European Commission

Key Enabling Technologies (KETs) Observatory

Second report
December 2015

DG Growth

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

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Contents

List of graphs

Chapter 3

Chapter 4

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

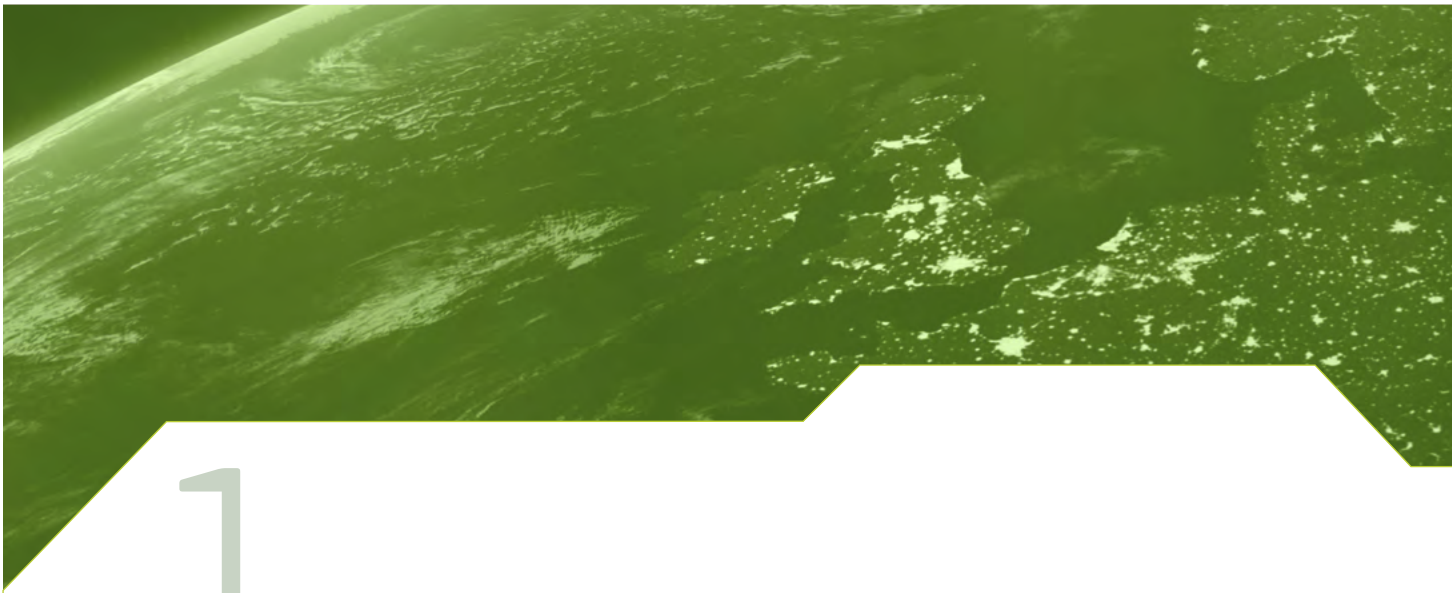
Note on country groups used in the report

AT	**Austria**
BE	**Belgium**
BG	**Bulgaria**
BR	**Brazil**
CA	**Canada**
CH	**Switzerland**
CN	**China**
CY	**Cyprus**
CZ	**Czech Republic**
DE	**Germany**
DK	**Denmark**
EE	**Estonia**
EL	**Greece**
ES	**Spain**
FI	**Finland**
FR	**France**
HR	**Croatia**
HU	**Hungary**
IE	**Ireland**
IL	**Israel**
IN	**India**
IS	**Iceland**
IT	**Italy**

JP	**Japan**
KR	**South Korea**
LT	**Lithuania**
LU	**Luxembourg**
LV	**Latvia**
MT	**Malta**
MX	**Mexico**
NL	**Netherlands**
NO	**Norway**
PL	**Poland**
PT	**Portugal**
RO	**Romania**
RU	**Russia**
SE	**Sweden**
SG	**Singapore**
SI	**Slovenia**
SK	**Slovakia**
TR	**Turkey**
TW	**Taiwan**
UK	**United Kingdom**
US	**United States**
ZA	**South Africa**

Main acronyms used in the report

AM	Advanced Materials
AMT	Advanced Manufacturing Technology
IB	Industrial Biotechnology
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 solve Europe's major societal challenges. Six KETs have been identified as important for Europe's future competitiveness: Advanced Manufacturing Technology, Advanced Materials, Nanotechnology, Micro- and Nanoelectronics, Industrial Biotechnology, and Photonics.

The European Commission adopted the European strategy for KETs in 2012[1], which aims to boost the industrial deployment of KETs in Europe. It defines KETs as "knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment". KETs are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. They are instrumental in modernising Europe's industrial base and in driving the development of entirely new industries. The KETs strategy has strong support from EU Member States, regions, industry and other stakeholders involved in industrial innovation.

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.

The KETs Observatory data show that in Europe, KETs based products represent a production volume of almost €1 trillion and 19.2% of total EU-28 production (2013). Hence, those countries and regions that master KETs will be at the forefront of future advanced and sustainable economies. KETs deployment will contribute to achieving the reindustrialisation, energy and climate change

1 COM (2012) 341, A European Strategy for Key Enabling Technologies – A bridge to growth and jobs.
2 Final report of the HLEG on KETs, June 2011.
3 The Prodcom codes that are selected to calculate the production data of the technology generation and exploitation approach represent KETs based components or intermediary systems, and result in a rather narrow list of selected Prodcom codes to ensure comparability among countries and regions at a worldwide stage.

targets simultaneously, by making them compatible and reinforcing their respective impacts on growth and job creation.

KETs Observatory

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[2]. Therefore, the European Commission established a KETs Observatory to analyse and allow comparison of the performance of countries in relation to the six KETs. Consequently, the KETs Observatory provides EU, national and regional policy makers 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 trends in technology, trade, production, turnover or employment in a specific KET can use the KETs Observatory to identify leading or emerging countries/regions.

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, North America). The KETs Observatory entails two complementary approaches to capture the performance of KETs at different stages of the deployment value chain:

- The "technology generation and exploitation approach" informs about the ability of countries to generate and commercialise new knowledge. It outlines the relative position of EU-28 countries for their technology, trade, production and turnover performance (no absolute numbers are provided)[3]. This approach looks at KETs- based components and intermediary systems, and thus only covers a specific part of the value chain. The following indicators are used:

  - Technology indicators (patent) measure the ability to develop new technological knowledge relevant to industrial applications

- Production indicators measure the relevance and dynamics of the production and uptake of KETs based components

- Trade indicators (export – import) measure the ability to commercialise KETs based components

- 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

- Composite indicators measure the ability of countries to cover the KETs deployment value chain from technology development to commercialisation.

• The "technology diffusion approach" has been developed to capture to what extent the EU is using the potential of KETs to improve its competitiveness (1) by manufacturing KETs based products and (2) applying KETs in production processes. This approach covers a larger part of the value chain as it captures the contribution of KETs to the value creation of production and demand, based on an assessment of the relevance of KETs for the competitiveness of products[4]. This approach provides an overview of Europe's position in absolute and relative terms.

The following indicators are used:

- Employment indicators are based on production data and reveal how a country performs in employment enabled by the value creation of KETS in various industries.

- Production and demand indicators show to what extent the EU can use the potential of KETs to improve its competitiveness by manufacturing KETs based products and applying KETs in production processes.

"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	

Second report: focus on the impact of KETs for the wider economy

• This second report presents the results of the technology diffusion approach, which aims to show to what extent the EU is using the potential of KETs to improve its competitiveness by manufacturing KETs based products. This approach provides an overview of Europe's position in absolute and relative terms over the period 2003-2013.

• The first report, published in May 2015, discussed the results of the technology generation and exploitation approach that informs about the ability of countries to generate and commercialise new knowledge (e.g. KETs based components and intermediary systems). It outlined the relative position of EU-28 countries compared to other competing economies (North America, East Asia) for their technology, trade, production and turnover performance.

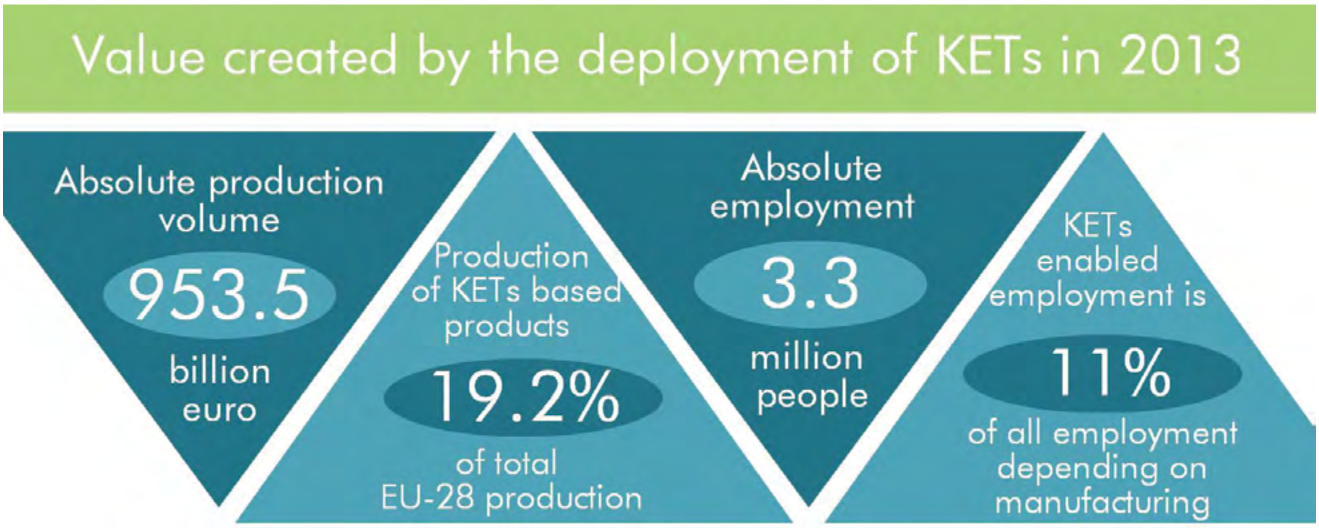
The 2012 European strategy for KETs defined a **KETs based product** as (a) an enabling product for the development of goods and services enhancing their overall commercial and social value; (b) induced by

[4] The Prodcom codes that are selected to calculate the production data of the technology diffusion approach represent KETs based products. The Prodcom codes were weighted by experts to assess the uptake of KETs in the wider economy by estimating the increase in competitiveness induced by KETs. The result is a broad list of selected Prodcom codes.

