European Commission

Key Enabling Technologies (KETs) Observatory

First annual report
May 2015

DG Growth

This report has been prepared in 2013 - 2015 for the European Commission, DG for Internal Market, Industry, Entrepreneurship and SMEs by:

IDEA Consult, Brussels, Belgium

Center for European Economic Research (ZEW), Mannheim, Germany

Niedersächsisches Institut für Wirtschaftsforschung (NIW), Hannover, Germany

TNO, Delft, Netherlands

CEA, Grenoble, France

Ecorys UK, Birmingham, UK

Fraunhofer Institute for Systems and Innovation Research ISI

Karlsruhe, Germany

Project leader:
Els Van de Velde, IDEA Consult

Authors:
Els Van de Velde (IDEA), Christian Rammer (ZEW), Birgit Gehrke (NIW), Pieterjan Debergh (IDEA), Paula Schliessler (ZEW), Pia Wassmann (NIW)

Design & editing:
Laya Taheri (Ecorys UK), Keith Jude (Ecorys UK), Jo Hargreaves (Ecorys UK)

Contents

List of graphs

Chapter 3

Chapter 4

Note on country groups used in the report

AT	**Austria**		JP	**Japan**
BE	**Belgium**		KR	**South Korea**
BG	**Bulgaria**		LT	**Lithuania**
BR	**Brazil**		LU	**Luxembourg**
CA	**Canada**		LV	**Latvia**
CH	**Switzerland**		MT	**Malta**
CN	**China**		MX	**Mexico**
CY	**Cyprus**		NL	**Netherlands**
CZ	**Czech Republic**		NO	**Norway**
DE	**Germany**		PL	**Poland**
DK	**Denmark**		PT	**Portugal**
EE	**Estonia**		RO	**Romania**
EL	**Greece**		RU	**Russia**
ES	**Spain**		SE	**Sweden**
FI	**Finland**		SG	**Singapore**
FR	**France**		SI	**Slovenia**
HR	**Croatia**		SK	**Slovakia**
HU	**Hungary**		TR	**Turkey**
IE	**Ireland**		TW	**Taiwan**
IL	**Israel**		UK	**United Kingdom**
IN	**India**		US	**United States**
IS	**Iceland**		ZA	**South Africa**
IT	**Italy**			

EU-28	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom
East Asia	China (incl. Hong Kong), India, Japan, Singapore, South-Korea, Taiwan
North America	Canada, Mexico, US

Main acronyms used in the report

AM	Advanced Materials
AMT	Advanced Manufacturing Technology
HS	Harmonized System
IB	Industrial Biotechnology
IPC	International Patent Classification
MNE	Micro- and Nanoelectronics
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne
NT	Nanotechnology
PHOT	Photonics
Prodcom	PRODuction COMmunautaire

1.

Executive summary

Key Enabling Technologies (KETs) provide the basis for innovation in a wide range of products and processes across all industrial sectors (emerging and traditional), and are essential to solving Europe's major societal challenges. Six KETs have been identified as important for Europe's future competitiveness: Advanced Materials, Nanotechnology, Micro- and Nanoelectronics, Industrial Biotechnology, Photonics, and Advanced Manufacturing Technologies.

The European Commission defines KETs as 'knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment'. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs are instrumental in modernizing Europe's industrial base and in driving the development of entirely new industries.

KETs enable process, goods and service innovation throughout the economy and are of systemic relevance: they are at the heart of game-changing products such as smartphones, high performance batteries, light vehicles, nano medicines, smart textiles and many more besides.

Globally, the market is estimated to be worth more than € 1 trillion in 2015 – but the benefit will go only to those who master these key enabling technologies and embed them into new products and processes. Those nations and regions mastering KETs will be at the forefront of future advanced and sustainable economies. The deployment of KETs will contribute to achieving the reindustrialization, energy and climate change targets simultaneously, making them compatible and reinforcing their respective impacts on growth and job creation.

The European strategy for KETs, adopted in 2012, aims to boost the industrial deployment of KETs in Europe. The KETs strategy has strong support from EU countries, regions, industry and other stakeholders involved in industrial innovation.

[1] Final report of the HLEG on KETs, June 2011.

KETs Observatory at a glance

The KETs Observatory aims to provide EU, national and regional policymakers with information on the deployment of KETs both within the EU-28 and in comparison to other world regions (East Asia and North America). Currently, the following indicators are used (technology generation and exploitation approach) to capture the performance of KETs at different stages of the deployment value chain:

- Technology indicators (patent) measure the ability to produce new technological knowledge relevant to industrial applications
- Production indicators measure the relevance and dynamics of the production and absorption of KETs-based components
- Trade indicators (export – import)measure the ability to produce and commercialize internationally competitive products based on new technological knowledge
- Turnover indicators at headquarter level measure the ability of industries/businesses to compete in the market for KETs components, and to transfer new technologies and innovations to industrial applications

The KETs Observatory will soon be extended with additional indicators from the technology diffusion approach.

KETs Observatory: data on the performance of countries

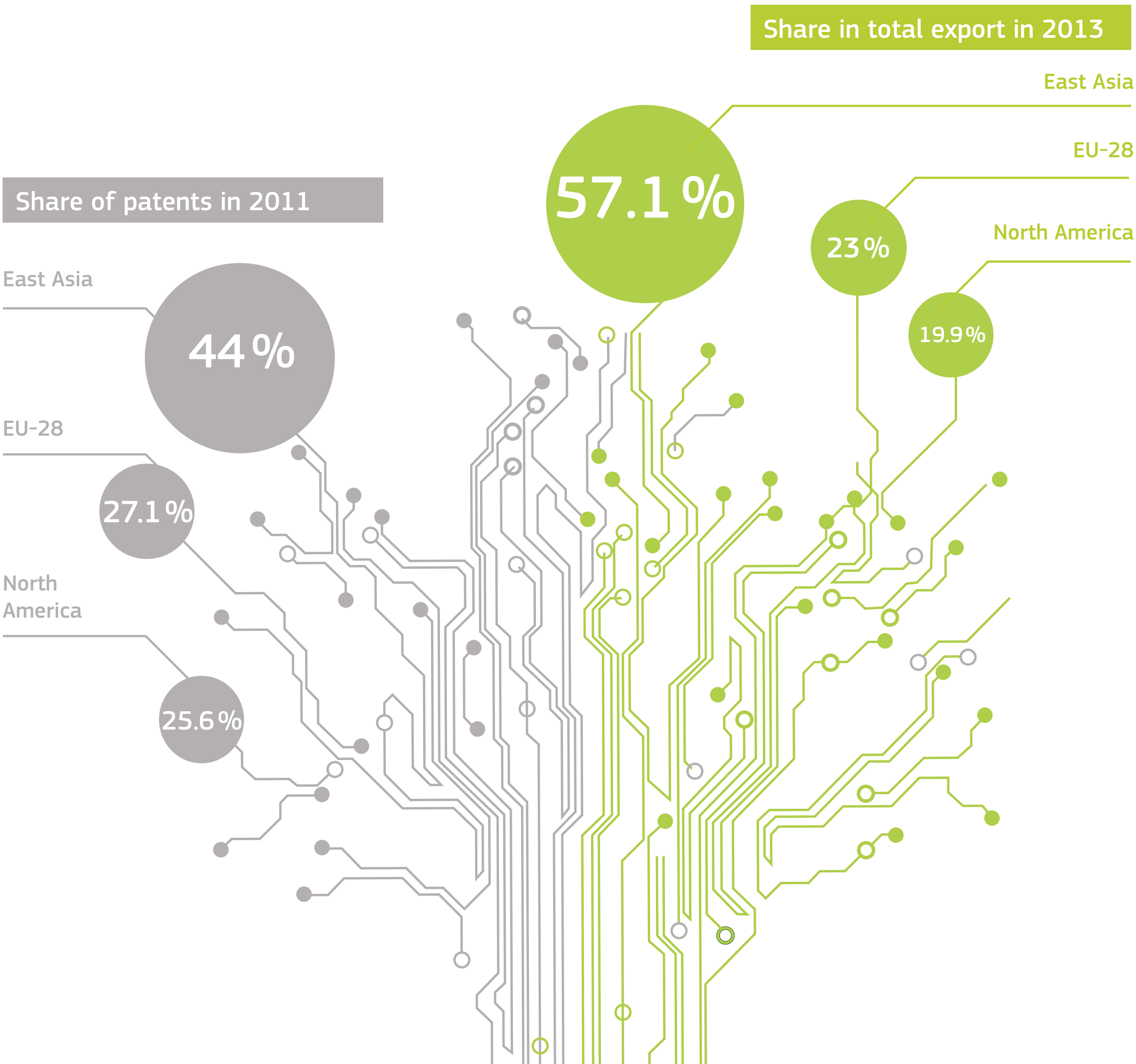
The High-Level Expert Group on Key Enabling Technologies noted in 2011 an urgent need for stakeholders to have relevant information on KETs deployment, to inform strategy and decision-making[1]. Therefore, the European Commission established a KETs Observatory, tasked with the mission of performing analyses and allowing the performance of countries in relation to the six KETs to be compared. The objective of the KETs Observatory is to provide EU, national and regional policymakers with information on the deployment of KETs both within the EU-28 and in comparison to other world regions (East Asia and North America). Any public or private stakeholder that is interested in tracking developments in technology, trade, production or turnover in a specific KET can use the KETs Observatory to identify leading or emerging countries in that KET. In addition, the KETs Observatory allows for an in depth analysis of available data on KETs, providing a clear idea of where Europe and individual Member States stand in their deployment.

First annual report: focus on KETs-based components and intermediary systems

- The first annual report discusses the results of the technology generation and exploitation approach that looks at the ability of countries to generate and commercialize new knowledge. It outlines the relative position of the EU-28 countries in terms of their technology, trade, production and turnover performance. Therefore, no absolute numbers are provided.

- A second annual report will present the results of the technology diffusion approach, which aims to show to what extent the EU can use the potential of KETs to improve its competitiveness by manufacturing KETs-based products. This approach will provide an overview of Europe's position in absolute terms.

KETs are fundamental technology 'bricks' that lie at the heart of an increasingly wide range of goods and services, and have a role as innovation accelerators for downstream industries. The results presented in **this first annual report** compare the performance of countries related to the ability of industries/businesses to transfer new knowledge to industrial applications through the production and trade of **KETs-based components and intermediary systems** (such as an optical device or a microelectronic unit to be used in a machine or in transport equipment). KETs-based components and intermediary systems are the building blocks of a variety of end-user products. Hence, the **results in this report do not relate to the entire value chain** of several industries, but focus on a particular aspect of the value chain – namely the transfer of new knowledge in diverse industrial applications. The data in this report reveal how a country's technological performance in KETs translates into success in international trade and production.



I-Europe in a global context

Europe holds the strongest position in Advanced Manufacturing Technology.

As regards Advanced Manufacturing Technology, Europe is leading in terms of share of patents and shares in total export, and depicts a high and increasing trade surplus compared to East Asia and North America. A main reason for the good performance of the EU-28 in Advanced Manufacturing Technology is related to the different nature of technological advances in this KET. New technological solutions in Advanced Manufacturing Technology rest on the integration of other technologies (such as Micro- and Nanoelectronics, Advanced Materials or Photonics) into complex products. Moreover, the EU-28 can benefit from its long history in developing and applying advanced technologies in manufacturing, and a dense network of Advanced Manufacturing Technology producers and users.

In the other five KETs, Europe has lost ground – mainly to East Asia.

On the global level, the general trend shows that East Asia could expand its share of patents and its share in total export in all KETs during the past decade, while the EU-28 and North America have lost ground in most KETs. The good KET performance of East Asia is mainly driven by the strong ecosystem in electronic components and its importance for multiple KETs like Micro-and Nanoelectronics, Photonics and Advanced Materials. East Asia has players in the entire value chain including material producers, equipment suppliers, chip manufacturers, electronic device manufacturers, etc.

- **In Advanced Materials**, Europe has gained importance compared to North America with regard to share of patents, while it has lost ground to East Asia. In trade, the share in total export has remained relatively stable and Europe has maintained its second position.

- **In Nanotechnology**, Europe is continuously lagging behind in terms of share of patents compared to North America and East Asia, while the trade position is slightly more favorable. In the last decade, East Asia has been able to improve its position, especially in trade.

- **In Micro- and Nanoelectronics**, the performance of Europe is further decreasing both in terms of share of patents and share in total export, and is strongly falling back behind North America and East Asia.

- **In Industrial Biotechnology**, Europe is a moderate performer. It has a rather stable share of patents, while its share in global exports is decreasing. East Asia shows high shares of total export, while its performance in terms of patenting is rather weak, although increasing. For North America, the opposite relation occurs, i.e. a leading position in patenting compared to a low share of total export.

- **In Photonics**, East Asia is the leading region both in terms of patenting and trade. The trade performance of this KET is dominated by a single product group, namely photosensitive semiconductor devices. In terms of patenting, Europe performs better than North America, which has seen a strong decline over the past decade.

II- A European perspective: performance, trends and implications

Among the EU-28 Member States, Germany holds the strongest position in all KETs. In general, Germany performs well above the other European countries in terms of share of patents, share of production, share in total export, and share in turnover. France, Italy and the UK are often present in the top five of each KET for several indicators, while some smaller Member States like Belgium and Denmark have excellent positions in particular KETs.

- **In Advanced Materials**, high patent shares translate into high shares in total export with the same six leading countries for both performance measures. The same countries are the strongest in share of production; the only exception is the Netherlands, which drops out of the top six countries. The share in turnover is dominated by Germany and France.

- **Nanotechnology** is the only KET where Germany does not hold the top position. Although Germany has the highest share of patents, share in total export and share in turnover, Spain occupies the first position regarding share of production. The good performance of Spain can be explained by the presence of chemical companies active in advanced paints and coatings.

- **In Micro- and Nanoelectronics**, Germany, France and the Netherlands hold the top positions in terms of share of patents, share in total export and share in turnover. The only exception is the share of production where the Netherlands is performing less strongly and Italy has surpassed France in 2013 to occupy the second position.

- **In Industrial Biotechnology**, Belgium has the highest share in total exports, taking the lead before Germany and France. The strong Belgian export performance is largely due to shipments between multinational firms and driven by high intra-EU exports. Denmark has a positive trade balance and occupies the third position with regard to share in production, indicating that they hold a competitive advantage in this KET.

- **In Photonics**, the share of production is dominated by Germany, which has a leading position with around 50 % of production shares. Germany's patent share and share in total export are respectively around 10 %, while the share of all other countries is less than 4 %.

- **In Advanced Manufacturing Technology**, Germany appears to be in a comfortable first position from all perspectives – technology, production, trade and turnover. The share in turnover is particularly dominated by Germany, as its share is higher than the sum of all other EU countries combined. The Netherlands and Italy hold the second and third positions with regard to share of production and share in total export, while France occupies the second position in share of patents and share in turnover.

III- Case study: focus on main competitors

When comparing the performance of the EU-28 with its main competitors in North America (i.e. the US) and East Asia (i.e. China, Japan and South Korea), the increase in share in total export of East Asian countries is predominant. Depending on the KET, East Asia's export growth is driven either by China (incl. Hong Kong), South Korea or Japan. In general, China demonstrates good trade figures, but has a weaker performance in patenting. Japan, which has several multinationals active in the various KETs, tends to score well in share of patents and share in turnover. In Europe, Germany, as the largest and highly export-oriented economy, tends to score well.

- **In Advanced Materials**, the share in total export for the EU-28 is higher than for Japan, whereas Japan has the highest share of patents and share in turnover. Interestingly, while China still exhibits a low share of patents and share in turnover, it already exceeds Japan, the US and Germany with respect to its share in total export.

- **In Nanotechnology**, the US shows the highest patent share, followed by the EU-28 and Japan. In terms of share in total export, the EU-28 ranks first, well ahead of China and Japan. Although Japan's share in total export decreased significantly in the last decade, it still performs well with regard to turnover. Indeed, Japan has the highest nanotechnology-related business turnover in 2013.

- **In Micro- and Nanoelectronics**, Japan clearly dominates the worldwide patenting, while it also holds a high share in turnover in 2013. China, which shows the highest share in total export, has a low share in turnover, implying that the good trade performance of this country is largely driven by foreign multinationals. The low share in turnover points to the less privileged position of the EU-28 in terms of decision power, especially compared to the US.

- **In Industrial Biotechnology**, the degree of patenting, trade and turnover does not necessarily coincide. While the US is leading in patenting, it is surpassed by the EU-28 and China when it comes to share in total export, and by the EU-28 when it comes to share in turnover. From this result, one may conclude that there is a clear division of labor in IB: while the US is specialized in patenting, the production and export of goods is (to some extent) transferred to countries with a competitive advantage in manufacturing these goods, such as China.

- **Photonics** plays an important role in China, South Korea and Japan. While the patent share is increasing for China and South Korea, it is still low compared to their export shares, indicating that these two countries may be specialized in manufacturing Photonics products that have been invented in other economies. This seems especially true for China, as shown by their low performance in turnover. The US and EU-28 exhibit decreasing shares in both patenting and total export.

- **In Advanced Manufacturing Technology**, the EU-28 has a strong position and is leading in terms of patenting, trade and turnover. Contrary to their performance in the other five KETs, China and South Korea exhibit low shares of patents, low shares in total exports and low shares in turnover for Advanced Manufacturing Technology. The good performance of the EU-28 is related to the different nature of technological advances in this KET, which is based on the integration of other technologies into complex products.

Conclusion

The results presented in this report show that several Member States have capabilities in technology (patenting), trade, production and turnover. However, these capabilities need to be reinforced in order to remain competitive with other countries in other regions like North America and East Asia. The report also identifies some emerging Member States that have capabilities in either technology (patenting), trade, production or turnover, and need to be supported in order to further flourish in the area of specific KETs-based components and intermediary systems. In addition, there are also Member States that are not yet so active in KETs. For these countries, the KETs Observatory can act as an information source to identify KETs-relevant activities in Member States that can serve as possible benchmarks.

2. Introduction

2.1 Policy context

Europe is a global leader in the development of KETs. However, one of Europe's major weaknesses with regard to KETs lies in its difficulty in translating its knowledge base into goods and services. The European Strategy for KETs aims to accelerate the rate of exploitation of KETs in the EU and to reverse the trend of de-manufacturing in order to stimulate growth and jobs.

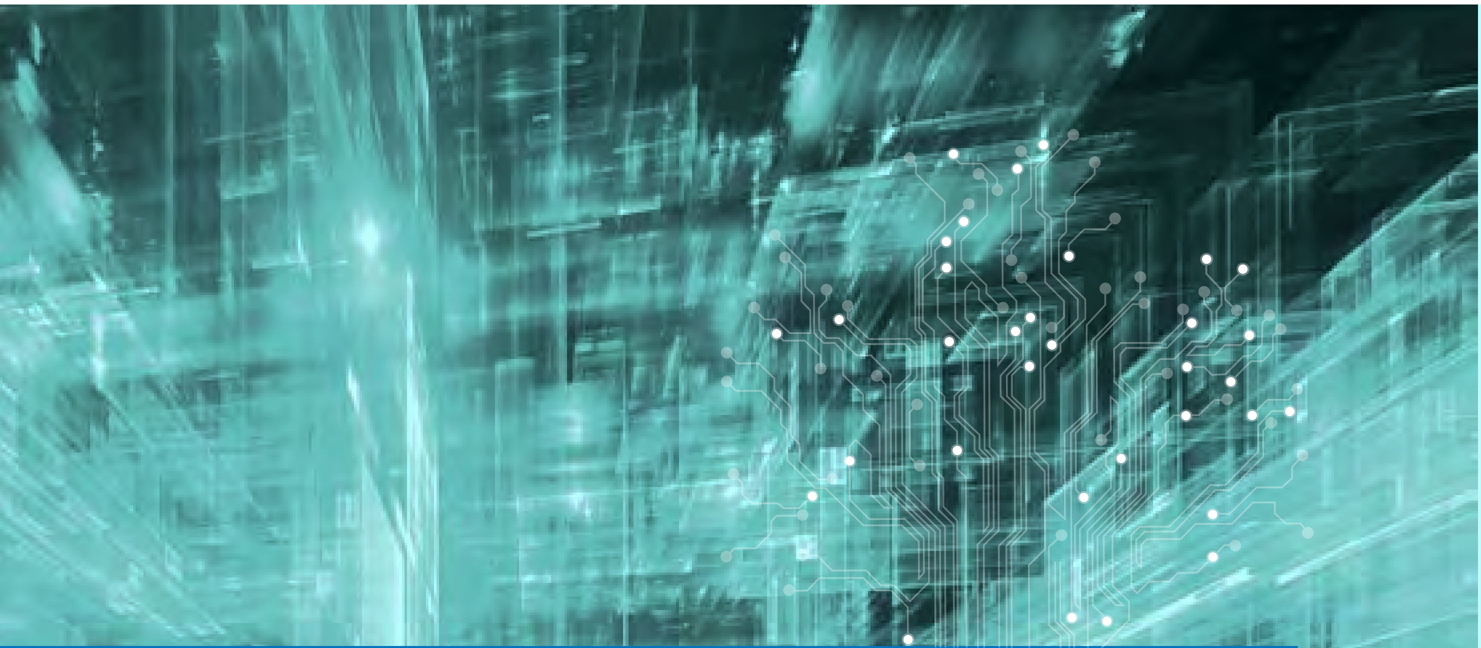
In 2009 the Commission published its Communication "Preparing for our future: Developing a common strategy for key enabling technologies in the EU". This strategy clearly identifies the need for Europe to facilitate the industrial deployment of KETs in Europe in order to make its industries more innovative and globally competitive[2]. KETs are characterized by their economic potential, their value adding enabling role, their technology-intensity and their capital intensity.

The KETs Communication of 2009 announced the setting up of a High Level Expert Group on Key Enabling Technologies with representatives from EU Member States, industry, the European Investment Bank and the research community. The High Level Group was asked to provide the Commission with policy recommendations and a long-term strategy on how to improve conditions for the deployment of KETs.

[2] Advanced Manufacturing Technology (AMT), Micro- and Nanoelectronics (MNE), Photonics (PHOT), Advanced Materials (AM), Industrial Biotechnology IB) and Nanotechnology (NT) have been identified as the EU's six Key Enabling Technologies (COM(2009)512).

[3] COM(2012) 341, A European Strategy for Key Enabling Technologies – A bridge to growth and jobs.

[4] COM(2012) 582, A Stronger European Industry for Growth and Economic Recovery.



The group presented its final report in June 2011. The recommendations of the High Level Group were carefully considered by the Commission in the context of the elaboration of the European Strategy for KETs. The KETs strategy is outlined in the Communication adopted by the Commission in June 2012[3]. The importance of KETs in delivering sustainable growth, creating high-value jobs and solving societal challenges has also been underlined in the reinforced industrial policy Communication[4].

In its report of June 2011, the KETs High Level Expert Group recommended that “the European Commission establishes a European KETs Observatory Monitoring Mechanism tasked with the mission of performing analysis ...” (Recommendation nr. 11) considering the lack of validated market data on development and take-up of KETs. At the end of 2011, the European Commission launched a feasibility study in order to assess various elements of this future Observatory.

In its 2012 Communication, the Commission announced its intention to launch a monitoring mechanism on KETs in order to provide relevant market data on the supply of and demand for KETs in the EU and other regions, and to make the results of the monitoring mechanism publicly available on a dedicated website.

In 2013, the European Commission launched a project involving the setup and implementation of a KETs Observatory (project duration: 2013-2015). The objective of the KETs Observatory is to provide EU, national and regional policymakers with information on the deployment of KETs both within the EU-28 and in comparison to other world regions (East Asia and North America). Knowing the recent trends and developments of KETs-related technology and products in the EU in comparison to other competing economies may serve as a basis for the construction and implementation of dedicated industrial policies. The project is realized by a consortium comprising IDEA Consult, TNO, CEA, ZEW, NIW, Ecorys UK and Fraunhofer ISI (as sub-contractors). This first annual report describes and analyses the situation of EU countries and third countries with regard to KETs on the basis of quantitative results. It compares the performance of countries related to the ability of industries/businesses to transfer new knowledge to industrial applications, and to produce and trade KETs-based components and intermediary systems (such as an optical device or a microelectronic unit to be used in a machine or in transport equipment).

2.2 Data context

The indicators that are discussed in the first annual report reveal how a country performs in relation to the ability of industries/businesses to transfer new knowledge to industrial applications and to produce and trade KETs-based components and intermediary systems. The data provided by the KETs Observatory rest on two complementary approaches, namely the technology generation and exploitation approach, and the technology diffusion approach.

The first annual report discusses the results of the technology generation and exploitation approach, which informs about the ability of countries to generate and commercialize new knowledge. This approach represents only one part of the overall economic value behind KETs. It informs about the technology commercialization potential available in individual countries. The various indicators used in this approach are particularly suitable to capture the multidimensionality of performance of both the EU-28 as a whole, and for individual EU Member States. The indicators nicely illustrate how a country's technological performance in a particular KET translates into success in international production, trade and turnover activity.

The second approach (technology diffusion approach) shows to what extent the EU can use the potential of KETs to improve its competitiveness by manufacturing KETs-based products and by applying them in the production of manufacturing goods, both in the sectors that produce KETs as well as, and more importantly, in other industries. The results of this approach will be discussed in the second annual report.

The data used in the KETs Observatory are retrieved from existing statistical classification systems and databases in order to allow for comparability of results among all KETs and countries. This means that the KETs Observatory can only report on data up to 2013 as more recent data is not yet available. The first annual report, therefore, also only provides data up to 2013, so possible effects of the implementation of the Action Plan of the European Commission are not yet visible. The intention is to update the data on the KETs Observatory yearly, so that the impact of the Action Plan and other policy measures can be monitored. The target audience of this report is therefore policy makers that can employ the data to monitor a country's development in the area of KETs.

As the KETs Observatory relies on existing data and classification schemes, there are certain implications toward the interpretation of the data that is presented in the next sections. Technology indicators are forward-looking as they use patents to inform about the potential of companies to produce new technological knowledge relevant to industrial applications. As the disclosure of a patent application is usually delayed by 18 months according to patent law, this means that this report only contains data up to 2011 as it is based on the most recent Patstat version from April 2014. Data for the year 2012 will be available in June 2015.

The production indicators rely on the data of the Prodcom database to indicate the production and absorption of KETs-based components. As several values are confidential in this database, the graphs on production data do not contain information on all countries. Appendix III provides an overview of the data availability for each KET. 2013 is the most recent year for which data is available.

Trade indicators inform on the ability to produce and commercialize internationally competitive products based on new technological knowledge. There is no information on Taiwan as the UN Comtrade database does not include information on Taiwan. The trade data are available up to 2013. For Micro- and Nanoelectronics (MNE), additional analyses are performed based on the World Semiconductor Trade Statistics database (WSTS), and the SEMI Fab Database to depict market trends and special features for this KET.

Turnover indicators report on turnover at the headquarter level and measure the ability of industries/businesses to compete in the market for KETs-based components. In the interpretation of the results, it is important to keep in mind that the turnover of a company is assigned to its headquarters and therefore informs about the decision power present in particular countries. The indicators provide insights into the location of the main business activities that will drive KETs-related technology generation and exploitation.

[5] The KETs taxonomy that has been developed is published in the methodology report that is available on the KETs Observatory website (www.ketsobservatory.eu).

2.3 Definition of KETs

In this project, KETs are defined as follows:

- **Advanced Materials** lead both to new, reduced cost substitutes to existing materials and to new, higher added-value products and services. Advanced Materials offer major improvements in a wide variety of different fields, e.g. in aerospace, transport, building and healthcare. They facilitate recycling, lowering the carbon footprint and energy demand, as well as limiting the need for raw materials that are scarce in Europe.

- **Nanotechnology** is an umbrella term that covers the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale. Nanotechnology holds the promise of leading to the development of smart nano and micro devices and systems, and to radical breakthroughs in vital fields such as healthcare, energy, environment and manufacturing.

- **Micro- and Nanoelectronics** deal with semiconductor components and/or highly miniaturized electronic subsystems and their integration in larger products and systems. They include the fabrication, the design, the packaging and test from nano-scale transistors to micro-scale systems integrating multiple functions on a chip.

- **Industrial Biotechnology** or white biotechnology is the application of biotechnology for the industrial processing and production of chemicals, materials and fuels. It includes the practice of using microorganisms or components of micro-organisms like enzymes to generate industrially useful products in a more efficient way (e.g. less energy use, or less by-products), or generate substances and chemical building blocks with specific capabilities that conventional petrochemical processes cannot provide. There are many examples of such bio-based products already on the market. The most mature applications are related to enzymes used in the food, feed and detergents sectors. More recent applications include the production of biochemicals and biopolymers from agricultural or forest wastes.

- **Photonics** is a multidisciplinary domain dealing with light, encompassing its generation, detection and management. Among other things it provides the technological basis for the economic conversion of sunlight to electricity, which is important for the production of renewable energy and a variety of electronic components and equipment such as photodiodes, LEDs and lasers.

- **Advanced Manufacturing Technology** encompasses the use of innovative technology to improve products or processes that drive innovation. It covers two types of technologies: process technology that is used to produce any of the other five KETs, and process technology that is based on robotics, automation technology or computer-integrated manufacturing. For the former, such process technology typically relates to production apparatus, equipment and procedures for the manufacture of specific materials and components. For the latter, process technology includes measuring, controlling and testing devices for machines, machine tools and various areas of automated or IT-based manufacturing technology.

The definitions of KETs are generally broad in nature and focus on the impact on industry and society. For the KETs Observatory, it is necessary to operationalize the definitions in order to translate KETs in IPC codes, Prodcom codes, etc. Therefore, a KETs taxonomy has been developed that is used as a source of inspiration by the experts[5]. It is important to note that the codes are an approximation and not a perfect representation of the different KETs.

The preliminary results of the first annual report have been presented to a variety of policy and business people. We would like to thank everyone who contributed to the content of this report by providing comments and suggestions.

3.

Europe in a global context

This section investigates the EU-28's technology and trade performance in each KET with respect to the development in other world regions, i.e. North America (US, Canada, Mexico) and East Asia[6] (Japan, China incl. Hong Kong, South-Korea, Singapore, India, Taiwan[7]). To monitor the EU's technology and trade performance, and to measure the ability of the EU-28 to produce and commercialize internationally competitive products based on new technological knowledge, the KETs Observatory works with four technologies and five trade indicators. More detailed information on these indicators can be found in Appendix I and in the Methodological Report. In this chapter, only the share of patents, share in total export and trade balance are discussed. The other indicators are available on the website (www.ketsobservatory.eu).

