, customers, subcontractors and competing firms) and intermediary organisations (consultants, technology centres, governmental offices and regulatory agencies), as well as public and private research centres and universities. It is within these networks that people are able to learn about, imitate and eventually create new products and ideas. Müller et al. (2009) note that, as a rich source of ideas and knowledge, the creative industries exhibit strong positive external effects on other innovating firms, such that a blind focus on their own innovative output is likely to underestimate the importance of the creative industries for the greater innovation system.

As prime producers of intellectual property, the creative industries are expected to be a particularly attractive source of external knowledge for innovating firms. They offer a diverse bundle of creative products and services, ranging from ideas for innovations to R & D support and product design (Müller et al., 2009). The design sector provides an especially good example of the supply-side effects. This sector has gained significant importance over the past years and has earned itself a steady place in contemporary production. Figures 5.9 and A.7 (in the appendix) show the extent to which other industries make use of inputs from the design sector. The descriptive statistics are calculated using the CIS 2006 micro data for a sample of 15 EU Member States.

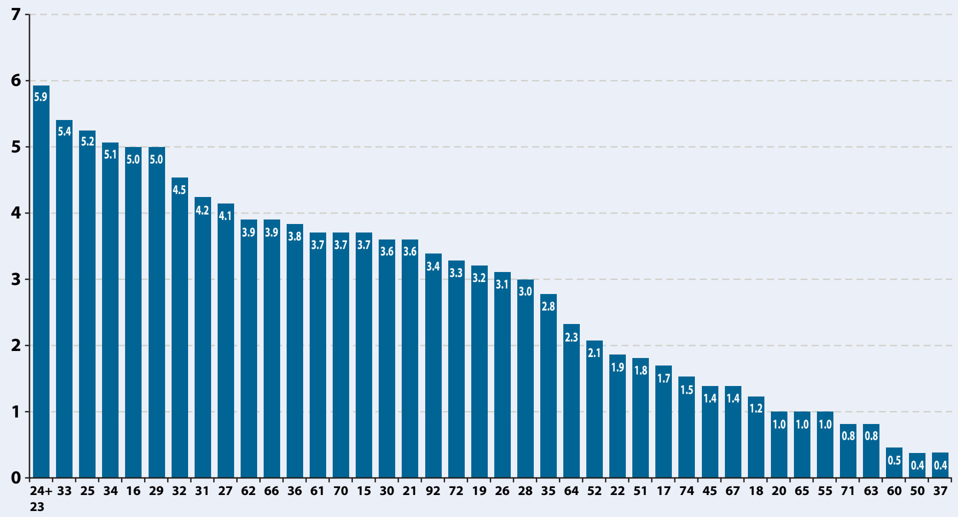
Figure 5.9 shows the proportion of firms that used industrial design registration as a protection method in a sample of 15 EU countries (largely from the new Member States). A design registration offers the opportunity to protect intellectual property rights against others who subsequently produce articles with the same or similar appearance.

Clearly, most industrial design registrations are found in manufacturing industries such as chemicals and pharmaceuticals, minerals, glass and ceramics, motor vehicles, tobacco and machinery. This shows that some forms of creativity, such as design, can be found in all industries; they are not restricted to a limited group of creative industry firms.

Another way to ascertain how and to what extent designers affect innovations in the greater economy is to look at the proportion of enterprises that introduce significant changes to the design of goods and services. Based on CIS 2006 data for four EU countries, Figure A.8 in the appendix shows that product design innovations can be found in all industries. In the chemical and pharmaceuticals sector, one fourth of the firms introduced product design innovations during the period 2004–06. A higher than average proportion of design innovators can be found in tobacco, banking, insurance, food and software. As expected, design innovations are less frequently reported in non-manufacturing industries such as transport and energy and water supply.

Descriptive evidence based on 14 EU countries shows that different knowledge sources are more frequently used in both software and architecture firms than in the non-creative (services) industries. For instance, 73 % of software firms answered that clients and customers are an important source of innovation (to a medium or high extent), compared to 39 % in the non-creative service industries. Another example refers to knowledge sourcing from universities: about a quarter of software and architecture firms regard university research as an important source of information for the innovation process, compared to 10 % in non-creative service industries. In addition, three of the remaining knowledge sources (i.e. government or public research institutes, scientific journals, trade/technical publications

Figure 5.9: Proportion of firms with industrial design registration across EU industries, 2004–06



Note: The x axis labels the NACE Rev. 1.1 codes. The sample includes Bulgaria, Cyprus, the Czech Republic, Estonia, Spain, Hungary, Ireland, Lithuania, Luxembourg, Latvia, Malta, Norway, Portugal, Romania and Slovakia. All numbers are weighted to reflect the population of firms.
Source: Community Innovation Survey 2006, WIFO calculations based on Eurostat data.

and consultants, commercial labs and private R & D institutes) are regarded as much more important by both software and architecture firms than firms outside of the creative industries. However, in advertising and publishing, the degree of importance of these information sources does not differ much from the non-creative service firms.

The CIS 2006 shows that in the western ([73]) and eastern ([74]) EU countries for which data are available, about one third of software and architecture firms are actually working together to innovate. In the western EU countries this proportion is twice as high as that of firms in the non-creative services sector; in the eastern EU countries it is 13 and 8 percentage points higher, respectively, than in the remaining service sectors. When it comes to choosing cooperation partners, software firms most commonly choose to work with their customers. Customers are involved in the innovation activities of about 28 % of firms in EU-West and 40 % in EU-East. In architecture and advertising, suppliers are the most important cooperation partners. It is interesting to note that in the EU-West countries, universities are the second most important cooperation partners for software firms (19 % of firms) and the third most important partners for architecture firms (also 19 %). For firms in non-creative industries, universities come only sixth. In the EU-East countries, universities are also much more relevant for software and architecture firms than for the rest of the economy. Overall this suggests that the importance of interaction between science and industry is most pronounced in software and architecture. It appears that these industries rely to a larger extent on new knowledge developed by universities.

As already mentioned, enterprises in the creative industry tend to be heavily involved in business-to-business activities. They produce creative intermediate goods that are used as inputs in non-creative industry sectors, thereby contributing to innovations in the wider economy. Bakhshi et al. (2008) show that, for a wide range of innovation measures, firms with stronger links to the creative industries have a stronger innovation performance. The underlying data consist of input-output tables for the UK at the 3-digit level, combined with the fourth UK community innovation survey. For example, Figure A.10 in the appendix shows that firms in industries that exhibit above-median B2B spending on creative industry products — expressed as a percentage of their gross output — have a stronger innovation performance than firms in industries with below-median B2B spending. Overall this indicates that the creative industries play a significant role in the transfer of knowledge, ideas and innovation in business-to-business transactions. This transfer becomes especially important in the flow of tacit knowledge in the sense of Polanyi (1977), who finds that the transfer hinges on personal communication in a creative environment.

([73]) EU-West includes Denmark, Ireland, Spain, Italy, Luxembourg, Portugal and Sweden.
([74]) EU-East includes Bulgaria, the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Romania, Slovenia and Slovakia.

This finding is consistent with more formal cross-sectional statistical analysis. In particular, econometric models explaining variations in innovative behaviour between firms suggest that firms in industries with stronger B2B linkages to creative industries are, all other things being equal, significantly more likely to introduce product innovations. The estimates suggest that firms that spend double the average amount on creative products — 6 % compared to 3 % of their gross output — are 25 % more likely to introduce product innovations new either to the firm or to the market. To put this result into perspective, according to the model these creative linkage impacts are similar in magnitude to the effect that access to government support has on innovation.

The direction of causality between spending on creative inputs and innovation cannot be established using these cross-sectional data alone. It is also difficult to be certain whether innovation is being driven directly by creative products (as inputs to the innovation process) or indirectly by knowledge transfer — possibly unremunerated — from the creative industries. Bakhshi et al. (2008), based on evidence drawn from the UK innovation survey, find some evidence that knowledge transfer from creative suppliers leads to improvements in product range and quality.

5.5. The policy dimension: summary and conclusions

5.5.1. Policy rationales

Irrespective of the general agreement as to the value of creative industries' policy, there remains substantial disagreement about the best objectives and forms of intervention. Answers vary according to the views held regarding the intended roles of such policies.

The economic rationale for government intervention in favour of the creative industries starts from the notion that this sector constitutes a significant locus of economic dynamism in the post-industrial world. This view evaluates cultural events, institutions and creative activities according to their significance for, or their positive contribution to, the aggregate economy. A survey among creative industries' policymakers in EU Member States indicates their increased awareness of the creative industries, including diverse definitions of these industries and consciousness that they stimulate growth and innovation in various ways. There is a substantial amount of empirical evidence on the primary and secondary economic impacts of the creative industries that would support this view. However, taken by itself this evidence establishes no particular role for sector-specific policies, but rather calls in the first place for horizontal policies to set up proper framework conditions and (re-)establish competitive markets and environments. In this spirit, a recent Green Paper launched by the European Commission (European Commission, 2010) emphasises the importance of fair market access and the role of competition policy in 'creating and maintaining the level playing field which ensures that there are no unjustified barriers to entry' (European Commission, 2010, p. 7). Accordingly, a policy agenda in support of the creative industries would have to include issues such as ensuring fair access to market and to finance, in particular for innovative SMEs, the promotion of cultural exchanges and trade in cultural/creative goods and services within the framework of international agreements (WTO, Unesco Convention on the Protection and Promotion of the Diversity of Cultural Expressions), the reduction of regulatory burdens on creative entrepreneurs and the protection of intellectual property rights.

Apart from establishing first-best framework conditions, the existence of market failure increases the acceptance of further policy intervention. The general support for policy intervention in the area of creative industries points to the overall consensus that the creative industries do indeed constitute a case of market failure in the sense that they give rise to externalities, information failures (Frey, 2003), or structural, institutional and regulatory deficiencies which affect creative industries' activities. These policy rationales apply more strongly to the cultural than to the more market-oriented segments of the creative industries; however, the role of policy would still be to correct these failures should the occasion arise.

Market failures

Producers of creative industries' goods and services face considerable uncertainties in demand. Since the returns are highly speculative, creative industry activities are hard to predict. Not having complete information on the pay-offs of their activities, creative industries' firms are unable to make rational profit-maximising decisions — one of the core assumptions in the neoclassical benchmark model.

Information failures apply especially to the financing of creative industry activities. Even if creative entrepreneurs demonstrate perfect foresight with respect to their future pay-offs, they still face severe difficulties in credibly proving the value of their projects to potential investors, because this would involve revealing information about the originality of the project. However, the creative industry business model is based on the notion of uniqueness and exploiting first-mover advantages; imitation at an early stage would thus be a substantial threat to setting up a new undertaking.

Neoclassical thinking oscillates between the ideas of competitive markets and a well-functioning price mechanism. In principle, entrepreneurial and financial risks could be traded away in markets, especially in insurance. However, the production of creative industries' goods involves a whole range of unknowns and contingencies, and there are few if any markets to underwrite all of these. Furthermore, since both the outcome value and probability distribution of a creative industries' venture are *ex ante* uncertain, there is no reason to believe that competitive markets price such risks appropriately and allocate resources for creative industries' activities efficiently.

In this perspective, demand uncertainties are not the prime problem — these could be met with smartly designed public procurement programmes — but rather the non-existence of proper markets and the lack of a properly functioning price mechanism. A prime policy task would therefore be to remove the barriers faced by creative industries' firms, in particular small businesses (SMEs), in accessing finance, especially start-up capital. Related policy measures involve improving access to (public) finance, taking initiatives to further develop venture funds and improving venture market regulation or reducing regulatory burdens.

The distinguishing feature of creative products is that their value arises mainly in the social sphere, and this introduces another source of market failure: strong externalities, both in the production and consumption of creative industries' products. This means that prices — if they exist — lose their signalling function and fail in their coordinating role of matching production and consumption plans. Where creative industries' activities do link production and consumption — and manufacturing and services in the greater economy — the core policy objective would be to upgrade creative industries' linkages so as to stimulate the emergence of vibrant clusters (Pratt, 2008). Besides addressing the specific market failures that hamper the activities of the creative industries, policies should therefore be particularly aware of (cross-) sectoral linkages and promote clustering.

This view has considerable implications for, for example, the protection of intellectual property rights (IPRs). Clearly, if IPRs are handled too rigidly this raises the transaction costs of knowledge spillovers. For this reason, open access policies and a stronger use of Creative Commons' licences for intellectual copyrights may do more to foster the technological and legal basis of the creative industry business model. Yet the principles of openness and participation may sometimes be hard to put into practice. Apparently, the use of Creative Commons challenges business models based on originality and uniqueness, and the unconditional enforcement of cooperation among competitors would be contested by the very group that such policies target.

Integrating creative industries in innovation systems

Section 5.4 strongly argues that the creative industries fit in well with the systemic and evolutionary concept of innovation. This perspective locates the bottlenecks of innovation not so much in the primary generation of knowledge but in a more fundamental problem. In the first place, firms are said to suffer from 'bounded vision' (Fransman, 1990). When faced with high-pressure deadlines, managers tend to disregard the value of new knowledge, unless it emerges from areas in which their firm is currently active. If they are aware of the importance of new knowledge, their firm's ability to transfer, assimilate and ultimately apply that knowledge to commercial ends often requires a (much too) high level of absorptive capacity. Modern approaches to innovation policy therefore focus on the acquisition of learning capabilities and problem-solving skills. According to this view, the contribution of the creative industries to the economy should not be argued in terms of their impact on economic value but rather of their specific mindset. When the creative industries are seen as a 'higher-order system that operates on the economic system' (Potts and Cunningham, 2008, p. 10), then supporting them would promote a distinct way of thinking and social interaction that is conducive to the whole functioning of the innovation system. Hence, policy rationales based on tertiary economic impact would be eager to build on the original problem-solving skills of the creatives. They would try to establish the creative industries as a kind of 'role model' for the more traditional parts of the economy, since creative industries show how to successfully master (or at least experience) the unknown, how to deal with the complexities and unforeseen aspects of daily business life and how to escape from lock-ins — in short, how to be creative (Potts and Morrison, 2009).