[5] The figure refers to the EU-28 value calculated as the sum of the "sold value" variable in the Prodcom survey for all products that EUROSTAT collects and for all countries that send data to EUROSTAT. It is calculated as total KETs production on total EU-28 production.

constituent parts that are based on Nanotechnology, Micro-Nanoelectronics, Industrial Biotechnology, Advanced Materials and/or Photonics; and, but not limited to (c) produced by Advanced Manufacturing Technology. The results presented in the report show the performance of EU-28 countries related to the value created by deploying KETs.

Results show that the absolute production volume of KETs based products amounts to €953.5 billion, 19.2% of total EU-28 production (production related to manufacturing)[5]. In addition, insight is provided into KETs enabled employment: absolute employment amounts to 3.3 million jobs or 11% of all employment depending on manufacturing.



I-Where do KETs secure jobs in Europe?

In Europe, the absolute employment enabled by all six KETs amounted to 3.3 million employees in 2013. This does not mean that all these employees are directly active in the production of KETs based products, but it implies that the value created by these employees is highly dependent on KETs innovations. In EU-28, the absolute employment enabled by Advanced Manufacturing Technology and Micro- and Nanoelectronics exceeds one million people, while Advanced Materials and Photonics enables the employment of respectively 976.000 and 760.000 in 2013. Industrial Biotechnology and Nanotechnology, KETs that are less mature in terms of the potential that has already been realised, have both generated overall employment of around 200.000 jobs and show a continuous increase in employment over time.

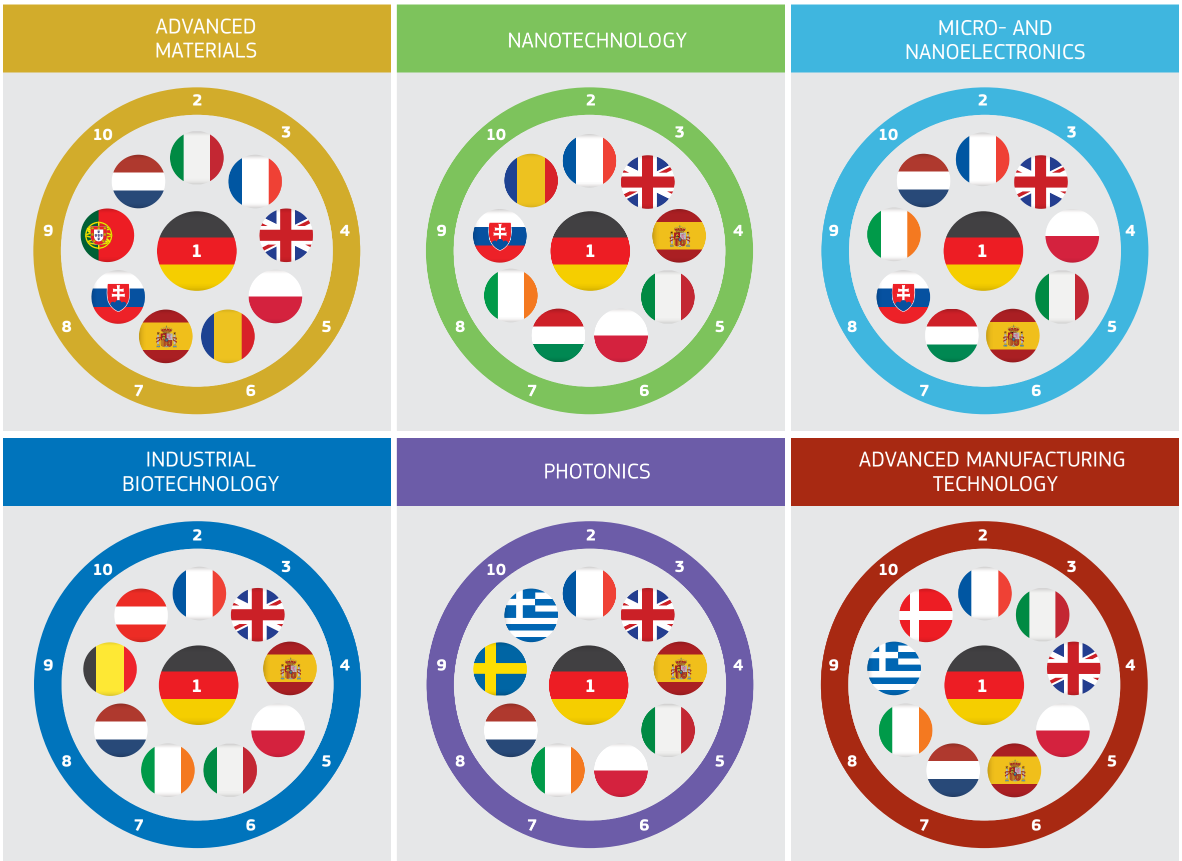
Key Enabling Technologies	Employment figures
Advanced Manufacturing Technology (AMT)	1 634 000 jobs
Micro- and Nanoelectronics (MNE)	1 394 000 jobs
Advanced Materials (AM)	976 000 jobs
Photonics (PHOT)	760 000 jobs
Nanotechnology (NT)	258 000 jobs
Industrial Biotechnology (IB)	236 000 jobs

Please note that the absolute numbers of the single KETs shown cannot be added up as significant double counting would occur. This is due to the fact that some KETs based products are linked to several KETs, due to their multi-KET dimension.

The calculation of data was conducted in close collaboration with Eurostat.

Among the EU-28 Member States, Germany holds the strongest position across all KETs. Both in absolute employment and share in employment, Germany occupies the number one position ahead of France, with the exception of Advanced Materials for which Italy takes the second place. Italy, the UK, Spain and Poland complete the top six countries for employment enabled by all KETs. The only exceptions are Romania and Spain, who hold 6th and 7th position respectively related to Advanced Materials. The share of KETs enabled employment is influenced by the size of a country e.g. Germany has the largest manufacturing industry in Europe with around 7.1 million employees in 2013, followed by Italy (3.8 million employees) and France (3 million employees). To mitigate this size effect, the KETs Observatory also elaborated other indicators (significance/specialisation) that provide additional insights.

Share of KETs enabled employment for the TOP 10 EU-28 countries



Share of KETs enabled employment for the TOP 10 EU-28 countries broken down by KET

Share of KETs enabled employment for the TOP 10 EU-28 countries

	ADVANCED MATERIALS	NANOTECHNOLOGY	MICRO- AND NANOELECTRONICS	INDUSTRIAL BIOTECHNOLOGY	PHOTONICS	ADVANCED MANUFACTURING TECHNOLOGY
AUSTRIA				10		
BELGIUM				9		
DENMARK						10
FRANCE	3	2	2	2	2	2
GERMANY	1	1	1	1	1	1
GREECE					10	9
HUNGARY		7	7			
IRELAND		8	9	7	7	8
ITALY	2	5	5	6	5	3
NETHERLANDS	10		10	8	8	7
POLAND	5	6	4	5	6	5
ROMANIA	6	10				
PORTUGAL	9					
SLOVAKIA	8	9	8			
SPAIN	7	4	6	4	4	6
SWEDEN					9	
UNITED KINGDOM	4	3	3	3	3	4

Share of KETs enabled employment for the TOP 10 EU-28 countries broken down by country positioning

These results reflect the systemic and enabling character of KETs. As KETs have a strong impact on the competitiveness of a wide range of industries, and as various KETs are often deployed in the production of certain goods, the results strongly reflect the strength of the overall industrial base of a country. A strong industrial base leads to a good performance in terms of benefiting from value created through KETs. However, in some cases we can observe a considerable good performance of countries without a strong manufacturing sector, but a rather high specialisation in certain KETs (e.g. Romania for Advanced Materials, due to a high labour intensity in this KET).

- **In Advanced Materials,** KETs enabled employment reaches almost 1 million jobs in 2013. **Germany leads in terms of share in employment followed by Italy and France.** The difference between Germany and its followers has increased in recent years. Ireland leads in terms of country significance, implying that Advanced Materials is a rather important area compared to the overall industrial activities taking place in Ireland.

- **In Nanotechnology,** KETs enabled employment exceeds 200.000 jobs in 2013, with a strong positive trend in the last ten years (Nanotechnology is still in an early maturity stage). Germany leads in terms of share in employment, followed by France, the UK and Spain. All countries show a strong rise in employment over time due to an increasing diffusion of Nanotechnology products. On the contrary, **only Ireland has a strong specialisation in nanotechnology employment.**

- **In Micro- and Nanoelectronics,** KETs enabled employment is around 1.4 million jobs in 2013. Germany exhibits the highest absolute employment. France still occupies the second position, although it experienced a loss of around 25% of employment in the last decade. The UK, Poland, Italy and Spain also show considerable activities in this KET. In addition, **Hungary and Slovakia are also among the TOP 10 leading countries in terms of absolute employment**. Together with Ireland, these countries are leading in terms of country significance, implying that Micro- and Nanoelectronics is rather important compared to the overall industrial activities taking place in these countries.

- **In Industrial Biotechnology,** KETs enabled employment exceeds 200.000 jobs in 2013, with a strong positive trend in the last ten years (Industrial Biotechnology is still in an early maturity stage). Germany occupies the leading position in employment, but the differences between EU countries are smaller compared to the other KETs. France and the UK hold the other top positions, but both experienced a significant decline over the last ten years. **With regard to country significance, Ireland occupies the first position, followed by Greece, Belgium and the Netherlands**.