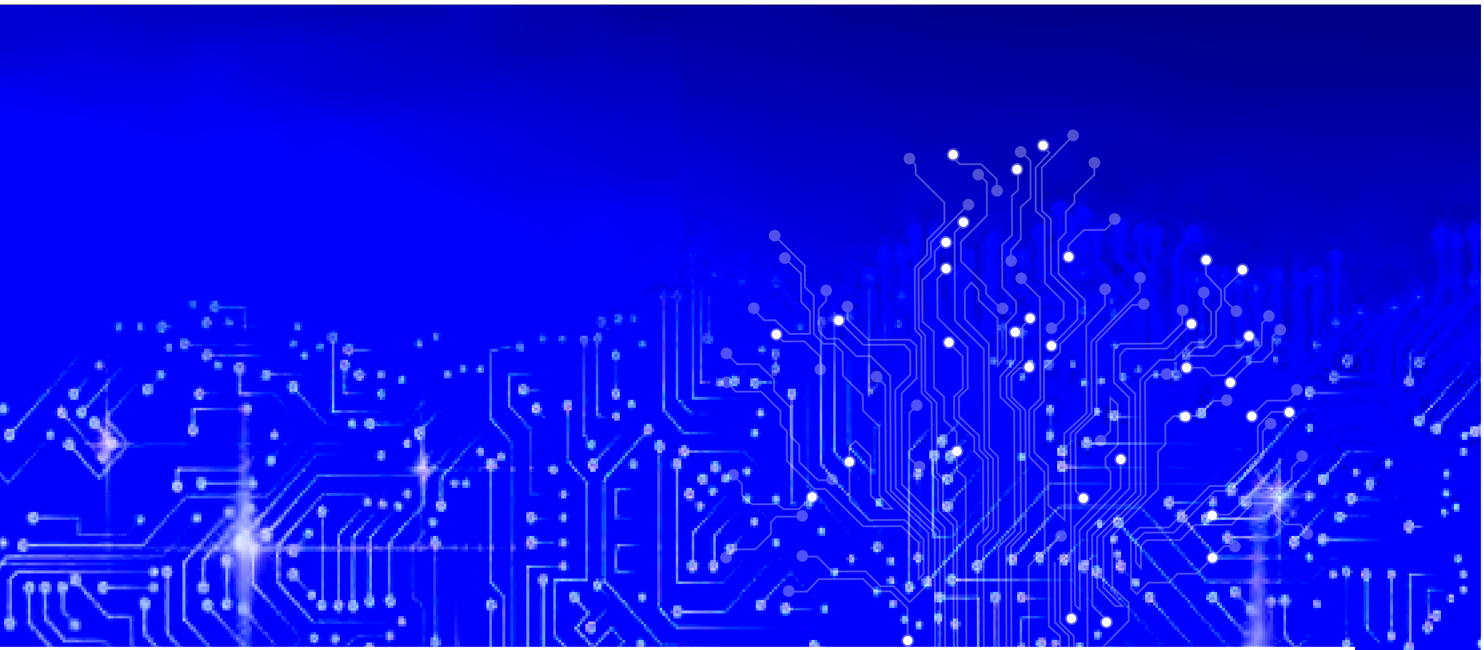
The share of patents is measured by dividing the number of patent applications of a certain country by the total number of patent applications in the respective KET area in the 45 countries considered[8]. It indicates the relevance of that country in the respective technology market. The share in total export is measured as the share of exports from a certain country over total exports of all 44countries considered[9]. It therefore indicates how much a country contributes to the total exports of all countries. The trade balance measures the difference between exports and imports in relation

6 As we primarily include countries located in East Asia (Japan, China, Hong Kong, Singapore, South-Korea, Taiwan) we choose to use the term East Asia to describe the Asiatic region.

7 Trade data for Taiwan are not available in international trade statistics.

8 The trends for share of patents do not differ when we consider the world instead of the 45 countries considered in this study.

9 Trade data for Taiwan are not available in international trade statistics.



to the total trade volume (exports plus imports) of a country. A positive value shows that a country exports more than it imports in a certain KET, which, in turn, indicates some type of competitive advantage.

For the share in total export, it is important to note that the analysis at the level of global regions (EU-28, North America, East Asia) only consider extra-regional trade flows while intra-regional trade flows (e.g. exports from UK to France or from Canada to the US) are ignored. This is owed to the fact that the three regions differ largely in the size of their internal market and the presence or absence of trade barriers which would lead to biased results when including both intra-regional and extra-regional trade flows.

The next paragraphs first discuss the results for all six KETs, followed by a more detailed description of each KET individually.

3.1 All six KETs

When interpreting the results for all six KETs combined, it is important to note that the regional trade performance for all six KETs is significantly shaped by the trade performance in Micro- and Nanoelectronics and Photonics, which account for the highest export and import volumes in the three world regions. In contrast, particularly in the EU-28, Industrial Biotechnology and Nanotechnology only account for small shares of KETs. This is mainly owed to the fact that Industrial Biotechnology and Nanotechnology primarily describe production processes and only a small amount of products can be directly linked to these technologies.

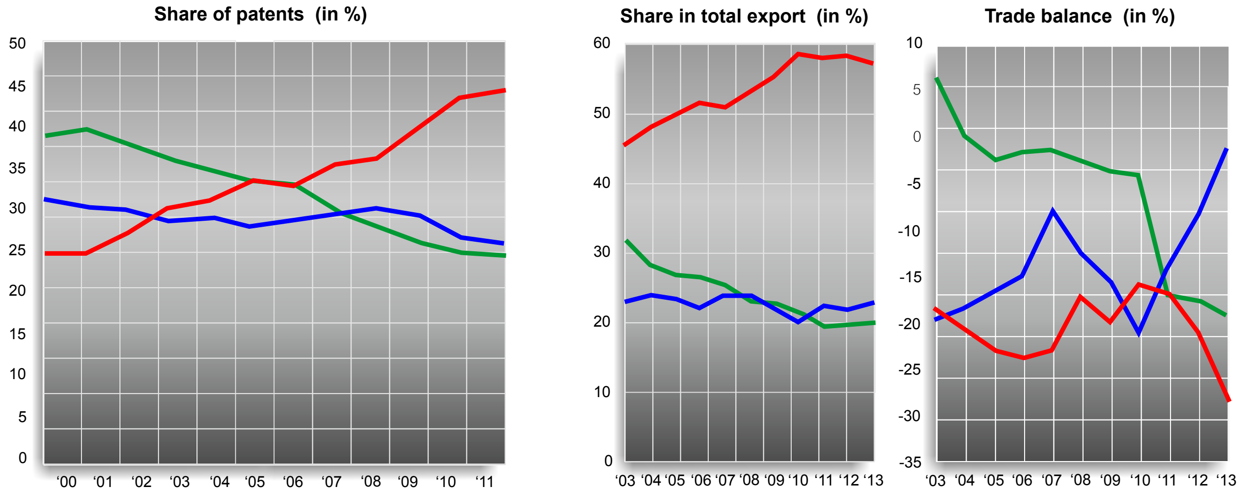
The share of patents, the share in total export and the trade balance for all six KETs combined are displayed in Figure 3-1. With respect to the technology performance, North America realized the largest share in patents of the three regions in 2000 (39 %). However, its share has then continuously decreased to a level of 26% in 2011. In contrast, East Asia´s patent share was rather low in 2000 (26%), but has continuously increased throughout the 2000s, exceeding the patent share of the EU-28 in 2003 and of North America in 2007. While East Asia has seen a strong increase and North America has experienced a strong decrease in their technology performance, the EU-28 has experienced only a modest decrease in its share in patents from 32% in 2000 to 27 % in 2011.

With respect to the trade performance, in terms of shares of total exports, it is again East Asia that experienced the largest increase between 2003 and 20013, while the share of both the EU-28 and Nord America decreased during the same time period. However, as Figure 3-1 depicts, the development between East Asia on the one hand and the EU-28 and North America on the other hand, has remain more or less constant since 2010. Since then, East Asia holds a share in total export of about 58% compared to the EU-28 (22 %) and North America (20 %) when considering all six KETs together. For East Asia, this implies an increase of more than 10 percentage points compared to 2003. This gain came exclusively at the expense of North America.

In contrast, the EU-28 succeeded in holding its share in total export relatively constant over the past decade.

In terms of trade balance (Figure 3-1), all three regions show negative values, indicating that their imports exceed their exports when considering all KETs together. Whereas North America depicts a continuous negative trend, the EU-28 reveals a distinct improvement since 2010. This can only partly be attributed to its comparably favorable performance in AMT (see chapter 3.7). It is rather driven by the sharp decline in photosensitive semiconductor devices as a result of price effects and cuts in solar PV subsidies in several EU-countries (c.f. sections 3.4 and 3.6).

Figure 3-1: Share of patents, share in total export, and trade balance of the EU-28 in regional comparison – all six KETs* (in %)



For regional analysis (EU-28, East Asia, North America), all indicators only refer to extra-regional trade.

*Export and import data for all six KETs are adjusted for double counts.

Source: PATSTAT database. – ZEW calculation & UN COMTRADE-Database. – NIW calculation

In general, the results for all **six KETs** show that both the share of patents and the share in total export have increased for Asia, decreased for North America and remained rather constant for the EU-28 throughout the observation period.

[10] Asian companies are getting a competitive advantage over time. We addressed the concern that the high numbers for Japan are driven by the Japanese system which pushes employees in firms to patent everything by limiting the analysis to international patents applied or at the European Patent Office or via the PCT route. These routes are only worthwhile for patents that are indeed expected to have some value. The grant rates for patents applied for by Japanese applicants and those from other countries do not differ, which supports this argument.

3.2 Advanced Materials

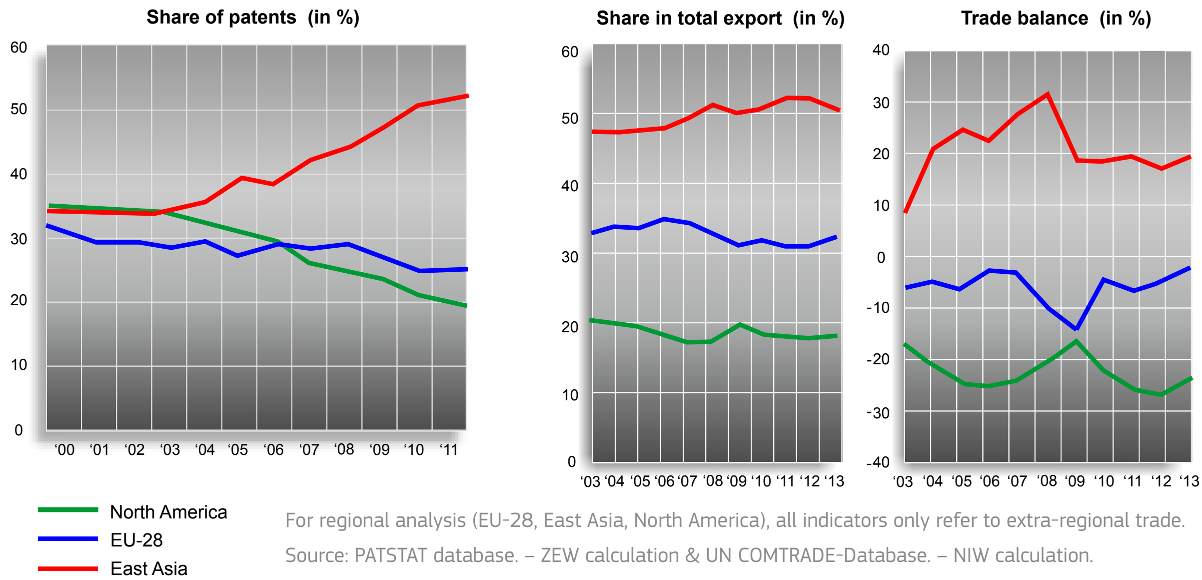
When interpreting the results of the various indicators in Advanced Materials (AM), it is important to keep in mind that Advanced Materials is a very diverse field, with many different subsectors (mainly chemicals, but also several glass, ceramic and other products).

Overall, East Asia shows the strongest performance in this KET, exceeding the EU-28 and North America in both technology performance and trade. As Figure 3-2 depicts, East Asia holds the number one position in share of patents (2011: 50 percent) and the highest share in total export (2013: 50 percent; EU-28: 32 %, North America: 17 %). Moreover, the region has a substantial trade surplus throughout the entire observation period (Figure 3-2). In contrast, the EU-28 and North America both reveal negative trade balances, indicating that their AM imports exceed their exports in AM.

The strong improvement of East Asia[10] in terms of new technological knowledge (2000: 30 percent, 2011: 50 percent) in the field of Advanced Materials has come particularly to the expense of North America (2000: 35 percent, 2011: 20 percent) that has fallen behind the EU-28 (2000: 30 percent; 2011: 25 percent). As Figure 3-2 reveals, the share of patents of EU-28 is also gradually decreasing but felt less sharply than North America's share. One may, therefore, conclude that the relatively stable North American trade performance in Advanced Materials still rests on innovative efforts from previous periods rather than current patenting activities.

The development of the trade performance illustrates that the share in total export has remained relative stable for all three regions over time. When looking at the product groups that are the main drivers of exports in the three regions, it becomes clear that East Asia's exports are driven mainly by electric accumulators, including separators, and wadding, gauze, bandages and similar articles, whereas the EU-28 is particularly strong in artificial joints, polyurethanes in primary forms, and in chemical elements doped for use in electronics (for instance in the form of discs or wafers). North America realizes their largest trade surplus in artificial filament tow.

Figure 3-2: Share of patents, share in total export, and trade balance of the EU-28 in regional comparison – Advanced Materials (in %)



For regional analysis (EU-28, East Asia, North America), all indicators only refer to extra-regional trade.

Source: PATSTAT database. – ZEW calculation & UN COMTRADE-Database. – NIW calculation.

In Advanced Materials, Europe has gained importance compared to North America with regard to share of patents, while it has lost ground to East Asia. In trade, the share in total export has remained relatively stable and Europe has maintained its second position.

3.3 Nanotechnology

Nanotechnology as well as Industrial Biotechnology mainly reflects production processes. Hence, only some products, respective components, are actually directly linked to these technologies. In the case of Nanotechnology this applies particularly for selected chemical products (e.g. inks, paints and coatings) for which Nanotechnology has become an increasingly important method of production.

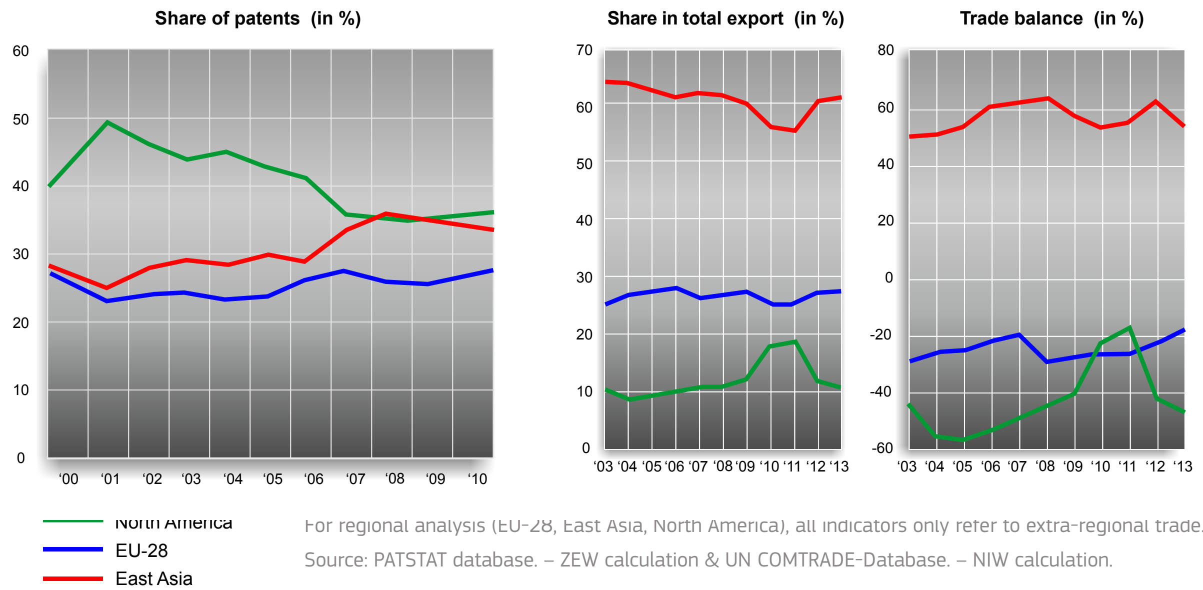
In Nanotechnology, the EU-28 reports low performance levels for both the share of patents (27 percent in 2011) and the share in total export (28 percent in 2013). East Asia and North America both realize patent shares of about 35 percent in 2011, whereas their shares in total exports differ significantly (East Asia: 60 percent, North America: 10 percent in 2013) (Figure 3-3).

When looking at the development over time, North America reports a rather weak and declining trade performance in Nanotechnology despite a still strong –though declining position in share of patents (Figure 3-3). By contrast the EU-28 depicts a modest upward trend in share of patents compared to the beginning of the decade[11] and a marginal upward trend in share in total export.

On the long-run, East Asia was able to increase its share of patents and the slight decrease in terms of its share in total exports 2010/2011 has been reversed recently (2012/2013) (Figure 3-3). A glance at the trade balances of the three regions underlines the positive development of East Asia's trade performance in Nanotechnology. Thus, East Asia reveals a positive trade balance throughout the entire observation period. In contrast, North America and the EU-28 both reveal trade deficits. Hence, the EU-28 and North America both constitute net importers of Nanotechnology.

When looking closely at the main drivers of extra-regional exports in the EU-28, it becomes obvious that ink, prepared pigments, opacifiers and colors, as well as glass frit in the form of powder, granules, and flakes dominate the EU-28 exports in this KET. These products all represent some components that are included in advanced paints and coating like coatings for cars, and are produced primarily by chemical companies.

Figure 3-3: Share of patent, share in total export, and trade balance of the EU-28 in regional comparison – Nanotechnology (in %)



For regional analysis (EU-28, East Asia, North America), all indicators only refer to extra-regional trade.
Source: PATSTAT database. – ZEW calculation & UN COMTRADE-Database. – NIW calculation.

In Nanotechnology, Europe is continuously lagging behind in terms of share of patents compared to North America and East Asia, while the trade position is slightly more favorable. In the last decade, East Asia has been able to improve its position, especially in trade.

[11] Note that technology indicators for Nanotechnology are only available until 2010 due to a time lag in tagging of Nanotechnology patents by EPO.

3.4 Micro- and Nanoelectronics

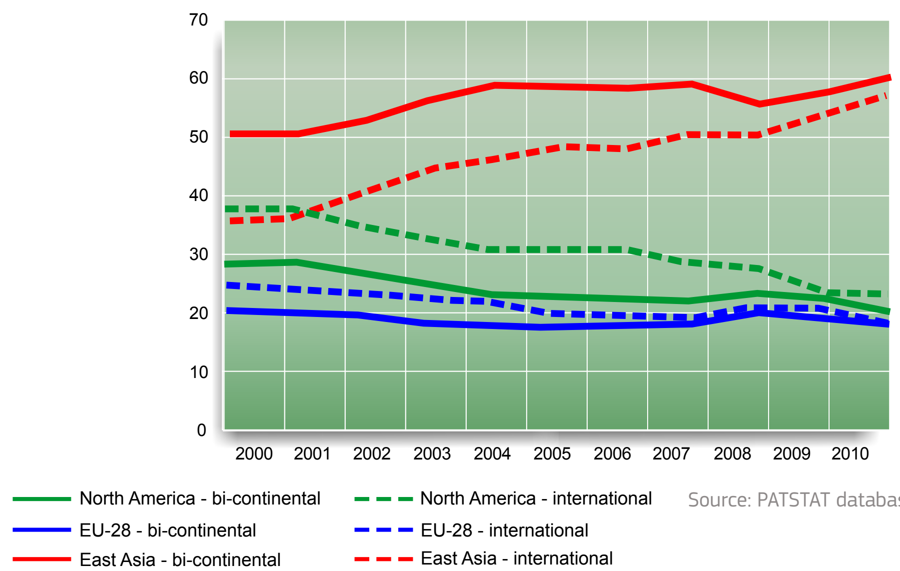
East Asia shows growing shares for both technology and trade indicators. The results for the EU-28 are consistent for share of patents and share in total export, showing a weak performance and a declining trend. North America shows a downward trend for both indicators. Yet when regarding the sales by country of company base, North America still holds the leading position (50 %) followed by East Asia (40 %), whereas the EU-28 is significantly lacking behind (10 %). This discrepancy reflects the ongoing shift of production and also research activities towards East Asia in the Micro- and Nanoelectronics (MNE) business while North American companies managed to maintain a strong position in the MNE market.

The technology performance of the EU-28 in Micro- and Nanoelectronics (MNE) is clearly behind East Asia and North America and has worsened over the past decade (Figure 3-4). The EU-28 share in the production of MNE patents fell from 24 % to 16 % between 2001 and 2011. East Asia is clearly the leading center of patenting in MNE, with patenting increasing by 54 percent over the past decade. This is mainly owed to the strong technology performance of Japan as traditional location of semiconductor companies, but also of South Korea and Taiwan. East Asia's share of patents in worldwide MNE patenting rose from 35 % to 50 %.

In order to address the concern that it is common for MNE companies to file patents not at the EPO, but only in a few countries as the global MNE market is concentrated in a few countries, we have investigated for MNE how the picture changes if we consider "bi-continental" patents, i.e. 1) patents applied in US + at least one EU country, or 2) US + Japan or China, or 3) at least one EU country + Japan or China. This approach results in a loss of quality and consistency as national patent offices apply different policies in assigning IPC codes and exhibit a lower quality in applicant address data. Moreover, the number of different patent applications needed to protect a certain invention differs widely among national offices (particularly with respect to Japan where one typically needs to apply much more patents as compared to Europe to receive the same protection for an invention). As expected, including national data via the concept of "bi-continental patents" results in an overemphasis of the Japanese and Korean patent data. The trends over time however do not change significantly (Figure 3-4).

We have further checked the concern that Japanese employees file many low-quality patents as firms strongly encourage patenting by their employees. However, the grant rates for EPO/PCT patents filed by Japanese firms are not lower than for other countries, such as Germany or the US. This problem therefore probably mostly occurs at the national patent office.

Figure 3-4: Share of patents of the EU-28 in regional comparison – Micro- and Nanoelectronics (in %)



Source: PATSTAT database. – ZEW calculation.

With regard to trade performance, East Asia has continuously increased its shares in total export in MNE between 2003 and 2013, whereas North America and the EU-28 both experienced a more or less steady decline in their export shares (Figure 3-5). As we will show in Chapter 5, the positive growth rate and the increase in East Asia's export share are mainly driven by the outstanding performance of China. Thus, whereas Japan as the traditional East Asian leader in MNE production has continuously lost shares during the last decade, China could increase its share in total export in MNE by approximately 10 percentage points. Despite its gain in export shares, East Asia's trade balance did not increase in a similar rate, but actually declined.

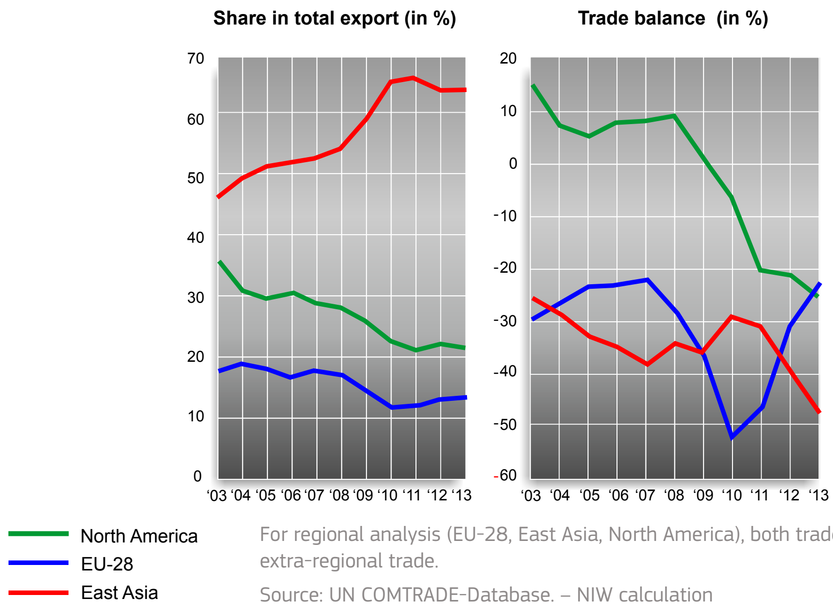
This trend is mainly owed to the fact that one leading East Asian country in MNE trade, namely Taiwan, is not represented in trade indicators as the UN COMTRADE database does not contains any data on Taiwan. In addition, the production of MNE products within Asia has increasingly moved towards Asian countries that are not included in the geographical definition of East Asia used for this study, including Malaysia, Thailand, Vietnam, Indonesia and the Philippines. To illustrate this: the five Asian countries included in the regional definition of East Asia (China (incl. Hong Kong), Singapore, South-Korea, Japan and India) exhibited MNE exports of 93 billion US-$ and imports of about 217 billion US-$ from countries outside this region (extra-trade). Almost 80% of the imports (170 billon US-$) came from Malaysia, the Philippines, Thailand, Vietnam and especially the UN Comtrade category "rest of Asia", that essentially contains Taiwan. Thus, these countries not included in the definition of East Asia (i.e. Taiwan, Malaysia, Philippines, Thailand) reveal a relative better trade performance particularly in standardized components as integrated and electronic circuits.

This is due to the shift of several production steps of MNE devices (mainly back-end production: test, assembly, pack and ship, but also minor parts of front end production) to lower developed countries with lower production costs. Given the fact that the semiconductor industry is very dynamic with short product life-cycles, and investment needed for new semiconductor production facilities is very high, production facilities have to reach a high volume of output quickly in order to generate sufficient returns on investment. Therefore, economies of scale and labor costs are important aspects in several production steps. As both can be realized more easily in East Asia than in the EU and North America, countries like Taiwan, China, Korea and Singapore (and, in recent years, other Asian countries), have increasingly become major production locations in Micro- and Nanoelectronics.

The EU-28 maintains a negative trade balance throughout the last decade indicating that the EU-28 imports more MNE products than it exports. The significant deterioration between 2007-2010 as well as the improvement 2011-2013 is mainly owed to changes in the import volume of photosensitive semiconductor devices that account for about 50 % of MNE imports in 2010 and 2011. The EU-28's imports of those products sharply increased between 2007 and 2010, because the European demand for solar PV was profoundly growing. Thus, the EU market was open for less expensive imports of photosensitive semiconductor devices particularly from China. In contrast, the decline in those imports since 2011 is mainly driven by the reduction of public subsidies of solar PV in several EU countries. North America has started with a positive trade balance in 2003, but turned from a net exporter of MNE into a net importer in 2009.

[12] Data from WSTS still refer to EU-27 and not to EU-28. Regarding the location of the main global players within the semiconductor industry, this difference does not affect the results.

Figure 3-5: Share in total export and trade balance of the EU-28 in regional comparison – Micro- and Nanoelectronics (in %)



For regional analysis (EU-28, East Asia, North America), both trade indicators only refer to extra-regional trade.

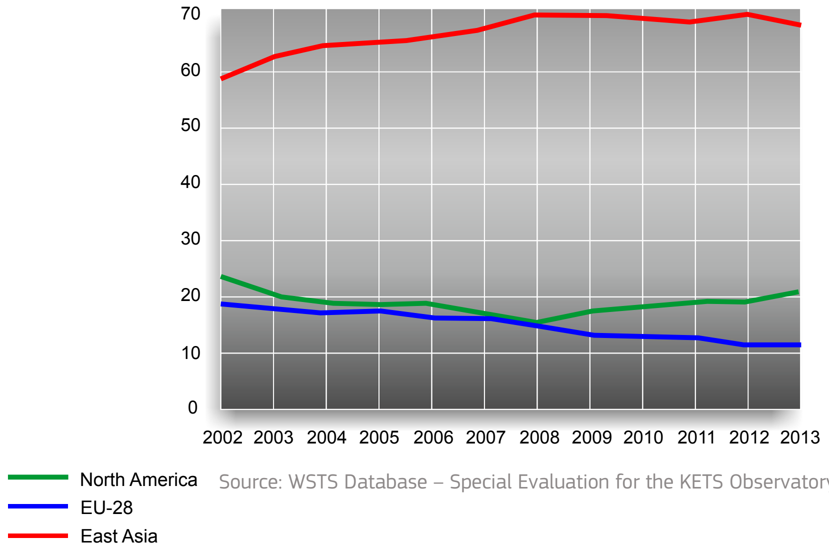
Source: UN COMTRADE-Database. – NIW calculation

Given the fact that in MNE, the production is characterized by a pronounced division of labor, the sole focus on shares of exports may not provide a comprehensive picture about the market activities in this KET. This is because the production of MNE-related products and components is organized in several production steps that often take place in different countries. Therefore, MNE related products and components may have been "exported" three or four times before they are being sold. Moreover, the export volume covered in trade statistics is often defined by the country of back-end production (i.e. assembly, test, pack and ship), while the decision power and important parts of the front-end production (i.e. research and development) that accumulates approximately 80 % to 85 % of total costs and value added take place in other countries, even world regions. Looking solely at exports may, therefore, reveal a biased picture on the market activities in MNE.

Therefore, we provide additional information on the market performance of the EU, North America and East Asia by analyzing data obtained from the World Semiconductor Trade Statistics (WSTS) database and the Semiconductor Equipment and Material Association (SEMI) Fab database. As outlined in the box below, the WSTS is based on the sales figures of semiconductor companies realized in the various countries and world regions. The Fab database provides i.a. data on production capacities measured by the production quantity (i.e. normalized - 8 inches equivalent - wafer size per month). By relying on firm-level micro-data that depicts business activities, the general focus of the WSTS and SEMI data differs from that of the UN Comtrade database that provides aggregated data on exports and imports by products and country dyads. Both firm-level micro-data as well as aggregated export and import data are relevant and offer important insights: while the official UN Comtrade trade database reveals the EU-28's competitiveness in MNE trade compared to North America and East Asia, the WSTS depicts information on market volume and its development over time in the respective world regions. Furthermore, the firm-level databases also provide data for Taiwan, one of the major players in semiconductor and therefore also MNE production.

As Figure 3-6 illustrates, the market development in MNE is driven by a similar trend as the shares in total export. That is, East Asia reveals both the highest market shares (measured by the value of shipments to each region) and the highest shares of exports (see Figure 3-5) for the period between 2002 and 2013. In contrast, the market shares (measured by shipments) and the share of exports of the EU-27[12] and North America are significantly lower.

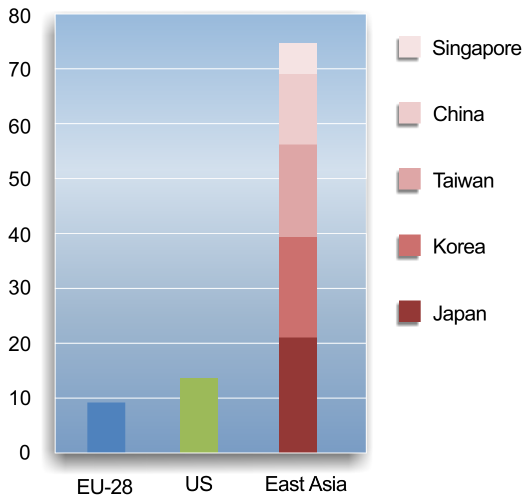
Figure 3-6: Trends in sales of semiconductor firms in regional comparison (sales in $M)



Source: WSTS Database – Special Evaluation for the KETS Observatory - NIW illustration.

This regional discrepancy may mainly be driven by the high production capacities located in East Asia. Particularly back-end production is concentrated there (back-end is the final step of a semiconductor process, while wafer is at the beginning of the process[13]). This also explains the high export shares of this region. When looking at the distribution of the production capacities (measured by the production quantity) by region (Figure 3-7), in 2013, East Asia's share is more than twice the size of the share of the EU-27 and the US together. Overall, the share of these three regions amounts to approximately 97 % of the global semiconductor production. Within the EU-27, Germany (2.8%), France (2.3%) and Italy (0.9%) are the three largest producers of wafers.