Some related and encouraging best-practice examples can be found in the area of social innovation. Actors simulate mental disorders (borderline personality disorders, depression, schizophrenia, etc.) to help medical students develop their communication skills with future patients. Artists rehearse musical and theatrical performances with prisoners and at-risk youth, thereby teaching them things such as team spirit, discipline, reliability and shared responsibility for the success of a joint project — indispensable social skills and prerequisites for later employability. Creative sector activities that are of practical value for society give rise to quaternary economic effects.

5.5.2. Policy approaches

5.5.2.1. The superposition of policy levels

Creative industries' policies needs are identified and dealt with at various levels. As a result, opportunities and challenges arise in the superposition and coordination of these policy levels. The main ones are the following:

Interdisciplinarity: Creative industries are the archetypal cross-cutting policy field. In addition to cultural and economic policies (including established subfields such as competition, industry, enterprise and SMEs), they span regional policy, technology and innovation policy, employment and social affairs, education and the information society. While far from exhaustive, this list shows that creative industries' policies significantly overlap with other policy areas. In designing and implementing a coherent creative industry policy agenda, it is of the utmost importance to recognise these interlinkages and to create interfaces among the various fields of action. Setting proper framework conditions, as outlined in the previous section, is a good place to start.

Horizontal versus sector-specific: Designing creative industry policy measures fluctuates between creating new sector-specific instruments and absorbing creative industries into existing support measures. Before reinventing the wheel once more, it seems wise to screen the usefulness and applicability of existing measures and to consider redesigning them if necessary. For instance, many of the challenges the creative industries face are the same as for service firms, simply because most of them fall into the service sector. Similarly, many creative industries face the same structural barriers to growth and innovation as SMEs, simply because most of them operate on a (very) small scale. Measures to help creative industries become more competitive and innovative should, as far as possible, be integrated into the overall support structures for service firms, SMEs and non-technical innovation.

Heterogeneity between the subsectors: At the same time, the subsectors of the creative industries are quite heterogeneous in terms of their business models, organisational modes, cooperation structures and economic performance. There is no policy that fits them all. Acknowledging (sub-)sectoral specificities, differences in the targeted size of the firms and even differences in the characteristics and types of creative industry entrepreneurs leads one to quite different conclusions regarding policy support, support structures and policy initiatives.

From local to supranational levels: The diversity among the creative industries is a very good reason for aligning specific policies to local or regional circumstances. On the other hand, supportive horizontal policies are also essential and call for policy intervention at a national or even supranational level. From a beneficiary point of view, a multiplicity of policies at different levels can be useful but also a source of complication. Coordination is crucial to help organisations reach out simultaneously to local, regional, national and supranational support programmes. The following section illustrates how creative industry policies are viewed at national and EU levels.

5.5.2.2. Policies at national and EU level

As the research is concentrated on creative industries in EU Member States, it is essential to get an overview of the priorities at national level before taking an interest in EU policies. In the context of this study, a survey was carried out in which 32 ministries and 17 agencies and organisations took part. Some 90 % of ministries were found to have used the term 'creative industries'; the survey also confirms that the governance structure is split between ministries of the economy and ministries of culture. Ministries of economy are typically in charge of design and software, games and the Internet (more than 70 % of those surveyed claim so), while the ministries of culture cover the 'traditional' areas of cultural policy.

It is worth noting that, in the context of creative industries, institutions concentrate their efforts on 'art and entertainment' and 'information services' activities (see Part 5.2.1 on classification), while activities of the professional services tend to be neglected. The audiovisual sector, design and music are in the portfolio of about 40 % of the responding institutions. Architecture, fashion and advertising get only half as much attention, while the other industries and areas are somewhere in between. None of the included sectors — with the exception of advertising — could be excluded on this strictly empirical basis.

In practice, creative industries are expected to help achieve economic and non-economic goals, with a substantial bias towards economic objectives. The prime motivation is to support innovative activities (72 % of respondents claim that this motive is very important), followed by stimulating economic growth (63 %) and creating new jobs (53 %). These objectives are in line with the analytical findings of this study.

The first non-economic goal — securing cultural diversity — is 'very important' for 51 % of respondents and thus about average in this ranking. The least important motive is the replacement of declining industries. Only 14 % see this as a 'very important' objective while 36 % claim that this is 'not important'. This goal may, in fact, be far more important at regional or city levels than at national level. Indeed, there are plenty of examples, such as the Ruhr district or Barcelona, where creative industries helped revive declining areas.

Moving on from motives to more concrete implementation, the survey revealed trends in the instruments that are most used. 'Networking events' are the preferred means of intervention in Europe's creative economy. Some 70 % of the new Member States (EU-12) use networking events to support the players in this sector. In the EU-15 countries too, networking events are the most widely used form of intervention (57 %). 'Networking events' is a particularly fuzzy notion for a policy measure: it may cover conferences, workshops, websites or attempts to create interaction between distinct groups or within a group, etc. Networking activities seem to be low-key activities in most countries, where no explicit networking measures were observed. The most likely explanation is that a number of policy measures in the surveyed institutions do have networking components that stimulate interaction within the field, rather than a large number of initiatives which aim at networking as such. Grants as a means of intervention rank second in this regard (48 % within the EU-27), followed by the provision of management training (44 % within the entire EU). In certain cases, there are significant differences between practices in the new Member States and the EU-15: marketing and public relations support is almost twice as important in the EU-12 states as in the EU-15. The same is true for intellectual property rights (IPR) support: 35 % of the support institutions in the new Member States offer IPR support, whereas only 18 % in the EU-15 focus on this aspect. In general, the 12 new Member States rank each single intervention category relatively higher than the EU-15 members — except for insurance and access to external capital.

While intervention at national level is justified as a complement to local and regional policies, the same can be said of EU policies with regard to national and subnational policies.

5.5.2.3. The role of the EU

The EU's place, as far as creative industries' policies are concerned, is defined by its exclusive or shared powers and responsibilities.

The Lisbon Treaty which came into force in 2009 defines who is responsible for what in European governance, based on the principles of conferral, subsidiarity and proportionality. These principles ensure that action is taken as close as possible to the citizens. Powers and responsibilities are given to higher levels of governance only to the extent that lower levels cannot come up with sustainable solutions for the problem in hand.

The EU enjoys very few exclusive competencies. Its exclusive mandate is to legislate in the areas of international trade and customs and in setting the (competition) rules that shape the internal market. This is being both stressed and challenged, for instance, by the emergence of China as a powerful exporter of creative industries' products and the globalising market power of some strong players that provide ICT products.

Table 5.10: What are the main motives for your interventions in these sectors and areas?

	Very important (%)	Important (%)	Not important (%)	Rating	Responses
Supporting innovative activities	71.8	28.2	0.0	1.7	39
Encouraging economic growth	62.5	35.0	2.5	1.6	40
Creating new jobs	52.5	45.0	2.5	1.5	40
Increased international visibility of national products and services	54.1	37.8	8.1	1.5	37
Improving networking within the industry	47.4	50.0	2.6	1.5	38
Attracting creative professionals	45.9	48.6	5.4	1.4	37
Securing cultural diversity	51.3	30.8	17.9	1.3	39
Increasing the attractiveness of the country for tourists	48.6	34.3	17.1	1.3	35
Stimulating innovation in downstream industries	35.1	54.1	10.8	1.2	37
Improving the quality of life	39.5	44.7	15.8	1.2	38
Internationalisation of firms	35.1	43.2	21.6	1.1	37
Promoting start-up activities	34.2	44.7	21.1	1.1	38
Improving the attractiveness of the business location	21.6	62.2	16.2	1.1	37
Replacing declining industries	13.9	50.0	36.1	0.8	36

Source: Leoon Consulting.

Table 5.11: Instruments used to intervene in creative industries at national level (in % of respondents)

	EU-15	EU-12	EU-27
Networking events	57	70	63
Grants	39	60	48
Management training	36	55	44
Cluster support	25	40	31
Marketing and PR support	21	40	29
Access to external capital	25	25	25
IPR support	18	35	25
Business consultancy	18	30	23
Access to public institutions as potential clients	18	30	23
Loans	14	20	17
Office resources	11	20	15
Voucher schemes	4	5	4
Insurance	4	0	2

Source: Leoon Consulting.

The EU also aims at reinforcing the pivotal role of SMEs in Europe through the small business act. The small business act concerns all companies that are independent and have fewer than 250 employees. It offers a set of principles that intends to create a level playing field of competition for SMEs. Considering the typical size of creative industries' businesses, SME policies and more particularly the small business act are extremely relevant.

Single market policies constitute a powerful tool for the following purposes:

1. supporting the mobility of the creative class across Europe;

2. enforcing the implementation of the services directive ([75]) and thereby dismantling discrete barriers to creative entrepreneurship in Europe; professional services, which are the most neglected element in creative industries' policies at national level, are directly concerned by the services directive;

3. establishing 'a true single market for online content and services (borderless and safe EU web services and digital content markets), with high levels of trust and confidence, a balanced regulatory framework governing the management of intellectual property rights, measures to facilitate cross-border online content services, the fostering of multiterritorial licences, adequate protection and remuneration for rights holders and active support for the digitisation of Europe's rich cultural heritage' (European Commission, 2010a, p. 8; European Commission, 2010b, p. 7 and seq.);

4. standardisation, which increases market size through complementarities and provides economies of scale on the producer side as well as network externalities on the consumer side; to achieve this single market effect they promote the dynamic aspects of competition and may generate momentum; at the same time, consumers have a vital interest in maintaining the 'infinite variety of creative industries' products' and related infrastructures; this especially concerns cases where an old (technological) infrastructure is preserved, although a superior one exists.

The EU may support, coordinate or supplement action by the Member States in areas such as industry (including innovation), culture, tourism and education relevant for creative industries. For the most part, policy intervention that helps promote industries 'at the crossroads of arts, culture, business and technology' falls into this category.

It is very important to encourage, in particular, supportive action that helps set the agenda. In the first place, the failure to come up with an unequivocal sectoral labelling system is one main reason why there is a lack of appropriate creative industry policy agendas at national or regional levels. The lack of a common (statistical) definition of creative industries makes for a poor database, and this severely affects evidence-based policymaking. Economic insight based on hard facts is of key importance, and one important role for creative industries' policy is simply to gather these facts. The UK provides a good example of how the strong conceptual foundation for a policy field is accompanied by the availability of data which is then exploited for (re-)drafting policies. Since policymakers expect so many things of the creative industries, it is particularly regrettable that there is no systematic analysis and evaluation of the added value of intervention at different levels.

The EU is well placed to take on a coordinating role and to further develop and integrate expert knowledge on the common, as well as the distinct, patterns among the creative industries. For example, under the European Commission seventh framework programme for research, technological development and demonstration activities, it is anticipated that two pilot actions will be funded in 2011 to promote networking between the science and technology (S & T) base and the creative sector, in order to stimulate innovation. It is believed that this type of support — in essence, policy learning — would greatly help shape creative industries' policy at national, regional and local levels. The Amsterdam declaration of February 2010, calling for the creation of a 'European creative industry alliance' (ECIA), aims to create 'a favourable environment for the further development of this sector'. The early 2010 Green Paper on 'Unlocking the potential of cultural and creative industries' is another initiative designed to consult stake-

([75]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:376:0036:0068:EN:PDF holders on how to better tailor policies to the needs of creative industries. The Green Paper draws on meetings of experts and on recent initiatives taken in the Nordic countries, the UK, the Netherlands and Estonia ([76]).

Finally, this report shows that creative industries develop mainly within the context of knowledge-driven economies. Knowledge as a driver gains in importance as countries approach the technological frontier and are forced to invest strongly in their own technology development to further improve their competitive position. At the same time, knowledge dissemination is an important instrument in catching-up strategies.

Innovation and the emergence of creative industries have a strong local dimension and in many countries regions have gained more control over innovation policy with the objective of fully exploiting the local interactions that affect the innovation process and tailoring interventions to the local landscape. Knowledge, which is key in the development of creative industries, includes an important tacit component that cannot be easily codified and therefore requires direct interaction, on-the-job learning and workers' mobility to circulate. As recent experiences by both national and regional authorities have shown, there is scope for developing regional innovation policies to capture positive local externalities. Improving the efficiency with which partners interact and share knowledge and systematising their relationships are concrete possible actions.

Because it targets regions and is based on a policy approach which integrates sectoral interventions into a coherent framework tailored to the local context, the EU cohesion policy has been a key instrument for developing the economic and innovation potential of the creative industries. Its role is likely to grow in the future as in many countries, regions have gained more control over policy and innovation agendas have been developed at the sub-national level, focusing notably on regional clusters and capability building among knowledge producers. In particular, the cohesion policy will foster the design of innovation governance systems which reinforce horizontal (i.e. between local actors) and vertical (i.e. between local, regional, national and EU levels) coordination.