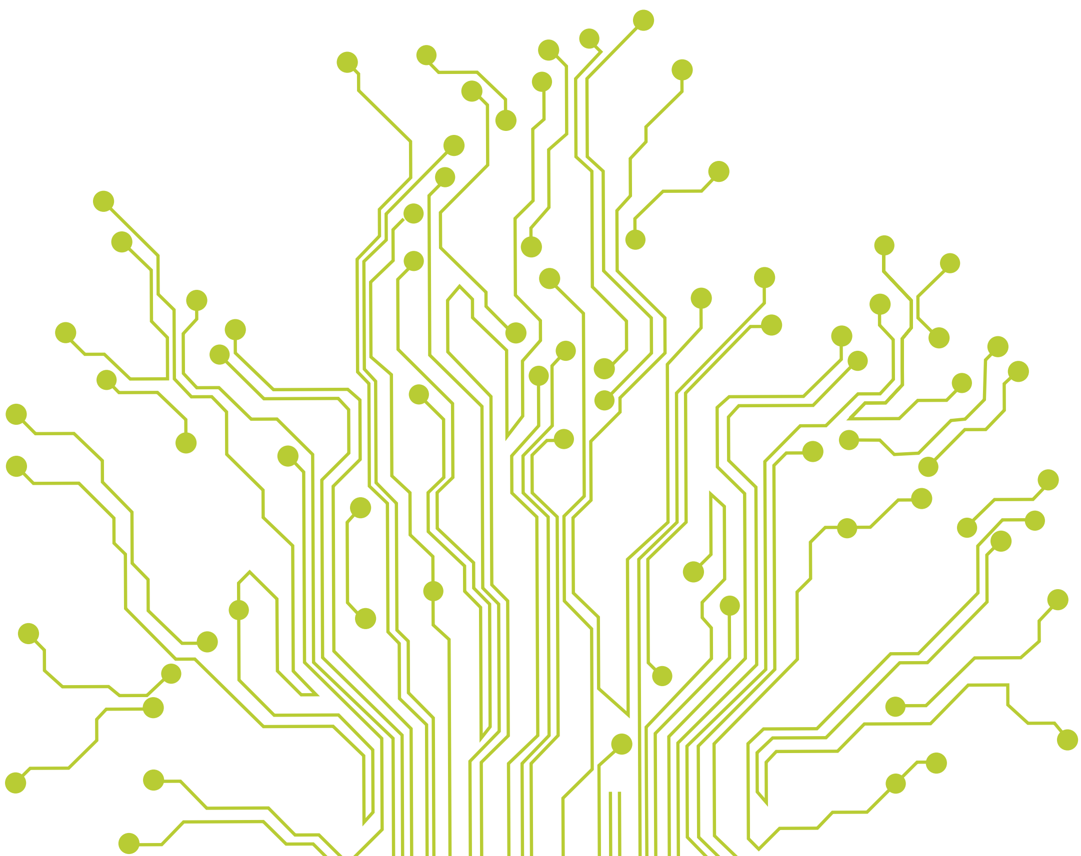
- **In Photonics,** KETs enabled employment exceeds 750.000 jobs. Germany is in top position, followed by France. These two countries were also the ones with the highest recovery of the TOP 10 countries, after a drop in Photonics employment during the economic crisis in almost all European countries. **Greece has also achieved an increase in KETs enabled employment in Photonics** and is among the TOP 10 countries.

- **In Advanced Manufacturing Technology,** KETs enabled employment exceeds 1.6 million jobs. The leading countries are Germany, France and Italy. **Ireland, Greece and Denmark are the countries with a strong specialisation in Advanced Manufacturing Technology**, implying that these countries devote a higher share of their resources to the production of Advanced Manufacturing Technology compared to other countries.

II- KETs enabled production value

Considerable value is created by the deployment of KETs in a variety of industries. In 2013, the absolute production for all EU-28 countries KETs based products amounted to €953.5 billion. Most value is created through Advanced Manufacturing Technology e.g. €561.3 billion (2013). Micro- and Nanoelectronics enables the second highest production volume (€306.2 billion in 2013), followed by Photonics (€294.2 billion in 2013) and Advanced Materials (€187.4 billion in 2013). Industrial Biotechnology and Nanotechnology lead to a smaller production volume, €104.6 and €70.5 billion respectively in 2013, which can be explained by a lower degree of maturity of these KETs.

Germany, as the largest economy, is the country with the highest production share of KETs based products. France consistently takes the second position for all KETs based products, although there is a considerable distance between the production share of France and Germany. For Industrial Biotechnology, the difference between the production shares of France and Germany is less pronounced. The TOP 5 further consist of Italy, the UK and Spain. As the value creation is mainly generated through the application of KETs in downstream sectors, countries with a strong industrial base tend to score well.



Share of KETs enabled production for the TOP 10 EU-28 countries

Share of KETs enabled production for the TOP 10 EU-28 countries broken down by KET

Share of KETs enabled production for the TOP 10 EU-28 countries

	ADVANCED MATERIALS	NANOTECHNOLOGY	MICRO- AND NANOELECTRONICS	INDUSTRIAL BIOTECHNOLOGY	PHOTONICS	ADVANCED MANUFACTURING TECHNOLOGY
AUSTRIA	10					
BELGIUM				8	8	9
CZECH REPUBLIC	7	7	9			
FRANCE	2	2	2	2	2	2
GERMANY	1	1	1	1	1	1
HUNGARY		8				
IRELAND	9	6	8	6	6	8
ITALY	3	5	4	3	4	3
NETHERLANDS			7	7	7	6
POLAND	6	10	6	9	10	7
SLOVAKIA			10			
SPAIN	5	4	5	4	5	5
SWEDEN	8	9		10	9	10
UNITED KINGDOM	4	3	3	5	3	4

Share of KETs enabled production for the TOP 10 EU-28 countries broken down by country positioning

Demand for KETs based products refers to level of adoption of KETs based products by consumers in a country, and subsequently about the market driven growth potential of relevant sectors.

With regard to share in total demand for KETs based products, Germany is leading the TOP 10 EU-28 countries of all KETs, with the exception of Industrial Biotechnology where it is in second position, behind France. The UK witnessed a strong growth in demand for KETs based products in recent years, while this growth is not visible in production.

- **In Advanced Materials,** high shares of production correlates with high shares in total demand with the same leading countries for both performance indicators. The only exception is Ireland which is present in the TOP 10 EU-28 countries with regard to share of production, but drops out of the TOP 10 concerning share in total demand. **Ireland does perform well with regard to KET specialisation as well as the Czech Republic, Slovakia and Germany.**

- **In Nanotechnology,** Germany heads the rankings both in terms of share of production and share in total demand. Especially with regard to share of production, the difference with the rest of the TOP 10 countries is considerable. It is likely that this will even increase as the absolute production volume of Germany in the area of Nanotechnology rose significantly over the past years. **Hungary leads in terms of Nanotechnology specialisation**, implying that Nanotechnology is rather important compared to the overall industrial activities taking place in Hungary.

- **In Micro- and Nanoelectronics,** Germany, France, the UK and Italy hold the top positions in terms of share of production and share in total demand. **Spain and Poland also show considerable activity in this area. Slovakia heads the ranking of country significance**, implying that Micro- and Nanoelectronics is rather important compared to the overall industrial activities taking place in Slovakia.

- **Industrial Biotechnology** is the only KET where Germany does not hold the top position in terms of share in total demand. In 2003, the share in total demand of France for Industrial Biotechnology-based products was almost twice as high as the share in total demand for Germany. Ten years later, there is only a small difference between the share in total demand for France and Germany i.e. 16.0% versus 14.8% respectively. Although Germany has the highest share of production in Industrial Biotechnology, it only surpassed France from 2008 onwards. **Ireland has a strong specialisation in Industrial Biotechnology**, implying that it devotes a higher share of its resources to the production of Industrial Biotechnology compared to other countries.

- **In Photonics,** the share of production and share in total demand are dominated by Germany. **Germany is the only country that has substantially increased its absolute production volume in the last decade**. The share of production of France has declined since 2003 and remains about constant in recent years, although its absolute production volume and its country significance have increased since 2009 onwards.

- **In Advanced Manufacturing Technology,** the share of production is dominated by Germany, which has a leading position with 33.4% of production shares in 2013. France, Italy and the UK follow at a distance with 11.5%, 9.4% and 8.5% respectively. While most countries experienced a slight decline in share in total demand, **Poland is the only country that continuously increased its share in total demand over the last five years**. Ireland leads in terms of country significance, followed by Slovakia.

III- Overall performance of Member States throughout the deployment value chain

The composite indicator measures the ability of countries to cover the KETs deployment value chain from technology development to commercialisation.

The results indicate that in general, Middle and Western European countries dominate the rankings, with a few exceptions of some Eastern European countries that are performing well such as the **Czech Republic for Photonics and Hungary for Advanced Materials**. Overall, there is a high correlation between the production and trade performance of countries for almost all KETs (with exception of Micro- and Nanoelectronics). However, the link between performance in technology on the one hand and production and trade on the other hand differs between the KETs. This implies that KETs specialisation patterns emerge along the deployment value chain.

"KETs Deployment Value Chain"			
New Technology	Competitive Innovations		Commercialisation
Patent Composite Indicator	Production Composite Indicator	Trade Composite Indicator	Turnover Composite Indicator*
Share	Share	Share	Share
Significance	Significance	Significance	Significance
Specialisation	Specialisation	Specialisation	Specialisation
		Trade balance	

*Not part of the second report, but available on the KETs Observatory website

- **In Advanced Materials,** Belgium and Germany perform strongly in the technology, production and trade composite indicators. In contrast, the performance of other EU-28 countries varies between the different indicators. Overall, there are indications that a kind of specialisation takes place within Member States: while some countries are specialised in early technology development (e.g. France, Austria, and the Netherlands), others take up this technology knowledge and implement it along their industrial value chains (e.g. Hungary, Ireland). In 2013, Hungary occupies the third position in the production composite indicator. **The trade composite indicator show a strong performance of the Czech Republic (second position), while the UK shows a constant decreasing trade performance. Along with the also decreasing performance in production and stagnant development in technology one can state that the UK runs the risk to significantly lose its competitive edge in Advanced Materials**.

- **In Nanotechnology, Spain is the leading country for technology, production and trade composite indicators across time.** This is noteworthy as a lot of countries performing well for production and trade are generally less successful for technology (e.g. Poland, the Netherlands, Sweden, and Austria) and the other way around (e.g. the Czech Republic and Romania). This might be due to the fact that new potential products in this technology with less industrial maturity have not yet been commercialised. Only three countries have a positive trend in their production activities over the last few years: Spain, France, and Poland.

- **In Micro- and Nanoelectronics,** France, Germany, the Netherlands, Austria, Italy and the UK perform well in all three dimensions of the composite indicators, with a similar performance. These findings highlight that the EU landscape of Micro- and Nanoelectronics is quite compact. In contrast, there is a set of less performing countries (e.g. Estonia, Lithuania, Latvia and to some extent Finland) that show a rather low performance for all dimensions of the composite indicators. In order to diffuse micro- and nanotechnological solutions in industrial applications on a EU-wide scale, one could further strengthen the technology leaders and support countries in the low performing group in developing production and trade activities in order to establish some kind of EU-wide specialisation pattern. **Countries like Germany, Italy and Austria thereby could act as leaders initiating knowledge-spillovers to production and trade in other European countries**.

- **In Industrial Biotechnology,** Denmark is the leading country for the technology, production and trade composite indicator. France shows a strong performance for production and trade, but to a lower extent for technology. Respectively, high technology performance is not necessarily connected with high performance levels in production and trade. **Hungary, Portugal, and Poland are in the TOP 10 for technology, but have not yet been able to transfer their technology developments in industrial applications and trade**. Comparably to the previous KETs, some countries like Romania, Estonia, and the Czech Republic show the weakest performance in Industrial Biotechnology with regard to all three dimensions. This result indicates that Industrial Biotechnology is not yet broadly diffused in the EU industrial value chains.