Figure 3-7: Share of production capacity by country of Fab Location in 2013 (in Waferstarts per month; 8 inches equivalent) – regional comparison

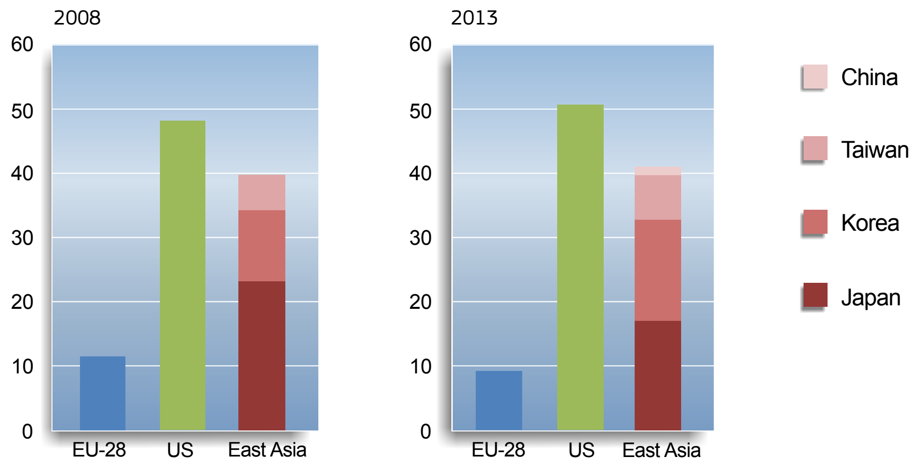


Source: SEMI Fab Database – Special Evaluation for the KETs Observatory - NIW illustration

[13] Front-end refers to the fabrication from a blank wafer to a finalized wafer (microchips that are still on the wafer), and Back-end refers to dicing the wafer into individual chips and processes (test, assembly, packaging, etc).

However, the picture looks quite differently when assessing the sales of semiconductors by country of company base (Figure 3-8). Here, the US reveals the highest share, while the share of East Asia is significantly lower. Particularly China's share is only marginal when considering sales by country of company base. This finding suggests that parts of the front-end production and most of the back-end production of US and European owned firms take place in Asian countries (often Malaysia, Philippines, Taiwan, and China), whereas R&D as one important part of the global value chain is still concentrated in the highly developed home countries. The exception is Japan, where still all steps of the semiconductor production chain are in place. While the USA could expand its production share by country of company base by two and a half percentage points between 2008 and 2013, the share of the EU-27 decreased during the same period of time by more than two percentage points, adding up to merely 9 % in 2013. Hence, in contrast to its main competitors (North America and East Asia), the EU-27 performs rather poorly when it comes to influencing and shaping future developments in semiconductor industry. As R&D is very important in Micro- and Nanoelectronics (given the very dynamic industry with short product life-cycles) the rather low and decreasing share of relevant decision-making capacity certainly is a deficit of the EU.

Figure 3-8: Share of sales (in US-$) by country of company base – regional comparison



Source: WSTS Database – Special Evaluations for the KETs Observatory- NIW illustration

In Micro- and Nanoelectronics, the performance of Europe is further decreasing both in terms of share of patents and share in total export, and is strongly falling back behind North America and East Asia.

Additional data source information

In order to provide a comprehensive picture on the market activities in MNE, the World Semiconductor Trade Statistic (WSTS) and the SEMI Fab Database are used as additional source of information along with the official UN Comtrade database. The World Semiconductor Trade Statistics (WSTS) (https://www.wsts.org/GENERAL/DATA-RECIPROCITY) is a private database provided by the World Semiconductor Trade Statistics association. It contains market statistics based on revenue data of its member firms operating in the semiconductor industry. The Semiconductor (SEMI) Fab Database (http://www.semi.org/eu/MarketInfo) is also a private database provided by the SEMI Industry Research and Statistics group association. The data contain i.a. information on production quantities and is therefore particularly suitable for market research and competitive analysis.

3.5 Industrial Biotechnology

Industrial Biotechnology (IB) as well as Nanotechnology mainly reflects production processes. Hence, only some products respective components are directly linked to these technologies. In the case of IB this applies particularly for selected chemical products for which biotechnology has become an increasingly important method of production, though not all these products are necessarily produced using biotechnological processes.

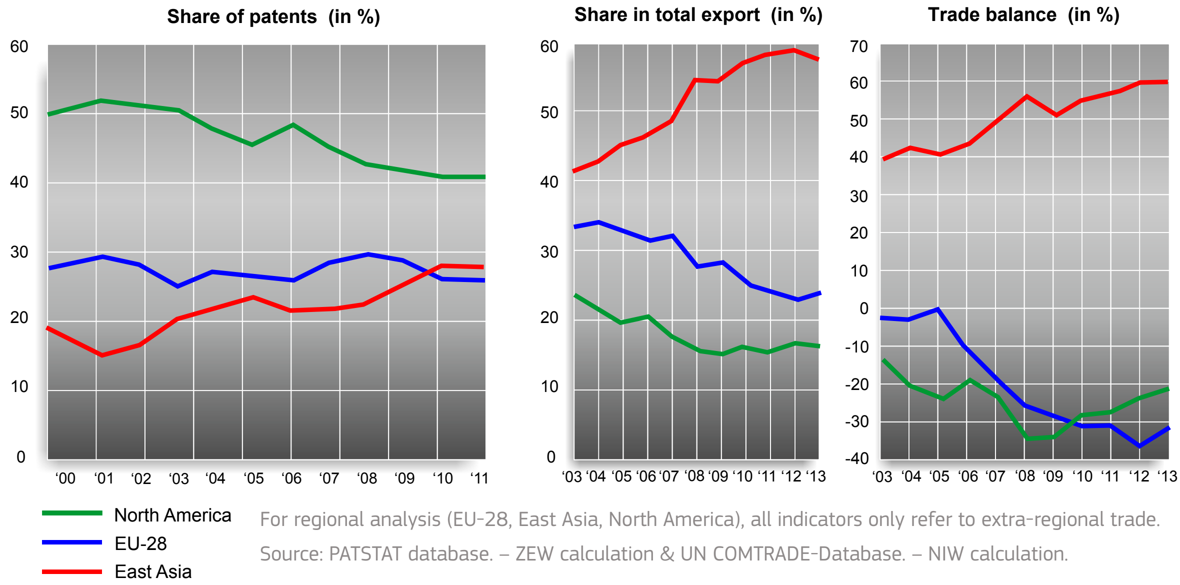
Comparing technology and trade performance in Industrial Biotechnology provides a complex result. While East Asia holds an outstanding position in trade with IB products as depicted by the high share of total export (about 60 %) and its positive trade balance, its performance in terms of patenting is rather weak, although increasing. Since 2010, the share of patents of East Asia has surpassed the share of patents of EU-28. For North America, the opposite relation occurs, i.e. a leading position in patenting compares with a weak trade performance (see Figure 3-9). The trade indicators (i.e. share in total exports and trade balance) for the EU-28 clearly show a downwards trend while the technology indicator is rather stable.

The divergent results for technology and trade indicators suggest that trade performance in IB is not much related to patenting. One reason for this finding may relate to the fact that most IB products considered for trade indicators are chemical products which are manufactured within production networks of large multinational companies. The location of patenting versus production and trade in IB are often not the same, i.e. new technology is mainly developed at the headquarters' R&D labs, while production takes place close to the users of the products, at locations with low production costs (e.g. low energy prices) and with good access to raw materials. Such locations are often situated outside the country where the headquarters are positioned.

As Figure 3-9 depicts, East Asia continuously increased its positive trade balance during the last decade at the expense of North America and the EU-28. This indicates that East Asia continuously exports more IB products than it imports. While the trade balance of the EU-28 has been nearly balanced at the beginning of the millennium, since, 2005, there has been a tremendous downward trend that can mainly be attributed to changes in global production chains of basic chemicals. North America, in contrast, has experienced a decline of its already negative trade balance during 2003 to 2008, but could recently reverse its downward trend. This is mainly driven by the improved performance of the US where chemical manufacturing is able to profit from lower energy costs.

Referring to IB products, the EU-28 and North America are net exporters of insecticides whereas their overall negative trade balance is mostly determined by the high import surplus of amino-acids and provitamins and vitamins. Moreover, the EU-28 shows a remarkable positive trade balance in prepared enzymes, whereas North America gains an export surplus in acetic acid and lysine. By contrast, East Asia holds a positive trade balance in nearly all IB products excluding acetic acid.

Figure 3-9: Share of patents, share in total export, and trade balance of the EU-28 in regional comparison – Industrial Biotechnology (in %)



For regional analysis (EU-28, East Asia, North America), all indicators only refer to extra-regional trade.

Source: PATSTAT database. – ZEW calculation & UN COMTRADE-Database. – NIW calculation.

In Industrial Biotechnology, Europe is a moderate performer. It has a rather stable share of patents, while its share in global exports is decreasing. East Asia shows high shares of total export, while its performance in terms of patenting is rather weak, although increasing. For North America, the opposite relation occurs, i.e. a leading position in patenting compared to a low share of total export.

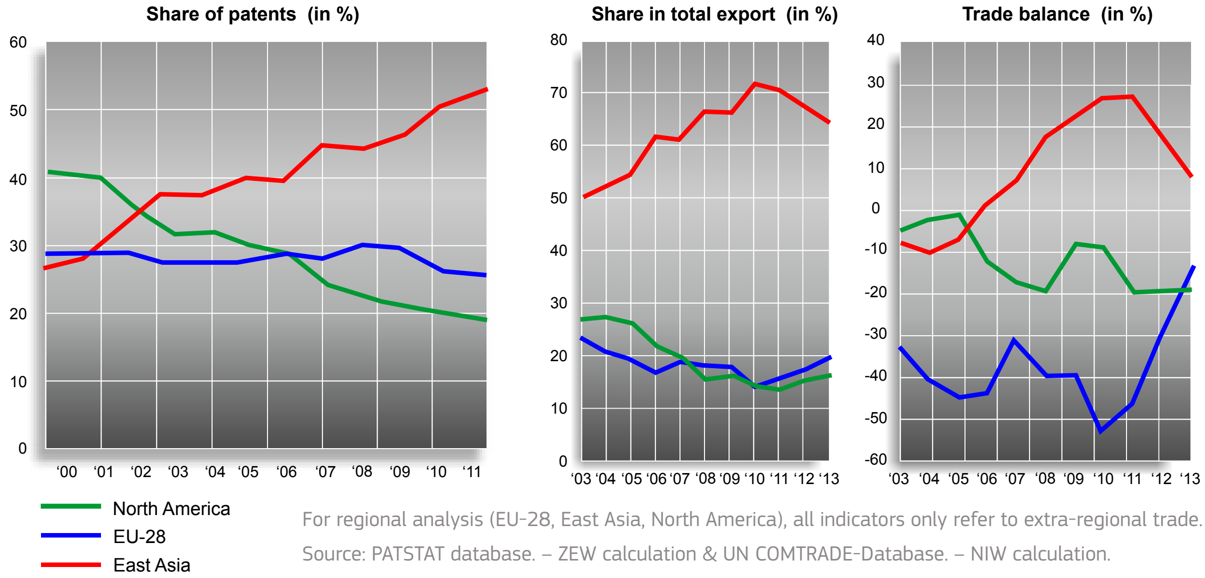
3.6 Photonics

In Photonics, the trends in technology and trade performance of the EU-28, North America and East Asia are rather consistent (Figure 3-10). East Asia is the leading region both in terms of share of patents and share in total export. East Asia's share in total exports is higher than the combined share of North America and the EU-28 both in patenting and total exports.

As Figure 3-10 illustrates, East Asia is improving its technology performance substantially and has become the leading region for patenting in Photonics. The share of patents of East Asia in global Photonics patenting grew from 26 % (2000) to 53 % (2011) while the one of North America has declined during the same period from 41 % to 19 %. Most recently, EU-28's share in global Photonics patenting fell slightly to 26 percent. Between 2003 and 2013 East Asia could increase its share in total exports in Photonics by more than 10 % points at the expense of the EU-28 and North America, who both experienced a decline in Photonics shares in total exports in the same period.

With respect to the trade balance, North America has turned from an almost even result in 2005 to a constantly large trade deficit in Photonics (Figure 3-10). In contrast, East Asia depicts an increasing trade surplus from 2003 to 2010/11, followed by a sharp decline in 2012/2013.The trade balance of the EU-28 as a traditional net importer of Photonics showed a pronounced downfall until 2010 and a significant improvement from 2011 onward. This development is mainly driven by photosensitive semiconductor devices that accounted for about 35 percent of the EU-28's Photonics imports in 2007, increased to more than 60 % in 2010/2011 and fell to one third in 2013. The recent decline is the result of price effects but also due to the cuts in public subsidy of solar PV in several EU countries. Overall, this example shows that the trade development in Photonics as a whole (similar to Micro- and Nanoelectronics) is dominated by a single product group, namely photosensitive semiconductor devices, that shadow other innovative and successfully performing photonic fields. This implies that there are a lot of more or less weighty product groups, in which the EU-28 attained high export growth rates between 2007/08 and 2012/13 for instance lasers, lenses, specific medical and other instruments and apparatus, that often also exhibit a positive trade balance.

Figure 3-10: Share of patents, share in total export, and trade balance of the EU-28 in regional comparison – Photonics (in %)



For regional analysis (EU-28, East Asia, North America), all indicators only refer to extra-regional trade.

Source: PATSTAT database. – ZEW calculation & UN COMTRADE-Database. – NIW calculation.

In Photonics, East Asia is the leading region both in terms of patenting and trade. The trade performance of this KET is dominated by a single product group, namely photosensitive semiconductor devices. In terms of patenting, Europe performs better than North America, which has seen a strong decline over the past decade.

3.7 Advanced Manufacturing Technology

Advanced Manufacturing Technology includes all production equipment that deploys a KET or any other innovative technology. Hence, the technology and trade performance in Advanced Manufacturing Technology (AMT) shows a strong position of the EU-28 for all groups of indicators (Figure 3-11). The EU-28 is leading in terms of share of patents and shares in total export and depicts a high and increasing trade surplus. The technology indicator for AMT provides a significantly different picture than for the five other KETs. The EU-28 holds the highest share of patents, producing 41 % of all AMT patents in 2011. East Asia had a patent share of 29 % in that year and North America produced 25 % of all AMT patents in 2011. The EU-28 share went up until 2009 (47 %) but markedly fell in 2010 and 2011 when East Asia increased its patent output substantially. North America lost patent shares between 2005 (32 %) and 2009 (22 %). Referring to the share in total export, the gap between the EU-28, North America and East Asia is less profound than those regarding the other five KETs. The EU-28 managed to extend its leading position between 2007 and 2013, while North America lost ground not only compared to the EU-28, but also to East Asia.

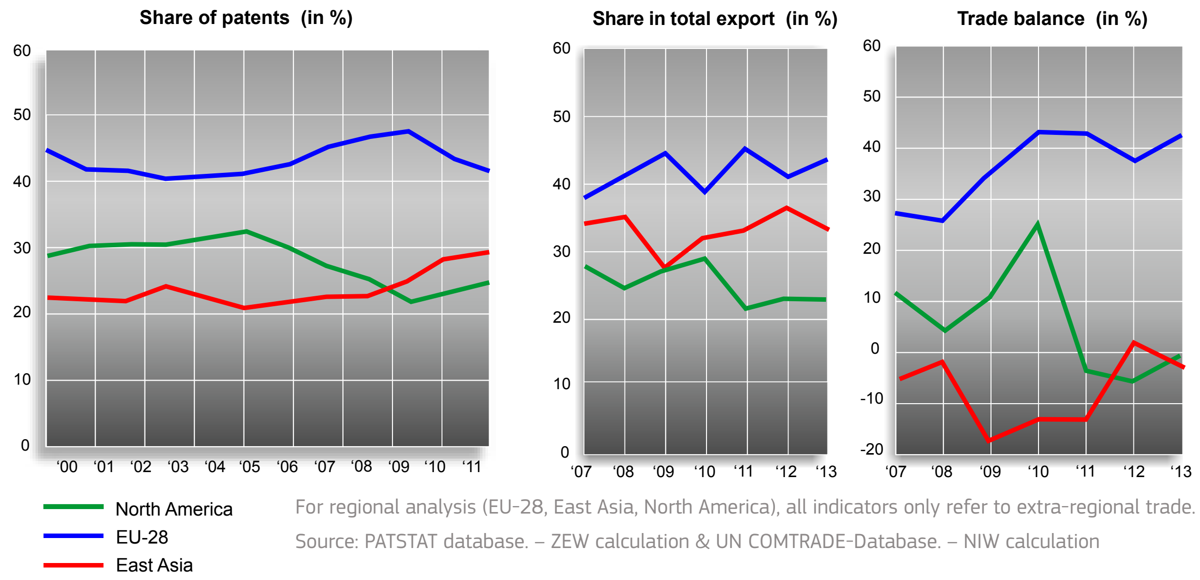
A main reason for the rather good performance of the EU-28 in AMT is related to the different nature of technological advance in this KET. New technological solutions in AMT basically rest on the integration of other technologies (such as Micro- and Nanoelectronics, Advanced Materials or Photonics) into complex products.

Hence, when looking at the product groups that drive the EU-28's extra-regional exports, it becomes evident that the EU-28 exports are strongly driven by machines and apparatus for the manufacture of semiconductor devices of electronic integrated circuits and machining centers for working metals. In addition, measuring and checking instruments, apparatus, and machines also play an important role. The design of these machineries requires in-depth knowledge of different technologies, including managerial capacities to design complex innovation processes that involve experts from different fields. In addition, economic success of new AMTs strongly rest on a deep understanding of the challenges and requirements in the clients' markets which typically needs a long market experience and close interaction with clients.

This may explain why emerging economies face more difficulties in establishing a competitive AMT industry as compared to the other five KETs. The EU-28 can profit from its long history in developing and applying advanced technologies in manufacturing, and a dense network of AMT producers and users. An additional factor that explains the strong trade performance of the EU-28 is the fact that the two largest customers of these machineries (i.e. China and the US) are both located outside Europe, so that Europe's trade balance is particularly strong.

The positive trade balance of the EU-28 indicates that the EU-28 continuously exports more AMT products than it imports (Figure 3-11). In contrast, North America, a traditional net exporter of AMT products has turned into a net importer in 2011. The reverse development can be observed for East Asia whose traditional trade deficit has improved to a fairly even trade balance in 2012/2013.

Figure 3-11: Share of patents, share in total export, and trade balance of the EU-28 in regional comparison – Advanced Manufacturing Technology (in %)



For regional analysis (EU-28, East Asia, North America), all indicators only refer to extra-regional trade.

Source: PATSTAT database. – ZEW calculation & UN COMTRADE-Database. – NIW calculation

In Advanced Manufacturing Technology, Europe is leading in terms of share of patents and shares in total export, and depicts a high and increasing trade surplus compared to East Asia and North America.

4. A European perspective: performance, trends and implications

This section describes the EU-28's technology, trade, production and turnover (at headquarter level) performance in all six KETs and in the individual KETs. To monitor the EU-28's performance and to measure the ability of the EU to produce and to commercialize competitive products based on new technological knowledge, the KETs Observatory works with four technology, production and turnover indicators, and with five trade indicators that are described in Appendix I and the Methodological Report. The various indicators are particularly suitable to capture the multidimensionality of performance of both the EU-28 as a whole, and for individual EU Member States. Furthermore, the indicators nicely illustrate how a country's technological performance in a particular KET translates into success in international production, trade and turnover activity.

The following sections focus on the country-level and depict the technology, production, trade and turnover dynamics for selected EU-28 Member States. In this chapter, the general insights and results obtained from the following indicators are examined:

- **Share of patents:** measured by dividing the number of patent applications of a certain country by the total number of patent applications in the respective KET area.
- **Share of production:** gives the share of production of a KET for a certain country in total production of all countries considered.
- **Share in total export:** measured as the share of exports from a certain country over total exports of all countries considered.
- **Share in turnover:** measured by dividing the total turnover in the respective KET in a certain country by the total turnover of all countries considered.

These indicators are influenced by the size of a country as larger countries are more likely to produce more patents and have more export etc. than small countries. This implies that large economies tend to perform better as they tend to contribute more than smaller economies. This was not an issue in the previous chapter as each region (EU-28, North America, and East Asia) has about the same economic size. It does, however, matter in this chapter, as the EU Member States differ considerably in size, implying that Germany often appears at the top, while Malta appears at the bottom.

In addition, information is provided on the trade balance and the share of EU-28 exports attributed to EU-extra and EU-intra trade as this provides insights into the amount of EU-28 trade that happens within the EU community. This chapter presents the results for the 10 EU Member States with the highest shares in the respective KET (i.e. top 10).

This implies that the top 10 countries presented in each graph differ according to their relative performance in technology, trade, production and turnover. For example, a country may appear in the top 10 with regard to the share of patents, while it might only occupy a fifteenth position in share of production.

The KETs Observatory also considers indicators like country significance and KET specialization, to mitigate the size effect to which the "share" indicators are subjected to. Detailed results for all indicators and for the entire list of EU-28 Member States, as well as for the other 18 non-EU-28 countries, can be found on the website (www.ketsobservatory.eu). An example of how information can be derived from the website is depicted in Appendix II.

With respect to trade indicators it is important to note that while the EU-28 average (Chapter 3) only considers EU-extra trade, on the country-level, both EU-intra and EU-extra trade flows are considered.

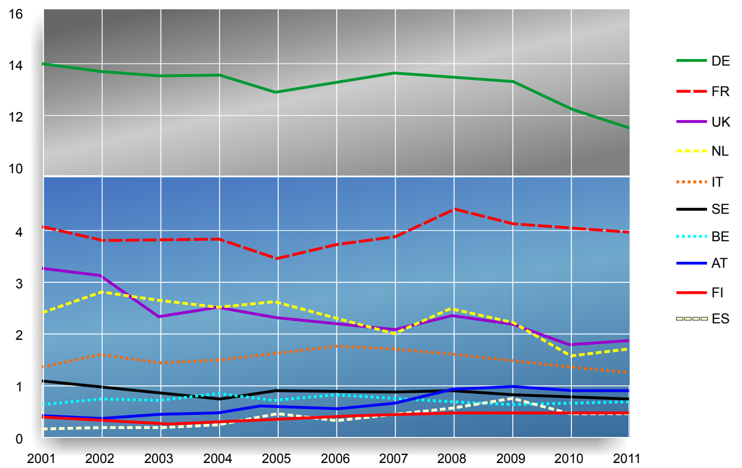
Regarding share in turnover, it is important to note that in this chapter share in turnover is calculated for the EU-28 only, as no time series for non-EU countries are available. In interpreting the share of turnover, it is also important to keep in mind that the turnover is assigned to the headquarters of a company and hence informs about the decision power in KETs-related business activities.

4.1 All six KETs

Technology performance

The technology performance among the top 10 European countries with respect to share of patents for all six KETs is displayed in Figure 4-1. Germany is the country with the highest patent share, followed by France, the UK, and the Netherlands. Italy and Austria follow in fifth and sixth position. Belgium, Sweden, Spain and Finland complete the top 10 European countries.

Figure 4-1: Share of patents for the top 10 EU-28 countries in all six KETs (in %)



Including the 10 EU-28 countries with the highest share of patents in the respective KET with respect to the patents of all 45 countries considered.

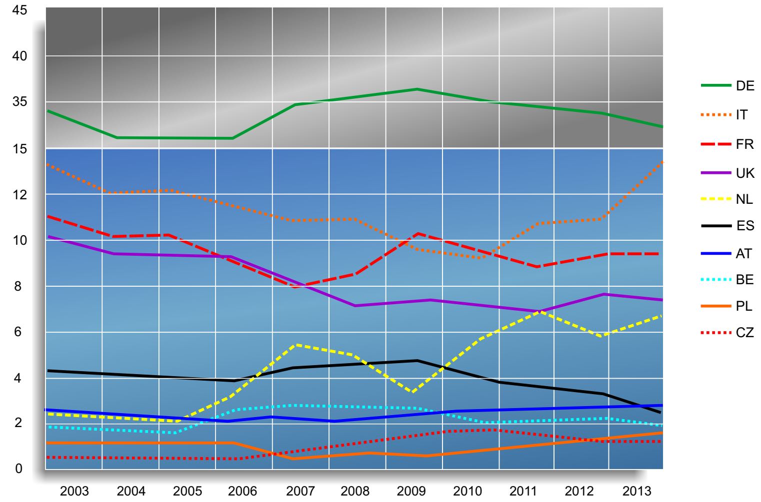
Source: PATSTAT database. – ZEW calculation

Production performance

The production performance indicator for all six KETs shows a high share of production for Germany, followed by Italy, France, the UK and the Netherlands (Figure 4-2). The production share of Germany, as the largest economy within the EU-28, is considerably higher compared to other Member States. With an exception for 2009 and 2010, Italy occupies the second position, before France and the UK. The Netherlands has witnessed an increase in share of production, and also Poland noted its highest share in 2013.

[14] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

Figure 4-2: Share of production for the top 10 EU-28 countries in all six KETs (in %)



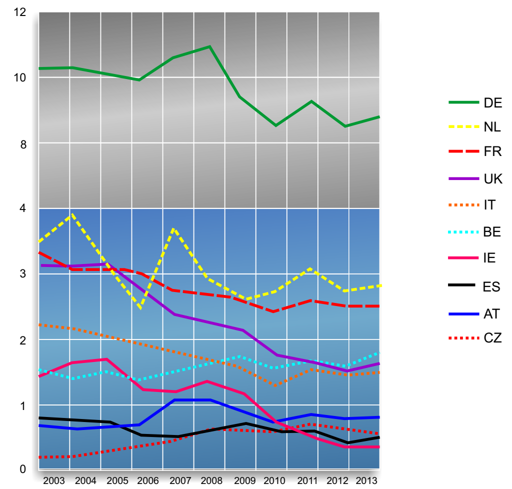
Including the 10 EU-28 countries with the highest shares of production in the respective KET with respect to the production of all EU-28 countries.

Source: PRODCOM database. – IDEA Consult calculation.

Trade Performance

Considering all KETs together, Germany, as the largest economy within the EU-28, is also the largest exporter, realizing a share in total export of nearly 10 % (Figure 4-3). In contrast, the Netherlands and France, as the second and third largest exporter of KETs within the EU-28, only realize a share in total export of about 3 %, with Belgium, the UK and Italy realizing a share of nearly 2 %.The shares in total export of the remaining EU-28 countries do not exceed the 1 % threshold. Thus, the shares that European countries realize in global exports of all six KETs are generally lower than those gained in total manufacturing trade. This is due to the fact that the trade performance for all six KETs is significantly shaped by the trade performance for Micro- and Nanoelectronics and Photonics, in which the EU-28 shows a relative weak production and trade performance (Chapter 3).

Figure 4-3: Share in total exports for the top 10 EU-28 countries in all six KETs (in %)

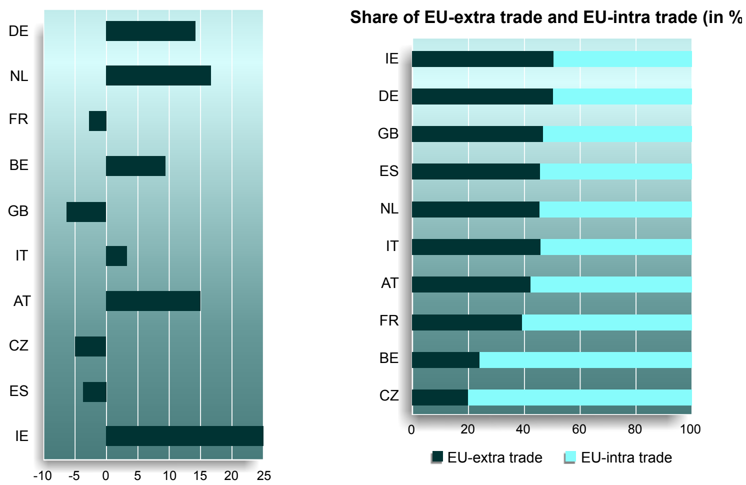


Including the 10 EU-28 countries with the highest shares in total export in the respective KET with respect to the exports of all 44 countries considered[14].

Source: UN COMTRADE-Database. – NIW calculation

In terms of trade balance, out of the larger top 10 European KETs exporters, only Germany, the Netherlands, and Belgium reveal positive trade balances and realize a trade surplus when taking all six KETs together (Figure 4-4). In contrast, France, the UK and Italy reveal a negative trade balance, indicating that their imports in all KETs exceed their exports. Among the smaller EU-28 exporters, Ireland and Austria are the only countries with a trade surplus. In the remaining top 10 countries, KETs imports exceed KETs exports. Most of the trade with manufacturing goods happens within the EU community. Therefore, it is interesting to compare the share of EU-intra trade exports with the share of EU-extra trade exports on the country level. As Figure 4-4 reveals, Ireland is the only top 10 country that exports more KETs in countries outside the community. In the majority of top 10 countries, the shares are fairly even with a slight shift in favor of EU-intra trade exports. Only in Belgium, Hungary and the Czech Republic do over 70 % of KETs exports remain within the community.

Figure 4-4: Trade balance for the top 10 EU-28 countries in all six KETs* and share of EU-28 exports attributed to EU-extra and EU-intra trade in all six KETs*, 2013



Including the 10 EU-28 countries with the highest shares in total export in the respective KET in 2013 with respect to the exports of all 44 countries considered.[15]

*Export and import data for all six KETs are adjusted to avoid double counts.

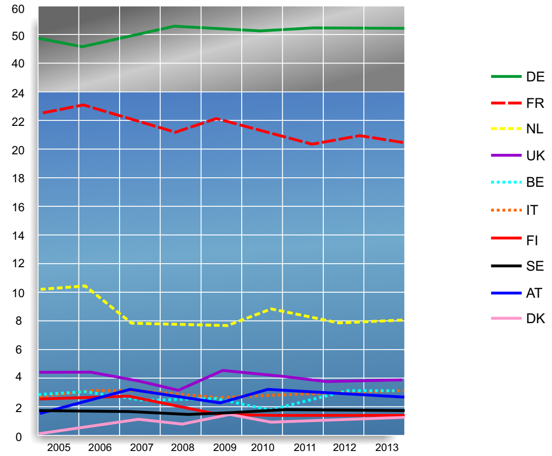
Source: UN COMTRADE-Database. – NIW calculation

Turnover performance

Looking at the share in turnover for all six KETs, it is no surprise that Germany is the clear market leader in the EU-28, as it is the market leader for all individual KETs (Figure 4-5). France occupies the second position (20.6 % in 2013), followed by the Netherlands (8.1 % in 2013). The UK and Belgium take the fourth and fifth positions, before Italy and Austria. Spain does not appear in the graph as it is only ranked in eleventh position. When evaluating these results, it should be taken into account that the turnover for all six KETs combined is significantly shaped by the business performance in Advanced Materials, which accounts for the highest turnover. In addition, turnover is assigned to the headquarters of companies and hence informs about the decision power present in particular countries.

[15] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

Figure 4-5: Share in total exports for the top 10 EU-28 countries in all six KETs (in %)



Including the 10 EU-28 countries with the highest shares in turnover in the respective KET with respect to the turnover realized in all EU-28 countries.

Turnover is attributed to the headquarters of companies.

Source: Orbis database. – IDEA Consult calculation.