5.6. Conclusions

The EU-27's creative industries employ about 6.7 million people, which represented 3.0 % of total employment in 2008. In the EU-27, they accounted for 3.3 % of total GDP in 2006. Their employment share is lower in the EU than in the US (3.0 % versus 3.9 %), but they have been one of the fastest-growing parts of the EU economy, with an average employment growth of 3.5 % per year between 2000 and 2007, compared to 1 % for the total economy. In the current recession, employment decreased by 2.5 % in 2009 after an increase of 2.4 % in 2008. The majority of the growth during this period came in software consulting and supply, which represents the largest creative industry segment (37 % of total employment in the creative industries in EU-27). It is important to note that the strong growth in the creative industries is not limited to software consulting and supply, or to a specific creative occupation. In addition to software consulting and supply, there is strong growth in motion pictures, video and television programme production, sound recording and music publishing activities, which averaged an employment growth rate of 2 % per year between 2000 and 2008. Employment in advertising and architecture is also rising faster than average in the creative industries.

Similarly, an increasing percentage of people are being employed in creative occupations in the economy. In the EU-15, employment in creative occupations grew at around 3 % per year on average between 2002 and 2008; the highest growth was recorded for artistic entertainment occupations (5.7 %), followed by social science and related professionals (5.0 %) and architects, engineers and computing professionals (each 3.3 %). Creative occupations are increasing both within and outside of the creative industries, indicating that creative professions spread to other industries.

A number of demand and supply factors are contributing to the rise of the creative industries. Key drivers of the creative economy include innovation, information and communication technologies (e.g. digital technologies), talent and skills. Other factors include wealth (i.e. GDP per capita), leisure time and disposable household income, macroeconomic performance and the initial level of the creative industries in the economy. In a group of eight EU Member States, spending on cultural services increased from 1.0 % to 1.3 % of GDP between 1999 and 2005.

What the creative industries share is a particular kind of skilled labour force and a high share of very small businesses and sole entrepreneurs with no employees. In a group of 22 EU Member States, 95 % of creative industry firms have less than 10 employees, and 58 % of these businesses are sole entrepreneurs. Another important common characteristic of the creative industries is their strong inter-industry linkages, in particular between advertising and publishing but also among advertising, audiovisual, arts and entertainment businesses. In addition, creative industry firms are more innovative, co-operate more often with external partners and engage

([76]) 'A creative economy Green Paper for the Nordic region' (Nordic Council, 2007), 'Creative Britain — New talents for the new economy' (UK, 2008), 'Creative value — Culture and economy policy paper' (Netherlands, 2009) and 'Potential of creative industries in Estonia' (2009).

more frequently in innovation-related training activities. Furthermore, they use external sources of information and knowledge (e.g. consumers, universities) more often and more intensively than non-creative industry firms. An important aspect is that different creative industry segments are geographically concentrated in a few large city regions.

Creative occupations also have similar spatial patterns, including strong urban concentration. This rural–urban gap in the share of creative industries and/or creative occupations is highly persistent over time. Among urban areas in the EU, human capital and population size are the main factors in the concentration of creative industries. In particular, the location quotient (i.e. the local concentration of employment in the creative industries relative to the nation as a whole) rises proportionally with local human capital, but less proportionally with population size and GDP per capita. Past population growth and foreign citizenship do not play a role.

The creative industries share many common characteristics, but there are also important differences. Forms of non-standard work such as part-time work, temporary contracts and holding multiple jobs are much more common among writers, creative/performing artists and artistic entertainment professionals than among other creative professionals. There are also wide differences in the level of productivity and employment performance. Finally, some creative industries are undergoing a process of restructuring. Print and television advertising is being partly replaced by digital advertising, while physical media such as CDs and DVDs are being replaced by digital distribution (subscriptions, pay per view, advertisement-based services, etc.).

Besides the direct effect on value added and employment, creative industries have a broader impact on the economy. Evidence based on input-output tables for two EU countries (Denmark and United Kingdom) shows that industry purchases of creative products account for a significant proportion of total intermediate purchases. In particular, firms in all industries rely on software supply and advertising to operate efficiently and successfully. Publishing and audiovisual activities are important input factors in the education sector. There is some evidence that firms with stronger supply-chain linkages are more innovative. Another aspect of the wider role of creativity is that product design innovations, as well as design registrations, can be found in all industries. This clearly shows that some forms of creativity are not restricted to a limited group of creative industry firms.

Another key result is that the creative industries' initial share of the economy had a positive and significant effect on the growth rate of GDP per capita at regional (NUTS 2) level in 10 EU countries during 2002–07. The positive effect of the creative industries on economic growth remains robust even when general human capital is accounted for. This positive effect could be related to the fact that the resulting increased concentration of creative industry firms within a region facilitates knowledge spillovers. This is consistent with studies comparing one country to another that show technology-led and skill-intensive industries having a significant positive impact on the growth of GDP per capita.

Interdisciplinarity will play a key role in pushing forward research and policymaking in the area of creative industries. Policies combining different fields (such as economics and culture) are set to become even more prominent. Indeed, creative industries can benefit from several policies already in place in the field of culture (such as promoting diversity and promoting cultural heritage) or in the area of economics (innovation policies, access to finance, etc.). At the same time, more tailored approaches that further bring together the various perspectives can complement the existing policies. As far as the EU is concerned, the 'European creative industry alliance' and the consultation to unlock 'the potential of cultural and creative industries' are two cases in point. The former takes into account the artistic and creativity potential of these sectors and focuses on business-related policies research and innovation, clusters and access to finance. The latter wants to tap the full potential of the EU's cultural and creative industries. It has a broad scope and ranges from innovation and education to economic development. By casting their net wide, these recent initiatives exemplify a new way of reconciling economic and cultural objectives.

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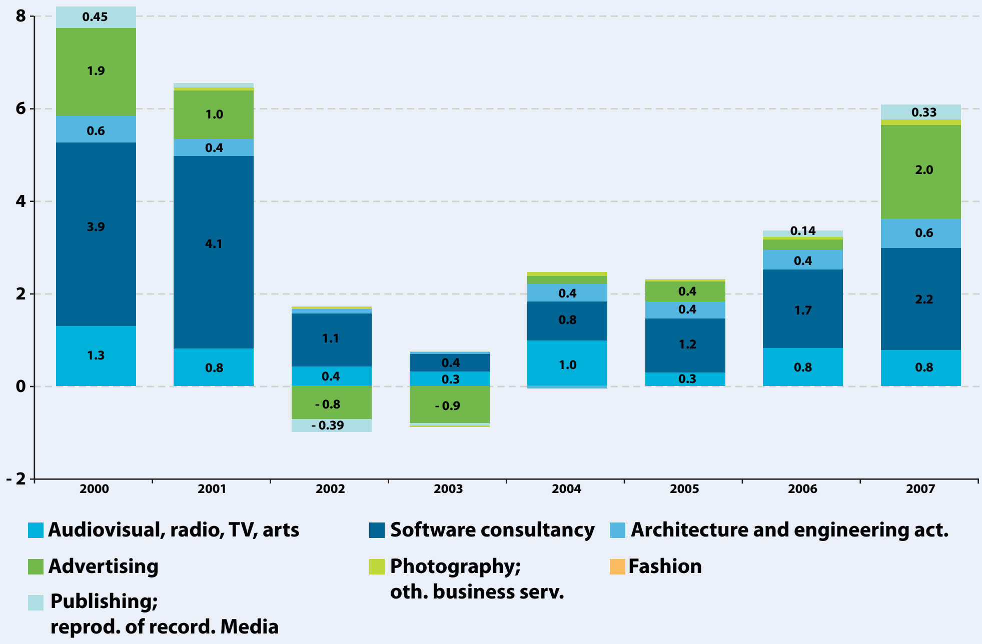
Annex

Table A.1: Definition of the creative industries

Mapping Document Chapter	Sector	NACE Rev. 1.1 (Based on NACE Rev. 1.1)	Description	Proportion of code taken
1	Advertising	74.4	Advertising	1.00
2	Architecture	74.2	Architecture and engineering activities and related technical consultancy	0.25
3	Art and	52.48	Other retail sale in specialised stores	0.05
	antiques	52.5	Retail sale of second-hand goods in stores	0.05
4	Crafts	Majority of businesses too small to be picked up in business surveys		
5	Design	No codes match this sector		
		17.7	Manufacture of knitted and crocheted articles	0.005
6	Designer	18	Wearing apparel; dressing and dyeing of fur	0.005
	Fashion	19.3	Manufacture of footwear	0.005
		74.87	Other business activities n.e.c.	0.025
7	Video,	22.32	Reproduction of video recording	0.25
	film and	74.81	Photographic activities	0.25
	photography	92.1	Motion picture and video activities	1.00
9 & 10	Music	22.14	Publishing of sound recordings	1.00
	and	22.31	Reproduction of sound recording	0.25
	the	92.31	Artistic and literary creation and interpretation	1.00
	visual and	92.32	Operation of arts facilities	1.00
	performing	92.34	Other entertainment activities n.e.c.	0.50
	arts	92.72	Other recreational activities n.e.c.	0.25
		22.11	Publishing of books	1.00
		22.12	Publishing of newspapers	1.00
11	Publishing	22.13	Publishing of journals and periodicals	1.00
		22.15	Other publishing	0.50
		92.4	News agency activities	1.00
8 & 12	Software, computer games	22.33	Reproduction of computer media	0.25
	and electronic publishing	72.2	Software consultancy and supply	1.00
13	Radio and TV	92.2	Radio and television activities	1.00

Figure A.1: Contribution of growth in employment in creative industries by subgroup in EU-27 (in %)



Source: Eurostat structural business statistics, Amadeus database and ZEW/AIT calculations.

Table A.2: Employment in the creative industries in the EU by sub-industry (in %)

		Persons employed (1 000s)			%		
		EU-26	EU-15	EU-11	EU-26	EU-15	EU-11
Creative industries related to information services					61.6	62.2	58.2
Publishing activities	J58	999 557	845 396	154 161	14.8	14.6	16.5
Motion picture, video & television programme prod. sound recording & music publishing activities	J59	415 376	371 096	44 280	6.2	6.4	4.7
Programming and broadcasting activities	J60	222 737	166 272	56 466	3.3	2.9	6.0
Computer programming, consultancy & related activities	J62	2 510 230	2 221 344	288 886	37.3	38.3	30.9
Creative industries in professional services					28.7	28.2	31.8
Architectural & engineering act. & rel. techl consult.	M711	2 499 147	2 147 128	352 019			
Architectural & eng. act. & rel. tech cons (weighted)		624 787	536 782	88 005	9.3	9.3	9.4
Advertising	M731	1 004 955	854 277	150 678	14.9	14.7	16.1
Specialised design activities	M741	165 704	150 002	15 702	2.5	2.6	1.7
Photographic activities	M742	171 430	147 360	24 070			
Photographic activities (weighted)		42 858	36 840	6 018	0.6	0.6	0.6
Translation and interpretation activities	M743	9 5 081	58 539	36 542	1.4	1.0	3.9
Creative, arts and entertainment activities	R90	650 768	557 303	93 465	9.7	9.6	10.0
Total creative industries employment (weighted)		**6 732 052**	**5 797 850**	**934 202**	**100.0**	**100.0**	**100.0**
Total creative industries employment (unweighted)		8 734 985	7 518 716	1 216 268			
Employment share of the creative industries (weighted)		3.0	3.2	2.1			
Employment share of the creative industries (weighted)		3.9	4.2	2.7			

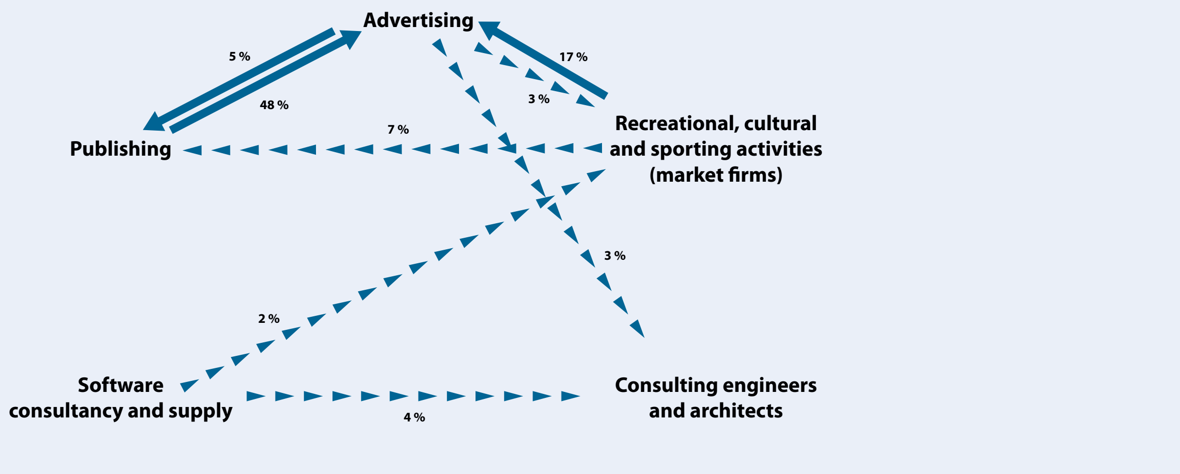
Note: EU-26 refers to the EU–27 excluding Malta. For the Czech Republic, Denmark, Ireland and the Netherlands, employment data for J 59 and J 60 are calculated based on the Amadeus database.
Source: Eurostat structural business statistics, national statistical offices, for R90: Amadeus database.