- **In Photonics,** there is a small group of leading countries with good performance in all three dimensions: Austria, Germany, the Czech Republic, Netherlands and the UK. This rather small group of high performing countries indicates that their activities in Photonics might be driven by specialised industrial structures favouring the use of photonic applications. For instance, **Germany and – in particular – Italy recently succeeded in revitalising their trade activities**. Both countries are important for the manufacturing of high performance machinery of the most modern generation that frequently includes photonics technology. This would imply that innovation policies should focus on the development of new application fields of photonics in industrial manufacturing. Finally, the **Czech Republic and Latvia are catching up,** although the Czech Republic shows decreasing values since 2011. **In production, Sweden shows a strong decline since 2010.**

- **In Advanced Manufacturing** Technology, Germany and Italy are among the leaders in all three dimensions (technology, production, trade) of this KET's industrial deployment. Countries like Austria, Sweden, France and the UK are following at a certain distance, still showing a somewhat coherent performance across all three dimensions. However, the picture is a bit different for the Netherlands, which performs less well in the field of technology, but holds the top position for trade and production. **Regarding trade, the UK seems to have lost touch with the leading group. The UK and Sweden are the only countries that show a clear negative dynamic in their trade performance**. In order to diffuse Advanced Manufacturing Technology, one could both strengthen the technological competences in already well performing countries, as well as shape regional specialisation patterns in low performing countries identified by the KETs Observatory (e.g. Latvia and Bulgaria).

Conclusion

The results presented in this report provide insight into the value created by the deployment of KETs and their relevance for Europe's economy and growth. **The production of KETs based products represents €953.5 billion or 19.2% of the total EU-28 production in 2013** and has increased over the past recent years. This production is associated with an absolute employment of **3.3 million jobs in 2013 or 11% of all jobs depending on manufacturing**. The results of the composite indicator demonstrate that KETs specialisation patterns are emerging along the deployment value chain. The data clearly show the importance of KETs for the European economy.

The KETs Observatory provides useful indications for which KETs and stages in the deployment value chain a country performs well. The KETs Observatory and its detailed data are a strong complement to regional and national innovation policy strategies as the scope of the KETs Observatory allows for a unique comparison and positioning. Combined with other sources of information such as the JRC smart specialisation platform (which assists EU countries and regions to develop, implement and review their Research and Innovation Strategies for Smart Specialisation [RIS3]), the KETs Observatory is a useful tool for informed decision making with regard to smart specialisation strategies.

2. Introduction

2.1 Policy context: European strategy for KETs

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 Key Enabling Technologies (KETs) in Europe in order to make its industries more innovative and globally competitive[6]. KETs are characterized by their economic potential, their value adding enabling role, their technology-intensity, and 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.

The group presented its final report in June 2011. The recommendations of the High Level Group

[6] 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).

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

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

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[7]. 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[8].

In 2013, a new High Level Expert Group on KETs was set up to advise the Commission on the implementation of the European Strategy for KETs and identify a clear scope for future actions in order to further foster the KETs and improve their impact in the European economy. In June 2015, the High Level Group presented its final report "KETs: Time To Act". The report presents a set of eight recommendations to ensure a full implementation of the European Strategy for KETs (see Box 1). It highlights the launch of the KETs Observatory as an important source to obtain quantitative and qualitative information to promote KETs policies at national and regional level.

Box 1:
Recommendations of the HLG-KET, outlined in the final report "KETs: Time To Act"

1. Boost European technology infrastructures to support industry
2. Strengthen KETs pilot lines and demonstration activities
3. Unleash significant investment into manufacturing through new EU tools
4. Escalate regional Smart Specialisation Strategies to a European level
5. Establish bonding bridges between KETs and societal challenges for a sustainable and competitive Europe
6. Ensure European interests are met in trade and investment agreements
7. Fully exploit the dual-use potential of KETs
8. Invest in KETs-related skills to ensure Europe's innovation potential

In its final 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. The Commission announced in its 2012 Communication 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.

At the end of 2011, the European Commission launched a feasibility study in order to assess various elements of this future Observatory.

In 2013, the European Commission (EC) has launched a project involving the set-up and implementation of a Key Enabling Technologies (KETs) Observatory (project duration: 2013-2015)[9]. The objective of the KETs Observatory is to provide EU, national and regional policymakers with information on the deployment of Key Enabling Technologies both within the EU-28 and in comparison to other world regions (East Asia, 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 first report, published in May 2015, compared 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. The second report discusses 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.

The target audience of these reports are policy makers that can employ the data to monitor a country's performance in the area of KETs. As the indicators of the KETs Observatory provide objective data on the performance of countries in specific KETs, they can be a useful source for policy makers to draft their smart specialisation strategies. For example, if a Member State performs well in a specific KET and proves to be highly specialized in this KET, the strengths in that KET might be further reinforced by a dedicated smart specialisation strategy.

In the context of the revision of their innovation strategies in 2012-2014, many regions and Member States already indicated 'KETs' or some specific KETs as policy priority, as documented on the online "Eye@RIS^3" tool of the European Commission. As additional source of information, the KETs Observatory provides useful indications for which KETs and stages in the deployment value chain a country performs well. For example, lagging regions can identify particular niches in the deployment value chain where it is important to stimulate the uptake of technologies e.g. to produce more efficient machine tools. Hence, a region or a Member State can smartly position itself and assess whether its performance is more 'supply-based' (strong community of technology suppliers leading to relatively strong patent performance), 'demand-based' (strong lead-users, integrators of KETs based products or systems) leading to a relatively strong performance in terms of KETs based products), or a combination of both. **The KETs Observatory provides objective data on the performance of Member States throughout the deployment value chain that can help policy-makers in their strategic choices (e.g. reinforcing the technology base, attracting production and trade activities, linking different ecosystems).**

In the future, it would be recommended to reinforce and expand the 'interface' that makes the link between the 'evidence-based positioning' and the 'policy analysis and formulation'. The KETs Observatory could evolve towards a more interactive tool for policy-makers: the definition of analytical protocols (explaining in detail how to extract specific information) within the database would be a good idea to reinforce that interaction. Regular updates and specific analyses resulting in targeted 'policy reports' would nurture the political agenda and its priority settings with reliable and evidence-based information. The "KETs Observatory" would become a much more interactive instrument connecting evidence base with the policy debate (through seminars, presentations, etc.).

2.2 Data context

The indicators that are discussed in the second report assess the value created by the deployment of KETs in all manufactured goods. It builds upon the technology diffusion approach, which complements the technology generation and exploitation approach presented in the first report of the KETs Observatory.

The second report discusses the results of the technology diffusion approach that informs about the likely impact of KETs on the wider economy. This approach shows to what extent the EU can use

9 The project is realized by a consortium comprising IDEA Consult, TNO, CEA, ZEW, NIW, Ecorys UK and Fraunhofer ISI (as sub-contractors).

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 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 implies that the KETs Observatory can only report on data up to 2013 as more recent data is not yet available. This indicates that the second report 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. 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. The production and demand indicators rely on the data of the Prodcom database to indicate the value created by the deployment of KETs. As some values are confidential in this database, the graphs on production and demand does not contain information on all countries. Appendix II provides an overview of the data availability for each KET. **2013 is the most recent year for which data is available**.

Employment indicators provide insight about the labour resources enabled by the diffusion of KETs. They reveal how KETs contribute to securing existing jobs (as well as creating new jobs) through their innovation and competitiveness impact. As a consequence, the estimated size of "KETs enabled employment" is interpreted as employment that is dependent on the production and use of KETs based products.

2.3 Definition of Key Enabling Technologies

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 health care. 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, characterisation, 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 semi-conductor components and/or highly miniaturised 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.

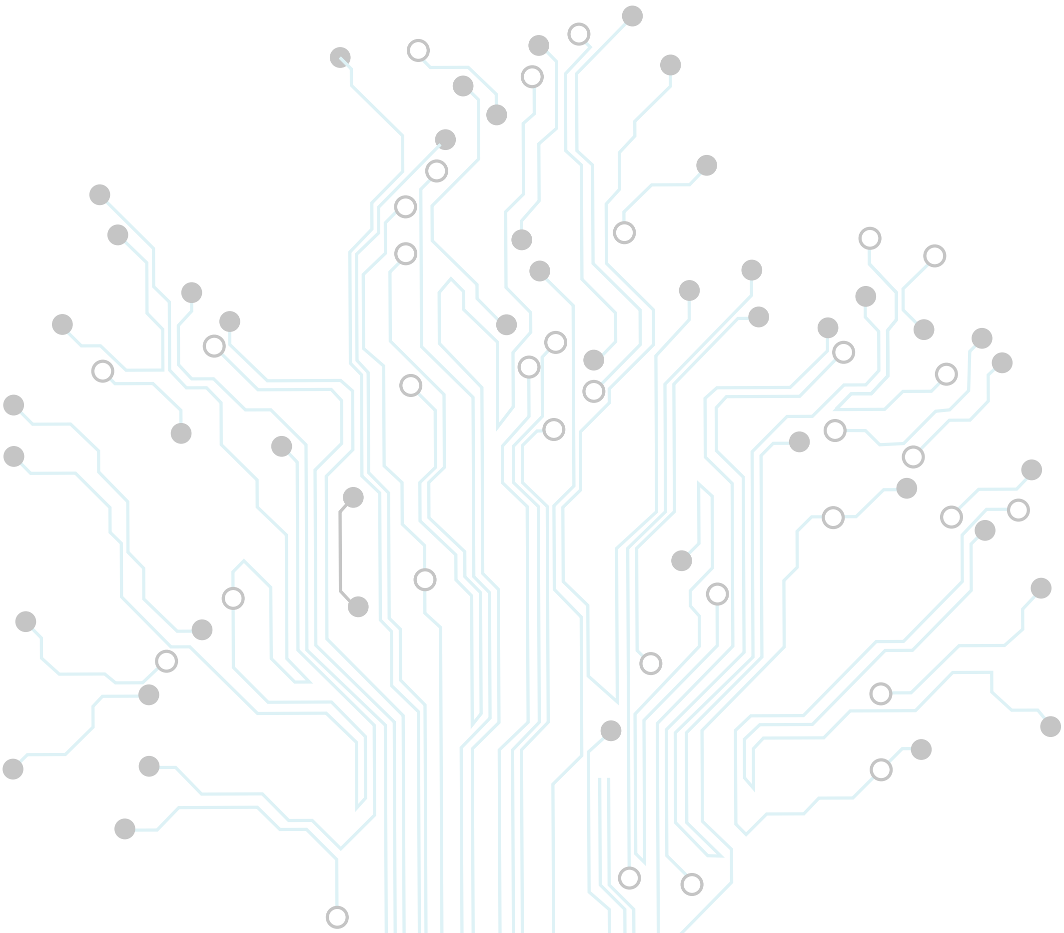
- **Industrial Biotechnology** or white biotechnology is the application of biotechnology for the industrial processing and production of chemicals, materials and fuels. It includes the practice of using micro-organisms or components of micro-organisms like enzymes to generate industrially useful products 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, control 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 operationalise the definitions in order to translate KETs in Prodcom codes. Therefore, a KETs taxonomy has been developed that is used as a source of inspiration by the experts[10]. It is important to note that the codes are an approximation but not a perfect representation of the different KETs.