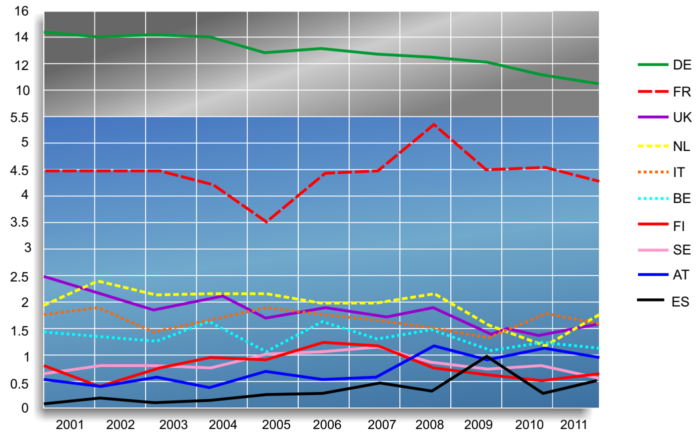
In general, the results for **all six KETs** show that although the share of patents has slightly decreased for Germany, they still occupy the first position, well before France and UK. Also the share of production, share in total export and share in turnover of Germany is well above the other countries.

4.2 Advanced Materials

Technology performance

The technology performance of the top 10 EU Member States with the highest shares of patent in Advanced Materials (AM) (as of 2011) is depicted in Figure 4-6. Germany holds the highest patent share in 2011 with about 10 %, followed by France with about 4 % and all remaining countries with shares below 2 %. This result is certainly attributed to the fact that Germany and France constitute the largest economies within the EU-28. Compared to 2001 the market share for Germany has decreased from 14 % to 10 %.

Figure 4-6: Share of patents for the top 10 EU-28 countries in Advanced Materials (in %)



Including the 10 EU-28 countries with the highest share of patents in the respective KET with respect to the patents of all 45 countries considered.

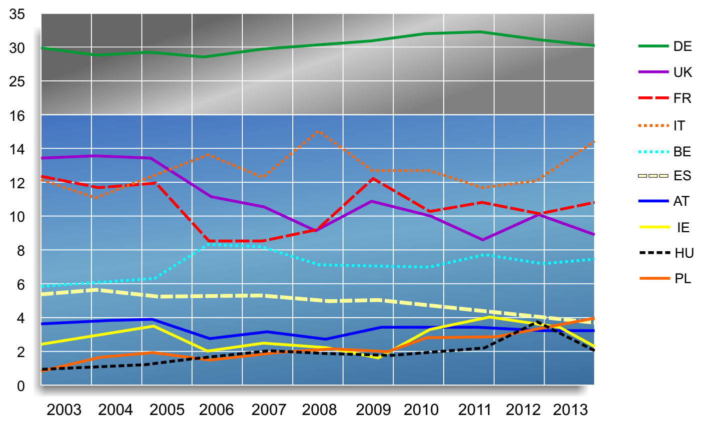
Source: PATSTAT database. – ZEW calculation.

Production performance

In production, significant gaps can be observed between countries at the level of the EU-28: Germany dominates the market with 31 % of shares in production in 2013, followed by Italy and France who rank second and third with scores of 14 % and 10.8 % (Figure 4-7). Prodcom codes like polyurethanes and other compounded rubber are driving the good performance of Germany and Italy.

The UK has lost its second position in 2006 to Italy, and from 2009 onwards, France also has a higher share of production. Belgium occupies the fifth position in 2013, followed by Poland (4.2 % in 2013). While Belgium has been able to maintain its share of production among others thanks to polyurethanes, Poland has witnessed an increase leading to a sixth position in 2013.

Figure 4-7: Share of production for the top 10 EU-28 countries in Advanced Materials (in %)



Including the 10 EU-28 countries with the highest shares of production in the respective KET with respect to the production of all EU-28 countries.

Source: PRODCOM database. – IDEA Consult calculation.

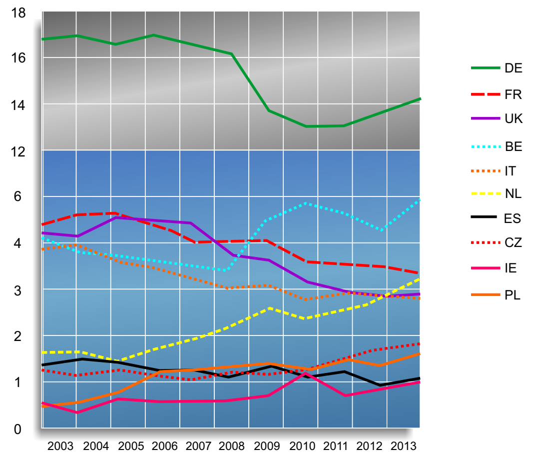
Trade performance

Regarding trade performance, it is not surprising that Germany, as the largest and highly export-oriented economy within the EU-28, also holds the highest share in total export (see Figure 4-8). Hence, throughout the entire time period, Germany accounted for approximately 15 % of total exports in AM. The remaining EU-28 countries only achieved shares in total export of about 4 %. Particularly for larger Member States like France, Italy or the UK, these are considerably low values. In contrast, the shares in total exports of nearly 6 % (Belgium) and 4 % (the Netherlands) are relatively large, considering the size of these countries. One reason for the relatively strong trade performance of these countries is the harbor effect of both countries, particularly referring to chemical products that are “traded” between multinational companies with locations in different countries.

[16] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

[17] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

Figure 4-8: Share in total exports for the top 10 EU-28 countries in Advance Materials (in %)



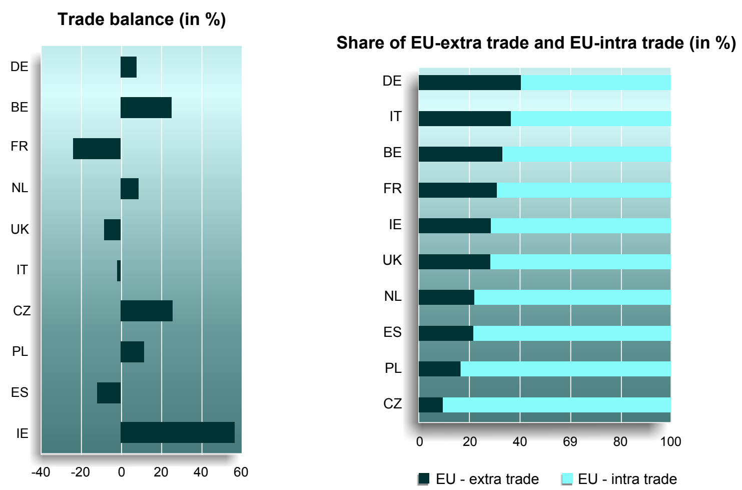
Including the 10 EU-28 countries with the highest market shares in the respective KET in 2013 with respect to the exports of all 44 countries considered.

Source: UN COMTRADE-Database. – NIW calculation

When looking at the trade balance in 2013 (Figure 4-9), it becomes evident that out of the top 10 countries, the relatively large economies of the old Member States such as France, Italy, Spain and the United Kingdom show a negative trade balance, indicating that they are net importers of AM. In contrast, Germany and Belgium as two large exporters, but also smaller export countries like the Czech Republic and Ireland, reveal an export surplus in AM. In the case of the Czech Republic this finding is mainly due to "gauze, bandages and similar articles" produced in subcontracting for multinational companies, while in the case of Ireland exports are driven by artificial joints.

When comparing the share of EU-intra trade exports with the share of EU-extra trade exports on the country level, the dominance of intra-trade in Advanced Materials becomes obvious for all top 10 EU exporters. As Figure 4-9 illustrates, Germany and Italy export about 40 % of their exports to countries outside the community, whereas at least 80 % of the exports of Poland and the Czech Republic remain within the EU. The other top 10 countries show extra-trade shares between 20 % and 30 % in 2013.

Figure 4-9: Trade balance for the top 10 EU-28 countries in Advanced Materials and share of EU-28 exports attributed to EU-extra and EU-intra trade in Advanced Materials, 2013



Including the 10 EU-28 countries with the highest market shares in the respective KET in 2013 with respect to the exports of all 44 countries considered.[17]

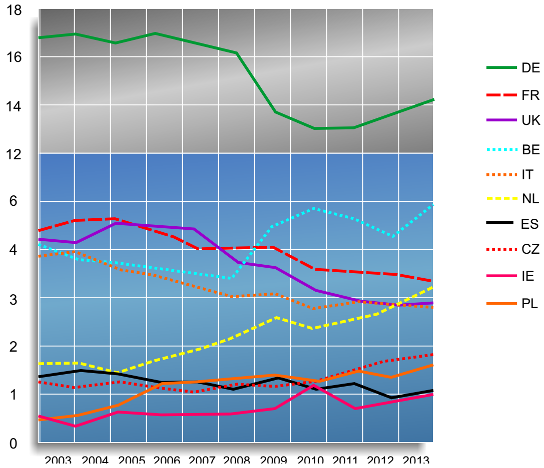
Source: UN COMTRADE-Database. – NIW calculation

Turnover performance

The share in turnover is dominated by Germany, which accounts for more than 45 % of the European total (Figure 4-10). This result is in line with Germany's large share of production and share in total exports. France follows in second position with around 30 %, while all other Member States have less than 10 %. The share in turnover of Austria (6.1 % in 2013) and Belgium (5.5 % in 2013) are quite high compared to Italy (3.8 % in 2013) and the Netherlands (3.6 % in 2013).

As stated before, Advanced Materials is a very diverse field, with many different subsectors including chemicals, materials, but also advanced applications in glass and ceramics. In addition, companies from downstream industries that integrate Advanced Materials into their products/systems (e.g. in the medical, aerospace or defense areas) are also included.

Figure 4-10: Share in turnover for the top 10 EU-28 countries in Advanced Materials (in %)



Including the 10 EU-28 countries with the highest shares in turnover in the respective KET with respect to the turnover realized in all EU-28 countries.

Turnover is attributed to the headquarters of companies.

Source: Orbis database. – IDEA Consult calculation.

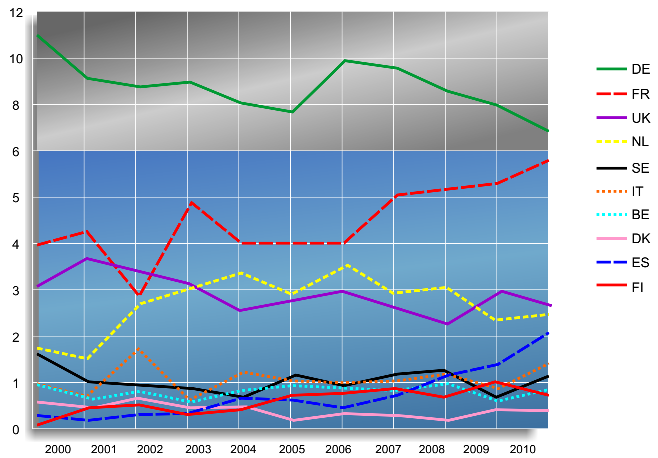
In Advanced Materials, high patent shares translate into high shares in total export with the same six leading countries for both performance measures. The same countries are the strongest in share of production; the only exception is the Netherlands, which drops out of the top six countries. The share in turnover is dominated by Germany and France.

4.3 Nanotechnology

Technology performance

Figure 4-11 displays the development of the technology performance in Nanotechnology within the EU-28 Member States with the highest shares of patents in 2011. We find the largest countries, Germany and France, to exhibit the highest patent shares, followed by the UK, the Netherlands, Spain and Italy.

Figure 4-11: Share of patents for the top 10 EU-28 countries in Nanotechnology (in %)



Including the 10 EU-28 countries with the highest share of patents in the respective KET with respect to the patents of all 45 countries considered.

Source: PATSTAT database. – ZEW calculation

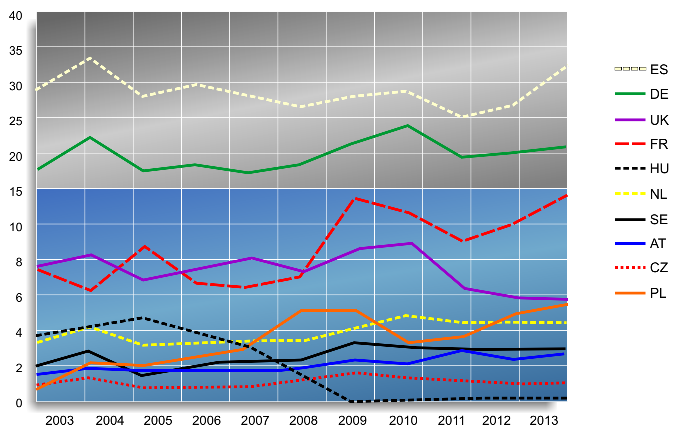
Production performance

Looking at the share of production, Spain occupies the first position, followed by Germany and France (Figure 4-12). However, it has to be remarked that for Germany, some production data is confidential resulting in an underestimation of the share of production for Germany. The good performance of Spain can be explained by the dominance of Spain in the production values of particular Prodcom codes related to advanced paints and coatings (e.g. coatings for cars). These paints and coatings are produced primarily by chemical companies.

Spain has a large scale production in this field. For example, BASF Coatings has a plant in Guadalajara, Spain.

In interpreting the results, it is important to keep in mind that Nanotechnology mainly describes production processes: there is only a small amount of products that can be directly linked to this technology. In addition, for some countries like Italy and Ireland, the data is confidential and hence not displayed in the graphs. An overview of the data availability for production data is given in Appendix III.

Figure 4-12: Share in production for the top 10 EU-28 countries in Nanotechnology (in %)



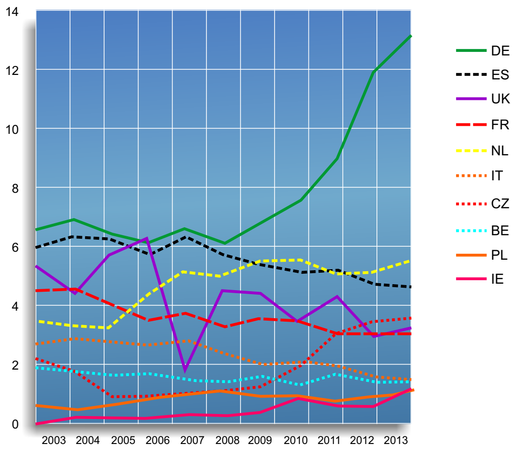
Including the 10 EU-28 countries with the highest shares of production in the respective KET with respect to the production of all EU-28 countries.

Source: PRODCOM database. – IDEA Consult calculation

Trade performance

Also in Nanotechnology, Germany holds the largest share in total exports (13 %) out of the EU-28 and well-exceeds the share of the remaining top 10 exporters, also those of the other larger economies (i.e. France, Italy) (Figure 4-13). Germany's exports are mainly attributed to inks (excluding printing ink) and electric accumulators. By a large margin, the Netherlands follows with the same product groups as Germany, as does Spain (whose exports in Nanotechnology are driven by chemical components for advanced paints and coatings) with shares of about 5 %. The Czech Republic, the UK and France attain values between 4 % and 3 %, with the remaining countries having shares of less than 2 %. Particularly from 2008 onward, Germany profoundly increased its share in total Nanotechnology exports, which can be mainly attributed to high growth rates of inks (excluding printing inks) and electric accumulators. Out of the remaining EU-28 countries, the Netherlands and the Czech Republic (exclusively inks) are the countries that could mostly improve their shares of total exports in Nanotechnology), whereas the UK and Italy have experienced the highest losses in export market share.

Figure 4-13: Share in total exports for the top 10 EU-28 countries in Nanotechnology (in %)



Including the 10 EU-28 countries with the highest shares in total export in the respective KET with respect to the exports of all 44 countries considered[18].

Source: UN COMTRADE-Database. – NIW calculation

Despite Germany's large market share, in 2013, the country's trade balance is almost even. Thus, German exports do not exceed its imports in Nanotechnology (Figure 4-14). Similar to Germany, France, Italy and Poland also reveal negative trade balances in Nanotechnology (Figure 4-14). In contrast, the Netherlands, Spain, the Czech Republic and Ireland hold a positive trade balance in 2013. However, the latter does not carry much weight in terms of shares of total export.

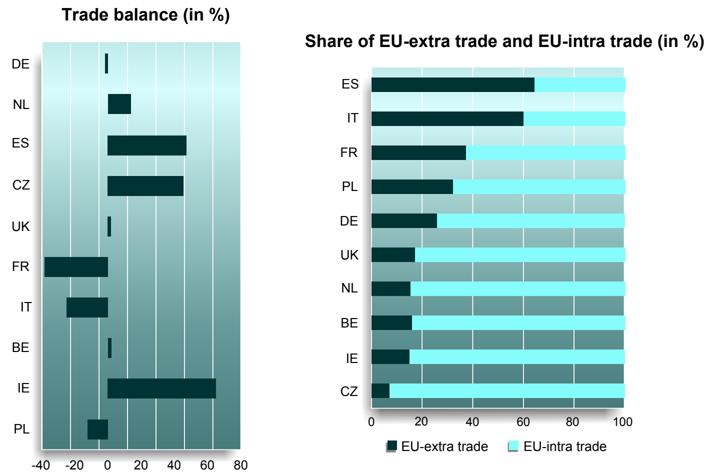
Since most of the EU-28's trade happens within the community, it is interesting to compare the countries' shares of EU-intra trade exports with their shares of EU-extra trade exports in Nanotechnology. Here, we see a very heterogeneous picture (Figure 4-14). While Spain and Italy export the majority of their Nanotechnology products to non-EU-28 countries, more than 80 percent of the Nanotechnology exports of the UK, the Netherlands, Belgium, Ireland and the Czech Republic remain within the community.

[18] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

[19] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

[20] http://www.bayer.com/en/nanotechnology.aspx.

Figure 4-14: Trade balance for the top 10 EU-28 countries in Nanotechnology and share of EU-28 exports attributed to EU-extra and EU-intra trade in Nanotechnology, 2013



Including the 10 EU-28 countries with the highest market shares in the respective KET in 2013 with respect to the exports of all 44 countries considered.[19]

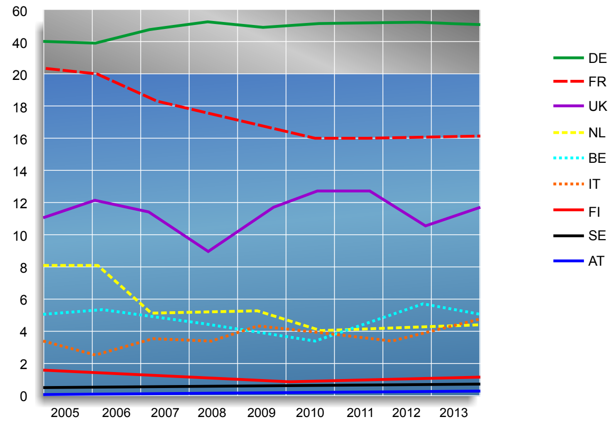
Source: UN COMTRADE-Database. – NIW calculation

Turnover performance

Germany has the largest share in turnover at headquarter level and accounts for 49 % in 2013 (Figure 4-15). While Germany has witnessed an increase in 2007 and 2008, and has been able to maintain its share in turnover, France has experienced a decline from 2005 onwards. It still occupies the second position, before the UK, Belgium, Italy and the Netherlands. Although Spain has a high share of production and share in total export, it does not have a high share in turnover. This indicates that there is significant activity in Spain in the domain of Nanotechnology that is driven by subsidiaries of foreign companies. For example, several chemical companies have subsidiaries in Spain that are active in the area of paints and coatings.

The wide application of Nanotechnology is reflected in the industry coverage of the companies considered in this KET, including chemicals, materials, metals, medical, electronics, aerospace, defense, and consumer products. An example is Bayer, which advocates making use of the opportunities offered by Nanotechnology[20].

Figure 4-15: Share in turnover for the top 10 EU-28 countries in Nanotechnology (in %)



Including the 10 EU-28 countries with the highest shares in turnover in the respective KET with respect to the turnover realized in all EU-28 countries.

Turnover is attributed to the headquarters of companies.

Source: Orbis database. – IDEA Consult calculation.

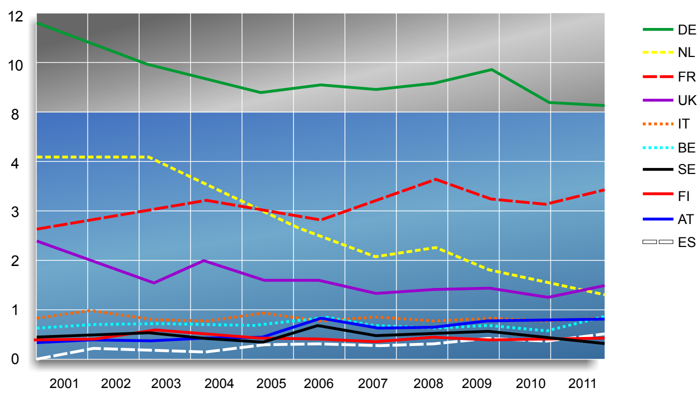
Nanotechnology is the only KET where Germany does not hold the top position. Although Germany has the highest share of patents, share in total export and share in turnover, Spain occupies the first position regarding share of production. The good performance of Spain can be explained by the presence of chemical companies active in advanced paints and coatings.

4.4 Micro- and Nanoelectronics

Technology performance

Within the EU-28, Germany holds by far the highest share in patents (Figure 4-16). The top five is further populated by France, the Netherlands, the UK and Italy. While Germany still exhibits a patent share of about 8 % (starting from a patent share of 11.5 % in 2000), all remaining EU-28 countries exhibit patent shares below 4 %. The decline of the share of patents of the Netherlands (from 4.2 % to 1.4 %) is particularly worth mentioning.

Figure 4-16: Share of patents for the top 10 EU-28 countries in Micro- and Nanoelectronics (in %)



Including the 10 EU-28 countries with the highest share of patents in the respective KET with respect to the patents of all 45 countries considered .

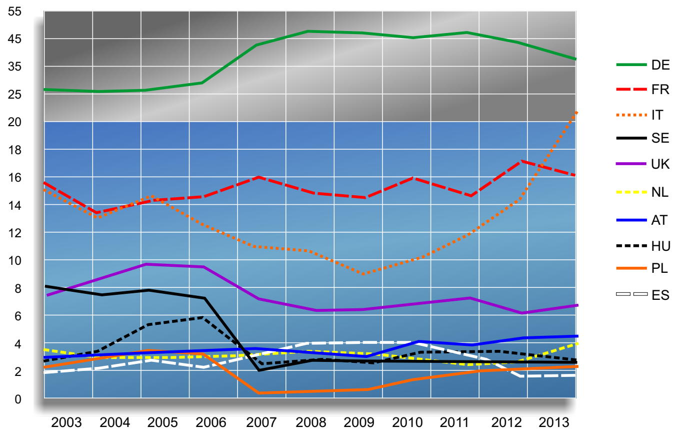
Source: PATSTAT database. – ZEW calculation

Production performance

Germany holds the highest share of production, although they experienced a decline in 2012 and 2013 (Figure 4-17). The decline can mainly be attributed to the production of photosensitive semiconductor devices, which have experienced a decline since 2011 as a result of the reduction of public subsidies for PV in several EU countries (see also section 3.4). On the contrary, Italy has increased its share of production (mainly thanks to the production of other electronic integrated circuits) and has surpassed France in 2013 to take second position. The share of production in France is characterized by a limited but steady increase. Although the UK and Sweden occupied the fourth and fifth position in 2004-2006, they lost ground in the subsequent years, especially Sweden.

Some countries like Ireland are not displayed in Figure 4-17 as the value for that country is confidential. Appendix III gives an overview of all countries for which data is included.

Figure 4-17: Share of production for the top 10 EU-28 countries in Micro- and Nanoelectronics (in %)



Including the 10 EU-28 countries with the highest shares of production in the respective KET with respect to the production of all EU-28 countries.

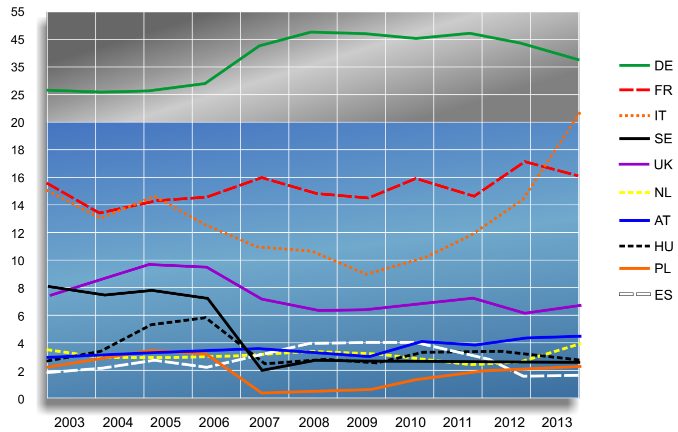
Source: PRODCOM database. – IDEA Consult calculation.

Trade performance

With respect to the share in total export (Figure 4-18), the share of Germany (as the largest exporter out of the EU-28), accounts for less than 6 % of global MNE exports in 2013. France and the Netherlands follow with shares of 2.7 %, and 1.6 %. In the remaining top 10 EU-28 Member States, the share in total export of MNE is below the 1 % threshold. Interestingly, Malta, as one of the smallest economies within the EU-28 is one of the top 10 EU-28 exporters of MNE products, even though its share in total exports is considerably small (0.3 % in 2013). The assumingly good performance of Malta is mainly driven by the fact that STMicroelectronics, one of the large European MNE companies located in France, operates an assembly plant there. However, as the Maltese plant only conducts the last steps of back-end production (pack and ship, c.f. chapter 3.4), the value added that actually takes place in Malta may be rather low.

Altogether, the trade performance of the EU-28 shows that the region is relatively weak in trade in MNE. As indicated above (see chapter 3.4), this is mainly attributed to the fact that in MNE, economies of scale and labor costs are important aspects in several production steps. As both can be realized more easily in East Asia than in the EU (or North America), the traditional weak trade performance of the EU has further deteriorated during the last decade, particularly at the expense of the UK, Ireland, the Netherlands and Germany.

Figure 4-18: Share in total exports for the top 10 EU-28 countries in Micro- and Nanoelectronics (in %)

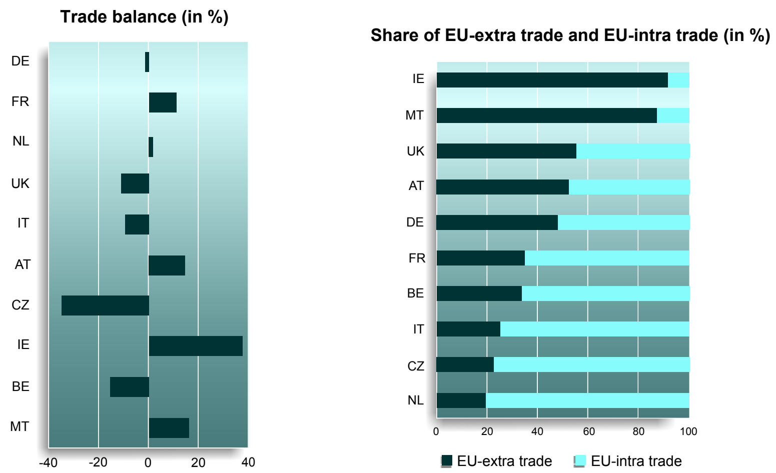


Including the 10 EU-28 countries with the highest shares in total export in the respective KET with respect to the exports of all 44 countries considered[21].

Source: UN COMTRADE-Database. – NIW calculation

With respect to the trade balance (Figure 4-19), only Ireland, Austria, Malta, and, to a lesser extent, France and the Netherlands, reveal a positive trade balance in 2013. The remaining top 10 countries (among others, the larger economies of Germany, the UK and Italy) depict a trade deficit in MNE. Since nearly 60 % of the EU-28 trade in MNE components happens within the EU community, it is interesting to compare the share of EU-intra trade exports with the share of EU-extra trade exports on the country level. Figure 4-19 illustrates that more than 60 % of the Dutch, Czech, Italian and Belgian MNE exports remain within the community. At the same time, Ireland (as a location of back-end production for INTEL) and Malta (STM, as described above) export more than 80 % to countries outside the community.

Figure 4-19: Trade balance for the top 10 EU-28 countries in Micro- and Nanoelectronics and share of EU-28 exports attributed to EU-extra and EU-intra trade in Micro- and Nanoelectronics, 2013



Including the 10 EU-28 countries with the highest market shares in the respective KET in 2013 with respect to the exports of all 44 countries considered[22].

Source: UN COMTRADE-Database. – NIW calculation

[21] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

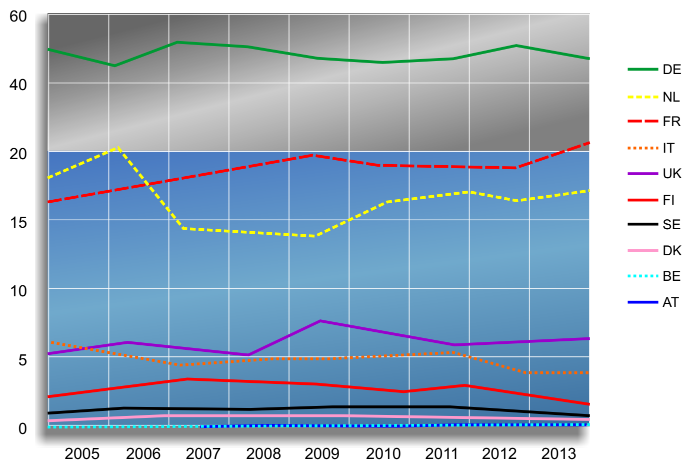
[22] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

Turnover performance

Figure 4-20 shows the turnover at headquarter level for Micro-and Nanoelectronics. Germany has about 50 % of the European share in turnover in this KET. France follows in second position with around 20 % while the Netherlands occupies third position with 17.5 % in 2013. The UK, Italy and Finland follow, after which shares in turnover of the remaining EU countries are quite small. As discussed in section 3.4, Europe performs rather poorly compared to the US and East Asia. Europe only has a few companies with large-scale Micro-and Nanoelectronics activities compared to other countries like the US or Japan. Next to large players, several Member States are home to niche players that play a distinct role in the European ecosystem.

In this study, turnover is assigned to the headquarters of a company which implies, for example, that the turnover of Intel is attributed to the US. Intel has important and extensive activities in Ireland which are relevant for the European economy, but the decision power resides in the US.

Figure 4-20: Share in turnover for the top 10 EU-28 countries in Micro- and Nanoelectronics (in %)



Including the 10 EU-28 countries with the highest shares in turnover in the respective KET with respect to the turnover realized in all EU-28 countries.

Turnover is attributed to the headquarters of companies.

Source: Orbis database. – IDEA Consult calculation.

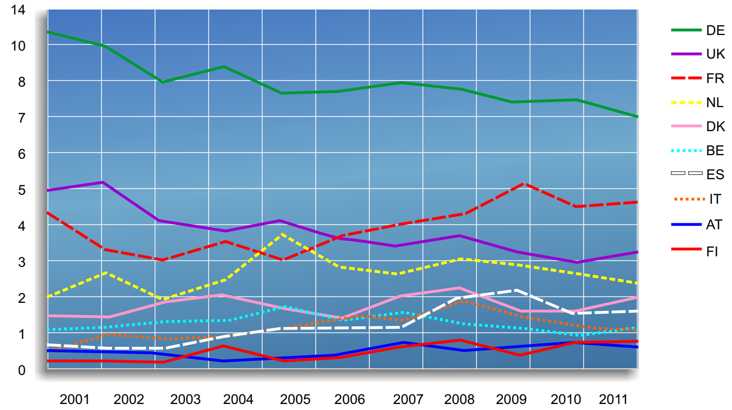
In Micro- and Nanoelectronics, Germany, France and the Netherlands hold the top positions in terms of share of patents, share in total export and share in turnover. The only exception is the share of production where the Netherlands is performing less strongly and Italy has surpassed France in 2013 to occupy the second position.