Table A.3: Annual change in turnover in France, 2008 and 2009 (in %)

	Performing arts	Support activities to performing arts	Artistic creation	Operation of arts facilities
	Change in turnover in current prices (in %)			
2008	0.1	1.5	- 0.9	0.8
2009	- 3.7	- 1.6	- 5.0	3.5
	Change in turnover in constant prices (in %)			
2008	1.9	3.3	0.8	1.7
2009	- 1.4	0.8	- 2.7	6.6

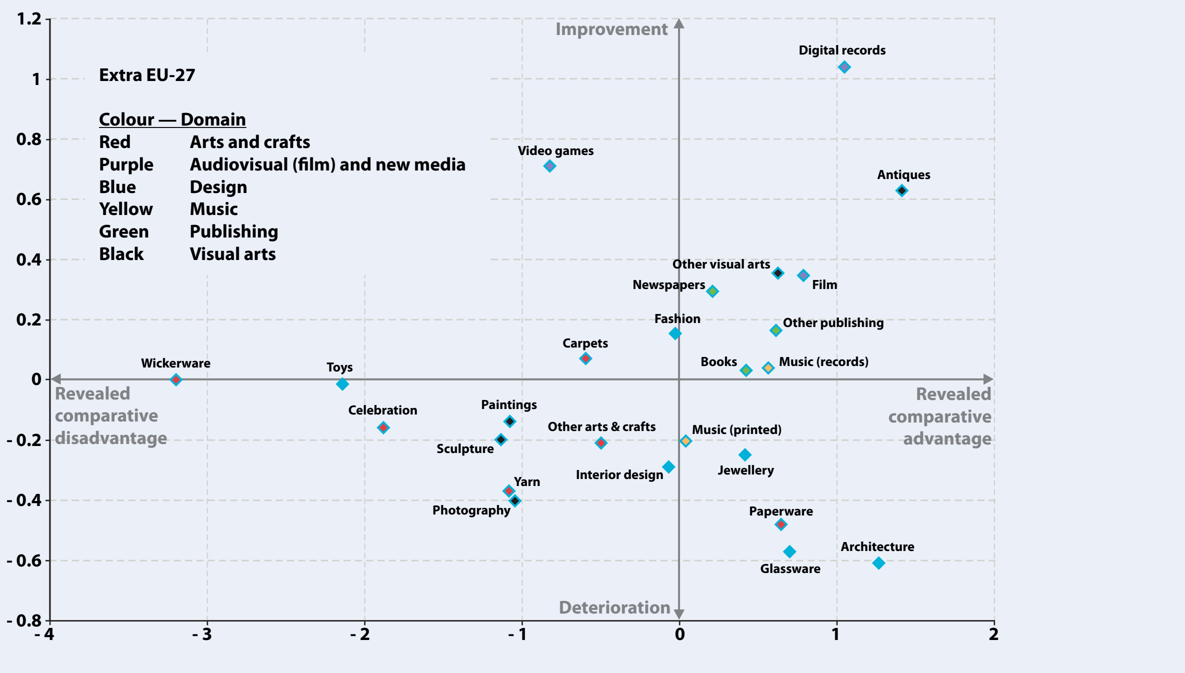
Source: INSEE

Figure A.2: Supply chain linkages between different creative industries



Note: The numbers represent the share of intermediate production in total production. Only higher-than-average supplier chain linkages are shown.
Source: Danish input-output table by price unit, supply, use and supplying industries.

Figure A.3: EU-27 revealed comparative advantage 2005 and change therein since 2000



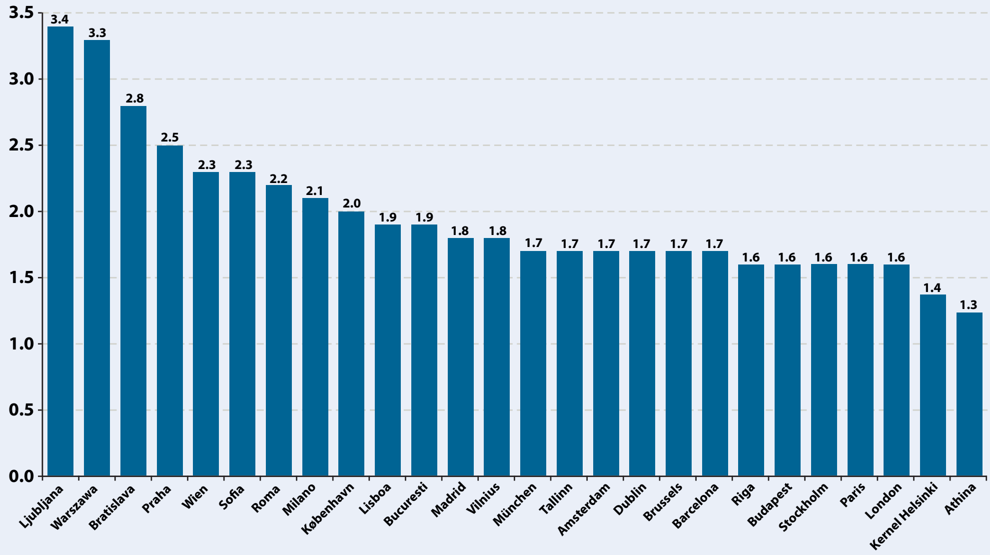
Note: Intra-regional trade is not accounted for.
Source: Unctad global databank on world trade in creative products — WIFO calculations, Balassa (1965).

Table A.4: Barriers to international trade (in %)

	Very important	Fairly important	Some importance	Not important	Unknown/not applicable
			Cross-border trade not relevant (products not exportable)		
Software consultancy and supply	15	8	7	30	39
Architectural & engineering activities	18	6	6	21	49
Advertising	18	12	10	19	41
All NACE branches — Total	19	7	6	21	46
			Difficulties in identifying potential clients abroad		
Software consultancy and supply	12	16	14	16	42
Architectural & engineering activities	17	9	7	10	56
Advertising	12	15	11	16	46
All NACE branches — Total	14	10	8	14	54
			Establishing a commercial presence abroad		
Software consultancy and supply	17	15	10	19	40
Architectural & engineering activities	18	10	5	12	55
Advertising	14	11	12	19	44
All NACE branches — Total	16	9	6	16	53
			Insurance, guarantee systems, etc. issues		
Software consultancy and supply	9	11	12	21	46
Architectural & engineering activities	11	8	8	11	62
Advertising	8	6	14	19	52
All NACE branches — Total	9	7	8	17	58
			Lack of international standards for services		
Software consultancy and supply	18	16	12	15	39
Architectural & engineering activities	14	10	8	9	58
Advertising	8	13	13	17	50
All NACE branches — Total	15	9	7	15	54
			Language and cultural barriers		
Software consultancy and supply	13	16	14	18	40
Architectural & engineering activities	10	13	10	12	55
Advertising	17	9	14	18	43
All NACE branches — Total	12	10	10	16	51
			Movement of personnel on a temporary basis		
Software consultancy and supply	14	9	10	23	43
Architectural & engineering activities	15	9	7	15	55
Advertising	14	8	9	24	45
All NACE branches — Total	13	7	7	19	54
			Taxation issues		
Software consultancy and supply	12	8	11	23	46
Architectural & engineering activities	9	7	10	12	62
Advertising	11	9	12	20	48
All NACE branches — Total	10	7	8	18	57
			Other barriers		
Software consultancy and supply	8	1	1	16	73
Architectural & engineering activities	8	1	1	14	75
Advertising	10	1	4	16	69
All NACE branches — Total	7	1	2	15	75

Source: Eurostat structural business statistics, WIFO calculations.

Figure A.4: Location quotient of the creative industries in capital cities and semi-capitals, 2006



Note: The data refer to the LQ based on (weighted) employment in the creative industries as percentage of total employment of the enterprise sector (excluding non agricultural and public sector) and finance and insurance. The definition of the creative industries is based on the DCMS. A location quotient higher than 1 indicates higher than average national concentration.

Source: Amadeus database, ZEW/AIT calculations.

Table A.5: Impact of the employment share of the creative industries on regional GDP growth

Dep. Var.: average annual change in GDP per capita in PPS between 2002–07

	(i)		(ii)		(iii)	
	Coef.	**t**	**Coef.**	**t**	**Coef.**	**t**
Log GDP per capita in PPS, 2002	- 0.012 (**)	- 2.56	- 0.010 (*)	- 1.71	- 0.010 (**)	- 2.04
Investment ratio, 2002			0.076 (***)	3.14	0.078 (***)	3.71
Share of working age population with tertiary education, 2002					0.085 (***)	4.50
Employment share of the creative industries, 2002	0.154 (***)	2.80	0.201 (***)	3.12	0.111 (*)	1.68
Dummy variable for capital city region	- 0.006	- 1.59	- 0.011 (***)	- 3.05	- 0.014 (***)	- 3.76
# of obs	178		143		140	
R-squared	0.080		0.165		0.282	
Wald test of joint significance of tertiary education share and share of creative industry employment, p-value						0.00
Dep. Var.: Real growth rate of regional GDP at market prices 2002–06						
	Coef.	**t**	**Coef.**	**t**	**Coef.**	**t**
Log GDP in million EUR current prices, 2002	- 0.002 (*)	- 1.89	- 0.002	- 1.51	- 0.001	- 0.90
Investment ratio, 2002			0.047 (***)	2.72	0.085 (***)	4.56
Share of working age population with tertiary education, 2002					0.103 (***)	7.40
Employment share of the creative industries, 2002	0.142 (*)	1.91	0.203 (**)	2.30	0.064	0.79
Dummy variable for capital city region	0.000	- 0.07	- 0.002	- 0.37	- 0.006	- 1.07
Constant	0.036	3.14	0.020 (*)	1.68	- 0.010	- 0.81
# of obs	117		117		111	
R-squared	0.065		0.120		0.421	
Wald test of joint significance of tertiary education share and share of creative industry employment, p-value					0.00	

Note: (*) significant at 10 %; (**) significant at 5 %; (***) significant at 1 %. The regression is based on NUTS 2 data for 10 EU countries (Belgium, Germany, Spain, France, Italy, Netherlands, Austria, Finland, Sweden and United Kingdom).

Source: Eurostat structural business statistics, Amadeus database and WIFO calculations.

Figure A.5: Intermediate inputs in total UK demand for UK creative products, 1992–2004