The preliminary results of the second report have been presented to a variety of policy makers and business representatives. We would like to thank all people that contributed to the content of this report by providing comments and suggestions. Our special thanks go to Eurostat for their continuous support in this project.



[10] The KETs taxonomy that has been developed is published in the methodology report that is available on the KETs Observatory website (https://ec.europa.eu/growth/tools-databases/ketsobservatory/).

3. Where do KETs secure jobs in Europe?

This section describes the employment performance of the EU-28 countries in each KET. Employment indicators provide insight in the labour resources used enabled by the diffusion of KETs.

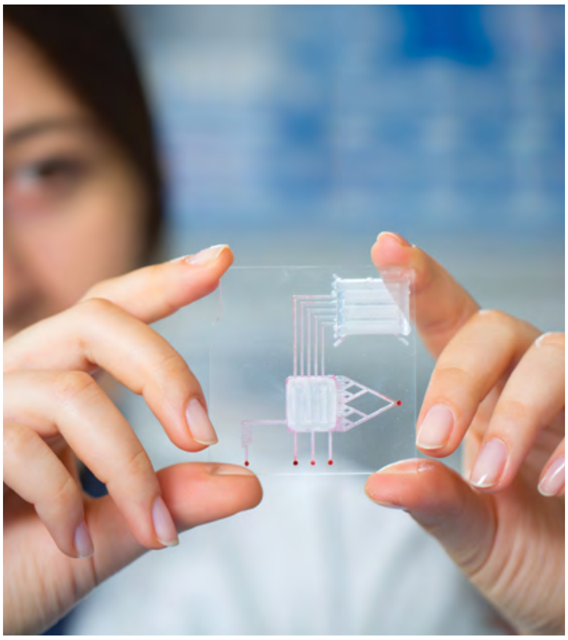
They reveal how a country performs in employment enabled by the value creation of KETs in various industries. The estimated size of KETs enabled employment is interpreted as employment that is dependent on the production and use of KETs based products.

The employment figures cover direct and indirect employment linked to KETs based products:

- Direct employment linked to manufacturing of KETs based products
- Indirect employment linked to research activities performed in companies and technical services

The employment figures do not cover:

- Upstream R&D jobs of service providers or public R&D institutes



[11] https://ec.europa.eu/growth/tools-databases/ketsobservatory/

In Europe, the absolute employment enabled by all six KETs represents 3.3 million employees (in 2013):

Key Enabling Technologies	Employment figures
Advanced Manufacturing Technology (AMT)	1 634 000 jobs
Micro- and Nanoelectronics (MNE)	1 394 000 jobs
Advanced Materials (AM)	976 000 jobs
Photonics (PHOT)	760 000 jobs
Nanotechnology (NT)	258 000 jobs
Industrial Biotechnology (IB)	236 000 jobs

Please note that the absolute numbers of the single KETs shown cannot be added up as significant double counting would occur. This is due to the fact that some KETs based products are linked to several KETs, due to their multi-KET dimension.

The calculation of data was conducted in close collaboration with Eurostat

In this report, we present two closely interrelated indicators for employment for each KET: the absolute number per country and the respective share in employment. The latter is measured by dividing the total employment in the respective KET in a certain country by the total employment of all countries. Both indicators are influenced by the size of a country as larger countries usually have larger downstream industry sectors than small countries. This implies that large economies tend to perform better compared to smaller economies.

This chapter presents the results for the 10 EU Member States with the highest shares in the respective KET (i.e. top 10). The KETs Observatory also considers indicators like country significance and KET specialisation, to mitigate the size effect to which the "share" indicators are subjected to. The results for all indicators (shares, significance, specialisation), can be found on the website[11]. **An illustration of the significance and specialisation indicators can also be found in the policy profiles and newsletters that are published on the KETs Observatory website. For example, the policy profile of Poland entails insights with regard to country significance for Nanotechnology while the fourth newsletter zooms in on the employment specialisation for Nanotechnology.**

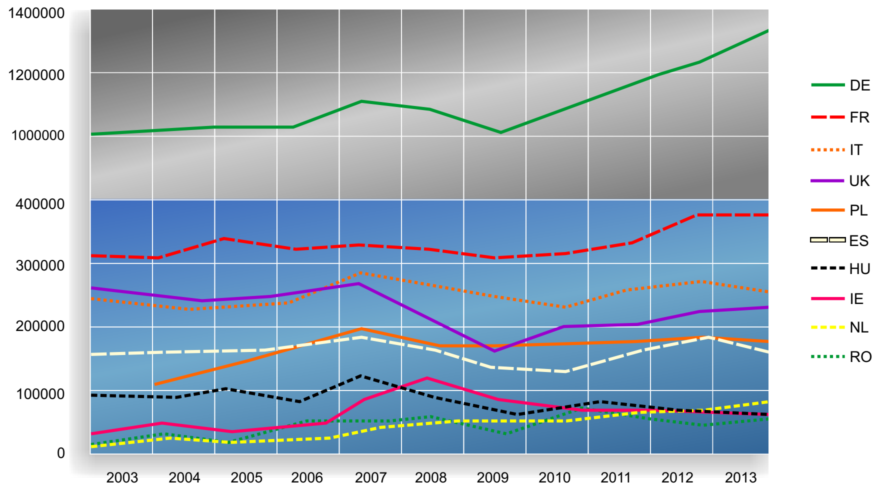
Regarding the results that will be discussed in the next section, we observe only few examples of smaller Member States with a strong position in one or another KET in contrast to the results obtained in the technology generation and exploitation approach of the KETs Observatory. As KETs have a strong impact on the competitiveness of a wider range of industries and as various KETs are often deployed in the production of certain goods, the results strongly reflect the strength of the overall industrial base and the size of the economy of a country. Hence, France performs quite well and holds the second position in most KETs, with the exception of Advanced Materials. This overall performance of France is significantly better compared to the performance in the technology generation and exploitation approach (focusing on KETs components and intermediary systems). This is due to the fact that France has a strong position in the application industries of KETs (e.g. automotive, pharma, etc.), while it is less specialised in the production of certain components. The situation in Poland is similar: Poland holds the fifth position for employment in total manufacturing in the EU-28 and follows closely behind the UK. In other words, Poland has relatively more KETs enabled employment compared to most other EU countries. Only in a few cases, countries with no particular strong manufacturing industry perform well, for example Romania for Advanced Materials and Greece for Photonics and Advanced Manufacturing Technologies. In these cases, the countries show a rather high specialisation in the respective KET.

3.1 All six KETs

Figure 3-1 shows the absolute employment of 10 EU-28 countries for all six KETs. In interpreting the results for all six KETs, it is important to note that the total employment for all six KETs is significantly beneath the sum of the individual KETs, as data is adjusted for double counts. In downstream industries, various KETs are often deployed for research & development as well as production in parallel. For example, the development and production of "Semiconductor light emitting diodes (LEDs)" is dependent on technological knowledge and KETs based products of MNE, Photonics, Advanced Materials as well as Nanotechnology.

Regarding absolute employment, Germany ranks first with above 1.300.000 employees after high gains since 2009. It is followed by France and Italy. The UK comes on a fourth position, while Poland ranks fifth slightly in front of Spain. Since 2010, all TOP 10 countries achieve employment gains with the exception of Romania. In the case of the later, **productivity gains have outpaced the production growth and consequently employment decreases**. In total, **KETs enabled employment exceeds 3.3 million jobs,** which represent 11% of all employment depending on manufacturing.

Figure 3-1: Absolute KETs-enabled employment for the TOP 10 EU-28 countries in all six KETs

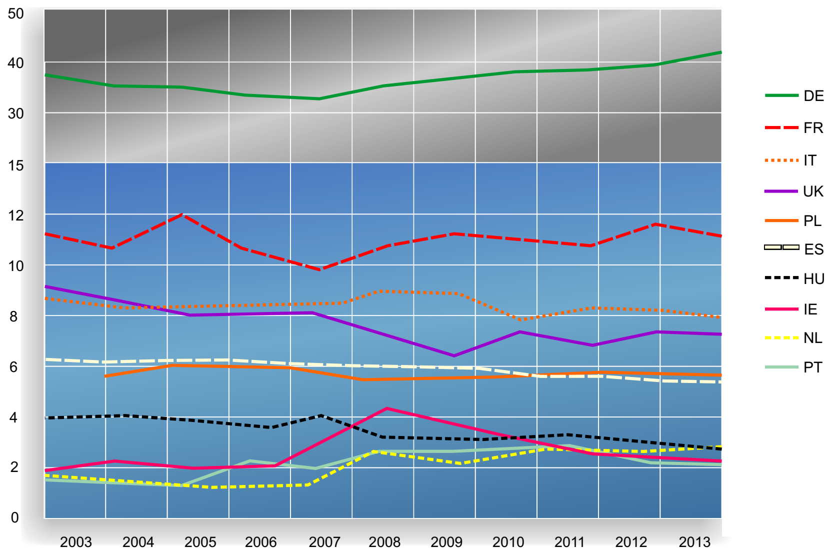


Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations.

[12] The graphs on country significance can be retrieved from the KETs Observatory website

Figure 3-2 shows that Germany outreaches a share in employment of more than 40% in 2013, after a decrease to 35% in 2007. France shows a rather constant share in employment of around 10%, while Italy and UK both achieve a share slightly above 5%. **Hungary is positioned seventh, before countries like Ireland, the Netherlands and Portugal. Also with regard to country significance, Germany scores well and occupies the second position behind Ireland[12]. This implies that a significant part of Germany's and Ireland's labour resources are used to manufacture KETs based products.**

Figure 3-2: Share in KETs-enabled employment for the TOP 10 EU-28 countries in all six KETs (in %)



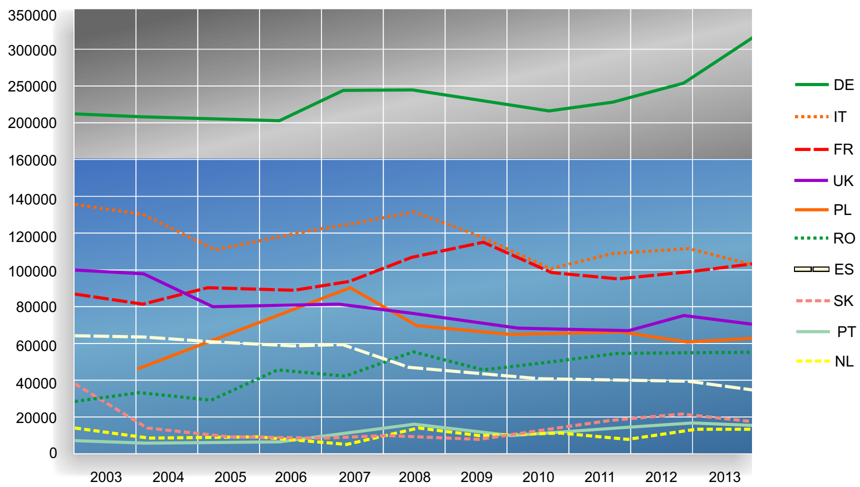
Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations.