4.5 Industrial Biotechnology

Technology performance

In 2001, the highest shares of patents were held by Germany (7 %) and France (4 %) (Figure 4-21). The overall share of the EU-28 countries was about 26 %, with all countries other than Germany and France exhibiting shares of 3 % or less than 3 %. While the overall EU-28 patent share has declined only slightly from 2000 to 2011, the German share has decreased by more than 40 %. This decline has been compensated by the growth of shares in many of the smaller EU-28 countries.

Figure 4-21: Share of patents for the top 10 EU-28 countries in Industrial Biotechnology (in %)



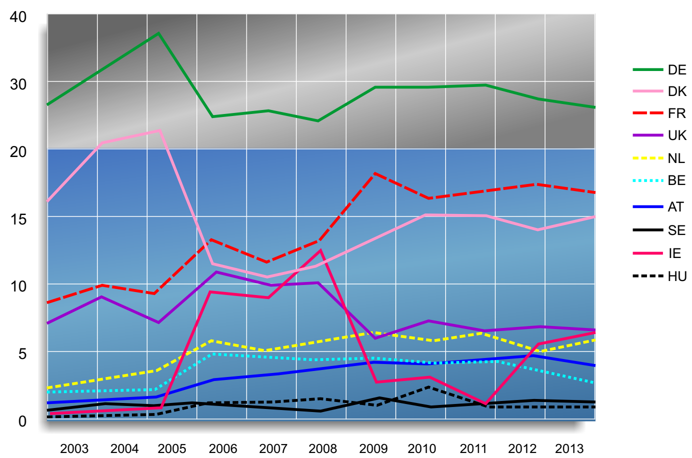
Including the 10 EU-28 countries with the highest share of patents in the respective KET with respect to the patents of all 45 countries considered.

Source: PATSTAT database. – ZEW calculation

Production performance

In production, Germany ranks first in terms of shares in production (26.7 % in 2013), followed by France (16.9 % in 2013) and Denmark (15 % in 2013) (Figure 4-22). In 2013, Italy occupies the fourth position, but as the data for the previous years is confidential, no data series for Italy can be shown. Germany and Denmark both had an increase in the years 2003-2005, followed by a strong decline in 2006. In 2008 there was a recovery, but by that time, France had strengthened its position to occupy the second position, partly caused by growth in the area of other fungicides, bactericides and seed treatments. On the contrary, Ireland had a high production share in the period 2006-2008, followed by a strong decline in 2009. From 2012 onwards, Ireland seemed to recover.

Figure 4-22: Share in production for the top 10 EU-28 countries in Industrial Biotechnology (in %)



Including the 10 EU-28 countries with the highest shares of production in the respective KET with respect to the production of all EU-28 countries.

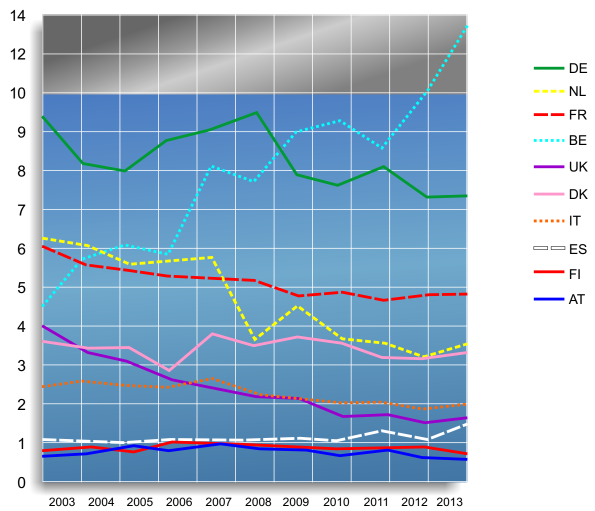
Source: PRODCOM database. – IDEA Consult calculation.

[23] Source: UN COMTRADE-Database. – NIW calculation

Trade performance

Comparing technology and trade performance, we see that Belgium, with a patent share of only about 1 %, scores highest in shares of total exports with a share of 13 % in 2013 (Figure 4-23). In doing so, it takes the lead before Germany and France, whose shares in total exports declined between 2003 and 2013. The strong Belgian performance is mainly driven by extremely high intra-EU exports, most of which are intra-company trade of large chemical companies (see Figure 4-24). These companies run operations both in Belgium and neighboring countries (Germany, the Netherlands) which form an inter-linked production network, including the exchange of commodities between plants. As Belgium plants tend to be specialized in the production of more basic chemicals used as input in downstream production, exports of Belgium are particularly high. Furthermore, for Belgium and the Netherlands, harbor effects have to be taken into account. Overall, it is notable that the top 10 group consists entirely of older Member States. Compared to the size of their economy, along with Belgium and the Netherlands, Denmark holds comparably high export shares.

Figure 4-23: Share in total exports for the top 10 EU-28 countries in Industrial Biotechnology (in %)



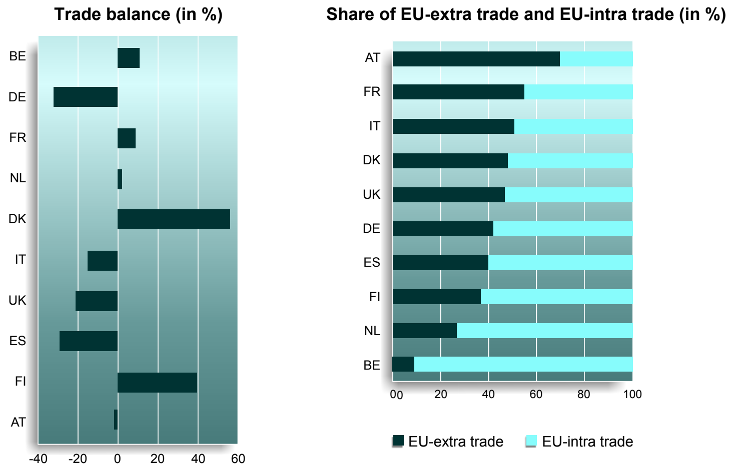
Including the 10 EU-28 countries with the highest shares in total export in the respective KET with respect to the exports of all 44 countries considered[23]

Source: UN COMTRADE-Database. – NIW calculation

Countries with large export market shares do not necessarily reveal positive trade balances. Germany, for instance, has a significantly negative trade balance, indicating that it imports more IB products than it exports, despite a relatively large overall market share of IB, whereas France and Belgium both attain a small trade surplus (Figure 4-24). In contrast, Denmark and Finland in particular have positive trade balances (both due to prepared enzymes), indicating that they hold competitive advantages in IB. However, given the relatively small market shares of these countries, their clearly positive trade balance does not outbalance the negative balances of Germany, Spain, the UK and Italy.

Since most of the EU trade in total manufacturing happens within the community, it is interesting to compare the countries' share of EU-intra trade exports with the share of EU-extra trade exports in IB. Figure 4-24 reveals that the high Belgian export market share in IB is nearly exclusively attributed to EU-intra trade. More than 90 % of the Belgian IB exports remain within the EU-28. As outlined above, this result is largely due to shipments between multinational firms. The same applies for the Netherlands, the fourth largest European exporter of IB products. For most of the other European countries, the shares of EU-intra and EU-extra trade in IB are fairly equal. The only exception is Austria, which exports over 60 % of its IB exports to countries outside the EU.

Figure 4-24: Trade balance for the top 10 EU-28 countries in Industrial Biotechnology and share of EU-28 exports attributed to EU-extra and EU-intra trade in Industrial Biotechnology, 2013



Including the 10 EU-28 countries with the highest market shares in the respective KET in 2013 with respect to the exports of all 44 countries considered[24]

Source: UN COMTRADE-Database. – NIW calculation

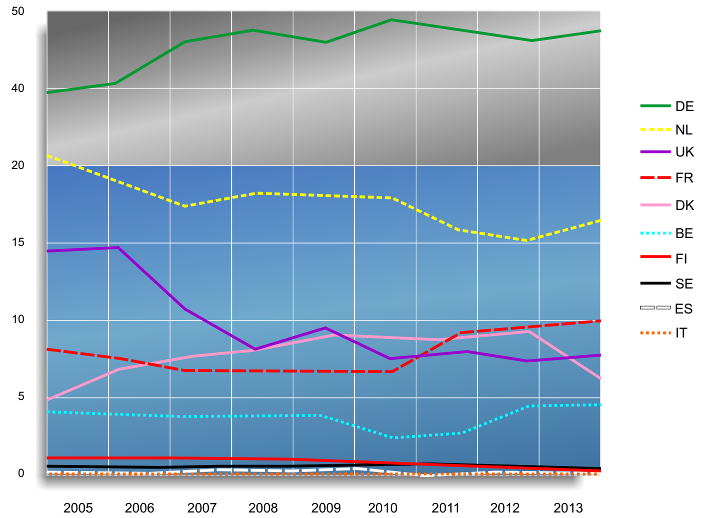
Turnover performance

Considering the share in turnover in Industrial Biotechnology, Germany takes up the largest share of EU countries, followed by the Netherlands (Figure 4-25). The Netherlands has a share in turnover of around 20 % showing a small decline in the last few years. France and the UK are ranked third and fourth respectively, followed by Denmark and Belgium. While France has been able to increase its share in turnover, the UK has witnessed a decline from 17.2 % in 2005 to 9.0 % in 2013.

Germany has increased its share in turnover since 2005, which can be partly attributed to the efforts of the chemical industry to develop and integrate Industrial Biotechnology-based processes into their operations. Industries that are represented in Industrial Biotechnology are mostly companies that use IB for production of (specialty) chemicals and materials, but also for applications in other areas like food and advanced biofuels. The good performance of Denmark in share of production and total export is somewhat less visible in share in turnover, although Denmark remains in the top five in the EU-28 for this indicator too. One of the main companies driving the solid performance of Denmark is Novozymes, a world-class enzyme producer.

[24] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

Figure 4-25: Share in turnover for the top 10 EU-28 countries in Industrial Biotechnology (in %)



Including the 10 EU-28 countries with the highest shares in turnover in the respective KET with respect to the turnover realized in all EU-28 countries.

Turnover is attributed to the headquarters of companies.

Source: Orbis database. – IDEA Consult calculation.

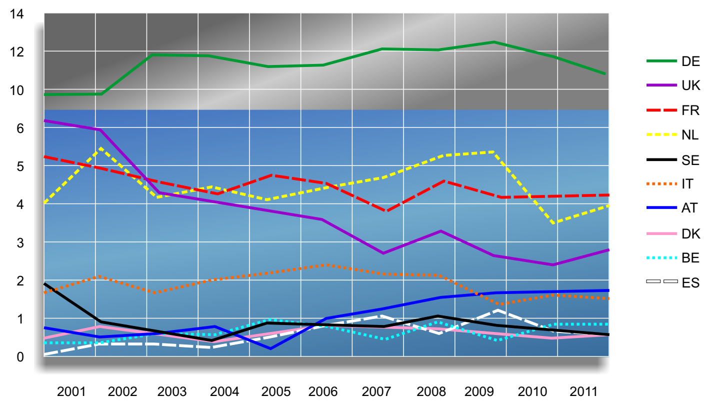
In Industrial Biotechnology, Belgium has the highest share in total exports, taking the lead before Germany and France. The strong Belgian export performance is largely due to shipments between multinational firms and driven by high intra-EU exports. Denmark has a positive trade balance and occupies the third position with regard to share in production, indicating that they hold a competitive advantage in this KET.

4.6 Photonics

Technology performance

The share of patents in Photonics is displayed in Figure 4-26. Germany holds the highest patent share with more than 10 %; all other countries have shares of 3,5 % and below in the generation of Photonics patents in 2011. The decreasing share of the EU-28 overall is due to a decline across almost all countries.

Figure 4-26: Share of patents for the top 10 EU-28 countries in Photonics (in %)



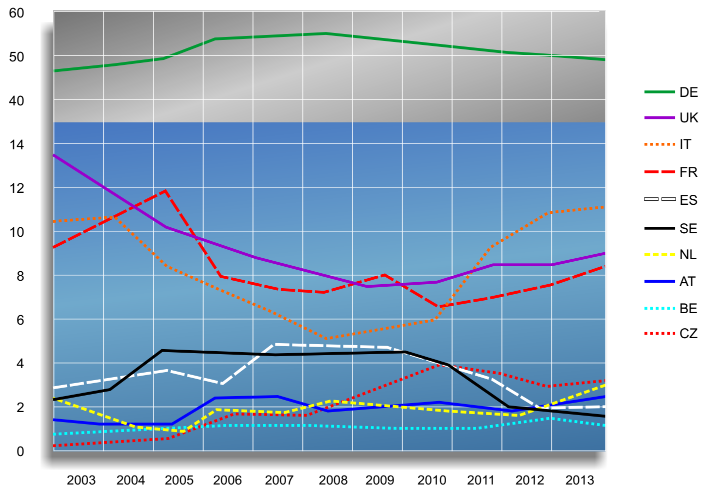
Including the 10 EU-28 countries with the highest share of patents in the respective KET with respect to the patents of all 45 countries considered.

Source: PATSTAT database. – ZEW calculation

Production performance

The share of production in Photonics is dominated by Germany, which has a leading position with around 50 % of production shares (Figure 4-27). This implies that about 50 % of European production in the area of Photonics takes place in Germany. The decline in recent years is mainly due to the reduced production of photosensitive semiconductor devices since 2011 as several EU countries have reduced the share of public subsidiaries for PV (see also section 3.4). Other countries like Italy, the UK and France have experienced a decline in share of production from 2005-2006 onwards to less than 10 %, with a slight increase in the most recent years. Italy seems to have recovered best. The Czech Republic, on the other hand, was able to increase its share of production in 2005-2010, but has experienced a small decline from 2010 onwards.

Figure 4-27: Share in production for the top 10 EU-28 countries in Photonics (in %)



Including the 10 EU-28 countries with the highest shares of production in the respective KET with respect to the production of all EU-28 countries.

Source: PRODCOM database. – IDEA Consult calculation.

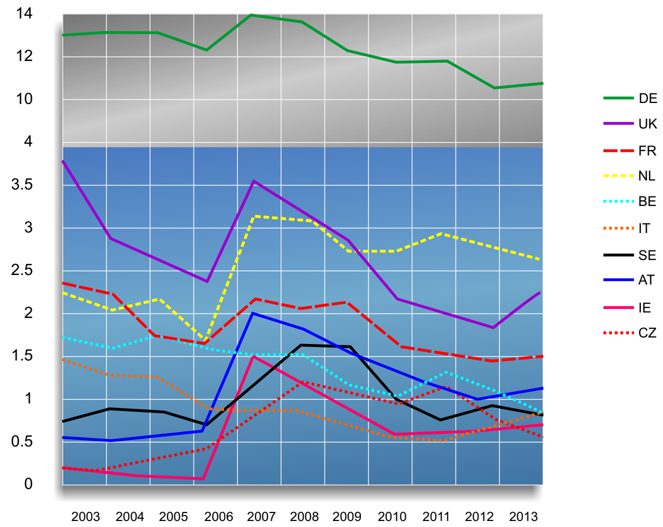
Trade performance

Germany constitutes the largest exporter of Photonics in the EU-28 with a share in total export of 10 % in 2013. This result is mainly driven by the size of the German economy. In contrast, the shares of the remaining EU countries are considerably smaller and do not exceed the 2,5 % threshold. However, as Figure 4-28 reveals, Germany has significantly lost ground in the global perspective since 2007 (14 %), because other countries (especially in East Asia) realized distinctly higher export growth. Out of the remaining top 10 countries, the Czech Republic (the only Eastern European country among the top 10) realized an increase in its share of total exports in Photonics between 2003 and 2012. The relatively good performance of the Czech Republic is mainly attributed to several production foundries for photosensitive semiconductor devices of multinational solar PV companies. However, in recent years, those capacities have been clearly reduced.

[25] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan

[26] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

Figure 4-28: Share in total exports for the top 10 EU-28 countries in Photonics (in %)



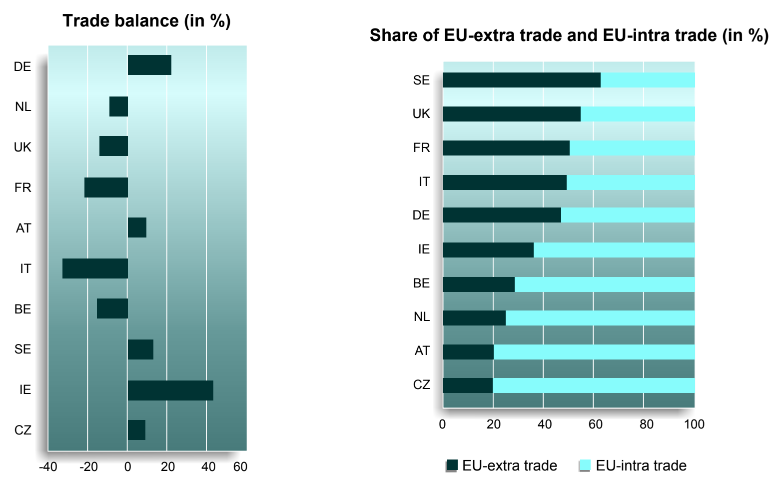
Including the 10 EU-28 countries with the highest shares in total export in the respective KET with respect to the exports of all 44 countries considered[25].

Source: UN COMTRADE-Database. – NIW calculation

With regard to the trade balance, Ireland, Germany and, to a lesser extent, Austria, Sweden and the Czech Republic are the only top 10 EU-28 countries that reveal positive trade balances in 2013 (Figure 4-29). This indicates that they are net exporters of Photonics and hold a competitive advantage in this KET. In the remaining EU-28 countries, the trade balance is negative.

Since most of the EU-28 trade happens within the community, it is interesting to compare the share of EU-intra trade exports with the share of EU-extra trade exports in Photonics. As Figure 4-29 reveals, at least half of the exports of Sweden, the UK and France are destined for countries outside the EU-28. The other five top 10 exporting countries constitute a significantly larger share of EU-intra trade. This is particularly true for the Czech Republic, one of the smaller Eastern European Member States, which exports most of its Photonics into other EU-28 countries. Hence, in the Czech Republic, the share of EU-intra trade amounts to 80 %.

Figure 4-29: Trade balance for the top 10 EU-28 countries in Photonics and share of EU-28 exports attributed to EU-extra and EU-intra trade in Photonics, 2013



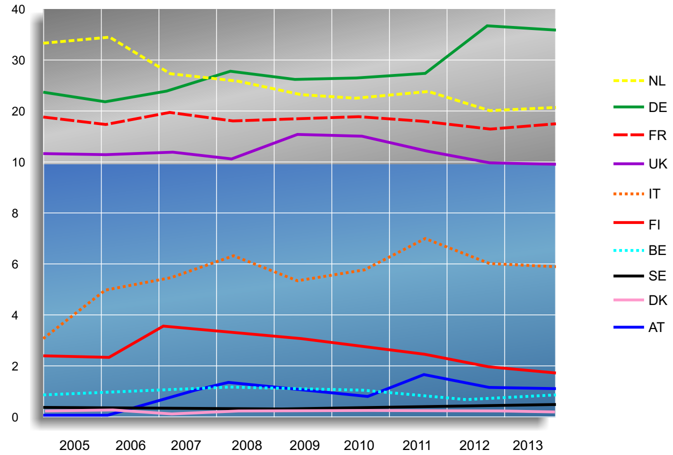
Including the 10 EU-28 countries with the highest market shares in the respective KET in 2013 with respect to the exports of all 44 countries considered.[26]

Source: UN COMTRADE-Database. – NIW calculation

Turnover performance

When comparing the share in turnover, Germany is the leader in Photonics, followed by the Netherlands and France (Figure 4-30). The UK and Italy are ranked fourth and fifth, followed by a group of countries that represent only a minor share. In 2005 and 2006, the Netherlands had the top position in share in turnover with 34.8 % in 2006, but they have experienced a decline since resulting in a share of 21.9 % in 2013. Germany, on the other hand, has known an increase in share in turnover, increasing from 24.6 % in 2005 to 36.2 % in 2013. The strategy of Germany to invest and support the Photonics industry seems to pay off.

Figure 4-30: Share in turnover for the top 10 EU-28 countries in Photonics (in %)



Including the 10 EU-28 countries with the highest shares in turnover in the respective KET with respect to the turnover realized in all EU-28 countries.

Turnover is attributed to the headquarters of companies.

Source: Orbis database. – IDEA Consult calculation.

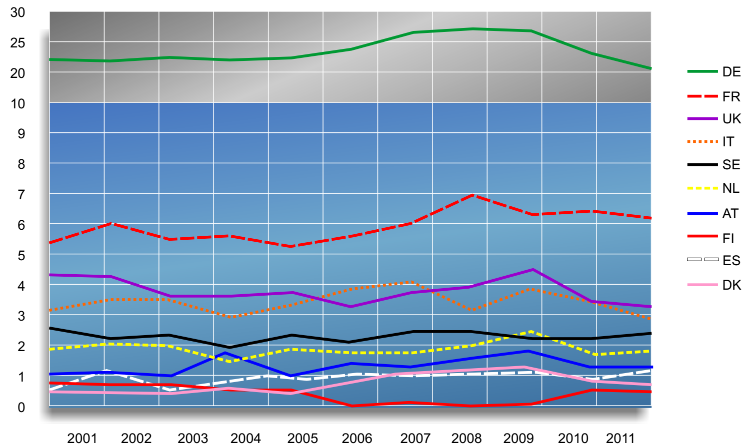
In Photonics, the share of production is dominated by Germany, which has a leading position with around 50 % of production shares. Germany's patent share and share in total export are respectively around 10 %, while the share of all other countries is less than 4 %.

4.7 Advanced Manufacturing Technology

Technology performance

In contrast to the other five KETs, the EU-28 holds the highest patent share in AMT, producing 38 % of all AMT patents in 2011. The German predominance in this technology field is visible across all technology performance measures: its share of patents is about 20 %, while all other countries have a share of less than 6 % (Figure 4-31).

Figure 4-31: Share of patents for the top 10 EU-28 countries in Advanced Manufacturing Technology (in %)



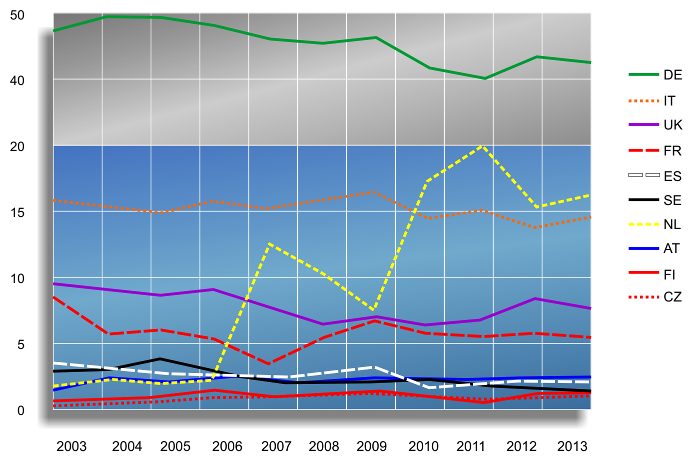
Including the 10 EU-28 countries with the highest share of patents in the respective KET with respect to the patents of all 45 countries considered.

Source: PATSTAT database. – ZEW calculation

Production performance

The share of production highlights a good position for Germany: the country ranks first with shares with a value of 42.2 % in 2013 (Figure 4-32). Italy shows a more or less constant share of production, but has been surpassed by the Netherlands from 2010 onwards. The Netherlands has seen a remarkable increase in its share of production, rising from 1.8 % in 2003 to 16.3 % in 2013. Also the Czech Republic has steadily increased its share of production from 0.7 % in 2003 to 1.5 % in 2013. The increase of the Netherlands is the main reason for the German decrease in share of production. The absolute values of production for this KET for Germany are actually increasing, with the exception of the 2008 and 2009.

Figure 4-32: Share in production for the top 10 EU-28 countries in Advanced Manufacturing Technology (in %)



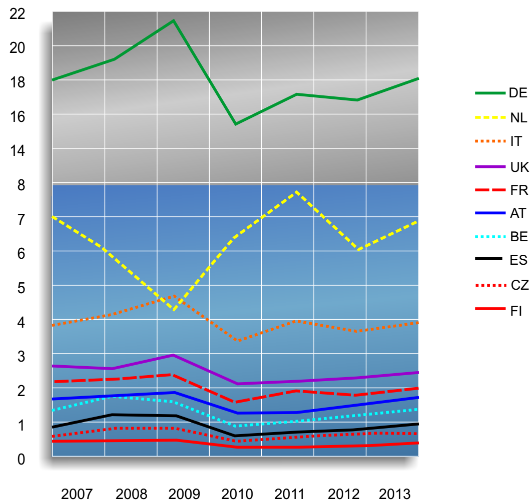
Including the 10 EU-28 countries with the highest shares of production in the respective KET with respect to the production of all EU-28 countries.

Source: PRODCOM database. – IDEA Consult calculation.

Trade performance

AMT is the only KET in which the EU-28 depicts an overall positive trade performance and has succeeded in holding its export surplus and comparative advantage over time. This is primarily down to the fact that AMT includes mainly smart machinery and production systems instead of electronic components, whose production has shifted to other global regions. Out of the EU-28 countries, it is again Germany that shows the highest export share (18 %) of all EU-28 countries in 2013 (Figure 4-33). Therewith, Germany's share is far above the shares of the Netherlands (7 %), and of Italy (nearly 4 %) in 2013. The high export share for the Netherlands, though scoring only sixth in share of patents, is mostly attributed to ASML, one of the global players for photolithography systems for the semiconductor industry[27]. The shares in total export of all other top 10 EU-28 Member States are below 3 %.

Figure 4-33: Share in total exports for the top 10 EU-28 countries in Advanced Manufacturing Technology (in %)



Including the 10 EU-28 countries with the highest shares in total export in the respective KET with respect to the exports of all 44 countries considered.[28]

Break in series 2006 to 2007 due to methodological changes. Hence, trade indicators for AMT can only be analyzed from 2007 onwards.

Source: UN COMTRADE-Database. – NIW calculation

As Figure 4-34 reveals, the vast majority of top 10 countries are net exporters of AMT. Only Belgium shows an import surplus. The Netherlands has the highest trade balance among the top 10 EU-countries with an indicator value of above 60 in 2013.

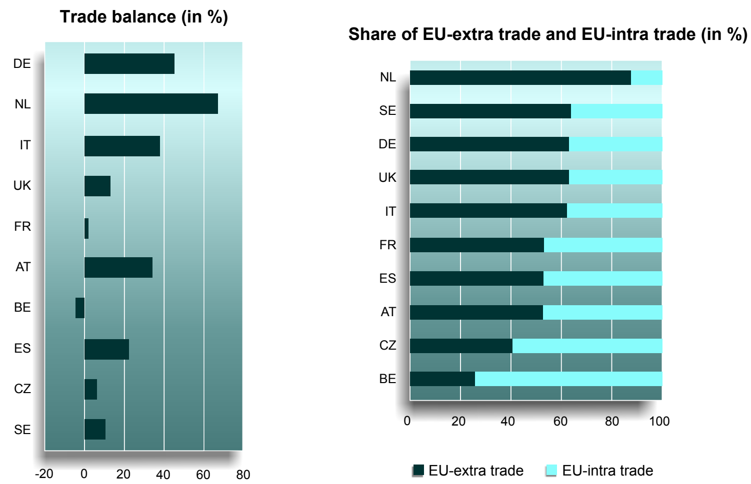
In contrast to the remaining KETs, in Advanced Manufacturing Technology, the EU-28 exports mostly to countries outside the community. As Figure 4-34 reveals, this applies especially to the two largest EU-28 exporters: Germany and the Netherlands. Only Belgium and the Czech Republic reveal comparably higher shares of intra-trade. With the exception of single deflections (Germany, the Netherlands) during the great recession of 2009-2010, the export shares for the top 10 European countries remained rather stable from 2007 to 2013.

[27] The respective product group is called "machines and apparatus for the manufacturing of semiconductor devices and electronic integrated circuits".

[28] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

[29] The UN COMTRADE database contains no data on Taiwan, hence no trade data is available for Taiwan.

Figure 4-34: Trade balance for the top 10 EU-28 countries in Advanced Manufacturing Technology and share of EU-28 exports attributed to EU-extra and EU-intra trade in Advanced Manufacturing Technology, 2013



Including the 10 EU-28 countries with the highest market shares in the respective KET in 2013 with respect to the exports of all 44 countries considered.[29]

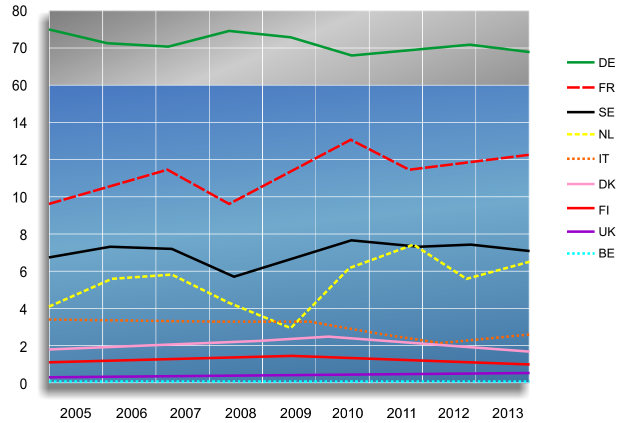
Source: UN COMTRADE-Database. – NIW calculation

Turnover performance

The share in turnover in Advanced Manufacturing Technology is dominated by Germany, as its share in turnover is higher than the sum of all the other EU countries combined (Figure 4-35). The good performance of Germany in technology, production and trade is also confirmed in the share of turnover. Germany has a share of 68.6 % in 2013. France follows at a large distance with a share in turnover of 12.1 % in 2013. Sweden occupies the third position with 6.7 % in 2013, closely followed by the Netherlands (6.3 % in 2013). All other countries have a share in turnover of less than 2 % in 2013.

The excellent performance of Germany is further endorsed by strong consumer industries like automotive, electrical engineering (machinery), metal product producers, optical precision instruments, construction and agriculture machinery. The KET Advanced Manufacturing Technology is characterized in the EU-28 by many specialized niche players.

Figure 4-35: Share in turnover for the top 10 EU-28 countries in Advanced Manufacturing Technology (in %)



Including the 10 EU-28 countries with the highest shares in turnover in the respective KET with respect to the turnover realized in all EU-28 countries.

Turnover is attributed to the headquarters of companies.

Source: Orbis database. – IDEA Consult calculation.

In Advanced Manufacturing Technology, Germany appears to be in a comfortable first position from all perspectives – technology, production, trade and turnover. The share in turnover is particularly dominated by Germany, as its share is higher than the sum of all other EU countries combined. The Netherlands and Italy hold the second and third positions with regard to share of production and share in total export, while France occupies the second position in share of patents and share in turnover.

5. Case study: focus on main competitors

This chapter takes a closer look at the technology, trade and turnover performance of the EU-28 vis-à-vis its main competitors in North America (i.e. the US) and East Asia (i.e. China incl. Hong Kong, Japan, South Korea). As the comparison of the three global regions (Chapter 3) reveals, East Asia could increase its shares in total export in all KETs and has turned into a net exporter in all KETs except AMT. Thereby, depending on the KET, East Asia's export growth is driven either by China (incl. Hong Kong), South Korea or Japan. As all three economies represent different development stages, the comparison in this chapter is of particular interest. In contrast, the performance of North America is mainly determined by the US, constituting the by far biggest player in the region. In addition, for each KET and indicator under consideration, the two European member states with the most favorable indicator values are taken into account.