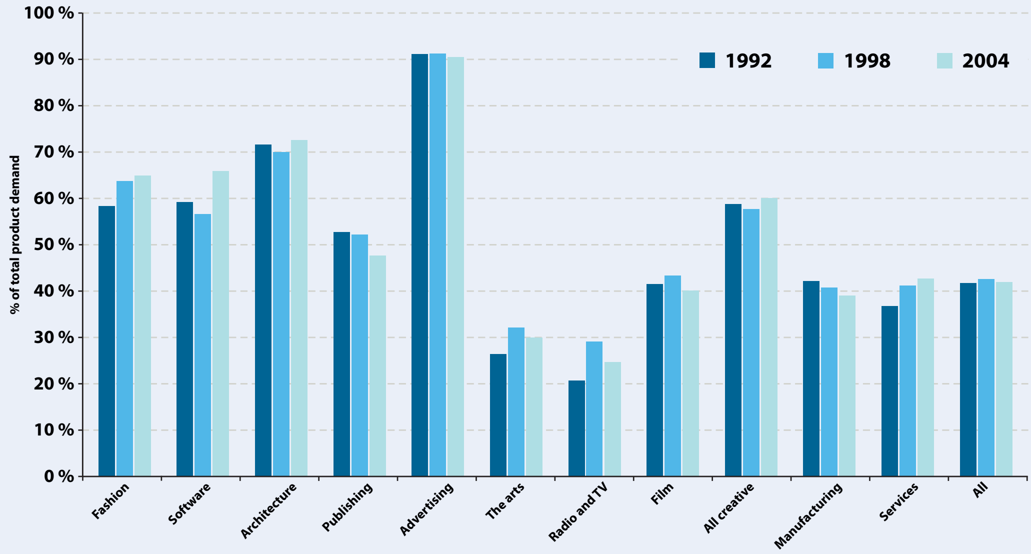
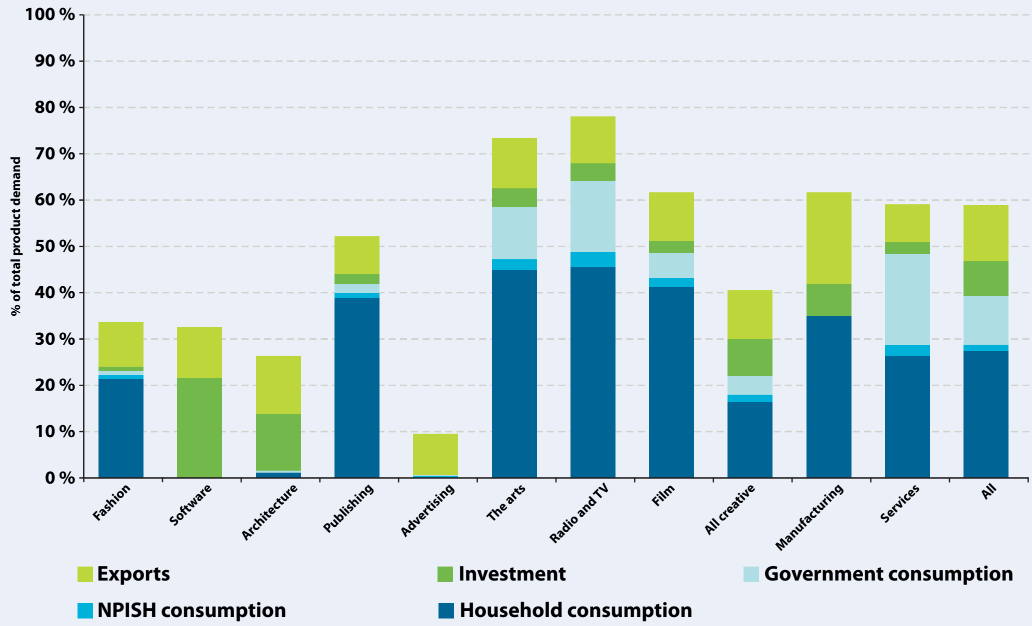
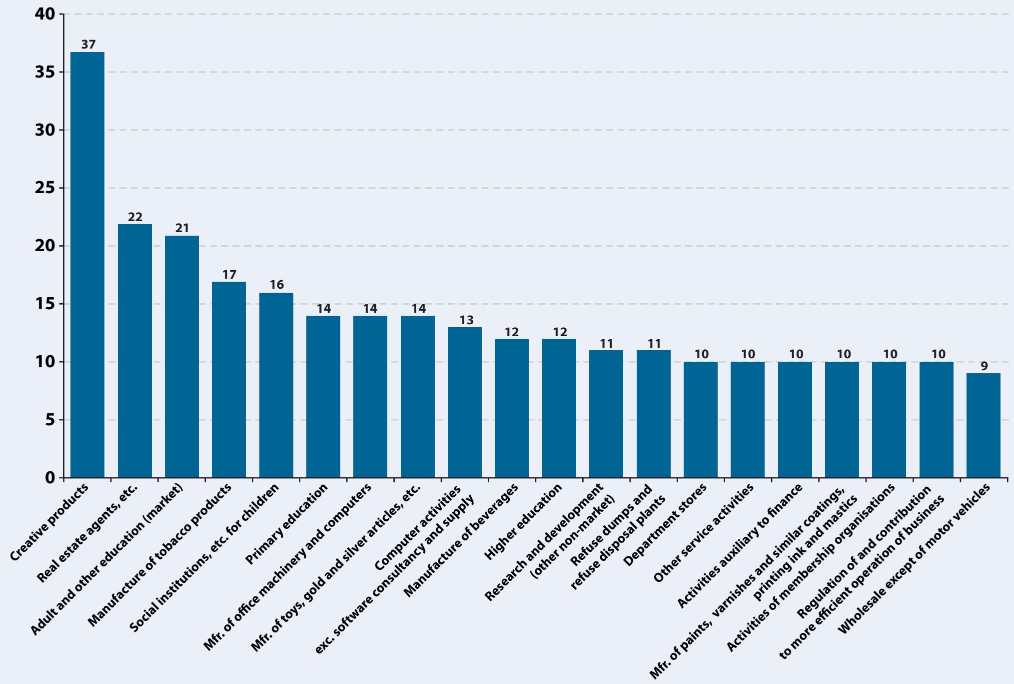


Figure A.6: Final demand for UK creative products, 2004



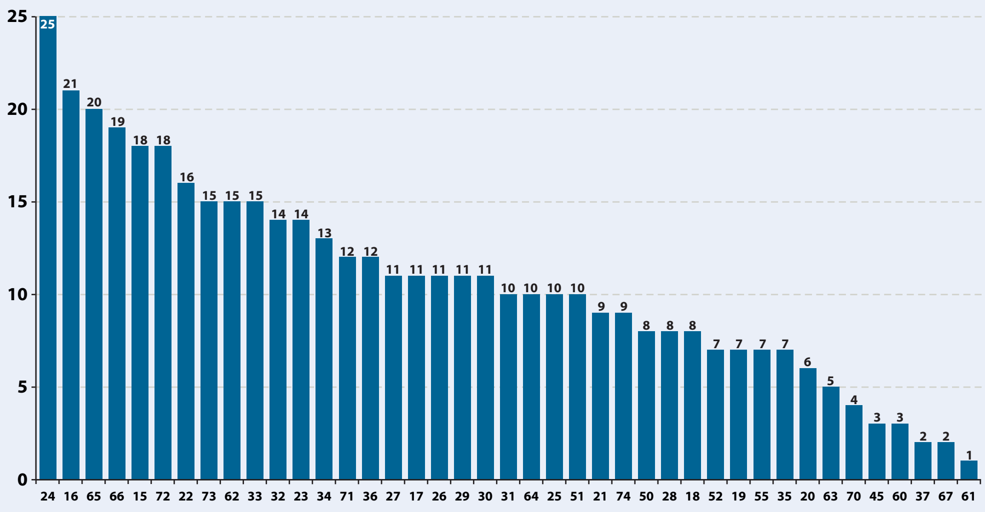
Source: ONS UK input-output supply and use tables, used in Experian (2007).

Figure A.7: Creative inputs used by other industries (in %)



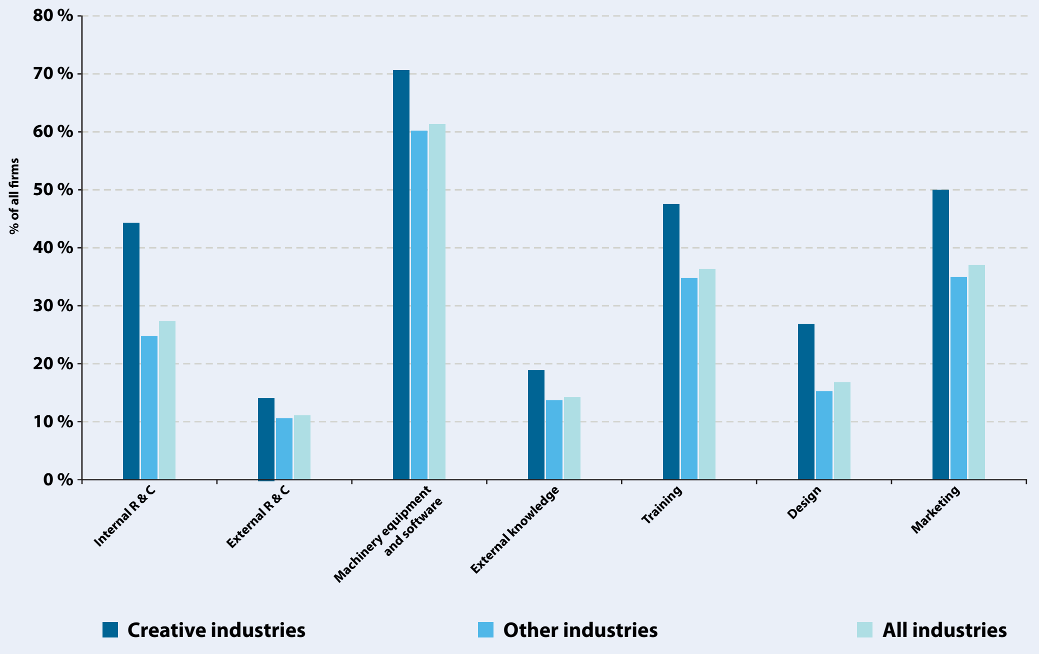
Note: This figure shows the 20 industries which receive the largest share of intermediate inputs from the creative industries in relation to the total industries' intermediate input.
Source: Danish input-output supply and use table, 2005.

Figure A.8: Proportion of enterprises that made significant changes to the product design of goods and services, 2004–06



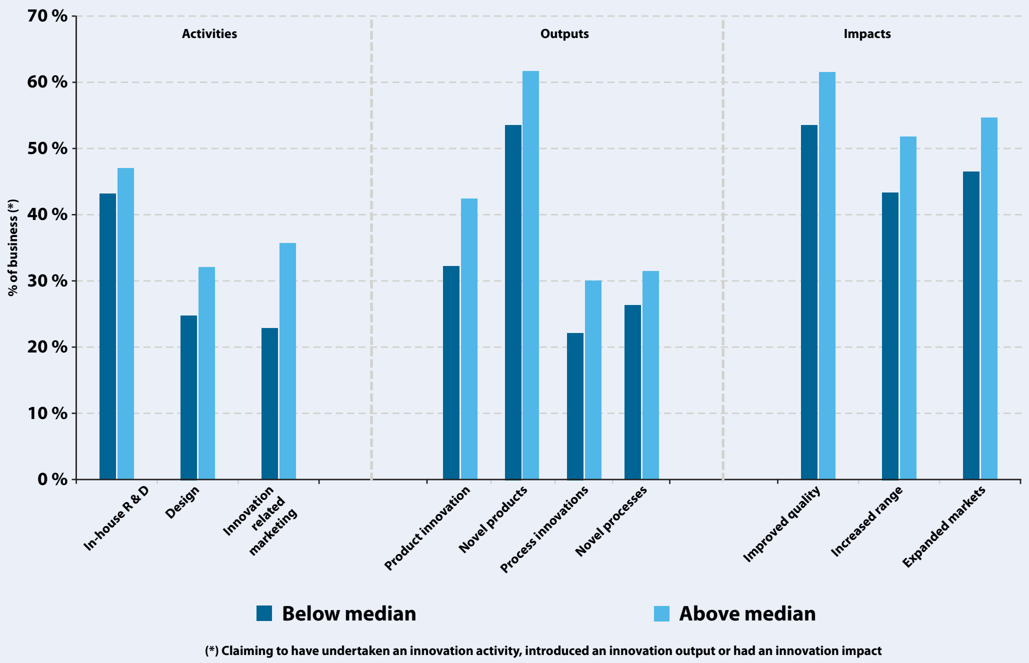
Note: The x axis contains the NACE codes. The sample includes Bulgaria, the Czech Republic, Cyprus and Romania. All numbers are weighted to reflect the population of firms.
Source: Community Innovation Survey 2006, WIFO calculations based on Eurostat data.

Figure A.9: The percentage of firms engaged in various innovation-related activities, UK, 2005–07



Source: De Propris et al. (forthcoming).

Figure A.10: Innovation performance of industries with strongest and weakest creative sector linkages (purchases of creative products), UK, 2002–04



Source: ONS UK input-output supply and use tables and fourth DIUS UK innovation survey, used in Bakhshi et al. (2008).

CHAPTER 6
Statistical Annex

6.1. Sectoral competitiveness indicators

Explanatory notes

Geographical coverage: All indicators refer to the EU-27.

Production index ([77]): The production index is actually an index of final production in volume terms.

Labour productivity: This indicator is calculated by combining the indexes of production and number of persons employed or number of hours worked ([78]). Therefore, this indicator measures final production per person of final production per hour worked.

Unit labour cost: This is calculated from the production index and the index of wages and salaries and measures labour cost per unit of production. 'Wages and salaries' is defined (Eurostat) as 'the total remuneration, in cash or in kind, payable to all persons counted on the payroll (including homeworkers), in return for work done during the accounting period, regardless of whether it is paid on the basis of working time, output or piecework and whether it is paid regularly wages and salaries do not include social contributions payable by the employer'.

Relative trade balance: This is calculated, for sector '*i*', as (Xi-Mi)/(Xi+Mi), where *Xi* and *Mi* are EU-27 exports and imports of products of sector '*i*' to and from the rest of the world.

([77]) The data are working-day adjusted for production.
([78]) The data are working-day adjusted for hours worked.

Revealed comparative advantage (RCA): The RCA indicator for product '*i*' is defined as follows:

$$RCA_i = \frac{\dfrac{X_{EU,i}}{\sum_i X_{EU,i}}}{\dfrac{X_{W,i}}{\sum_i XW_{,i}}}$$

where: X = value of exports; the reference group ('W') is the EU-25 plus 38 other countries (see list below); the source used is the UN Comtrade database. In the calculation of RCA, X_{EU} stands for exports to the rest of the world (excluding intra-EU trade) and X_W measures exports to the rest of the world by the countries in the reference group. The latter consists of the EU-25 plus the following countries: Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Azerbaijan, Bahamas, Bahrain, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, China, Hong Kong SAR, China, Macao SAR, Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Croatia, Cuba, Democratic Republic of the Congo, Djibouti, Dominican Republic, East Timor, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Georgia, Ghana, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, Iceland, India, Indonesia, Iran, Iraq, Israel, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Laos, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands Antilles, New Zealand, Nicaragua, Niger, Nigeria, North Korea, Norway, Occupied Palestinian Territories, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Qatar, Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia, Sierra Leone, Singapore, Somalia, South Africa, South Korea, Sri Lanka, Sudan, Suriname, Swaziland, Switzerland, Syria, Tajikistan, the former Yugoslav Repubic of Macedonia, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, Uruguay, USA, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia and Zimbabwe.

Statistical nomenclatures: The indicators in Tables 6.1 to 6.6 are presented at the level of divisions of the statistical classification of economic activities in the European Community (NACE Rev. 2 ([79]), while those in Tables 6.7 and 6.8 are presented in terms of divisions of the statistical classification of products by activity (CPA).

Data sources: Tables 6.1 to 6.6 are based on Eurostat's short-term indicators data. Tables 6.7 and 6.8 are based on United Nations' Comtrade.