The results for **all six KETs** show that regarding absolute employment and share in employment, Germany is leading, well before France, Italy and the UK. Ireland and Germany perform well with regard to country significance, implying that a significant part of their labour resources are used to manufacture KETs based products.

3.2 Advanced Materials

Figure 3-3 shows the 10 EU-28 countries with the highest employment for Advanced Materials (AM) (as for 2013). **Germany has the leading position with around 300.000 employees in 2013. Italy ranks second with around 100.000 employees. It is the only KET, for which Italy holds this position; the high value creation may be related to its strong performance in the production of AM components** (such as "Polyurethanes" and "Other compounded rubber", see First Report of the KETs Observatory). France holds the third position and the UK occupies the fourth position in 2013, followed by Poland. **Moreover, the Eastern European Countries Romania and Slovakia perform well at 6th and 8th position**. Here, an important reason is that Poland, Romania and Slovakia have high production values for the product groups belonging to "Manufacture of other parts and accessories for motor vehicles". The rather small overall increase in employment related to Advanced Materials can be mainly attributed to the maturity of several important materials already gained in the beginning of the covered time period[13].

Figure 3-3: Absolute KETs-enabled employment for the TOP 10 EU-28 countries in Advanced Materials

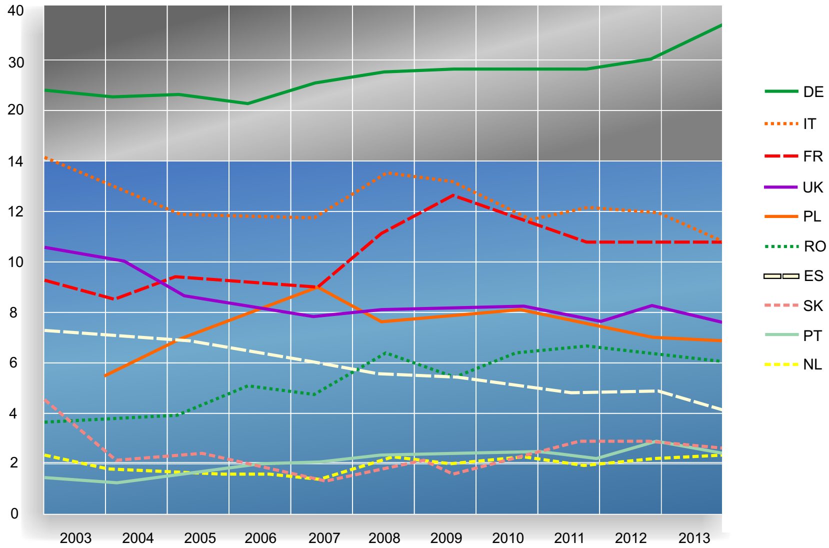


Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations

As the overall employment for Advanced Materials increases only slightly over time, the development of shares in employment shows a similar picture (Figure 3-4). **Germany ranks first in share in employment with 33%.** The strong growth in share in employment in 2013 is due to a strong increase in a particular production code, which is confidential. **Next, only Italy and France hold shares above 10%, but with a negative trend in the past years**. Some **Eastern European countries perform quite well as Poland and Romania possess around 5% of the shares in employment**. Overall, the shares mostly reflect the strength of the industrial sectors in the countries. The country significance in the EU-28 is rather stable with 3-4% over time. Although Germany leads in terms of share in employment, it is positioned only fifth in terms of country significance. **Ireland is leading the rankings, implying that Advanced Materials is rather important compared to the overall industrial activities taking place in Ireland**.

[13] The country significance in the EU-28 is rather stable with 3-4% over time. See the KETs Observatory website for more information on the country significance indicator.
[14] The graphs on KET specialisation can be retrieved from the KETs Observatory website.

Figure 3-4: Share in KETs-enabled employment for the TOP 10 EU-28 countries in Advanced Materials (in %)



Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations.

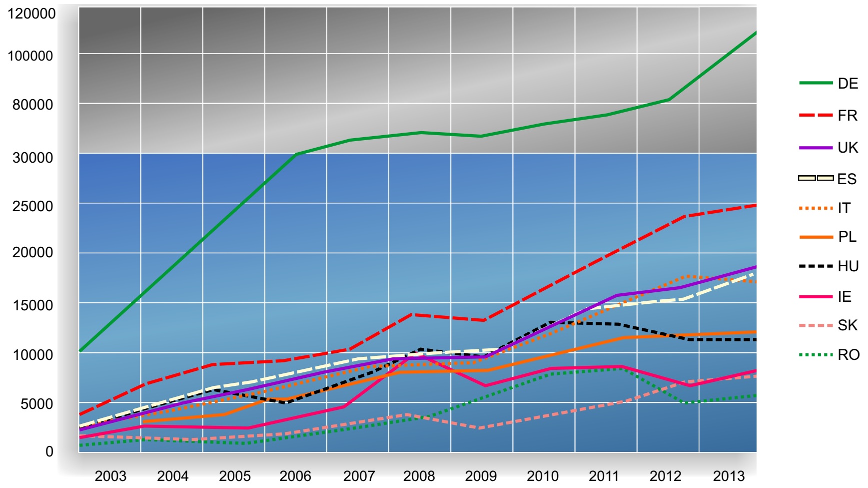
In Advanced Materials, KETs enabled employment reaches almost 1 million jobs in 2013. Germany leads in terms of share in employment followed by Italy and France. The difference between Germany and its followers has increased in recent years. Ireland leads in terms of country significance, implying that Advanced Materials is a rather important area compared to the overall industrial activities taking place in Ireland.

3.3 Nanotechnology

Figure 3-5 displays the absolute employment in Nanotechnology within the 10 EU-28 Member States with the highest number of KETs enabled jobs. **Germany ranks first with around 100.000 employees. France holds the second position, followed by the UK. Spain ranks fourth and Italy holds the 5th position losing two places compared to 2012. All countries show a strong rise in employment over time due to the increasing diffusion of Nanotechnology products with significant added value starting from a rather low level**. The increasing diffusion of Nanotechnology products takes place in areas where Germany has a high production activity (e.g. mainly related to “Manufacturing of motor vehicles” and “Photosensitive semiconductor devices, solar cells, photo-diodes, photo-transistors”).

Hence, Germany is able to benefit significantly and increasingly from diffusion of Nanotechnology with high added value even though Germany is not the main producer of Nanotechnology components and is rather export-oriented in these products (see First Report of the KETs Observatory). Spain, as leading producer of Nanotechnology components, also performs very well in value creation. The highest contribution of the value creation in Spain results from its production activities in the Prodcom code “Manufacturing of motor vehicles”. Even though the importance of Nanotechnology is estimated to be rather modest in the Prodcom code of “Manufacturing of motor vehicles”, the high production value associated with this code leads to a strong impact on the results. **With regard to country significance,** which reveals the share of production in Nanotechnology over the country’s total production, **Ireland holds the top position**[14].

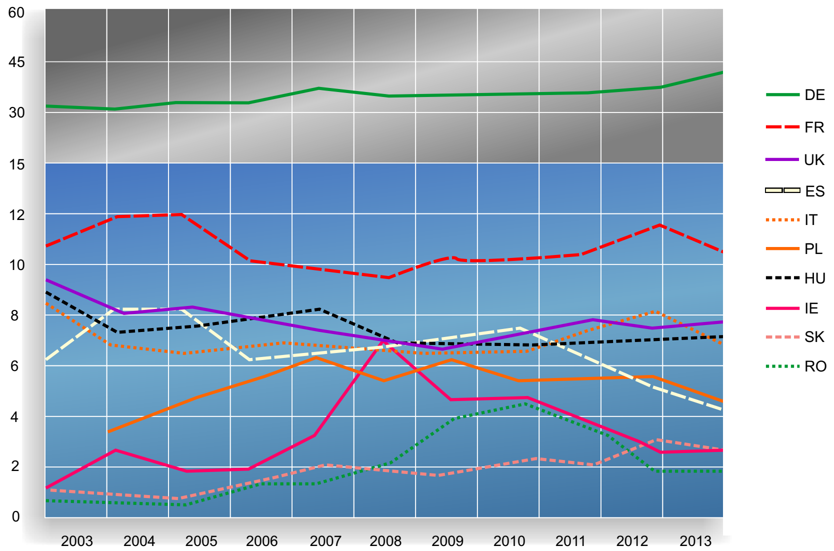
Figure 3-5: Absolute KETs-enabled employment for the TOP 10 EU-28 countries in Nanotechnology



Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations.

Looking at the share in employment, only small changes take place until 2012 (Figure 3-6). **In 2013 Germany outreaches the proportion of 40%, while no other country holds more than 10%**. France holds a rather stable share of around 10%, while the UK, Spain and Italy each have a share of around 7% in the last years. The results mostly reflect the overall size of industrial production, **only Ireland has a strong specialisation in nanotechnology employment**[15].

Figure 3-6: Share in KETs-enabled employment for the TOP 10 EU-28 countries in Nanotechnology (in %)



Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations.

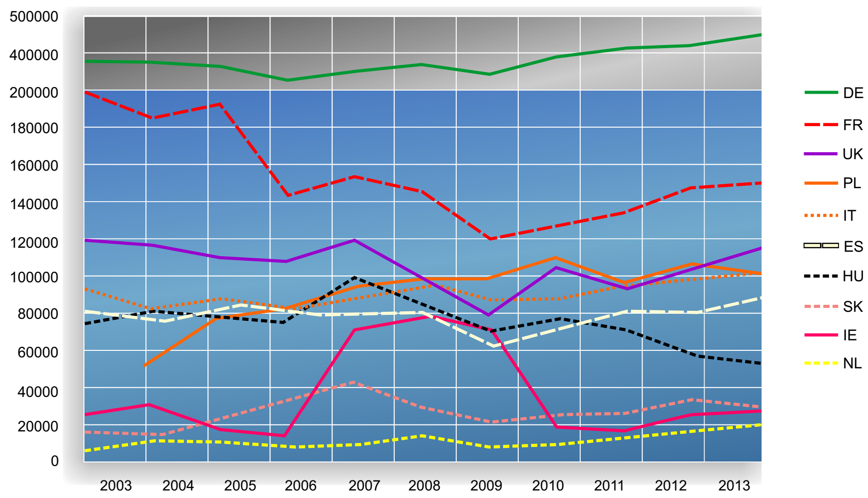
15 See the KETs Observatory website for more information on the KET specialisation indicator.