This section does not entail information on production as currently, production data is only available on European level. For these indicators, we use the Eurostat Prodcom database which provides statistics on the production of manufactured goods for EU-28. The consortium is currently assessing the availability of production data in non-EU countries.

For the trade indicators it is important to note several remarks. The market share for the EU-28 refers to a sample of 36 countries (i.e. all EU-28, North American and East Asian countries). By contrast, the indicator values for single countries are calculated with reference to these 36 countries plus 8 additional countries (Brazil, Island, Norway, Israel, Switzerland, Turkey, South Africa and Russia). This is due to the fact that for trade on a regional level, only extra-regional trade is considered, while for trade on a country level, both intra and extra-regional trade are taken into

account. As the remaining eight countries form a very heterogeneous group, it is unreasonable to include the extra-regional trade of a forth, artificially created region. Because of the slightly different reference group, the indicator values for China, Japan, South Korea and the US are approximately one to two percentage points lower compared to the EU-28 and its individual member states. However, basic structures and trends remain unaffected from the small bias in the reference group. In contrast to the previous section (Chapter 4), in this Chapter, the indicators for the individual EU-28 member states refer to EU extra-trade only. This approach allows a direct comparison with the EU-28 average and illustrates the contribution of single countries to the overall EU extra-trade position.

For the share in turnover on a global level, only data for the year 2013 is available. Due to budget restraints, no time series are available for regional comparison. This implies that time series are available for EU-28, but not for North America or East Asia. As a result, the share in turnover for the time series in chapter 4 are calculated with reference to the EU-28 only, while the share in turnover in this chapter for the year 2013 is calculated at global level.

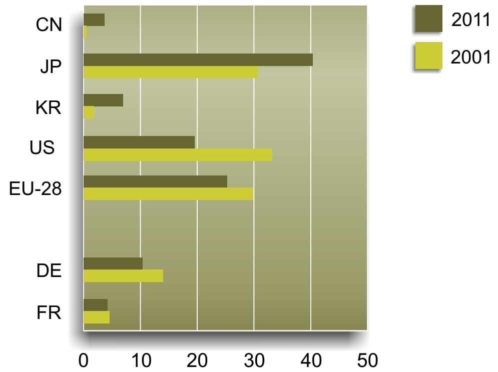
Hence, figures for EU countries for share in turnover in 2013 differ between the two chapters as they are calculated using a different reference group.

5.1 Advanced Materials

Technology performance

The technology performance for EU-28 and its main competitors is shown in Figure 5-1. The main competitor with respect to patent share in 2011 in Advanced Materials (AM) is Japan, who has outperformed the prior main competitor, the US, which had the highest market share in 2001. Japan is an important patent contributor. As mentioned in the previous chapters it is important to keep in mind that our analysis of patenting activity rests on patent applications to the European patent office or international patents via the PCT route in order to ensure international comparability. Particular patenting practices at national patent offices, such as the filing of bundles of patents in Japan that would transfer to a single patent at the EPO, are therefore not distorting our results. China and South Korea, though still rather unimportant with respect to their patent shares, are expected to further increase their patent shares in the future. In EU-28, Germany and France are leading with regard to share of patents.

Figure 5-1: Share of patents in Advanced Materials: EU-28 and main competitors (in %)



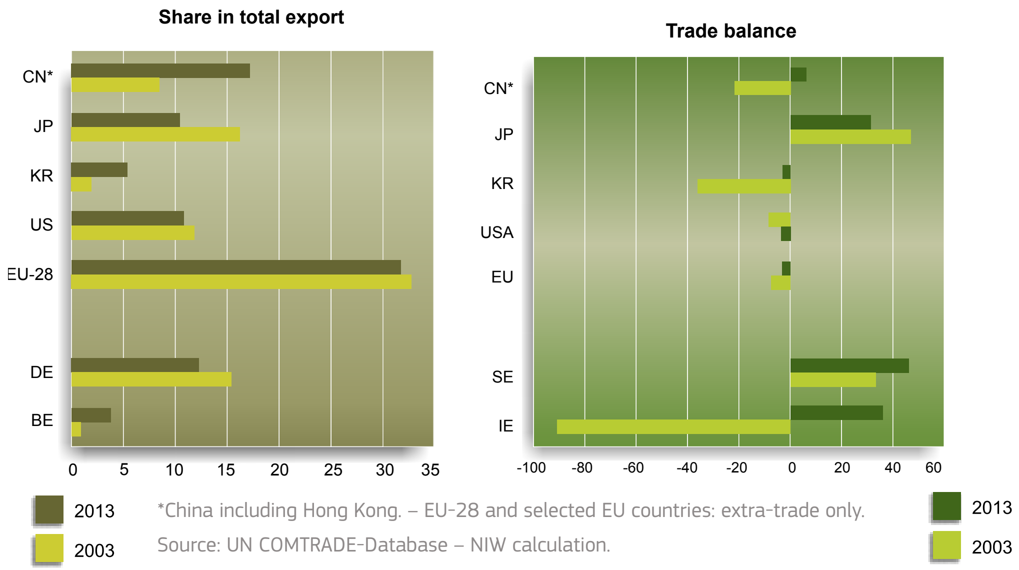
China including Hong Kong.

Source: PATSTAT database – ZEW calculation.

Trade performance

The trade performance in Advanced Materials (AM) for EU-28 and its main competitors is shown in Figure 5-2. The EU-28 constitutes the by far largest exporter with a share in total exports of over 30 %. In contrast, China only realizes a share in total exports of 17% and the US of 11% in 2013. Within the EU-28, Germany and Belgium are the two largest exporters of AM extra-regional exports. Despite its high market share, the EU-28 holds a trade deficit in AM, although single small member states (e.g. Sweden and Ireland) act as net exporter. In Sweden, exports are driven by ion-exchanges and electric accumulators, whereas Ireland is particularly strong in organic and inorganic compounds and artificial joints. Within the group of large competitors, only Japan reveals a clearly positive, but declining trade balance, whereas China, who constitutes a net importer in 2003, depicts a slightly positive trade balance in 2013 suggesting that Japanese companies produce intensively in China. This becomes also obvious when differentiating by product group. Thus, China's export growth is mainly attributed to electric accumulators. As Japan`s exports in the same product groups are declining, it suggests that Japanese companies have shifted their production capacities towards China.

Figure 5-2: Share in total export and trade balance in Advanced Materials: EU-28 and main competitors (in %)



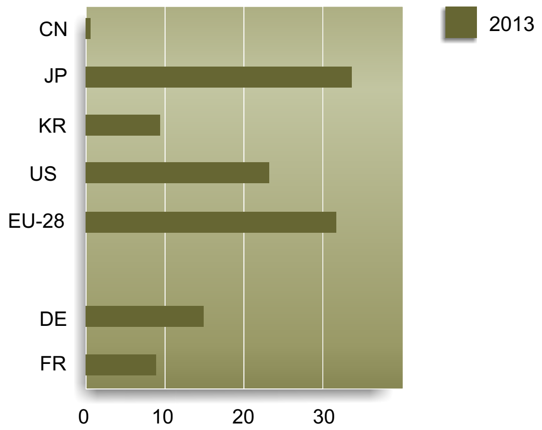
*China including Hong Kong. – EU-28 and selected EU countries: extra-trade only.

Source: UN COMTRADE-Database – NIW calculation.

Turnover performance

In terms of share in turnover, Japan ranks first, indicating that a high share of activities in Advanced Materials (AM) are performed by companies headquartered in Japan (Figure 5-3). The good performance of this country indicates that the Japanese companies are very active in the development and commercialization of AM technology. The EU-28 follows at a small distance, before the US and South Korea. China scores rather weak, implying that the good trade performance of this country is largely driven by foreign multinationals. This observation is not specific to Advanced Materials, as China does not perform well for any of the KETs in terms of share in turnover, suggesting that China has relatively little indigenous companies that develop and market KETs. The business activities in this country are mostly in hand of foreign multinationals, whose activities are assigned to the country of the headquarters and not China.

Figure 5-3: Share in turnover in 2013 Advanced Materials: EU-28 and main competitors (in %)



Turnover is attributed to the headquarters of companies.

Source: Orbis database – IDEA calculation.

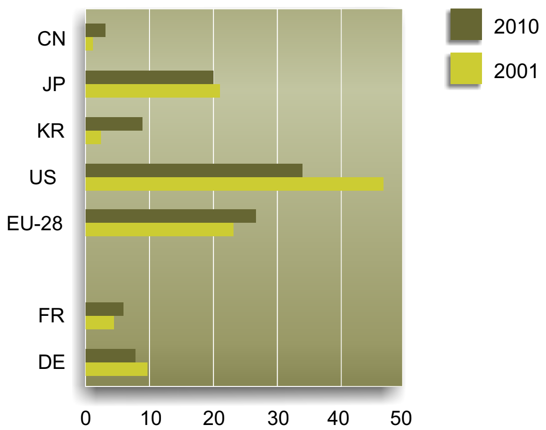
In Advanced Materials, the share in total export for the EU-28 is higher than for Japan, whereas Japan has the highest share of patents and share in turnover. Interestingly, while China still exhibits a low share of patents and share in turnover, it already exceeds Japan, the US and Germany with respect to its share in total export.

5.2 Nanotechnology

Technology performance

The technology indicators for Nanotechnology for EU-28 and its main competitors can be found in Figure 5-4. In Nanotechnology the US exhibit the highest patent share, followed by Europe. From 2001 to 2010 the US have lost parts of their share to Europe, South Korea and China. Japan did not increase its share from 2001 to 2010. Within Europe, France and Germany again score highest with respect to patent share, a fact that is strongly driven by their absolute size.

Figure 5-4: Share of patents in Nanotechnology: EU-28 and main competitors (in %)



China including Hong Kong.

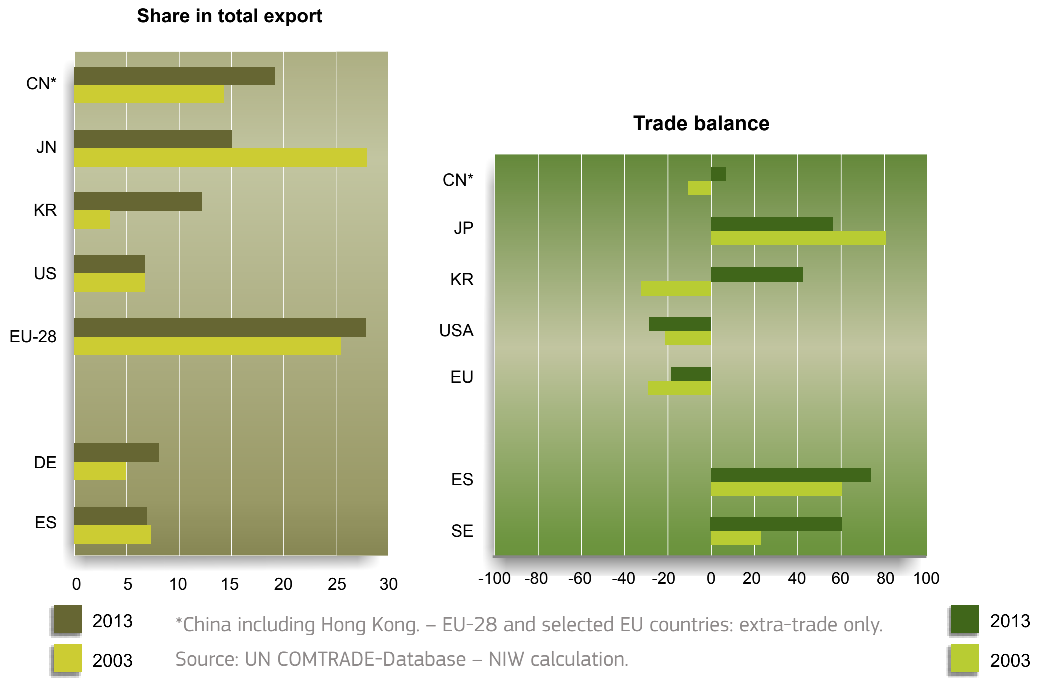
Source: PATSTAT database – ZEW calculation.

Trade performance

China and South Korea have profoundly expanded their export market shares in Nanotechnology (NT) during the last decade, while Japan has lost tremendous market shares in the same period (Figure 5-5).The US and Europe both slightly increased their market shares, but to a lower extent than China and South Korea. Yet, the EU-28 has gained the leading export position, constituting the largest NT exporter worldwide. Within the EU-28, more than half of the extra-exports are attributed to Germany and Spain. The strong performance of Spain is driven by the large scale production in advanced paints and coatings.

In terms of trade balance, China and South Korea have joint Japan as net exporters of NT during the last decade. By contrast, the US and the EU-28 show negative and declining trade balances, although some member states (i.e. Spain and Sweden) hold a high export surplus. Spain constitutes the EU-28 country with the largest trade surplus in 2013 and the second largest exporter of Nanotechnology products (behind Germany). The strong trade performance of Spain in Nanotechnology can be partially attributed to the large scale production in advanced paints and coatings (for instance coatings for cars) that are the main drivers of Spanish exports in this KET.

Figure 5-5: Share in total export and trade balance in Nanotechnology: EU-28 and main competitors (in %)



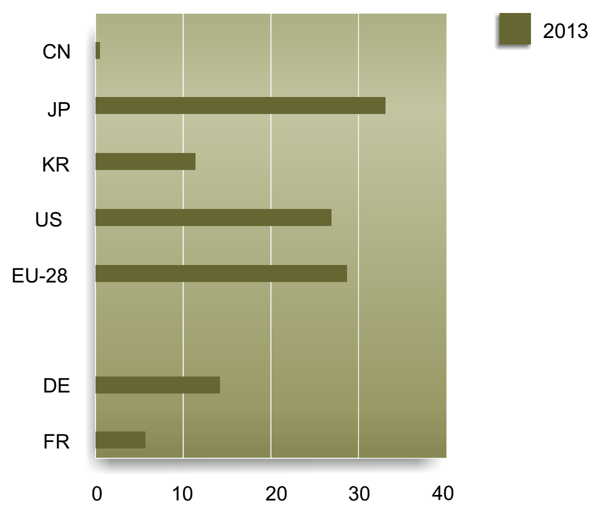
*China including Hong Kong. – EU-28 and selected EU countries: extra-trade only.

Source: UN COMTRADE-Database – NIW calculation.

Turnover performance

Japan has the highest share in turnover, followed by EU-28 and the US. South-Korea and Germany follow at some distance from the leading countries (Figure 5-6). China records an almost zero market share, indicating that its good trade performance is to be almost fully attributed to activities of foreign multinationals in this country. In the EU, Germany and France are the best performers.

Figure 5-6: Share in turnover in Nanotechnology in 2013: EU-28 and main competitors (in %)



Turnover is attributed to the headquarters of companies.

Source: Orbis database – IDEA calculation.

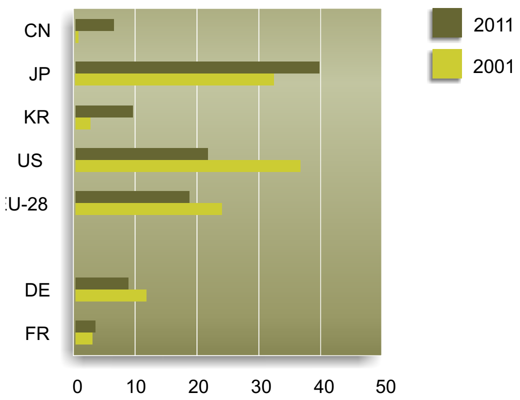
In Nanotechnology, the US shows the highest patent share, followed by the EU-28 and Japan. In terms of share in total export, the EU-28 ranks first, well ahead of China and Japan. Although Japan's share in total export decreased significantly in the last decade, it still performs well with regard to turnover. Indeed, Japan has the highest nanotechnology-related business turnover in 2013.

5.3 Micro- and Nanoelectronics

Technology performance

In Micro- and Nanoelectronics (MNE) Japan clearly dominates the worldwide share of patents in 2011, ranking before the US, EU-28 and South Korea with respect to patent share, while in 2001 the US was leading (Figure 5-7). The results are based on international patent applications (including patents applied at the European Patent Office (EPO) or through the so-called Patent Cooperation Treaty (PCT) procedure of the World Intellectual Property Organization). As mentioned in section 3.4, including bi-continental patents would result in an even higher share of patents for Japan.

Figure 5-7: Share of patents in Micro- and Nanoelectronics: EU-28 and main competitors (in %)



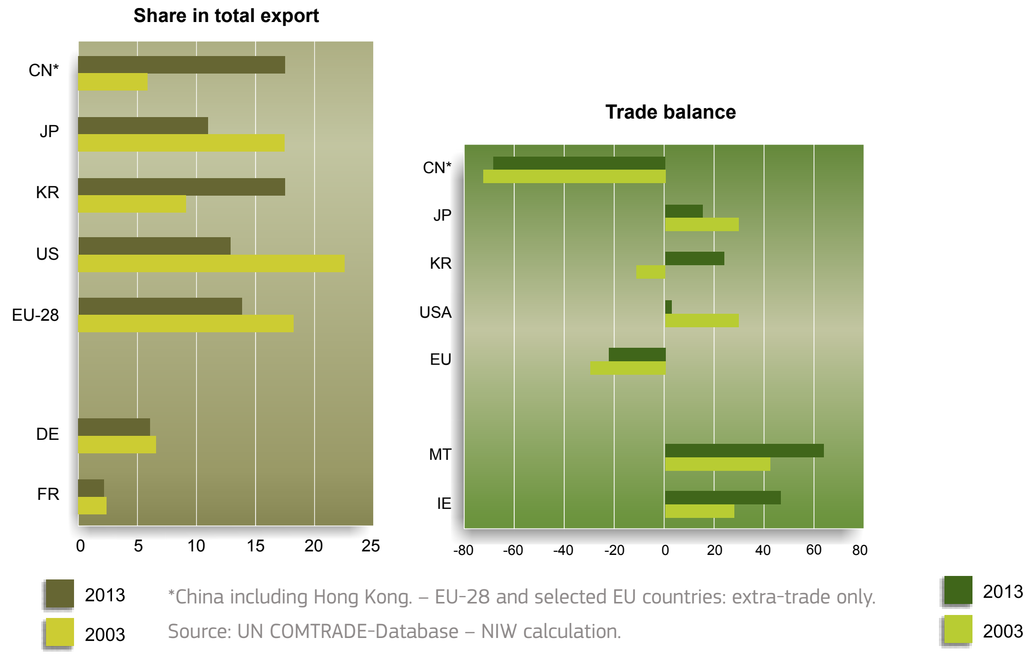
China including Hong Kong.

Source: PATSTAT database – ZEW calculation.

Trade performance

Regarding trade performance, in Micro- and Nanoelectronics (MNE), it is again China and South Korea, who could increase their export shares during the last decade, while the EU-28, Japan and the US experienced a decline (Figure 5-8).This is mainly due to the fact that large parts of the production of MNE components (e.g. semiconductors) has been shifted to countries with lower production costs, whereas high-quality services as Research and Development, design and decision making generally remain in the home countries (c.f. chapter 3.4). Within the EU-28, Germany and France constitute the largest exporters of MNE, both holding their shares in total export relatively constant over the past decade. Despite China's remarkable increase in export shares, its trade deficit is still very large, indicating that China's imports in MNE increased to a similar rate than its exports. The EU-28 also holds a negative trade balance in MNE, even though single, smaller countries (e.g. Ireland and Malta) realize an export surplus in 2013. The comparably strong trade performance of Malta is mainly driven by the fact that STMicroelectronics, one of the large European MNE companies operates an assembly plant there. However, as the Maltese plant only conducts the last steps of back-end production (pack and ship, c.f. chapter 3.4), the value added that actually takes place in Malta may be rather low. In contrast to the EU-28 as a whole, Japan and South Korea are net exporters in 2013, whereas the US as a traditional net exporter reveals a fairly equal trade balance in 2013.

Figure 5-8: Share in total export and trade balance in Micro- and Nanoelectronics: EU-28 and main competitors (in %)

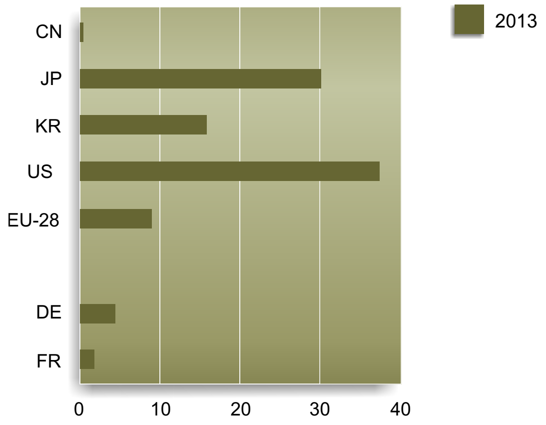


*China including Hong Kong. – EU-28 and selected EU countries: extra-trade only.
Source: UN COMTRADE-Database – NIW calculation.

Turnover performance

The share in turnover shows a leading role for the US in Micro-and Nanoelectronics, followed by Japan (Figure 5-9). The share in turnover differs compared to the share of sales shown in Figure 5-8. This can be explained by the fact that Figure 5-8 is focused on the share of sales in semiconductors, while Figure 5-9 also includes companies that create value added by the integration of Micro-and Nanoelectronics components and intermediary systems, in addition to semiconductor companies. The good position of Japan is driven by the rich ecosystem that exists in Japan in the electronics industry, including chip manufacturers, manufacturers of more complex electronic devices and products as well as equipment manufacturers. The EU represents only a minor share of global business activities, while China is almost absent, for reasons already discussed above (i.e. lack of multinational headquarters located in China).

Figure 5-9: Share in turnover in Micro-and Nanoelectronics in 2013: EU-28 and main competitors (in %)



Turnover is attributed to the headquarters of companies.

Source: Orbis database – IDEA calculation.

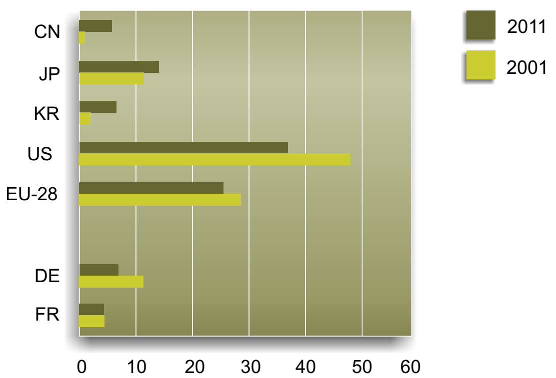
In Micro- and Nanoelectronics, Japan clearly dominates the worldwide patenting, while it also holds a high share in turnover in 2013. China, which shows the highest share in total export, has a low share in turnover, implying that the good trade performance of this country is largely driven by foreign multinationals. The low share in turnover points to the less privileged position of the EU-28 in terms of decision power, especially compared to the US.

5.4 Industrial Biotechnology

Technology performance

The technology performance of the EU-28 and its main competitors in Industrial Biotechnology (IB) is displayed in Figure 5-10. In Industrial Biotechnology (IB) patenting is still strongly dominated by the US, followed by EU-28. However, the US and Europe exhibit a decrease of their patent share over time for the benefit of China, Japan and South Korea.

Figure 5-10: Share of patents in Industrial Biotechnology: EU-28 and main competitors (in %)



China including Hong Kong.

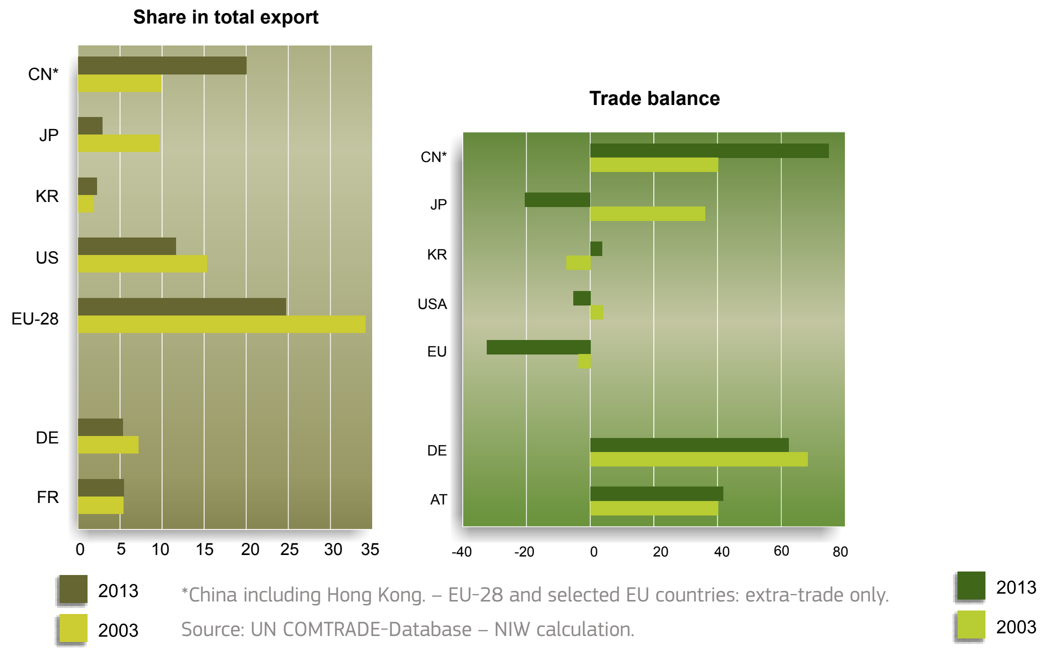
Source: PATSTAT database – ZEW calculation.

[30]There is no data for China available for Industrial Biotechnology.

With regard to trade performance in Industrial Biotechnology (IB), China could strongly increase its export share over the last decade and nearly closed up to the EU-28 that is still holding the leading position. Thereby, Germany and France are the main extra-regional exporters within the community (Figure 5-11). In contrast to China and South Korea, the EU-28, Japan, and the US lost export market shares in IB between 2003 and 2013. China could also expand its already high export surplus in the past decade as its imports increased less than its exports.

Along with China, South Korea also improved its trade balance between 2003 and 2013, turning from a net importer into a small net exporter of IB. On the contrary, the EU-28, Japan and the US constitute net importers of IB. However, within the EU-28, single member states reveal a positive trade balance (i.e. Denmark and Austria). Denmark reveals a relative strong position in Industrial Biotechnology that is mainly driven by its strong exports in enzymes, provitamins and vitamins. Hence, the Danish enzyme manufactures accumulate more than 70 % of the total enzyme production worldwide. Accordingly, the Danish exports in this product group are very high.

Figure 5-11: Share in total export and trade balance in Industrial Biotechnology: EU-28 and main competitors (in %)

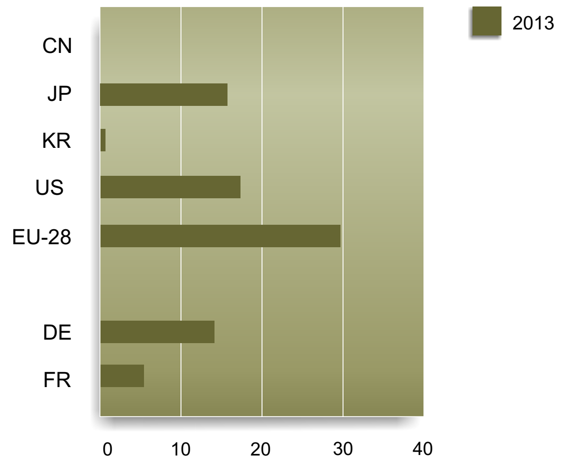


*China including Hong Kong. – EU-28 and selected EU countries: extra-trade only.
Source: UN COMTRADE-Database – NIW calculation.

Turnover performance

The graphs on shares in turnover indicate a leading role for the EU-28, as its share clearly exceeds that of the US and Japan (Figure 5-12). The good performance for EU-28 is primarily driven by the efforts of the European chemical industry to develop and integrate Industrial Biotechnology based processes into their operations. Except of Japan, other Asian countries do not seem to play a major role in terms of share in turnover[30].

Figure 5-12: Share in turnover in Industrial Biotechnology in 2013: EU-28 and main competitors (in %)



Turnover is attributed to the headquarters of companies.

Source: Orbis database – IDEA calculation.

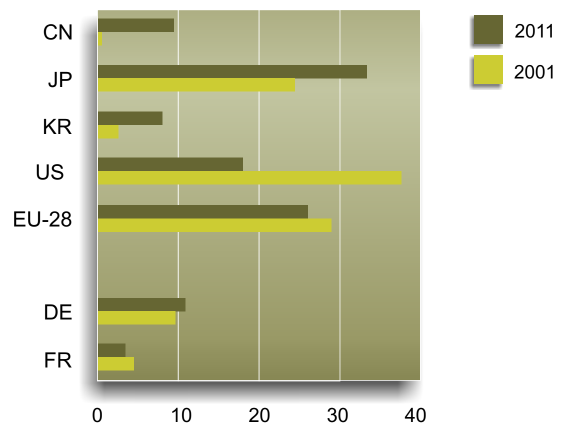
In Industrial Biotechnology, the degree of patenting, trade and turnover does not necessarily coincide. While the US is leading in patenting, it is surpassed by the EU-28 and China when it comes to share in total export, and by the EU-28 when it comes to share in turnover. From this result, one may conclude that there is a clear division of labor in IB: while the US is specialized in patenting, the production and export of goods is (to some extent) transferred to countries with a competitive advantage in manufacturing these goods, such as China.

5.5 Photonics

Technology performance

The technology performance in Photonics is displayed in Figure 5-13. Japan holds the highest patent share, followed by EU-28 and the US. While the three Asian countries have increased their share from 2001 to 2011, the US has experienced a decrease and the EU-28 countries have almost held their share constant, only experiencing a small decline. Within Europe, Germany and France hold the largest patent shares.

Figure 5-13: Share of patents in Photonics: EU-28 and main competitors (in %)



China including Hong Kong.

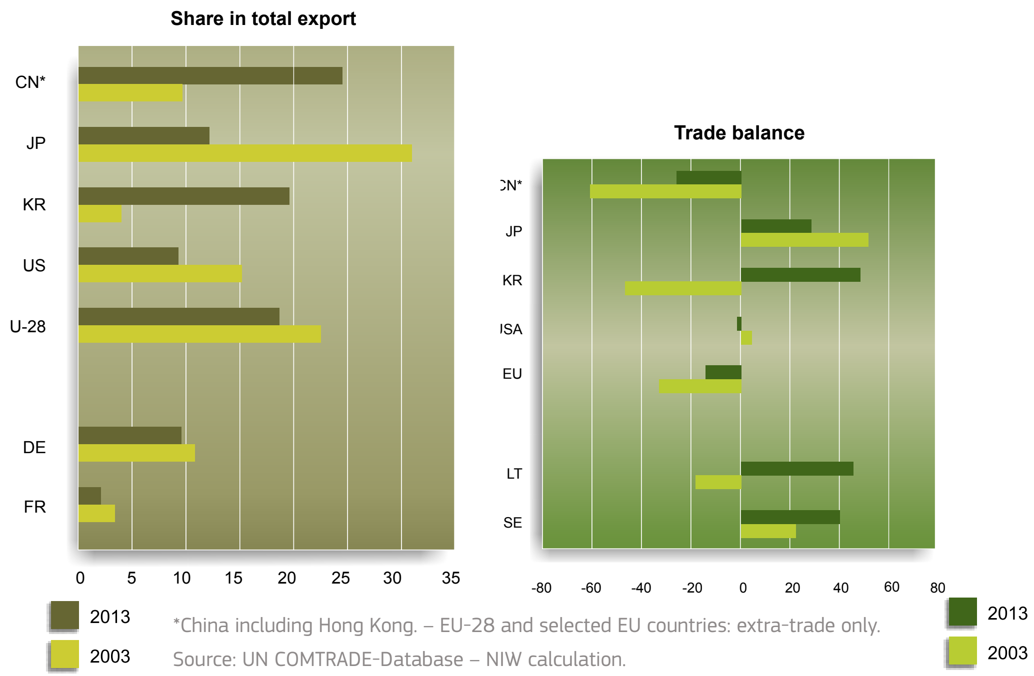
Source: PATSTAT database – ZEW calculation.