([79]) Compared to the statistical annexes of the previous publications, the new activity classification is used: NACE Rev. 2. The correspondance tables from NACE Rev. 2 — NACE Rev. 1.1 and from NACE Rev. 1.1 to NACE Rev. 2, are available on Eurostat:
http://epp.eurostat.ec.europa.eu/portal/page/portal/nace_rev2/introduction

Table 6.1: EU-27 — Industry production index, annual growth rate (%)

Code (NACE Rev. 2)	Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average 2004–09
B	MINING AND QUARRYING	- 1.1	1.9	- 2.3	- 3.1	0.5	- 3.2	- 2.1	- 6.4	- 4.3	0.4	- 3.6	- 11.1	- 5.1
C	MANUFACTURING	3.9	1.2	5.4	0.1	- 0.7	0.3	2.6	1.5	4.9	4.1	- 1.9	- 14.9	- 1.5
C10	Manufacture of food products	1.8	1.1	1.1	1.2	2.1	0.1	2.1	2.3	1.4	1.9	- 0.7	- 0.7	0.8
C11	Manufacture of beverages	- 0.6	6.1	- 1.3	2.7	2.7	2.0	- 2.3	1.2	4.3	1.6	- 2.0	- 2.7	0.5
C12	Manufacture of tobacco products	0.6	- 3.2	- 7.0	- 2.9	- 2.5	- 6.9	- 6.4	- 4.2	- 5.1	1.2	- 16.7	- 2.0	- 5.5
C13	Manufacture of textiles	- 0.4	- 5.6	2.1	- 3.2	- 4.7	- 3.3	- 4.4	- 5.7	- 0.4	- 1.3	- 9.8	- 17.2	- 7.1
C14	Manufacture of wearing apparel	- 3.6	- 9.2	- 4.7	- 4.4	- 10.8	- 6.4	- 5.0	- 9.0	2.4	2.3	- 3.3	- 11.5	- 4.0
C15	Manufacture of leather and related products	- 4.5	- 4.0	- 2.3	- 5.3	- 7.6	- 7.1	- 11.5	- 8.8	- 1.7	- 1.5	- 7.6	- 13.0	- 6.6
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	7.9	3.2	7.0	- 3.9	0.5	2.1	3.2	0.0	4.3	1.0	- 8.6	- 14.5	- 3.8
C17	Manufacture of paper and paper products	0.3	3.1	3.4	- 2.3	3.5	1.7	3.3	- 0.4	3.3	2.6	- 3.4	- 9.2	- 1.5
C18	Printing and reproduction of recorded media	8.8	2.6	1.9	- 2.5	- 0.5	- 1.5	1.2	2.1	0.4	0.5	- 2.6	- 7.6	- 1.5
C19	Manufacture of coke and refined petroleum products	0.9	- 4.8	6.1	0.1	- 3.6	2.3	5.7	- 0.1	2.0	- 0.3	3.1	- 7.9	- 0.7
C20	Manufacture of chemicals and chemical products	1.2	2.3	4.9	- 1.7	2.4	- 0.4	3.1	1.3	3.6	3.2	- 3.4	- 11.4	- 1.5
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	8.4	8.3	5.0	10.1	6.3	5.8	- 0.6	4.5	7.2	1.6	1.6	2.8	3.5
C22	Manufacture of rubber and plastic products	4.7	2.1	4.8	- 0.5	- 0.1	2.0	1.8	0.8	4.2	4.5	- 4.5	- 13.8	- 2.0
C23	Manufacture of other non-metallic mineral products	2.6	2.3	3.9	- 0.6	- 1.7	0.5	1.8	0.6	4.3	2.0	- 6.6	- 18.8	- 4.1
C24	Manufacture of basic metals	1.6	- 3.8	7.1	- 1.8	- 0.1	- 0.3	3.9	- 1.6	5.5	1.3	- 2.8	- 26.7	- 5.6
C25	Manufacture of fabricated metal products, except machinery and equipment	4.6	0.5	6.5	0.3	- 0.3	0.8	2.6	1.6	5.0	6.0	- 2.4	- 22.2	- 3.0
C26	Manufacture of computer, electronic and optical products	5.3	5.2	16.4	- 5.5	- 9.0	1.6	7.4	4.7	10.0	8.8	2.2	- 17.7	1.0
C27	Manufacture of electrical equipment	0.0	2.4	9.4	- 0.1	- 3.0	- 2.3	3.1	1.2	8.5	4.9	- 0.1	- 20.6	- 1.8
C28	Manufacture of machinery and equipment n.e.c.	3.0	- 1.9	6.0	1.4	- 2.0	- 0.8	4.1	3.9	8.3	8.4	1.3	- 25.9	- 1.8
C29	Manufacture of motor vehicles, trailers and semi-trailers	11.3	3.7	7.2	2.3	0.8	2.0	5.0	1.7	3.1	6.0	- 6.0	- 24.3	- 4.6
C30	Manufacture of other transport equipment	3.3	- 0.2	1.2	0.8	- 4.1	1.1	0.8	2.7	9.0	3.9	4.3	- 6.1	2.6
C31	Manufacture of furniture	6.1	3.2	1.7	- 1.7	- 4.3	- 2.4	0.5	0.4	3.3	3.1	- 4.9	- 16.8	- 3.3
C32	Other manufacturing	3.7	1.7	5.0	3.6	2.4	- 1.1	1.4	1.3	5.0	1.8	- 0.9	- 5.7	0.2
C33	Repair and installation of machinery and equipment	1.3	0.4	4.9	0.4	- 3.8	- 0.7	4.9	1.6	9.2	3.8	5.3	- 8.5	2.1
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	- 1.9	2.4	3.4	2.2	0.3	3.1	2.3	1.6	1.3	- 0.7	- 0.1	- 5.0	- 0.6
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	CONSTRUCTION	2.4	4.2	4.1	0.4	1.2	1.8	0.7	1.7	3.6	2.2	- 3.7	- 8.9	- 1.1

N/A: Data not available.

Source: Eurostat.

Table 6.2: EU-27 — Number of persons employed, annual growth rate (%)

Code (NACE Rev. 2)	Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average 2004–09
B	MINING AND QUARRYING	N/A	- 8.1	- 8.2	- 3.2	- 4.7	- 4.5	- 4.7	- 3.3	- 3.9	- 3.5	- 1.6	- 4.0	- 3.3
C	MANUFACTURING	0.6	- 1.8	- 0.6	0.0	- 2.0	- 2.0	- 1.9	- 1.4	- 0.8	0.5	- 0.3	- 7.3	- 1.9
C10	Manufacture of food products	0.8	- 0.7	- 0.7	- 0.6	- 0.9	- 0.5	- 1.2	0.1	- 0.1	0.1	- 0.1	- 2.1	- 0.4
C11	Manufacture of beverages	N/A	N/A	N/A	- 1.8	- 1.1	- 1.8	- 1.2	- 1.6	- 1.2	- 0.1	- 1.3	- 6.9	- 2.3
C12	Manufacture of tobacco products	N/A	- 9.2	- 3.6	- 3.3	- 0.4	- 5.7	- 5.6	- 2.7	- 1.6	- 9.6	- 7.8	- 4.4	- 5.3
C13	Manufacture of textiles	- 2.3	- 6.9	- 3.8	- 3.3	- 5.1	- 7.1	- 6.4	- 4.5	- 5.9	- 5.3	- 6.5	- 13.7	- 7.3
C14	Manufacture of wearing apparel	N/A	- 3.9	- 5.4	- 3.3	- 3.6	- 3.9	- 6.3	- 7.8	- 5.8	- 5.8	- 6.5	- 13.0	- 7.8
C15	Manufacture of leather and related products	- 3.1	- 6.5	- 3.2	- 1.0	- 0.8	- 4.3	- 6.8	- 5.7	- 2.8	- 3.2	- 5.7	- 12.0	- 5.9
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.2	- 0.3	- 1.3	- 1.1	- 1.7	- 1.2	- 1.4	- 0.8	- 1.1	0.8	- 2.3	- 12.5	- 3.3
C17	Manufacture of paper and paper products	1.2	- 3.4	- 1.5	- 1.6	- 0.8	- 2.9	- 1.6	- 2.6	- 2.5	- 2.6	- 2.0	- 4.6	- 2.9
C18	Printing and reproduction of recorded media	- 0.7	- 0.9	- 0.8	- 0.4	- 2.3	- 4.0	- 2.0	- 3.3	- 1.6	0.0	- 2.3	- 7.2	- 2.9
C19	Manufacture of coke and refined petroleum products	N/A	- 2.2	- 1.5	- 2.6	- 3.2	- 3.5	- 2.5	- 2.8	- 3.9	1.2	- 0.8	- 3.5	- 2.0
C20	Manufacture of chemicals and chemical products	- 1.3	- 2.8	- 2.8	- 0.8	- 1.7	- 2.6	- 3.2	- 2.1	- 1.2	- 0.6	- 2.0	- 5.0	- 2.2
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	- 0.2	0.4	1.5	1.9	2.3	- 0.3	- 2.6	- 1.2	1.8	0.9	- 2.2	- 3.0	- 0.8
C22	Manufacture of rubber and plastic products	3.8	- 0.9	2.4	1.0	- 0.9	0.3	- 0.1	- 0.7	- 0.8	1.5	0.6	- 6.5	- 1.2
C23	Manufacture of other non-metallic mineral products	0.6	- 2.1	- 0.6	- 0.7	- 2.4	- 2.6	- 2.1	- 1.0	- 0.6	1.3	- 2.1	- 10.8	- 2.8
C24	Manufacture of basic metals	0.3	- 3.6	- 4.3	- 0.3	- 4.1	- 3.2	- 3.9	- 1.2	- 1.0	- 0.4	- 0.5	- 7.9	- 2.2
C25	Manufacture of fabricated metal products, except machinery and equipment	2.1	0.0	0.8	0.8	- 1.1	- 1.2	0.1	- 0.3	1.4	3.3	2.6	- 8.5	- 0.4
C26	Manufacture of computer, electronic and optical products	0.7	- 2.1	4.1	2.0	- 5.7	- 4.3	- 2.8	- 1.1	- 0.7	1.1	- 2.0	- 8.3	- 2.3
C27	Manufacture of electrical equipment	2.4	- 1.7	1.8	0.1	- 3.9	- 4.1	- 1.3	- 0.5	1.0	2.6	1.2	- 7.2	- 0.7
C28	Manufacture of machinery and equipment n.e.c.	1.0	- 2.7	- 2.2	1.1	- 1.5	- 2.2	- 2.5	- 0.9	0.8	2.9	2.2	- 5.1	- 0.1
C29	Manufacture of motor vehicles, trailers and semi-trailers	3.2	0.2	2.0	1.8	- 1.0	- 0.4	0.1	- 0.8	- 1.0	- 0.2	0.8	- 9.4	- 2.2
C30	Manufacture of other transport equipment	- 1.4	- 2.0	- 2.4	- 0.1	- 1.4	- 2.7	- 1.6	0.6	0.6	2.9	2.0	- 3.6	0.5
C31	Manufacture of furniture	N/A	N/A	N/A	0.5	- 3.4	0.1	- 2.5	- 2.5	- 1.3	0.2	- 2.3	- 9.9	- 3.2
C32	Other manufacturing	- 1.0	- 2.0	- 5.3	1.0	- 1.6	- 0.3	- 1.1	- 1.7	- 0.5	0.2	0.3	- 3.5	- 1.1
C33	Repair and installation of machinery and equipment	1.6	- 1.9	- 5.0	0.0	- 2.8	- 2.4	- 1.0	- 0.7	0.4	0.4	3.6	- 2.5	0.2
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	N/A	- 3.3	- 4.0	- 2.8	- 4.3	- 4.4	- 3.8	- 2.4	- 1.2	- 1.4	- 1.0	- 0.2	- 1.2
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	N/A	- 0.7	0.9	- 1.5	- 0.7	0.0	- 0.9	- 1.6	1.4	0.0	- 0.9	0.9	0.0
F	CONSTRUCTION	1.5	1.1	0.1	0.2	- 0.5	0.7	1.4	2.5	4.0	4.8	- 1.0	- 7.9	0.4

N/A: Data not available.

Source: Eurostat.