In Nanotechnology, KETs enabled employment exceeds 200.000 jobs in 2013, with a strong positive trend in the last ten years (Nanotechnology is still in an early maturity stage). Germany leads in terms of share in employment, followed by France, the UK and Spain. All countries show a strong rise in employment over time due to an increasing diffusion of Nanotechnology products. On the contrary, only Ireland has a strong specialisation in nanotechnology employment.

3.4 Micro- and Nanoelectronics

Germany has the highest employment in Micro- and Nanoelectronics with around 430.000 employees in 2013 (Figure 3-7). Despite a loss of around ¼ of employment over time, France still holds the second position with 150.000 persons. The UK has lost its third position in 2009 and falls to the fifth position, but climbs up again to the third place in 2013. Poland ranks fourth and Italy ranks fifth, both with above 100.000 employees. **With Hungary and Slovakia (seventh and eight positions) two more Eastern Europe countries are among the top 10 leading countries. Both countries have a high specialisation in Micro- and Nanoelectronics, without single product groups dominating, but a rather diversified industry structure that takes up the benefits of Micro- and Nanoelectronics**. This indicates that these countries devote, together with Ireland, a higher share of their resources to the production of Micro- and Nanoelectronics, compared to other countries.

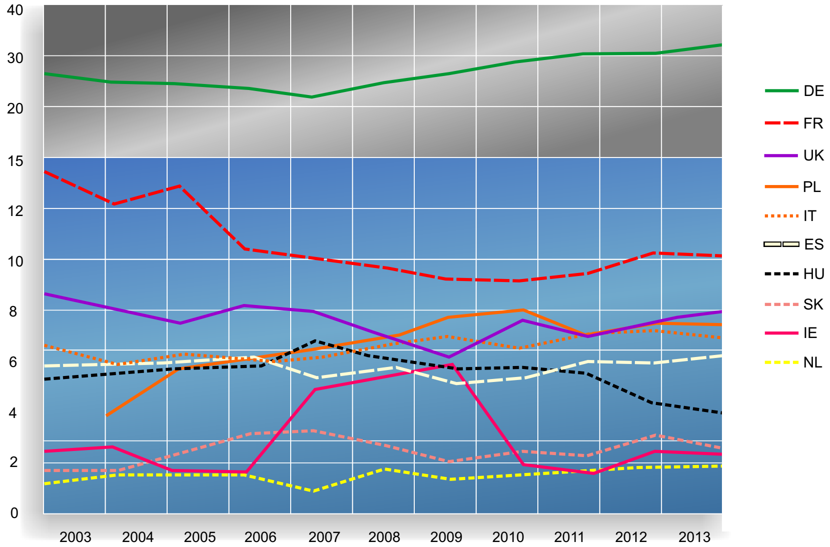
Figure 3-7: Absolute KETs-enabled employment for the TOP 10 EU-28 countries in Micro- and Nanoelectronics



Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations

Regarding shares in employment, Germany experienced a decline of around three percentage points between 2003 and 2007, but from 2007 onwards, it constantly wins shares and exceeds the 30% share in 2013 (Figure 3-8). Also France has lost around 3 percentage points from 2003 to 2007, but remains quite stable afterwards. In contrast, **Poland has doubled its employment share from 2004 to 2010, but has lost slightly afterwards**.

Figure 3-8: Share in KETs-enabled employment for the TOP 10 EU-28 countries in Micro- and Nanoelectronics (in %)



Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations.

In Micro- and Nanoelectronics, KETs enabled employment is around 1.4 million jobs in 2013. Germany exhibits the highest absolute employment. France still occupies the second position, although it experienced a loss of around 25% of employment in the last decade. The UK, Poland, Italy and Spain also show considerable activities in this KET. In addition, Hungary and Slovakia are also among the TOP 10 leading countries in terms of absolute employment. Together with Ireland, these countries are also leading in terms of country significance, implying that Micro- and Nanoelectronics is rather important compared to the overall industrial activities taking place in these countries.

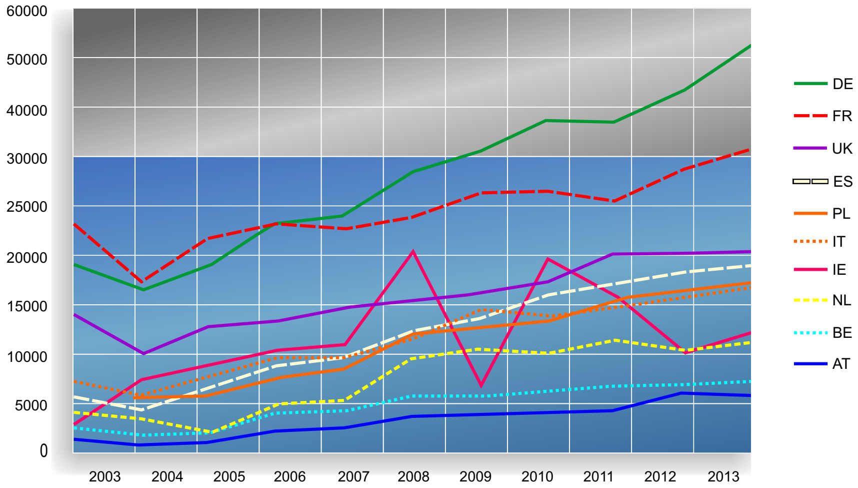
3.5 Industrial Biotechnology

The highest figures for absolute employment are held by Germany and France, respectively 50.000 and 30.000 (Figure 3-9). Similar to Nanotechnology, absolute employment in the EU rises significantly between 2003 and 2013 because of the increasing diffusion of IB- products with significant added value starting from a rather low level. However, **Germany clearly outperforms France over time and overtakes the first position in 2006**. The UK achieves a steady increase between 2005 and 2012, and ranks third. Instead, the development in Ireland fluctuates highly. While Ireland holds the third position in 2008 and 2010, it ranks sixth in 2013 behind Spain and Poland. However, **with regard to country significance**[16]**, Ireland still occupies the first position, followed by Greece, Belgium and the Netherlands**.

It has to be noted that no data is available for Denmark for reasons of confidentiality, while Denmark performs strongly in the production of IB components (see First Report of the KETs Observatory). Appendix II gives an overview of all countries for which data is included.

16 The country significance indicator reveals the share of production in Industrial Biotechnology over the country's total production. The graphs on country significance can be retrieved from the KETs Observatory website.

Figure 3-9: Absolute KETs-enabled employment for the TOP 10 EU-28 countries in Industrial Biotechnology

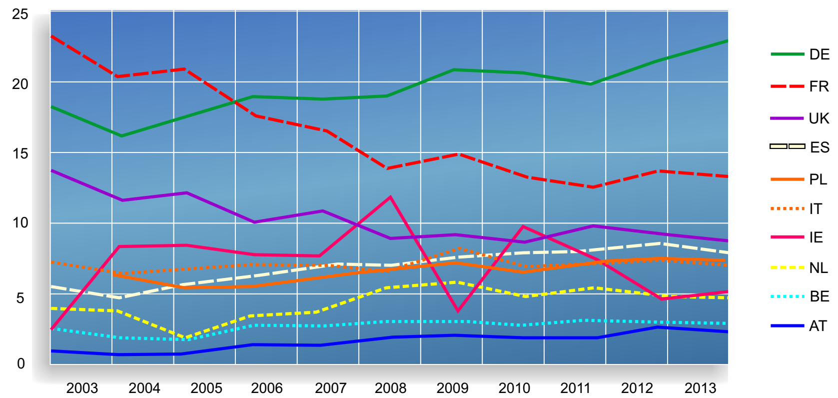


Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations

Regarding shares in employment, the differences between the EU countries are smaller compared to the other KETs (Figure 3-10). Germany has a share of around 22% and France of 13% in 2013. However rather high changes occur between 2003 and 2013.

The **UK and France have lost employment shares in most of the years, while Germany has increased its share quite steadily**. All other countries have some ups and downs, but with no clear trend. Noteworthy is the fifth position of Poland.

Figure 3-10: Share in KETs-enabled employment for the TOP 10 EU-28 countries in Industrial Biotechnology (in %)



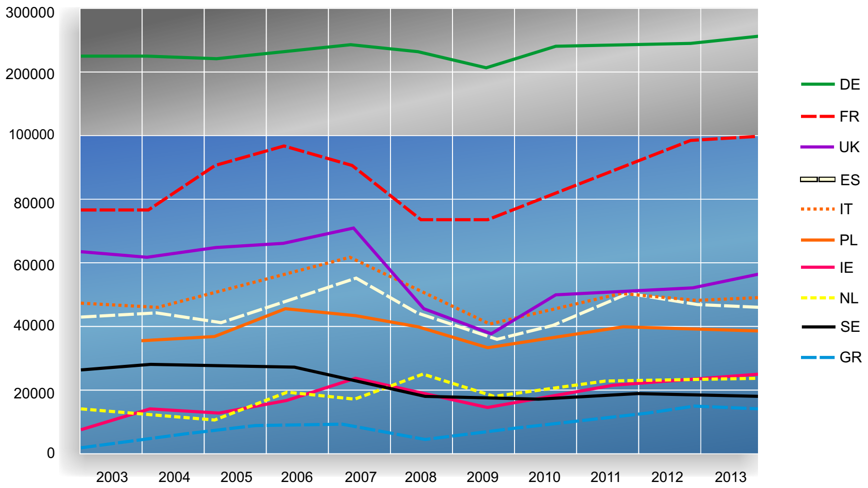
Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations.

In Industrial Biotechnology, KETs enabled employment exceeds 200.000 jobs in 2013, with a strong positive trend in the last ten years (Industrial Biotechnology is still in an early maturity stage). Germany occupies the leading position in employment, but the differences between EU countries are smaller compared to the other KETs. France and the UK hold the other top positions, but both experienced a significant decline over the last ten years. With regard to country significance, Ireland occupies the first position, followed by Greece, Belgium and the Netherlands.

3.6 Photonics

Figure 3-11 depicts the top 10-EU countries with the highest employment for Photonics. **Germany takes the leading position with over 250.000 employees**. France clearly holds the second position with around 100.000 employees. The UK comes as third, Spain as fourth and Italy as fifth with all around 50.000 employed persons. Poland holds the sixth position. The development is rather similar between the countries. While most of the top EU-countries achieve an increase in employment between 2003 and 2007, it drops significantly in 2008 and 2009 during the economic crisis. From 2010 onwards, employment has increased again. **With regard to country significance, Ireland scores well and occupies the first position**[17]. This implies that a significant part of Ireland's resources are used to produce products related to Photonics.