Trade performance

In terms of trade performance, China and South Korea have expanded their export shares in Photonics during the last decade, while the shares of Japan, the US, and the EU-28 significantly decreased. As Figure 5-14 depicts, out of the five competitors, only China and South Korea could improve their trade balance over time. However, contrary to South Korea, China still constitutes a net importer of Photonics. In contrast, Japan and South Korea have a positive trade balance, indicating that both countries export more than they import in this KET. East Asia's positive trade balance in Photonics (see Chapter 3) is therefore driven by Japan and South Korea, but cannot be attributed to trends in China. Particularly South Korea managed to improve its trade performance in Photonics over time, mainly due to a sharp increase of exports in photosensitive semiconductor devices. Thereby, South Korean producers of semiconductor devices do not represent subsidiaries of large MNEs. Instead, South Korea has become increasingly important as a headquarter location of semiconductor firms in East Asia, mainly at the expense of Japan (see Chapter 3.4). When looking at the share of sales in semiconductor devices by country of company base, South Korea could increase its sales by 5 M$ between 2008 and 2013, whereas Japan's sales in semiconductor devices by country of company base went down by almost 7 M$ in the same period of time (see Chapter 3.4).

The US and the EU-28 both reveal a deterioration in their trade balance and constitute net importers of Photonics, even though some small member states (i.e. Lithuania and Sweden) depict positive trade balances in 2013. In contrast to the EU-28 and the US, Photonics play a very important role in all three large East Asian economies (namely China, Japan and Korea).

Figure 5-14: Share in total export and trade balance in Photonics: EU-28 and main competitors (in %)

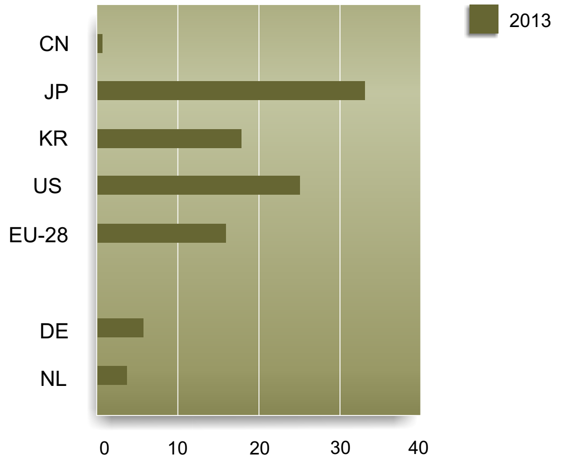


*China including Hong Kong. – EU-28 and selected EU countries: extra-trade only.
Source: UN COMTRADE-Database – NIW calculation.

Turnover performance

In Photonics, Japan ranks first in share of turnover, building on the same cluster of companies active in the electronics industry (e.g. Panasonic, Sony, ...) that also gave this country a top position in Micro- and Nanoelectronics, and to a lesser extent also on its machine tool industry (Figure 5-15). The US is ranked second, followed by South Korea in a third position and EU-28 in a fourth position. As for the other KETs, the turnover performance of China is marginal due to the fact that its Photonics activities are driven by foreign multinationals. The best European performers are the Netherlands and Germany.

Figure 5-15: Share in turnover in Photonics in 2013: EU-28 and main competitors (in %)



Turnover is attributed to the headquarters of companies.

Source: Orbis database – IDEA calculation.

Photonics plays an important role in China, South Korea and Japan. While the patent share is increasing for China and South Korea, it is still low compared to their export shares, indicating that these two countries may be specialized in manufacturing Photonics products that have been invented in other economies. This seems especially true for China, as shown by their low performance in turnover. The US and EU-28 exhibit decreasing shares in both patenting and total export.

5.6 Advanced Manufacturing Technology

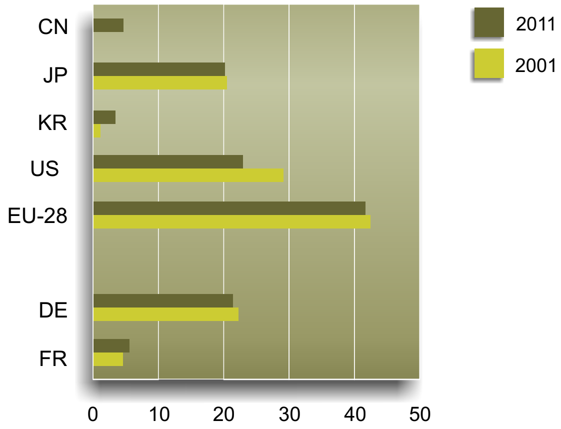
Technology performance

The technology performance in Advanced Manuf-acturing Technology (AMT) is displayed in Figure 5-16. The EU-28 countries hold the highest patent share, followed by the US and Japan. About half of the European patent share is generated by Germany that holds a share of about 20 %.

[31] As indicated in Appendix I, for AMT only the years from 2007 onward are assessed. This is owed to profound changes in HS codes that inhibit a meaningful comparison over time.

[32] The trade surplus is attributed to instruments using optical radiations and other measuring and checking instruments, milling machines and machinery centers for working metal..

Figure 5-16: Share of patents in Advanced Manufacturing Technology: EU-28 and main competitors (in %)



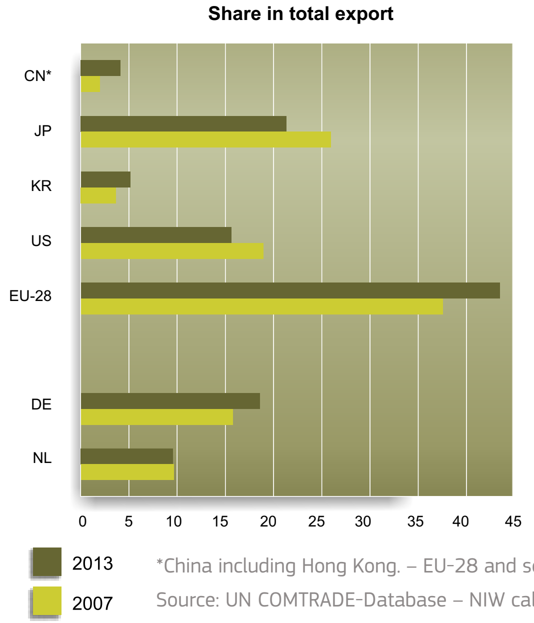
China including Hong Kong.

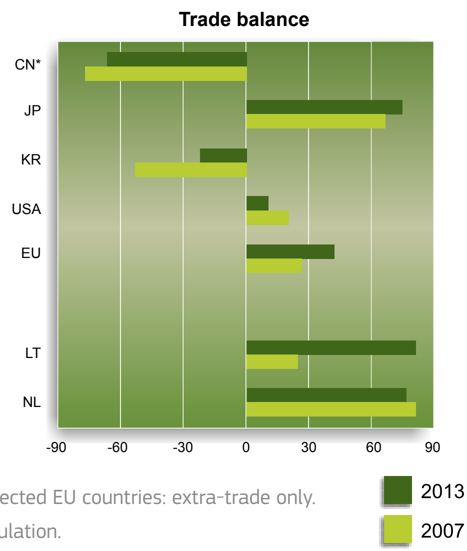
Source: PATSTAT database – ZEW calculation.

Trade performance

In Advanced Manufacturing Technology (AMT), the EU-28, Japan and the US still hold significantly larger shares in total export than China and South Korea (Figure 5-17)[31]. The same is true for the trade balance: while Japan, the US and the EU-28 all reveal positive trade balances, indicating that their exports in AMT exceed their imports, China and South Korea are both net importers of AMT products. In 2013, the Netherlands reveals the second highest trade surplus of all EU-28 countries (after Lithuania)[32], and constitute the second largest EU-28 exporter of AMT products (after Germany). This comparably strong Dutch trade performance in AMT is mainly driven by exports in machines and apparatus for the manufacturing of semiconductor devices and electronic integrated circuits. Here, the Dutch company ASLM, one of the global players for photolithography systems for the semiconductor industry, constitutes an important player.

Figure 5-17: Share in total export and trade balance in Advanced Manufacturing Technology: EU-28 and main competitors (in %)





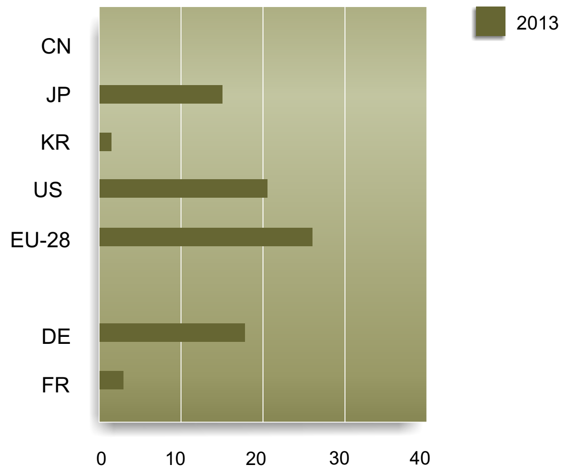
*China including Hong Kong. – EU-28 and selected EU countries: extra-trade only.

Source: UN COMTRADE-Database – NIW calculation.

Turnover performance

For Advanced Manufacturing Technology (AMT), the EU-28 is the global leader in terms of share in turnover (Figure 5-18). The US and Japan follow at the second and third place, while South Korea and China only represent a minor share. As already discussed in chapter 4, the good performance of the EU-28 can mainly be attributed to Germany.

Figure 5-18: Share in turnover in Advanced Manufacturing Technology in 2013: EU-28 and main competitors (in %)



Turnover is attributed to the headquarters of companies.

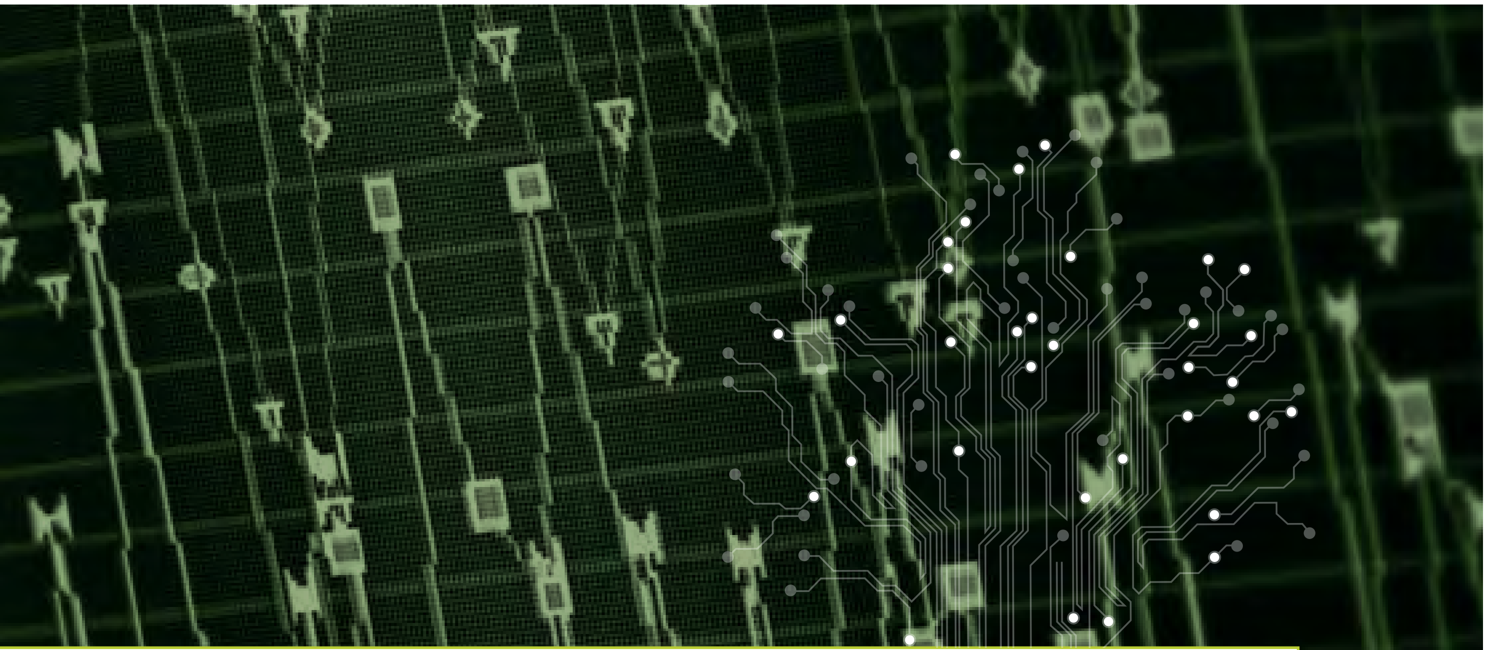
Source: Orbis database – IDEA calculation

In Advanced Manufacturing Technology, the EU-28 has a strong position and is leading in terms of patenting, trade and turnover. Contrary to their performance in the other five KETs, China and South Korea exhibit low shares of patents, low shares in total exports and low shares in turnover for Advanced Manufacturing Technology. The good performance of the EU-28 is related to the different nature of technological advances in this KET, which is based on the integration of other technologies into complex products.

6. Appendix I: Methodological background

6.1 Introduction

This section contains a description of the methodologies used to collect data on technology, production, trade and turnover (at headquarter level) indicators. It describes the methodologies in a comprehensive way. The methodologies developed in the KETs Observatory project are the result of extensive consultations with a diversity of technological, statistical and business experts. Retrieving KETs-specific data from existing databases is not straightforward as each database has its own rationale and the trade, production and turnover databases do not differentiate between different KET technologies. A narrow view has been maintained in order not to create too much noise by including data that only partially relate to KETs, but to select those data that reflect true KETs related activities. As the technology generation and exploitation approach focuses on KETs based components and intermediary systems, data that refer to end-user products are not included. For example, in Industrial Biotechnology, the production of enzymes is included while the production of detergents, for which enzymes play an important role, is not included. Hence, the results of this project are linked to the data we use to represent key enabling technologies. More detailed information on the choices that were made can be found in the methodology report.



The consortium has provided definitions for each KET (see previous chapter) and has translated these definitions in codes of existing classification systems. It is possible to extend the list of codes, for example by including more PRODCOM codes. However, this results in a worse picture as one introduces more noise by including data that is only partially related to KETs.

The objective of this study is to come up with indicators to compare the performance of countries with regard to specific KETs. Therefore, no absolute numbers are provided.

6.2 Indicator framework

The KETs Observatory attempts to measure the performance and development of KETs in Europe, both among the EU-28 Member States and vis-à-vis its main competitors in other world regions. In order to monitor EU performance in a comprehensive way, a set of indicators is used to capture performance at different stages of the value chain. The analysis rests on two complementary approaches, the “technology generation and exploitation” approach, and the “technology diffusion” approach (Figure 6-1).

While the technology generation and exploitation approach looks at the ability of countries to generate and commercialize new knowledge, the technology diffusion approach investigates the likely impacts of KETs on the wider economy. The combination of both approaches provides insight into the ability to transfer new knowledge and technology into value added and growth.

Indicators regarding the technology generation and exploitation approach include:

- **Technology indicators** measure the ability to produce new technological knowledge relevant to industrial application.
- **Production indicators** measure the relevance and dynamics of the production and absorption of KETs based components.
- **Trade indicators** measure the ability to produce and commercialize internationally competitive products based on new technological knowledge. Here, export shares or specialization patterns reveal how a country’s technological performance in KETs transcends into success in international trade.

- **Turnover indicators at headquarter level** measure the ability of industries/businesses to compete in the market for KETs based components and to transfer new technologies and innovations to industrial applications. These indicators provide information about where headquarters and hence decision power in KETs are located.

Indicators regarding the technology diffusion approach include:

- **Production and demand indicators** that show to what extent the EU can use the potential of KETs to improve its competitiveness by manufacturing KETs-based products and applying them in the production of manufacturing goods, both in the sectors that produce KETs as well as, and more importantly, in other industries.
- **Employment indicators** that reveal a country's performance with regard to KETs-related employment.

Figure 6-1 illustrates the position of the indicators used in the KETs Observatory across a deployment value chain that stretches from the invention of new technology (left column) to its application and diffusion (right column).

Figure 6-1: Indicator framework

"Deployment Value Chain"					
Technology generation and exploitation				*Technology diffusion*	
New Technology	*Competitive Innovations*		*Commercialisation*	*Application*	
Patents	**Production**	**Trade**	**Turnover**	**Production & Demand**	**Employment**
IPC	PRODCOM	HS	NACE/IPC	PRODCOM	PRODCOM/NACE
KETs-related inventions	KETs-based components and intermediary systems		KETs-related firm activities	KETs-related value creation	

The chosen indicator framework also addresses the well-known "valley of death" when commercializing new technology. While technology indicators report the production of new technology, production and trade indicators help to identify the extent of successful commercialization of this new technology and hence indicate whether the "valley of death" could be passed. The technology diffusion approach even goes beyond this perspective and looks at the potential of successfully commercialized new technology to trigger innovation and competitiveness across many industries.

For each source of data needed to generate indicators, different classification taxonomies apply. For each statistical classification system, a set of codes has to be defined that allows identifying KETs-related activities. The following four classification systems are used:

- **Technology indicators** rest on patent data taken from the European Patent Office's PATSTAT database. Patents are classified by field of technology, employing the International Patent Classification (IPC). The KETs Observatory uses a list of IPC codes that cover technologies directly representing one of the six KETs.
- **Trade data** is collected from the United Nation's COMTRADE database. Trade data is classified by products based on the Harmonized System (HS). The KETs Observatory uses HS codes that cover products that are directly based on KETs and that represent KET-components or intermediary systems (such as an optical device or a microelectronic unit to be used in a machine or in transport equipment) that can be used to deploy KETs in other manufacturing activities.
- **Turnover data** is taken from the Orbis database of Bureau van Dijk. Businesses are classified by economic activities using the NACE classification system. The KETs Observatory uses NACE codes that cover economic activities that are leading in the commercialization of KETs.

[33] Depending on the availability of appropriate data.

- **Production and demand data** is calculated based on the Eurostat Prodcom statistics. These statistics provide a classification of manufactured products. On the one hand, this data is used to indicate competitive KETs based innovations by covering products that are directly based on KETs and that represent KET-components and elements (see column 2 in Figure 6 1). On the other hand, for the purpose of indicating technology diffusion of KETs in total manufacturing, the classification is used to identify products that are depending on the use of KETs in order to be competitive (see column 4 in Figure 6-1).

- **Employment data** is calculated based on the production data from Eurostat Prodcom statistics multiplied with country and KETs specific estimates for employment per Euro of gross output (the inverse of productivity). The employment per Euro of gross output for a KET is estimated by the calculation of an average of the values of the respective sectors of a KET using Eurostat Structural Business Statistics.

The KETs Observatory covers the following countries[33]:

- EU-28
- Rest of Europe (Iceland, Norway, Switzerland and Turkey)
- North America (US, Canada and Mexico)
- East Asia (Japan, China (incl. Hong Kong), South Korea, Singapore, Taiwan and India)
- Other countries: Brazil, Israel, Russia and South Africa

The country coverage depends upon the database used and differs among the indicators. For example, the UN COMTRADE database contains no data on Taiwan; therefore no trade data is be available for Taiwan. For production data, some data is confidential and therefore not included in the analyses. Appendix III provides an overview of the data availability.

An international perspective is possible for technology, trade and turnover indicators, while it is to be examined if this is possible for production and demand indicators. The time coverage differs for the different indicators due to data availability; for example, patent data is not yet available for 2012.

The KETs Observatory also provides data on a regional level. Regions in this report refer to global regions, namely EU-28, North America (US, Canada, Mexico) and East Asia (Japan, China (incl. Hong Kong), South-Korea, Singapore, Taiwan, India).

The first annual report focuses on the technology generation and exploitation approach. The technology diffusion approach will be discussed in the second annual report.

6.3 Indicators of the technology generation and exploitation approach

This report contains a concise overview of the methodology applied in the KETs Observatory for the technology generation and exploitation approach. More detailed information on this approach or the technology diffusion approach can be found in the methodology report. The KETs Observatory works with four technology, production and turnover indicators; and with five trade indicators to monitor EU-28 performance and measure the ability of the EU to produce and to commercialize competitive products based on new technological knowledge.

Four indicators are available for technology, production, trade and turnover: 1-country significance (i.e. how important a certain KET is in a country's total patent activity, exports, production and turnover), 2-share of patents, share of production, share in total export or share in turnover (i.e. how important a country is for European or global patent activity, exports, production and turnover in the relevant KET), 3-medium-term dynamics (i.e. how KETs activities have changed over the past decade), and 4- KET specialization, indicating the relative significance of a particular KET. The second indicator is discussed throughout the remaining chapters of this report. All other indicators are not discussed in this report, but are available on the website.

For KET specialization, the indicators for patenting, production and turnover are not directly comparable to trade indicators. While KET specialization in patenting for example, measures whether a country devotes more or less activities towards patenting in a certain KET; KET specialization in trade uses the standard revealed comparative advantage (RCA) indicator which gives the ratio of exports to imports in a certain KET related to the same ratio for a country's total exports and imports (i.e. the RCA tells whether the trade balance in a certain KET is better or worse the total trade balance of the country).

In addition, trade performance also considers the absolute trade balance per KET as a fifth indicator. This indicator informs about a country's competitiveness in international trade by comparing the volume of exports and imports.

The various indicators are particularly suitable to capture the multidimensionality of performance of both the EU-28 as a whole, and for individual EU Member States. Furthermore, the indicators nicely illustrate how a country's technological performance in a particular KET translates into success in international production, trade and turnover activity.

6.4 Methodology for technology indicators

The following paragraphs give a short overview of the methodology that was developed for the technology indicators. More detailed information can be found in the methodology report.

6.4.1 Defining KETs based on IPC classification

Patent activities in KETs are identified based on IPC classes. For each KET, a list of IPC classes is used that represents new technological knowledge related to the respective KET[34]. The list of IPC classes for each KET was established in the following way:

1) For each KET, a conceptual definition has been developed which builds upon EC (2009a,b)[35] and various other industry sources. For a detailed discussion, see the background report of TNO and ZEW on KETs produced for the KET chapter in the European Competitiveness Report 2010 (Klein Woolthuis et al., 2010) .

2) Based on this conceptual definition, related IPC classes were identified, building upon earlier technology classification work done by OECD, the EU and in various reviews and studies on specific KETs (see Klein Woolthuis et al., 2010).

3) The initial list of IPC classes has been re-examined and improved during a feasibility study for the KETs Observatory (see Van de Velde et al., 2012)[36]. For this purpose, a variety of methods were employed: text field search, matching of patent applicants to business registers, examining patent activities of selected actors with a known track record in a certain KET, and analyzing the activities of organizations that predominantly patent in a certain KET.

4) A further refinement of IPC based KETs definition was done by consulting experts from CEA and IPTS, which led to some changes in the fields of Industrial Biotechnology, Micro-and Nanoelectronics, and Photonics.

6.4.2 Technology indicator data

The production of new technology is measured by the number of patents. Patent data is a widely used measure for tracking technology development activities. Patents refer to technical inventions that contain new knowledge, have a potential for commercial application and have proved a certain level of technical feasibility. Patents can therefore be regarded as a first step in the deployment of new technological knowledge. Nevertheless, patent data is not a perfect measure as not all new technologies are patented, and not all patents are commercialized. The great advantage of patent data is that it contains information on the technological area(s) a patent is related to, based on an internationally standardized classification system, the International Patent Classification (IPC) and other systems building upon IPC.

For the KETs Observatory, patent application data is preferred over data on granted patents because of the higher punctuality of application data. While patent applications are typically disclosed 18 months after the date of application, information on granted patents is often available only several years after application date.

In order to facilitate international comparability, only international patent applications are considered. International patent applications include patents applied at the European Patent Office (EPO) or through the so-called Patent Cooperation Treaty (PCT) procedure of the World Intellectual Property Organization.

[34] This list is available upon request.

[35] EC (2009a), Preparing for our future: Developing a common strategy for key enabling technologies in the EU, Communication from the Commission, COM(2009)512, Brussels: European Commission.

[35] EC (2009b), Current situation of key enabling technologies in Europe, Commission Staff Working Document accompanying the Communication from the Commission, COM(2009)1257, Brussels: European Commission.

[36] Klein Woolthuis, R., C. Rammer, B. Aschhoff, D. Crass, Kl. Cremers, C. Grimpe, F. Brandes, F. Diaz-Lopez, M. Mayer, C. Montalvo (2010), European Competitiveness in Key Enabling Technologies. Background Report to the European Competitiveness Report 2010, Delft and Mannheim.

[37] Van de Velde E., et al (2012), Feasibility study for an EU Monitoring Mechanism on Key Enabling Technologies.

Choosing international patents has the advantage that particularities of national patent offices are not distorting the results. National patent offices apply different policies in assigning IPC codes and exhibit a lower quality in applicant address data. Moreover, the number of different patent applications needed to protect a certain invention differs widely among national offices. In Japan or China for example, a bundle of several patents can be applied for that would result in only a single EPO patent. In that case comparing numbers of international and national patents would be misleading. EPO/PCT patents are assigned to countries based on the location of the applicant. In case a patent has applicants from more than one country, fractional counting is applied.

The applicant can either be a large enterprise, a SME, a public organization, a non-profit organization (such as universities or public research institutes) or a private individual. We choose applicant location instead of inventor location for country analysis since it is the applicant that is most likely to deploy and commercialize new technology. The location of the applicant is more likely the location where a decision about the commercialization and deployment of the technology protected by the patent will take place. Note that most large, multinational corporations apply patents developed at foreign subsidiaries under their subsidiary organizations (which are legally independent enterprises).

Patent data is taken from the PATSTAT database published by EPO twice a year (typically in April and October). The current version of technology indicators that are available on the website are calculated using the April 2014 edition of PATSTAT and cover the entire year 2011.

Patents that are assigned to more than one KET are fully counted as one patent for each KET. Each patent is allocated to the year of its priority date. In order to determine a patent's priority date, patent family information is used. This means, for instance, that a patent that was first applied at a national patent office and has later been transferred to EPO or PCT application procedure will be assigned to the year of the priority date of the initial application at the national office.

For the KETs Observatory, patent data from 2000 on is considered. Owing to the lag between priority date and disclosure of a patent application, as well as between applications, complete annual data is only available with a considerable time lag. For example, complete data for the year 2011 is only available with the April 2014 PATSTAT edition.

In total, 45 different countries are considered: EU-28 as well as Brazil, Canada, China (incl. Hong Kong), Iceland, India, Israel, Japan, Mexico, Norway, Russia, Singapore, South Africa, South Korea, Switzerland, Taiwan, Turkey and the US.

6.5 Methodology for production and trade indicators

This section discusses the methodology for the production and trade indicators. It details the conceptual approach of selecting KETs-relevant Prodcom codes for the technology generation and exploitation approach. The technology generation and exploitation approach only covers products that are directly based on KETs and that represent KET components or intermediary systems that can be used to deploy KETs in other manufacturing activities. More detailed information can be found in the methodology report.

6.5.1 Defining KETs based components and intermediary systems based on Prodcom and HS classification

The list of Harmonized System (HS) codes, which is used in trade analysis, is closely related to the list of Prodcom codes, used in production analysis. Therefore, first a list of relevant Prodcom codes has been established. Next, this list of Prodcom codes has been transferred into the HS classification system.

The initial list of Prodcom codes as identified in the feasibility study for the KETs Observatory (see Van de Velde et al., 2012) has been re-examined and improved using a variety of methods:

1) First, KETs applications have been assigned to manufacturing sectors or manufacturing activities to identify those sectors or activities (corresponding to NACE groups and classes) in which the particular KETs-related patent activities are concentrated. This approach is based on the assumption that the invention of new technologies and their exploitation stick together.

2) Second, relevant KETs based components have been identified on the basis of existing literature, web searches, and expert views. The so-identified KETs based components have been used to compile lists of adequate Prodcom codes which represent KETs components or – in a few cases – intermediary systems.

3) Third, Prodcom codes that represent end-products rather than components are excluded.

4) Feedback from experts within the consortium, results from the expert workshops organized by TNO, comments from external experts and information from KET-specific studies and reviews have been exploited.

To select the relevant HS codes for trade indicators, the refined list of Prodcom codes has been used. In this study, we directly convert Prodcom codes to HS codes when applicable. The following steps have been taken:

1) Most Prodcom codes (eight digit codes) can be directly linked to single six digit HS codes using convergence tables. In other cases a single HS code covers several eight digit Prodcom codes and vice versa[38][39].

2) In some cases, the correspondence between HS 2007 (the classification used from 2007 onwards) and HS 2002 (the classification used from 2002 to 2006) is ambiguous. This is especially the case for some codes relating to Advanced Manufacturing Technology (AMT), but a few codes in Photonics and Advanced Materials are also affected. Therefore, for AMT, trade indicators are only calculated from 2007 onwards.

The result is a narrow list of selected HS codes that represent true KETs related activities.

6.5.2 Production and trade data

The production data is taken from the Prodcom database of Eurostat, in close collaboration with Eurostat. Prodcom provides statistics on the production of manufactured goods and is updated annually. For the KETs Observatory, production data for the period 2003-2013 is considered.

The database covers EU-28[40], with the exception of Cyprus, Luxembourg and Malta as these countries are exempted from reporting Prodcom data to Eurostat and zero production is recorded for them for all products.

Trade data is extracted from the UN COMTRADE database. Owing to its worldwide coverage, this database is particularly suitable for an international comparison of trade indicators. An alternative database is COMEXT, which employs more detailed eight-digit product codes. However, as the COMEXT database only covers Europe and therefore does not allow for international comparison, it has been decided to use the UN COMTRADE database. UN COMTRADE provides export and import data on a six-digit level according to the Harmonized System (HS). The current version of trade indicators comprises data for the years 2003 to 2013, except for AMT which comprises data for the years 2007 to 2013.

On the global level (i.e. for a comparison between the EU-28, East Asia, and North America), all trade indicators have been adjusted for intra-regional export and import flows and therefore refer to extra-regional trade only. This is particularly relevant for the interpretation of export market shares in regional comparison. Merely considering total exports (i.e. exports to any other country) would overestimate the share of the EU-28, as within the EU-28, most exports flow to other EU Member States. Simultaneously, it will underestimate the shares of East Asia and North America since both regions comprise few large countries with vast domestic markets (US, Canada, and Mexico for North America; China including Hong Kong, Japan, South Korea, Singapore, and India for East Asia)[41].

In contrast, on the country level, trade indicators are calculated as the sum of all exports (respectively imports). They reveal a country's performance compared to the group of all 44 countries considered in the analysis. In addition, for EU-28 countries

[38] Cf. COMMISSION REGULATION (EU) No 860/2010 of 10 September 2010 establishing for 2010 the 'Prodcom list' of industrial products provided for by Council Regulation (EEC) No 3924/91.