Table 6.3: EU-27 — Number of hours worked, annual growth rate (%)

Code (NACE Rev. 2)	Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average 2004–09
B	MINING AND QUARRYING	N/A	N/A	N/A	- 3.0	- 8.3	- 2.7	- 4.2	- 3.3	- 4.1	- 2.9	- 1.5	- 4.8	- 3.3
C	MANUFACTURING	N/A	N/A	N/A	- 1.2	- 2.5	- 2.3	- 1.2	- 1.6	- 0.3	0.3	- 0.8	- 8.5	- 2.2
C10	Manufacture of food products	N/A	N/A	N/A	- 1.0	- 2.3	- 1.8	- 0.4	- 0.6	0.0	- 0.3	0.1	- 2.6	- 0.7
C11	Manufacture of beverages	N/A	N/A	N/A	- 0.8	- 3.9	- 0.7	0.2	- 3.0	- 3.8	- 0.4	- 1.9	- 5.5	- 3.0
C12	Manufacture of tobacco products	N/A	N/A	N/A	2.6	- 2.8	- 8.5	- 6.2	- 4.2	- 6.0	- 3.0	- 9.1	- 6.1	- 5.7
C13	Manufacture of textiles	N/A	N/A	N/A	- 3.3	- 4.8	- 6.3	- 5.3	- 5.8	- 5.5	- 2.4	- 5.4	- 13.4	- 6.6
C14	Manufacture of wearing apparel	N/A	N/A	N/A	- 4.0	- 3.5	- 3.8	- 3.7	- 4.1	- 4.4	- 5.1	- 6.1	- 13.8	- 6.8
C15	Manufacture of leather and related products	N/A	N/A	N/A	- 3.2	- 1.3	- 2.0	- 2.3	- 4.7	- 0.9	- 4.9	- 5.3	- 9.9	- 5.2
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	N/A	N/A	N/A	- 3.7	- 2.0	- 1.8	- 0.4	- 1.4	- 0.2	- 0.1	- 3.4	- 13.4	- 3.8
C17	Manufacture of paper and paper products	N/A	N/A	N/A	- 2.1	- 2.3	- 1.0	- 1.9	- 2.2	- 1.5	- 1.5	- 3.5	- 5.8	- 2.9
C18	Printing and reproduction of recorded media	N/A	N/A	N/A	- 0.3	- 3.7	- 3.7	- 3.0	- 3.4	- 0.7	0.5	- 2.0	- 5.9	- 2.3
C19	Manufacture of coke and refined petroleum products	N/A	N/A	N/A	- 2.4	- 4.3	- 1.4	- 0.1	- 1.0	- 3.3	0.8	2.5	- 8.7	- 2.0
C20	Manufacture of chemicals and chemical products	N/A	N/A	N/A	- 2.2	- 2.6	- 2.4	- 1.7	- 2.9	- 1.4	- 1.3	- 1.5	- 4.9	- 2.4
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	N/A	N/A	N/A	0.3	2.0	- 0.1	- 1.3	- 1.7	- 0.4	0.2	- 0.7	- 3.0	- 1.1
C22	Manufacture of rubber and plastic products	N/A	N/A	N/A	0.0	- 1.5	- 1.4	0.0	- 1.6	1.3	1.1	- 0.7	- 7.7	- 1.6
C23	Manufacture of other non-metallic mineral products	N/A	N/A	N/A	- 2.5	- 3.2	- 3.1	- 1.2	- 1.2	- 0.3	0.8	- 2.5	- 11.7	- 3.1
C24	Manufacture of basic metals	N/A	N/A	N/A	- 2.2	- 3.6	- 5.0	- 2.4	- 2.4	- 0.4	- 0.2	- 1.4	- 11.1	- 3.2
C25	Manufacture of fabricated metal products, except machinery and equipment	N/A	N/A	N/A	- 0.6	- 1.4	- 1.8	- 0.4	- 0.8	1.2	2.5	3.3	- 10.3	- 1.0
C26	Manufacture of computer, electronic and optical products	N/A	N/A	- 2.1	0.4	- 4.9	- 3.6	- 2.5	- 1.7	- 0.4	1.3	- 1.4	- 10.5	- 2.6
C27	Manufacture of electrical equipment	N/A	N/A	N/A	- 1.1	- 2.6	- 3.9	- 1.5	- 2.0	2.1	1.9	1.0	- 10.9	- 1.7
C28	Manufacture of machinery and equipment n.e.c.	N/A	N/A	N/A	- 0.6	- 2.4	- 2.2	- 1.2	- 1.4	1.4	2.9	1.1	- 8.9	- 1.1
C29	Manufacture of motor vehicles, trailers and semi-trailers	N/A	N/A	- 0.9	0.4	- 1.2	- 0.7	0.5	- 0.7	- 1.4	0.7	- 1.3	- 13.0	- 3.3
C30	Manufacture of other transport equipment	N/A	N/A	N/A	- 1.2	- 2.6	- 2.1	- 2.1	0.1	1.2	2.1	0.8	- 3.9	0.0
C31	Manufacture of furniture	N/A	N/A	N/A	0.3	- 4.3	- 3.1	- 1.1	- 3.6	0.4	0.8	- 3.3	- 10.8	- 3.4
C32	Other manufacturing	N/A	N/A	N/A	- 0.5	- 2.4	- 2.1	0.3	- 2.6	- 0.2	0.3	0.3	- 4.7	- 1.4
C33	Repair and installation of machinery and equipment	N/A	N/A	N/A	- 2.4	- 3.4	- 3.8	- 2.5	- 0.9	1.3	- 0.4	1.4	3.5	1.0
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	N/A	N/A	N/A	- 1.5	- 4.9	- 4.8	- 2.8	- 1.2	- 2.1	- 0.9	- 0.7	- 0.8	- 1.1
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	N/A	N/A	N/A	- 1.5	- 1.4	- 0.2	0.4	- 3.6	- 0.4	0.2	0.6	- 1.2	- 0.9
F	CONSTRUCTION	0.4	1.5	1.9	- 1.1	- 2.3	- 0.5	0.2	5.9	4.0	3.8	- 1.8	- 9.6	0.3

N/A: Data not available.

Source: Eurostat.

Table 6.4: EU-27 — Labour productivity per person employed, annual growth rate (%)

Code (NACE Rev. 2)	Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average 2004–09
B	MINING AND QUARRYING	N/A	10.8	6.4	0.1	5.5	1.4	2.8	- 3.2	- 0.4	4.1	- 2.0	- 7.3	- 1.8
C	MANUFACTURING	3.2	3.1	6.0	0.1	1.3	2.4	4.7	3.0	5.7	3.6	- 1.6	- 8.2	0.4
C10	Manufacture of food products	1.0	1.8	1.8	1.8	3.0	0.6	3.3	2.2	1.5	1.8	- 0.6	1.4	1.2
C11	Manufacture of beverages	N/A	N/A	N/A	4.6	3.8	3.8	- 1.2	2.8	5.6	1.7	- 0.7	4.5	2.8
C12	Manufacture of tobacco products	N/A	6.7	- 3.5	0.4	- 2.1	- 1.2	- 0.9	- 1.5	- 3.5	11.9	- 9.6	2.5	- 0.3
C13	Manufacture of textiles	1.9	1.3	6.0	0.1	0.4	4.2	2.1	- 1.3	5.9	4.3	- 3.6	- 4.1	0.2
C14	Manufacture of wearing apparel	N/A	- 5.6	0.8	- 1.2	- 7.5	- 2.5	1.4	- 1.3	8.7	8.5	3.4	1.8	4.1
C15	Manufacture of leather and related products	- 1.5	2.6	0.9	- 4.3	- 6.8	- 2.9	- 5.0	- 3.2	1.1	1.8	- 2.0	- 1.1	- 0.7
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	6.6	3.4	8.4	- 2.8	2.2	3.4	4.7	0.8	5.4	0.1	- 6.5	- 2.3	- 0.6
C17	Manufacture of paper and paper products	- 0.9	6.7	5.0	- 0.8	4.4	4.7	5.0	2.3	5.9	5.3	- 1.4	- 4.8	1.4
C18	Printing and reproduction of recorded media	9.6	3.5	2.7	- 2.1	1.8	2.6	3.2	5.6	2.0	0.5	- 0.4	- 0.3	1.5
C19	Manufacture of coke and refined petroleum products	N/A	- 2.6	7.7	2.8	- 0.4	6.0	8.4	2.8	6.2	- 1.5	3.9	- 4.5	1.3
C20	Manufacture of chemicals and chemical products	2.4	5.3	7.9	- 0.8	4.1	2.3	6.5	3.5	4.8	3.8	- 1.3	- 6.7	0.7
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	8.5	7.8	3.4	8.0	3.8	6.1	2.0	5.8	5.3	0.7	3.8	6.0	4.3
C22	Manufacture of rubber and plastic products	0.9	3.1	2.3	- 1.5	0.8	1.7	2.0	1.6	5.0	2.9	- 5.0	- 7.9	- 0.8
C23	Manufacture of other non-metallic mineral products	2.0	4.5	4.5	0.1	0.7	3.2	4.0	1.7	4.9	0.7	- 4.6	- 8.9	- 1.4
C24	Manufacture of basic metals	1.3	- 0.2	11.9	- 1.5	4.2	3.0	8.1	- 0.4	6.5	1.7	- 2.3	- 20.4	- 3.4
C25	Manufacture of fabricated metal products, except machinery and equipment	2.4	0.5	5.6	- 0.5	0.8	2.0	2.5	1.9	3.6	2.6	- 4.9	- 14.9	- 2.6
C26	Manufacture of computer, electronic and optical products	4.6	7.4	11.8	- 7.3	- 3.4	6.1	10.6	5.9	10.7	7.6	4.3	- 10.3	3.4
C27	Manufacture of electrical equipment	- 2.3	4.1	7.5	- 0.2	0.9	1.8	4.5	1.7	7.4	2.2	- 1.3	- 14.4	- 1.1
C28	Manufacture of machinery and equipment n.e.c.	2.0	0.8	8.4	0.3	- 0.5	1.4	6.8	4.8	7.5	5.4	- 0.9	- 21.9	- 1.7
C29	Manufacture of motor vehicles, trailers and semi-trailers	7.8	3.6	5.2	0.5	1.9	2.3	4.9	2.5	4.1	6.2	- 6.8	- 16.5	- 2.5
C30	Manufacture of other transport equipment	4.8	1.8	3.7	0.8	- 2.7	3.8	2.4	2.1	8.4	1.0	2.3	- 2.7	2.2
C31	Manufacture of furniture	N/A	N/A	N/A	- 2.2	- 0.9	- 2.5	3.1	2.9	4.6	2.9	- 2.7	- 7.7	- 0.1
C32	Other manufacturing	4.8	3.7	10.9	2.6	4.1	- 0.7	2.5	3.1	5.5	1.5	- 1.2	- 2.2	1.3
C33	Repair and installation of machinery and equipment	- 0.3	2.3	10.3	0.4	- 1.0	1.8	6.0	2.3	8.7	3.4	1.6	- 6.1	1.9
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	N/A	5.9	7.8	5.2	4.9	7.8	6.3	4.1	2.5	0.7	0.9	- 4.9	0.6
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	CONSTRUCTION	0.9	3.0	3.9	0.2	1.6	1.1	- 0.6	- 0.7	- 0.3	- 2.5	- 2.7	- 1.0	- 1.5

N/A: Data not available.

Source: Eurostat.

Table 6.5: EU-27 — Labour productivity per hour worked, annual growth rate (%)

Code (NACE Rev. 2)	Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average 2004–09
B	MINING AND QUARRYING	N/A	N/A	N/A	0.0	9.5	- 0.5	2.2	- 3.2	- 0.2	3.5	- 2.2	- 6.6	- 1.8
C	MANUFACTURING	N/A	N/A	N/A	1.2	1.9	2.7	3.9	3.2	5.1	3.7	- 1.1	- 7.0	0.7
C10	Manufacture of food products	N/A	N/A	N/A	2.2	4.5	1.9	2.5	2.9	1.3	2.2	- 0.8	1.9	1.5
C11	Manufacture of beverages	N/A	N/A	N/A	3.5	6.9	2.7	- 2.6	4.4	8.5	2.0	0.0	3.0	3.5
C12	Manufacture of tobacco products	N/A	N/A	N/A	- 5.3	0.3	1.9	- 0.2	0.0	1.0	4.3	- 8.3	4.5	0.2
C13	Manufacture of textiles	N/A	N/A	N/A	0.2	0.1	3.3	0.9	0.1	5.4	1.2	- 4.6	- 4.4	- 0.5
C14	Manufacture of wearing apparel	N/A	N/A	N/A	- 0.4	- 7.6	- 2.7	- 1.3	- 5.1	7.1	7.7	3.0	2.7	3.0
C15	Manufacture of leather and related products	N/A	N/A	N/A	- 2.1	- 6.4	- 5.2	- 9.5	- 4.3	- 0.8	3.6	- 2.4	- 3.4	- 1.5
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	N/A	N/A	N/A	- 0.2	2.5	4.0	3.7	1.3	4.6	1.1	- 5.4	- 1.3	0.0
C17	Manufacture of paper and paper products	N/A	N/A	N/A	- 0.2	5.9	2.7	5.3	1.9	4.9	4.2	0.1	- 3.6	1.4
C18	Printing and reproduction of recorded media	N/A	N/A	N/A	- 2.2	3.3	2.3	4.3	5.8	1.1	0.1	- 0.6	- 1.8	0.9
C19	Manufacture of coke and refined petroleum products	N/A	N/A	N/A	2.6	0.7	3.7	5.8	0.9	5.4	- 1.1	0.6	0.9	1.3
C20	Manufacture of chemicals and chemical products	N/A	N/A	N/A	0.5	5.1	2.1	4.9	4.4	5.1	4.5	- 1.9	- 6.8	0.9
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	N/A	N/A	N/A	9.8	4.2	6.0	0.7	6.4	7.6	1.4	2.2	6.0	4.7
C22	Manufacture of rubber and plastic products	N/A	N/A	N/A	- 0.5	1.4	3.4	1.8	2.4	2.9	3.4	- 3.8	- 6.6	- 0.4
C23	Manufacture of other non-metallic mineral products	N/A	N/A	N/A	2.0	1.6	3.7	3.1	1.8	4.6	1.2	- 4.2	- 8.0	- 1.0
C24	Manufacture of basic metals	N/A	N/A	N/A	0.4	3.7	5.0	6.4	0.8	5.9	1.5	- 1.4	- 17.5	- 2.5
C25	Manufacture of fabricated metal products, except machinery and equipment	N/A	N/A	N/A	0.9	1.1	2.6	3.0	2.4	3.8	3.5	- 5.5	- 13.2	- 2.0
C26	Manufacture of computer, electronic and optical products	N/A	6.4	12.3	- 5.9	- 4.3	5.4	10.2	6.5	10.4	7.4	3.6	- 8.1	3.8
C27	Manufacture of electrical equipment	N/A	N/A	N/A	1.1	- 0.4	1.6	4.6	3.2	6.2	2.9	- 1.0	- 10.9	- 0.1
C28	Manufacture of machinery and equipment n.e.c.	N/A	N/A	N/A	2.0	0.4	1.4	5.3	5.3	6.8	5.4	0.2	- 18.7	- 0.7
C29	Manufacture of motor vehicles, trailers and semi-trailers	N/A	5.5	5.0	1.9	2.0	2.7	4.5	2.4	4.6	5.3	- 4.7	- 13.0	- 1.3
C30	Manufacture of other transport equipment	N/A	N/A	N/A	1.9	- 1.6	3.3	2.9	2.6	7.7	1.8	3.5	- 2.3	2.6
C31	Manufacture of furniture	N/A	N/A	N/A	- 2.0	0.0	0.7	1.6	4.1	2.8	2.3	- 1.7	- 6.7	0.1
C32	Other manufacturing	N/A	N/A	N/A	4.1	4.9	1.1	1.1	3.9	5.2	1.4	- 1.2	- 1.0	1.6
C33	Repair and installation of machinery and equipment	N/A	N/A	N/A	2.9	- 0.4	3.3	7.6	2.5	7.8	4.2	3.8	- 11.5	1.1
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	N/A	N/A	N/A	3.8	5.5	8.3	5.2	2.8	3.4	0.2	0.6	- 4.2	0.5
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	CONSTRUCTION	2.0	2.7	2.1	1.6	3.6	2.3	0.5	- 3.9	- 0.4	- 1.5	- 1.9	0.9	- 1.4

N/A: Data not available.

Source: Eurostat.

Table 6.6: EU-27 — Unit labour cost, annual growth rate (%)

Code (NACE Rev. 2)	Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average 2004–09
B	MINING AND QUARRYING	- 2.3	- 4.2	- 2.6	8.2	- 0.7	7.1	4.0	1.4	8.9	4.9	10.8	11.7	7.5
C	MANUFACTURING	- 0.9	1.4	- 0.8	2.9	1.6	0.2	- 1.3	- 0.4	- 2.3	- 0.1	5.9	10.0	2.5
C10	Manufacture of food products	0.5	1.5	- 0.2	2.4	0.8	2.8	- 0.6	- 0.7	0.3	1.5	5.1	0.9	1.4
C11	Manufacture of beverages	N/A	N/A	N/A	0.7	- 1.8	2.0	3.7	- 1.6	- 4.2	0.8	5.0	1.0	0.2
C12	Manufacture of tobacco products	2.3	5.0	8.6	5.8	2.6	8.1	8.3	5.9	6.7	- 2.3	16.3	2.9	5.7
C13	Manufacture of textiles	2.4	6.7	7.7	2.0	3.1	0.5	0.4	2.9	- 2.8	0.6	9.1	5.3	3.0
C14	Manufacture of wearing apparel	4.1	10.1	14.9	1.2	9.5	2.6	1.8	4.3	- 3.6	- 0.4	3.2	2.6	1.2
C15	Manufacture of leather and related products	6.3	4.6	15.6	9.3	7.5	4.1	9.4	5.5	4.6	4.7	10.2	4.9	6.0
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	- 4.6	- 0.8	- 5.3	5.3	- 0.7	- 1.7	- 0.5	1.1	- 0.4	4.8	11.8	5.3	4.4
C17	Manufacture of paper and paper products	1.5	- 0.5	- 0.1	5.1	- 2.6	- 1.9	- 1.8	1.3	- 2.9	- 1.2	3.9	4.2	1.0
C18	Printing and reproduction of recorded media	- 6.1	0.1	2.9	5.6	0.7	- 1.2	- 1.0	- 1.6	- 0.6	0.9	4.9	1.9	1.1
C19	Manufacture of coke and refined petroleum products	- 2.1	7.7	6.2	0.0	8.7	- 5.5	- 2.2	3.1	1.2	2.2	5.6	7.5	3.9
C20	Manufacture of chemicals and chemical products	- 0.5	- 1.0	- 0.1	3.4	- 1.3	1.9	- 3.1	- 0.3	- 3.5	- 0.3	5.3	9.9	2.1
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	N/A	N/A	N/A	- 5.7	- 1.1	- 1.1	1.3	- 2.9	- 4.3	4.3	- 0.5	- 2.6	- 1.2
C22	Manufacture of rubber and plastic products	- 0.7	1.3	0.3	3.4	1.5	- 0.3	0.5	0.1	- 3.0	- 0.9	7.9	8.3	2.4
C23	Manufacture of other non-metallic mineral products	- 0.5	0.0	- 2.3	2.1	2.8	0.2	- 1.0	0.7	- 1.5	2.4	9.1	12.4	4.5
C24	Manufacture of basic metals	1.3	4.1	- 5.4	- 1.9	- 1.4	0.3	- 2.5	4.1	- 2.0	3.0	6.0	23.5	6.6
C25	Manufacture of fabricated metal products, except machinery and equipment	- 1.2	2.2	- 4.4	4.0	1.5	- 0.1	0.1	- 0.1	- 1.0	0.8	10.2	15.1	4.8
C26	Manufacture of computer, electronic and optical products	- 2.6	- 2.4	- 3.2	11.9	6.0	- 5.8	- 7.2	- 4.3	- 8.2	- 5.7	0.1	11.9	- 1.5
C27	Manufacture of electrical equipment	2.8	- 0.5	- 4.3	2.6	2.1	0.1	- 1.4	- 0.7	- 4.2	0.5	5.0	13.1	2.6
C28	Manufacture of machinery and equipment n.e.c.	0.3	3.9	- 2.9	2.9	2.9	1.7	- 1.9	- 2.4	- 3.6	- 1.6	4.7	27.1	4.2
C29	Manufacture of motor vehicles, trailers and semi-trailers	- 5.7	1.2	0.5	0.9	0.8	0.4	- 2.6	- 0.3	0.0	- 5.3	9.2	16.2	3.7
C30	Manufacture of other transport equipment	- 0.9	3.5	0.8	3.9	8.2	0.6	- 1.3	0.6	- 4.7	1.3	2.0	9.8	1.7
C31	Manufacture of furniture	N/A	N/A	N/A	5.3	4.4	- 0.5	- 1.3	- 0.2	- 0.4	0.6	7.3	11.4	3.6
C32	Other manufacturing	- 2.1	0.2	- 11.3	1.1	- 0.5	1.2	0.8	- 1.1	- 2.2	3.2	3.7	2.5	1.2
C33	Repair and installation of machinery and equipment	2.0	2.2	- 1.1	3.9	4.8	0.6	- 3.2	0.5	- 5.8	0.7	1.6	10.0	1.3
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	- 0.2	- 1.4	- 1.3	- 0.9	2.3	- 1.8	- 1.3	0.6	3.9	5.1	4.7	9.5	4.7
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	CONSTRUCTION	- 0.7	- 0.2	- 3.5	4.6	3.1	0.7	2.0	7.1	3.1	7.3	7.0	2.1	5.3

N/A: Data not available.

Source: Eurostat.

Table 6.7: EU-27 Revealed comparative advantage index

NACE code	Product	2007	2008
C10	Manufacture of food products	1.25	1.18
C11	Manufacture of beverages	1.67	1.67
C12	Manufacture of tobacco products	1.58	1.64
C13	Manufacture of textiles	0.85	0.80
C14	Manufacture of wearing apparel	0.79	0.81
C15	Manufacture of leather and related products	1.00	0.96
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.20	1.24
C17	Manufacture of paper and paper products	1.33	1.37
C18	Printing and reproduction of recorded media	1.24	1.70
C19	Manufacture of coke and refined petroleum products	0.87	0.89
C20	Manufacture of chemicals and chemical products	1.18	1.19
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	1.53	1.62
C22	Manufacture of rubber and plastic products	1.23	1.27
C23	Manufacture of other non-metallic mineral products	1.27	1.25
C24	Manufacture of basic metals	0.96	0.92
C25	Manufacture of fabricated metal products, except machinery and equipment	1.23	1.25
C26	Manufacture of computer, electronic and optical products	0.62	0.63
C27	Manufacture of electrical equipment	1.02	1.04
C28	Manufacture of machinery and equipment n.e.c.	1.19	1.24
C29	Manufacture of motor vehicles, trailers and semi-trailers	1.27	1.29
C30	Manufacture of other transport equipment	0.89	0.92
C31	Manufacture of furniture	1.32	1.30
C32	Other manufacturing	0.83	0.82

Note: There was a transition from NACE REV 1 to NACE REV 2, therefore the data are not completely comparable with the previous edition and are only available from 2007.

Source: Own calculations using Comtrade data.

Table 6.8: EU-27 Relative trade balance (X-M)/(X+M)

NACE code	Product	2007	2008
C10	Manufacture of food products	- 0.03	- 0.03
C11	Manufacture of beverages	0.21	0.20
C12	Manufacture of tobacco products	0.03	0.07
C13	Manufacture of textiles	- 0.01	- 0.01
C14	Manufacture of wearing apparel	- 0.19	- 0.19
C15	Manufacture of leather and related products	- 0.07	- 0.08
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.00	0.02
C17	Manufacture of paper and paper products	0.04	0.04
C18	Printing and reproduction of recorded media	0.08	0.05
C19	Manufacture of coke and refined petroleum products	- 0.03	- 0.02
C20	Manufacture of chemicals and chemical products	0.03	0.03
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.07	0.08
C22	Manufacture of rubber and plastic products	0.04	0.04
C23	Manufacture of other non-metallic mineral products	0.08	0.08
C24	Manufacture of basic metals	- 0.06	- 0.03
C25	Manufacture of fabricated metal products, except machinery and equipment	0.09	0.09
C26	Manufacture of computer, electronic and optical products	- 0.11	- 0.11
C27	Manufacture of electrical equipment	0.07	0.08
C28	Manufacture of machinery and equipment n.e.c.	0.16	0.17
C29	Manufacture of motor vehicles, trailers and semi-trailers	0.06	0.08
C30	Manufacture of other transport equipment	0.13	0.12
C31	Manufacture of furniture	0.04	0.04
C32	Other manufacturing	- 0.04	- 0.04

Note: There was a transition from NACE REV 1 to NACE REV 2, therefore the data are not completely comparable with the previous edition and are only available from 2007.

Source: Own calculations using Comtrade data.

ANNEX — List of background studies to the *European Competitiveness Report 2010*

Some parts of the European Competitiveness Report 2010 are based on or use materials prepared by a consortium led by WIFO, the Austrian Institute for Economic Research:

Chapter 1 on 'Growing imbalances and European industry, was coordinated by Jorge Durán-Laguna and benefited from contributions from Tomas Brännström, Jorge Durán-Laguna, João Libório and Agnes Magai. Statistical assistance is acknowledged to Luigi Cipriani and Bernhard Spitz. The chapter has substantially benefited from comments and suggestions from Josefina Monteagudo, Ruth Paserman and Guntram Wolff.

Chapter 2 on 'Trade in intermediate products and EU manufacturing supply chains' was coordinated by Mats Marcusson and is based on the background study 'Trade in intermediate products and EU manufacturing supply chains' by Robert Stehrer (1) (coordinator), Jyrki Ali-Yrkkö (2), Doris Hanzl (1), Neil Foster (1), Petri Rouvinen (2), Timo Seppälä (2), Roman Stöllinger (1) and Pekka Ylä-Anttila (2).

(1) *wiiw, Vienna Institute for International Economic Studies*.

(2) *ETLA, Research Institute of the Finnish Economy*.

Chapter 3 on 'Foreign corporate R & D and innovation in the European Union' was coordinated by João Libório and is based on the background study 'Foreign corporate R & D and innovation activities in the European Union' by Bernhard Dachs (1), Franziska Kampik (1), Bettina Peters (2), Christian Rammer (2), Doris Schartinger (1), Anja Schmiele (2) and Georg Zahradnik (1). Chris Allen, Andrea Conte, Matthieu Delescluse, Manuel Santiago Dos Santos and Alexander Tübke provided helpful comments on this study.

(1) *AIT, Austrian Institute of Technology, Business Unit Research, Technology & Innovation Policy*.

(2) *ZEW, Centre For European Economic Research*.

Chapter 4 on 'European competitiveness in key enabling technologies' was coordinated by Tomas Brännström and is based on the background study 'European competitiveness in key enabling technologies' by Birgit Aschhoff (1), Felix Brandes (2), Dirk Crass (1), Katrin Cremers (1), Fernando Diaz-Lopez (2), Christoph Grimpe (1), Rosalinde Klein Woolthuis (2), Michael Mayer (2), Carlos Montalvo (2) and Christian Rammer (1).

(1) *ZEW, Centre for European Economic Research*.

(2) *TNO, Netherlands Organisation for Applied Scientific Research*.

Chapter 5 on 'Innovation and competitiveness of the creative industries in the EU' was coordinated by Mata Jolles and is based on the background study 'Innovation and competitiveness of the creative industries' by Rahel Falk (project lead), Hasan Bakhshi, Martin Falk, Wilhelm Geiger, Susanne Karr, Catherine Keppel, Hannes Leo, Erich Pöttschacher and Roland Spitzlinger (WIFO, Austrian Institute of Economic Research).

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