[39] Only in a few specific cases, there is no direct link between PRODCOM and HS codes which implies that the respective inclusion or exclusion involves a certain over- or underestimation in trade flows. However, exploring possible weighting factors showed that the indicator values and basic trends are not affected by including or excluding parts of these HS codes. More detailed information can be found in the methodology report.

[40] In the next phase of this project, the consortium will explore available data sources for selected non-EU Member States on production indicators.

[41] Taiwan is missing in trade analysis, because the country is not covered by international trade databases (UN Comtrade, OECD) (see footnote 5).

[42] To calculate the technology indicators, we consider all patents.

[43] In the Orbis database, one can distinguish between primary NACE codes (which represent the NACE activity a given company gains the most revenue from) and secondary NACE codes (which represent the other NACE activities of a given company). In this study, we only select companies that have one of the KETs-relevant NACE codes as their primary NACE code because, varying from country to country, the assignment of secondary NACE codes to companies can be quite unreliable.

[44] SMEs tend to be less represented in Orbis as there are different thresholds per country for submitting an annual account.

[45] EU-28, Brazil, Canada, China (incl. Hong Kong), Iceland, India, Israel, Japan, Mexico, Norway, Russia, Singapore, South Africa, South Korea, Switzerland, Taiwan, Turkey and US.

trade indicators are calculated for intra-trade and extra-trade separately. This helps to investigate how single European countries succeed in international competition with KETs-related components within and outside the common market.

6.6 Methodology for turnover indicators

This section gives a short overview of the methodology developed for the turnover indicators. The turnover is assigned to the headquarters of a company and informs about the decision power present in countries. More detailed information can be found in the methodology report.

6.6.1 Defining KETs-related firm activities to identify turnover

In order to identify and select companies that are active in the deployment of the six KETs, we build upon the approach that has been used to compile the production and trade indicators in the technology generation and exploitation approach, as such leading to a logical and necessary consistency between the different approaches and types of indicators produced. Therefore, the turnover indicators measure the ability of EU industries to compete in the market for KETs based components and to transfer new technologies and innovations to industrial applications. The process of identifying KETs-relevant companies includes a three-step approach:

1) Based on the final list of Prodcom codes of the technology generation and exploitation approach, the relevant NACE codes can be identified. The approach leads to a narrow selection of NACE codes as we aim to focus on companies that are active in developing and exploiting KETs-related technology and products as they are an input for many industries, and have a large diffusion and spill over potential. This implies that we focus on companies active in enabling industries, which are of a strategic nature for Europe, US and East Asia, rather than in final markets. These companies are leading or have the potential to become leading in innovations that will contribute to the competitiveness of end-markets today and/or in the near future.

2) Next, we build upon the approach that has been followed to calculate the technology indicators. Our point of departure is a list of all applicants that applied for 10 or more patents from 2005 to 2010 at EPO or PCT. For each applicant, we identify the total number of patent applications and the number of patents falling into each of the six KET areas. A threshold of 10 or more patents is applied as below this threshold, the list contains a lot of individuals and research institutions[42].

3) The NACE codes as identified in step 1 are used to filter the list of patent applicants obtained in step 2, by matching the list of applicants with the list of companies with KETs-relevant NACE codes. This matching procedure results in a number of successful matches that are retained. Subsequently, the retained companies are checked for having relevant activities in the area of a particular KET using three criteria. The first criterion is the main (primary) NACE activity of the company[43]. The second criteria is the share of KET patents in the company's overall patent portfolio (e.g. a low share implies a limited focus on KETs); while the third criteria is the sales to KET patent ratio (a high ratio implies a poor fit with the activities of the firm).

This results is a narrow list of companies that are active in the development and/or commercialization of KETs-related components and intermediary systems.

6.6.2 Turnover data

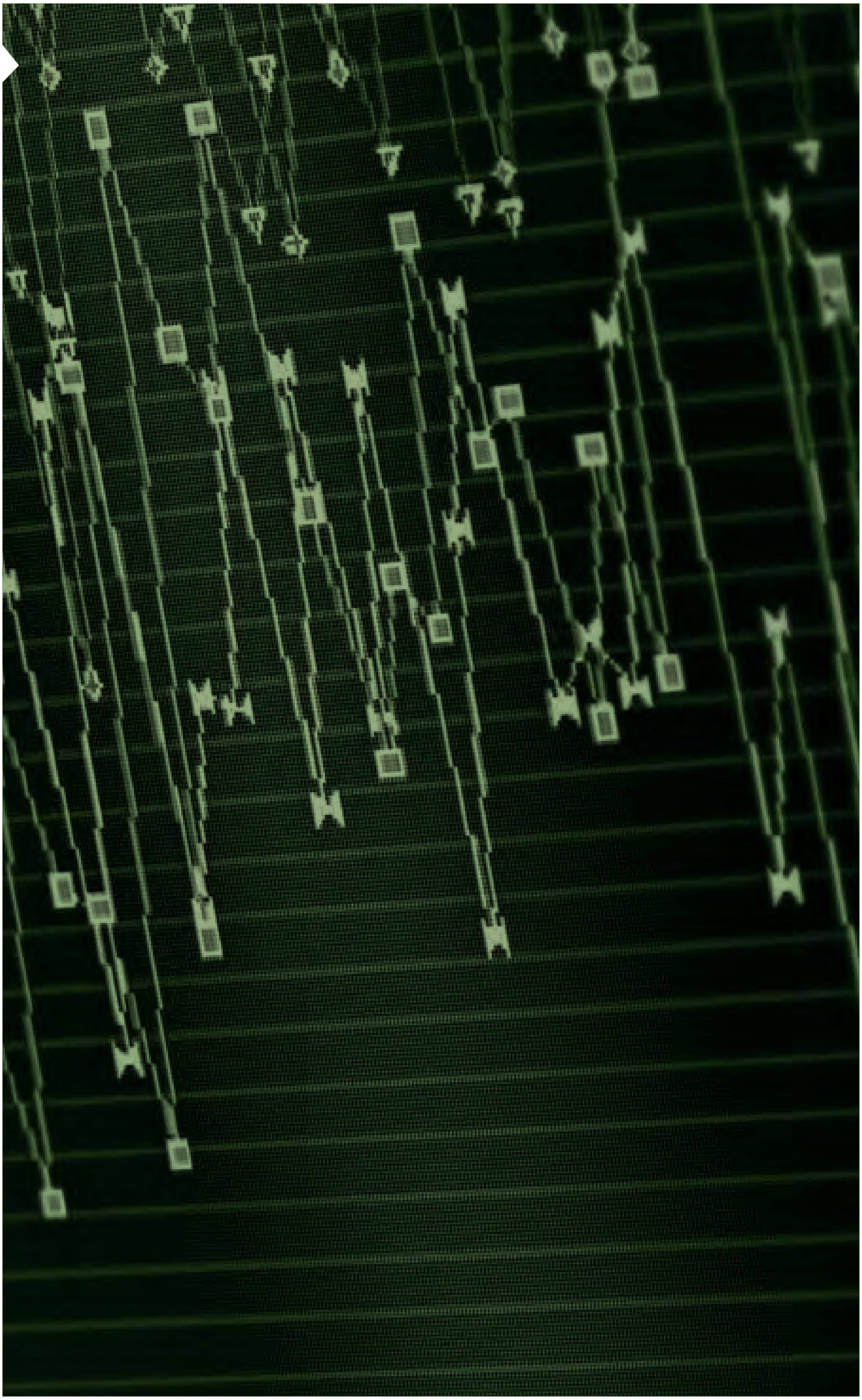
For the selected companies, turnover data is extracted from the Orbis database. Orbis is a financial-economic database that contains comprehensive information on both listed and unlisted companies worldwide, with an emphasis on private company information. The database is owned by Bureau van Dijk and has information on 120 million private companies worldwide (around 70 million European companies, 40 million US companies and 15 million Asia-Pacific companies)[44].

For the KETs Observatory, turnover data from 2005 onwards is considered. Only data from the global ultimate owner of a specific company is retained. The data covers all 45 countries considered in this study[45].

It is important to estimate the KETs-relevant activities of a company with regard to turnover. Small companies tend to focus their activities in a particular area. Medium-sized firms are more diverse, while large companies have activities in many economic areas and only part of them is related to the deployment of KETs. Therefore, the total turnover of a large company can often not be assigned 100% to a specific KET as this would imply an overestimation of the KETs-related turnover creation.

Moreover, the turnover from large companies totally discard the turnover from small and medium-sized companies in a particular country, as a multinational company often generates more turnover than the combined turnover of all SMEs in that particular country. As a consequence, weights were assigned to companies to capture the KETs-relevant activities based on the share of KET patents to the overall patent activity of a company. Weight is calculated by taking the share of KETs relevant patents in the overall patent portfolio of a company.

In interpreting the turnover indicators, it is important to keep in mind that turnover is assigned to the headquarters of a company. Turnover is assigned to the headquarters of a company as it is very difficult to assign this to the different subsidiaries of multinational companies. In order to determine the actual turnover that is being realized in a specific subsidiary in a particular country, one needs information on the KETs activity of individual subsidiaries. Some multinationals provide figures (turnover) with regard to specific subsidiaries, although this is not the case for all multinationals, especially not for East Asian companies. Provided that the information is available, it would even not be sufficient as input for the KETs Observatory. What is needed to estimate the KETs relevant share, is precise information on the actual activity of that subsidiary in the area of KET and its contribution to the subsidiary's turnover. Unfortunately, this information is hardly available as companies prefer not to share that (sensitive) information. As a result, the interpretation of the turnover indicators lies in the information they provide about the location of decision power in particular countries. The production and trade indicators on the other hand, do provide insights in the activities of subsidiaries of multinational companies in particular countries.



7.

Appendix II

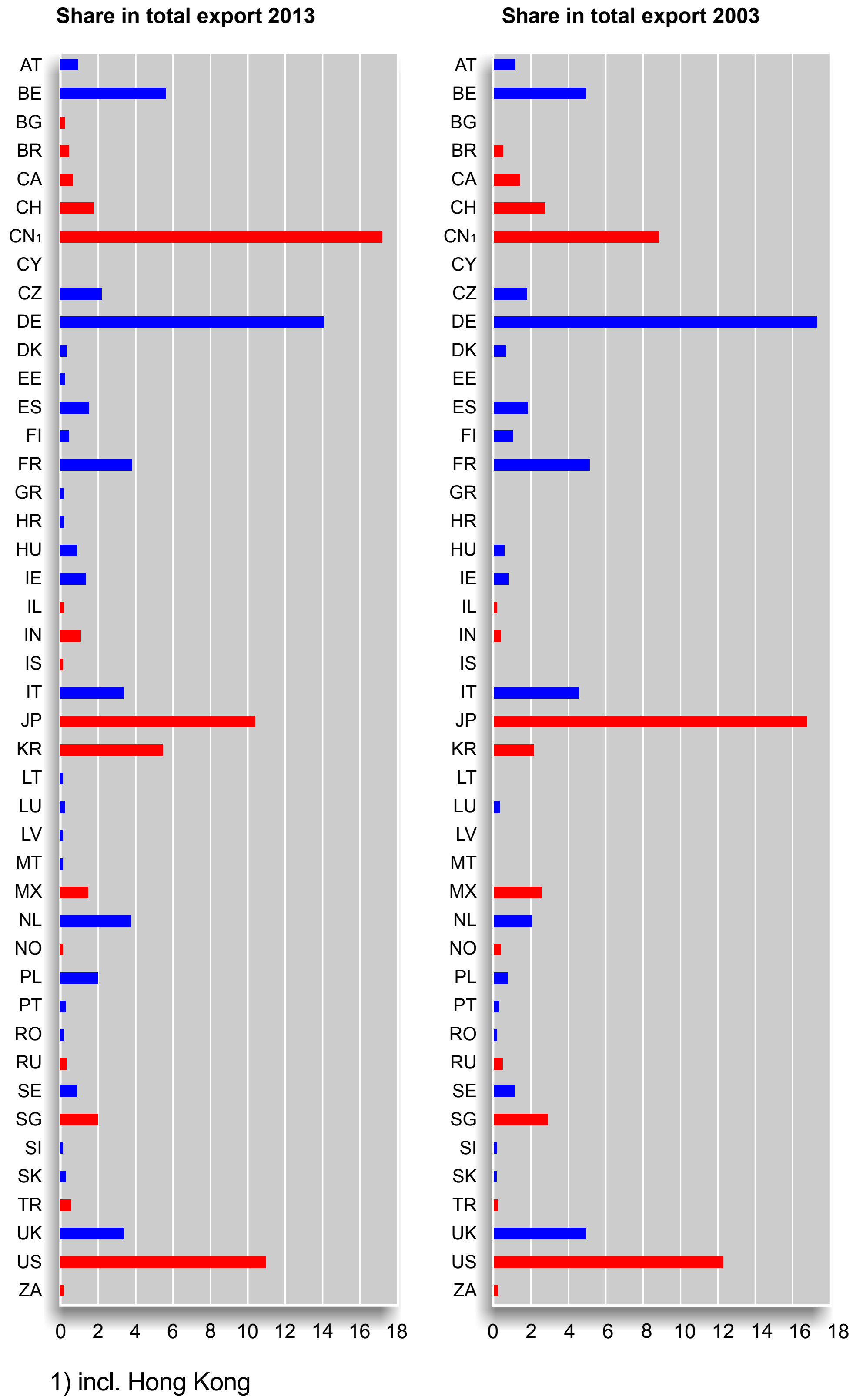
Detailed results for all indicators and for the entire list of EU-28 Member States, as well as for the other 18 non-EU-28 countries, can be found on the KETs Observatory website.

The following steps need to be taken in order to obtain the results:

1. Go to the KETs Observatory website www.ketsobservatory.eu
2. Click on KETs Deployment Visualization Tool
3. Click on Visualization Tool showing multi-annual trends across coun-tries per KET
4. Choose the KET of interest by clicking on it, for example “Advanced Materials” (upper row)
5. Select a category, for example “trade indicators” (upper left-hand corner)

6. Select the country you are interested in, for example "all countries" (upper right-hand corner)
7. Select the year you are interested in, for example "2013" (bottom left-hand corner)
8. You can then see the result in the graph and on the map
9. Click on the third icon to export the data, the map or the graph (bottom left-hand corner)
10. If you click on "Export Graph", you get results as displayed in Figure 7-1 to Figure 7-5

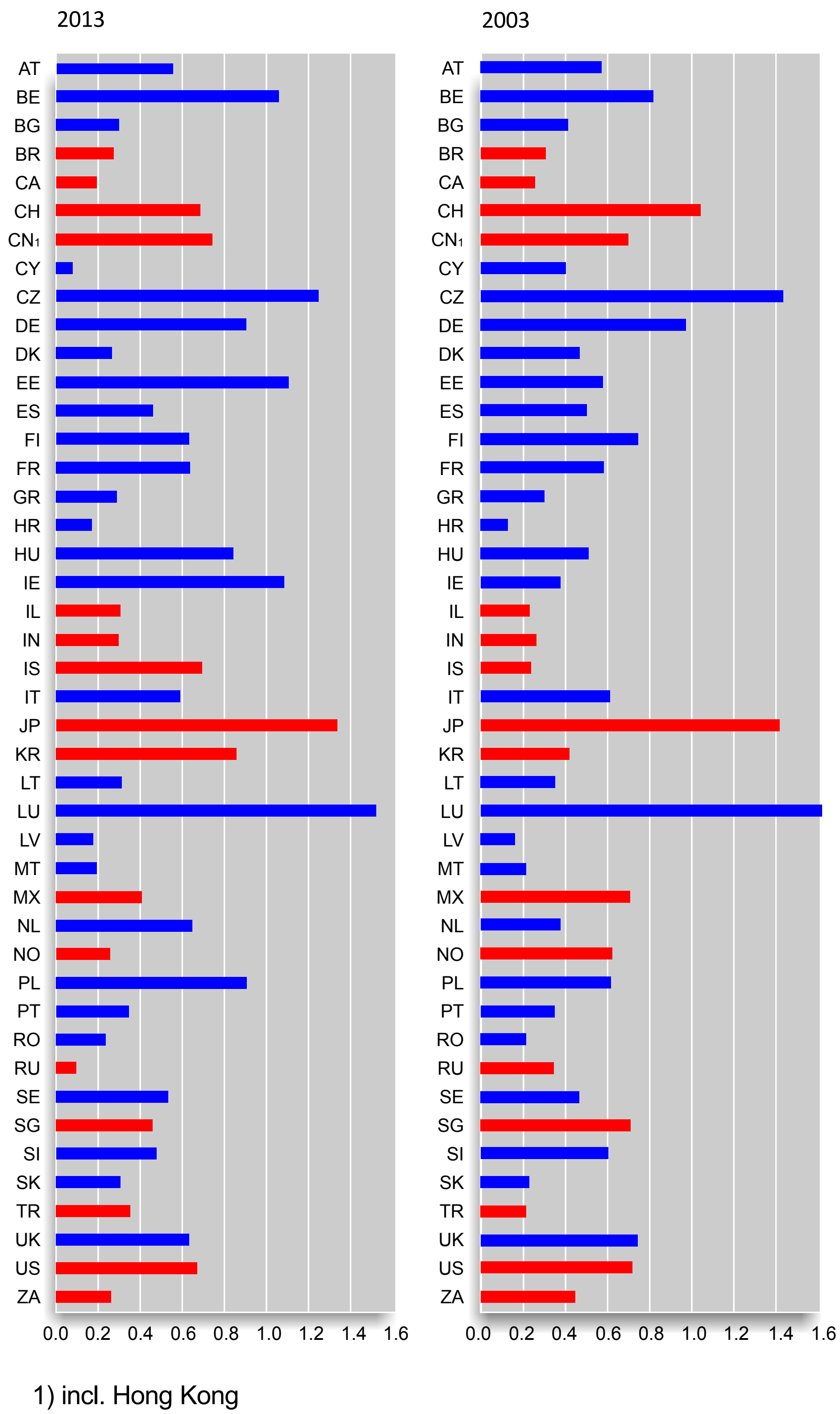
Figure 7-1: Advanced Materials: share in total export 2013 and 2003 (in %)



* China including Hong Kong.

Source: UN COMTRADE-Database. – NIW calculation.

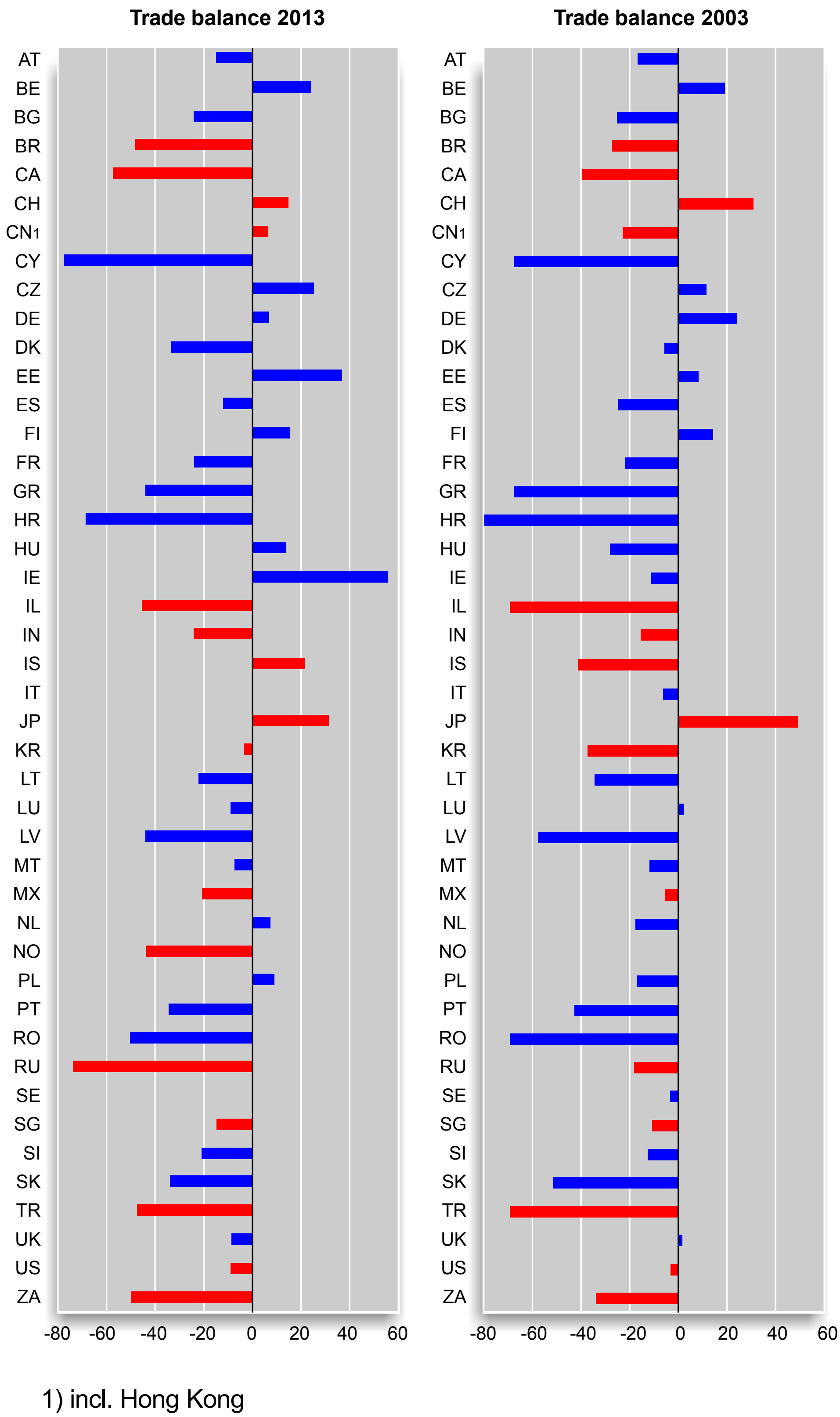
Figure 7-2: Advanced Materials: country significance in trade in 2013 and 2003 (in %)



* China including Hong Kong.

Source: UN COMTRADE-Database. – NIW calculation.

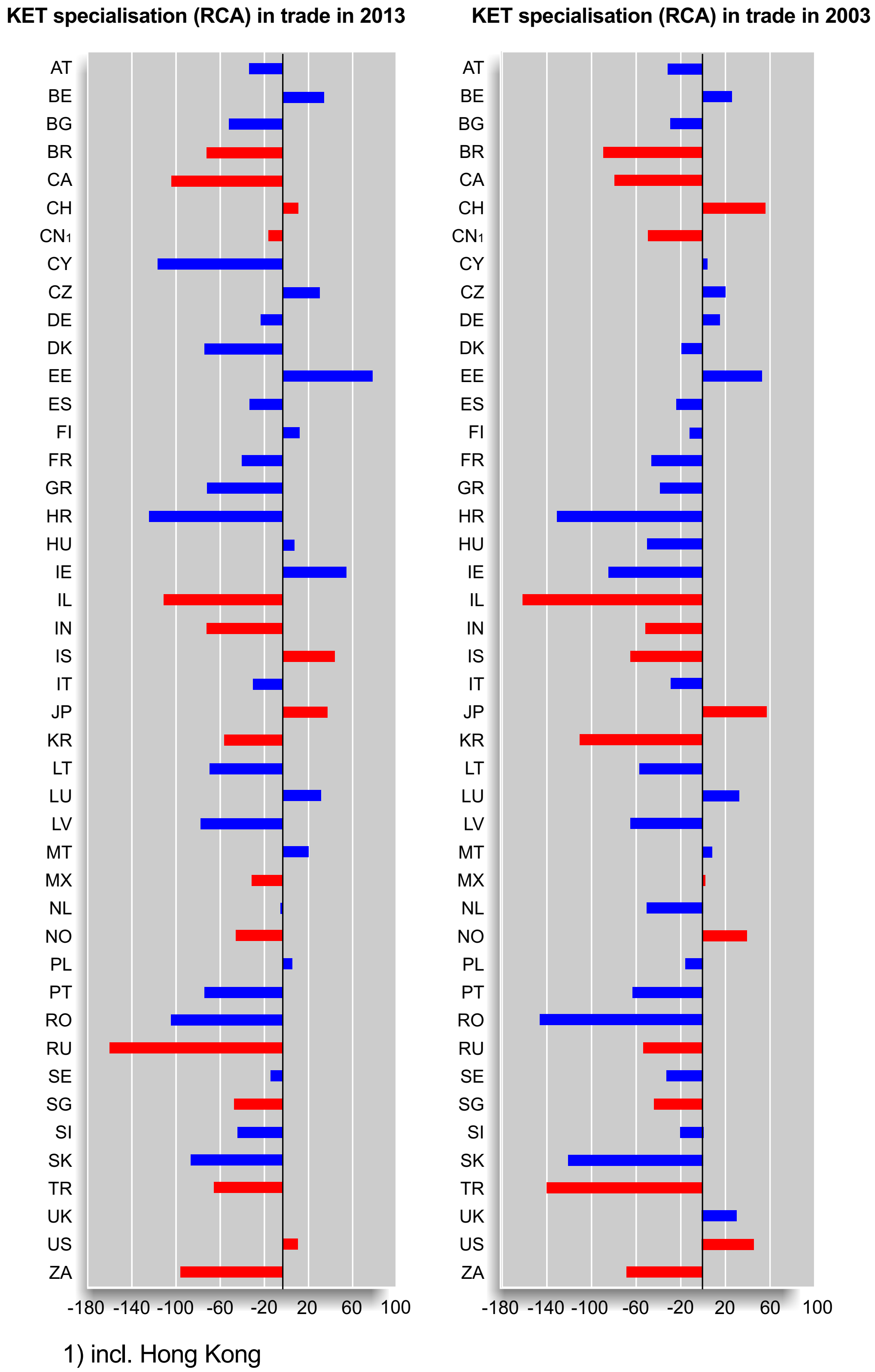
Figure 7-3: Advanced Materials: trade balance in 2013 and 2003 (in %)



* China including Hong Kong.

Source: UN COMTRADE-Database. – NIW calculation.

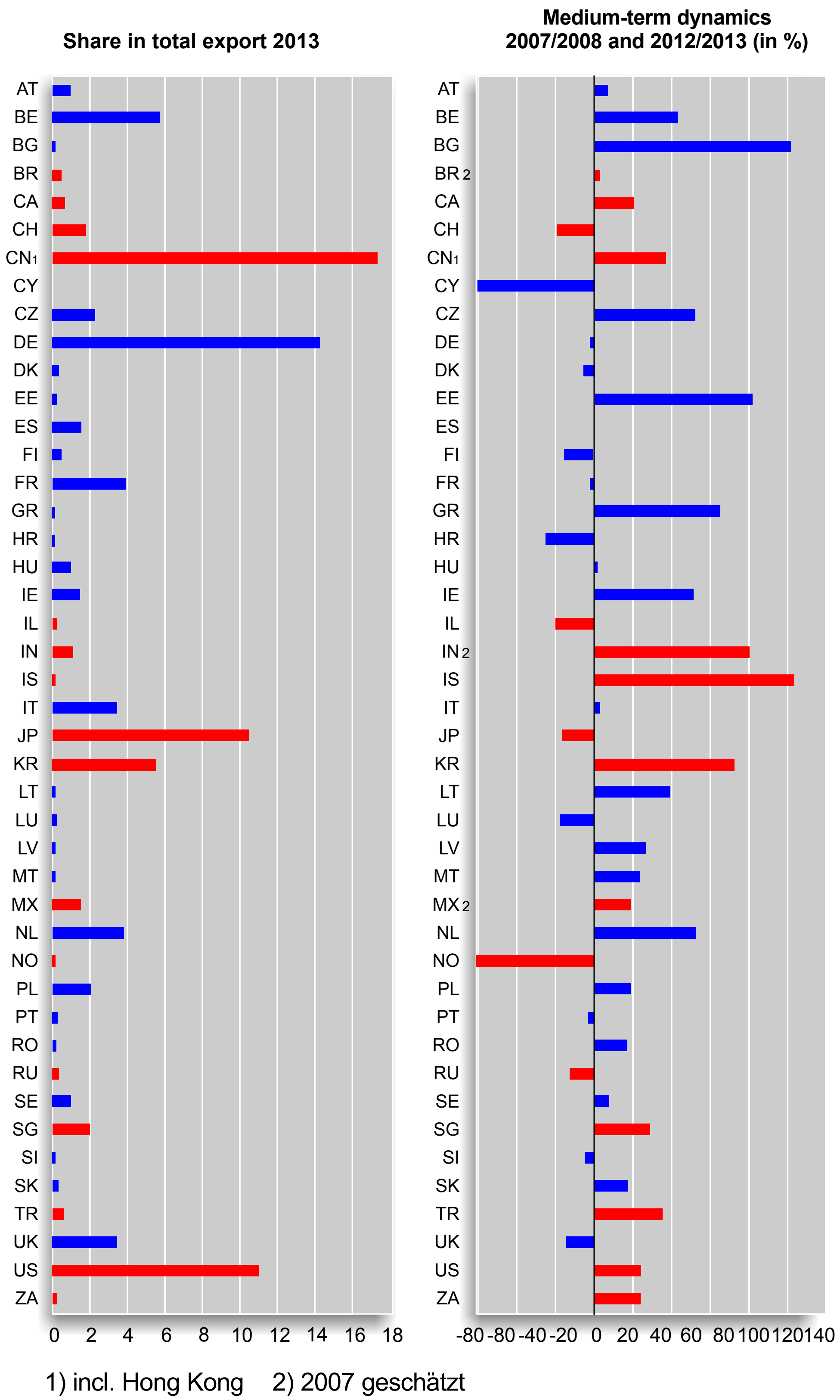
Figure 7-4: Advanced Materials: country significance in trade in 2013 and 2003 (in %)



* China including Hong Kong.

Source: UN COMTRADE-Database. – NIW calculation.

Figure 7-5: Advanced Materials: trade balance in 2013 and 2003 (in %)



* China including Hong Kong, 2007 estimated values.

Source: UN COMTRADE-Database. – NIW calculation.

8. Appendix III

Figure 8-1: Data availability for production indicators for the technology generation and exploitation approach for 2013

Country	Advanced Materials	Nano-technology	Micro- and Nano-electronics	Industrial Bio technology	Photonics	Advanced Manufacturing Technology
AT	A	A	A	A	A	A
BE	A	C	C	A	A	A
BG	A	C	A	A	A	A
CY	0	0	0	0	0	0
CZ	A	A	A	A	A	A
DE	A	A	A	A	A	A
DK	C	A	A	A	A	C
EE	A	A	A	A	A	A
ES	A	A	A	C	A	A
FI	A	A	A	C	A	A
FR	A	A	A	A	A	A
UK	A	A	A	A	A	A
GR	C	C	C	C	C	C
HR	A	A	A	A	A	A
HU	A	A	A	A	A	A
IE	A	C	C	A	A	A
IT	A	C	A	A	A	A
LT	A	A	A	A	A	A
LU	0	0	0	0	0	0
LV	C	C	A	C	C	A
MT	0	0	0	0	0	0
NL	A	A	A	A	A	A
PL	A	A	A	A	A	A
PT	A	C	C	C	A	A
RO	A	C	A	C	A	A
SE	A	A	A	A	A	A
SI	C	C	C	C	C	C
SK	A	A	A	A	A	A

A: data is available

C: data is confidential

0: zero production is recorded for Cyprus, Luxembourg, and Malta as according to the terms of the PRODCOM Regulation, these countries are exempted from reporting PRODCOM data to Eurostat.

Source: Prodcom - Database.-Eurostat calculation.