Figure 3-11: Absolute KETs-enabled employment for the TOP 10 EU-28 countries in Photonics



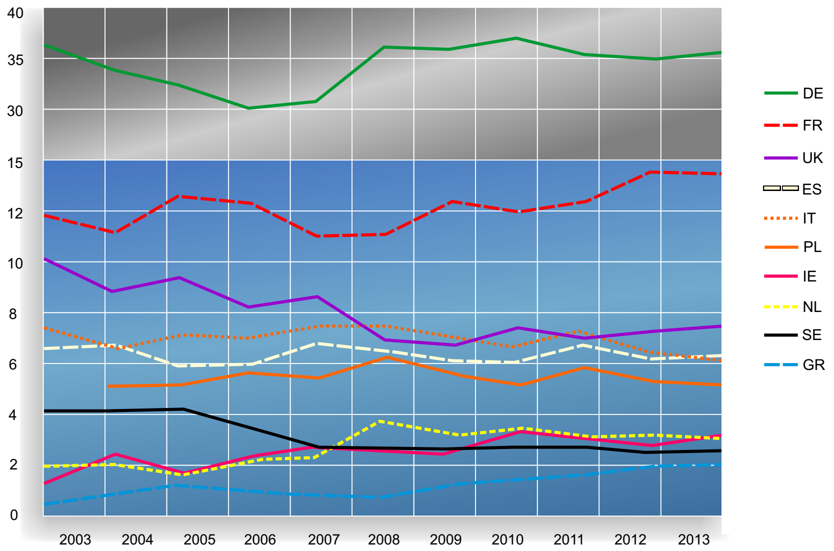
Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations

Looking at the share in employment, Germany holds around 35% in 2013, which is equal to 2003 (Figure 3-12). In the meantime, the share dropped to around 30% in 2006 and 2007 but it increased again from 2008 onwards. France holds 13% of the employment share and the UK around 7%. Italy ranks third or fourth until 2012, but drops to the fifth position in 2013. **The rather strong performance of Greece with the 10th position can be mainly attributed to its role as important user of KETs in some segments of food processing and production of pharmaceutical products.**

17 The graphs on KET specialisation can be retrieved from the KETs Observatory website..

18 The graphs on KET specialisation can be retrieved from the KETs Observatory website.

Figure 3-12: Share in KETs-enabled employment for the TOP 10 EU-28 countries in Photonics (in %)



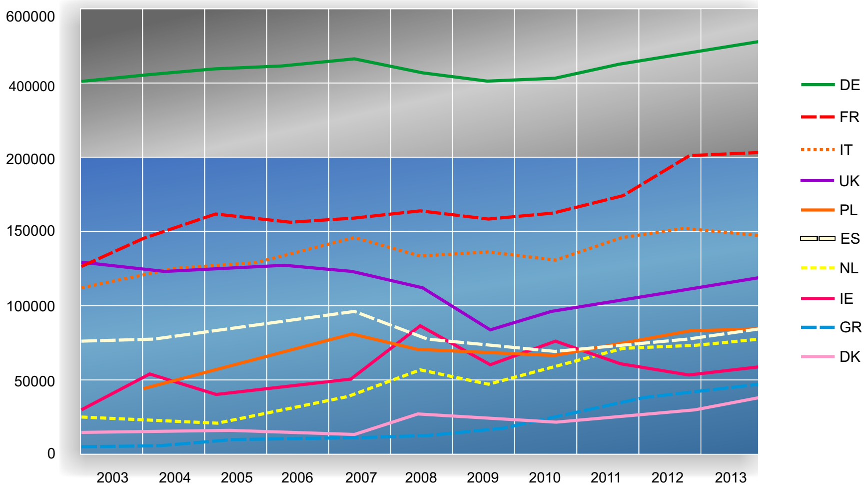
Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations

In Photonics, KETs enabled employment exceeds 750.000 jobs. Germany is in top position, followed by France. These two countries were also the ones with the highest recovery of the TOP 10 countries, after a drop in Photonics employment during the economic crisis in almost all European countries. Greece has also achieved an increase in KETs enabled employment in Photonics and is among the TOP 10 countries.

3.7 Advanced Manufacturing Technology

Regarding absolute employment in Advanced Manufacturing Technology, Germany is the leading country in the EU with around 500.000 employees. France ranks second with over 200.000 people employed, followed by Italy. The UK has lost its second position in 2003 and from 2006 onwards ranks fourth. Poland, Spain and the Netherlands hold the position five to seven with each around 80.000 employees (Figure 3-13). **Ireland, Greece and Denmark, the only countries with a strong specialisation in Advanced Manufacturing Technology, hold position 8 to 10**. This implies that these countries devote on average a higher share of their resources to the production of Advanced Manufacturing Technology than other countries do[18].

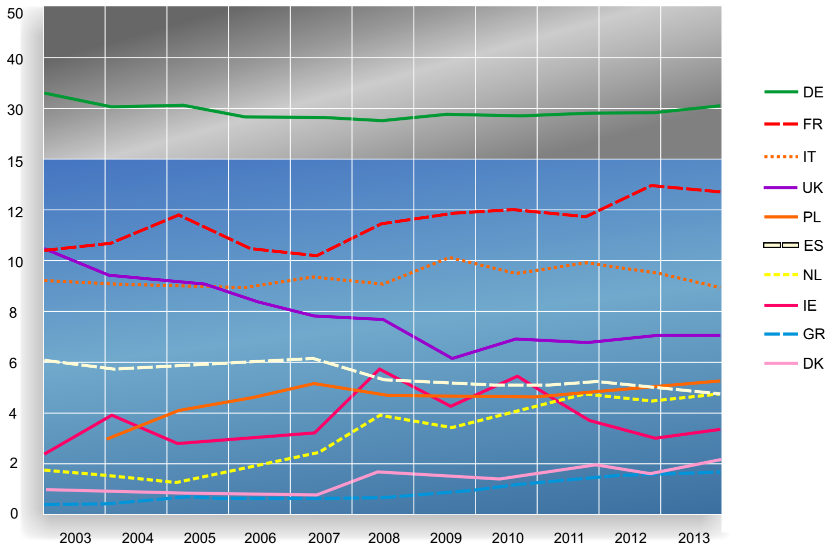
Figure 3-13: Absolute KETs-enabled employment for the TOP 10 EU-28 countries in Advanced Manufacturing Technologies



Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations

Germany has the highest share in employment with around 31%, while France has 13% in 2013 (Figure 3-14). Italy falls slightly beneath 10% in 2013. However, in contrast to the other KETs, Germany is losing a few percentage points in share in employment between 2003 and 2013, while France increases its share slightly. **Similar as for Photonics, the TOP 10 position of Greece can be mainly attributed to its role as important user of KETs in some segments of food processing and production of pharmaceutical products**.

Figure 3-14: Share in KETs-enabled employment for the TOP 10 EU-28 countries in Advanced Manufacturing Technology (in %)



Source: PRODCOM database and Eurostat – Fraunhofer ISI calculations

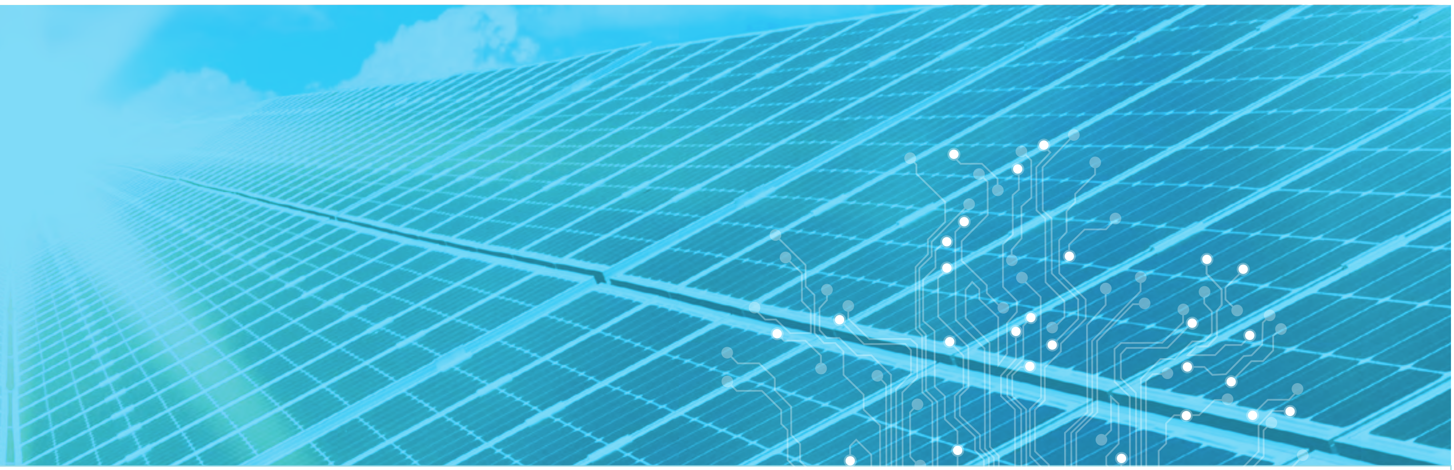
In Advanced Manufacturing Technology, KETs enabled employment exceeds 1.6 million jobs. The leading countries are Germany, France and Italy. Ireland, Greece and Denmark are the countries with a strong specialisation in Advanced Manufacturing Technology, implying that these countries devote a higher share of their resources to the production of Advanced Manufacturing Technology compared to other countries.

4.

KETs enabled production value

This section describes the EU-28's performance in production and demand, based on the technology diffusion approach. In this approach, the deployment of KETs is about enabling innovation and increasing the competitiveness, hereby capturing the innovative aspects of KETs. To monitor the EU-28 performance, the KETs Observatory works with four production indicators and six demand indicators. Demand for KETs based products refers to level of adoption of KETs based products by consumers in a country, and subsequently about the market driven growth potential of relevant sectors. For production and demand indicators, data for EU-28 Member States is available[19]. Hence, 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 EU countries presented in the next graphs will vary according to their relative performance in the respective KET. More detailed information on these indicators can be found in Appendix I and in the Methodological Report that is available on the KETs Observatory website[20]. The various indicators capture the extent to which KETs are important for innovation, efficient production and competitiveness and contribute to the value of production in Europe.

[19] The KETs Observatory does not cover production or demand data of non EU-28 Member States.
[20] https://ec.europa.eu/growth/tools-databases/ketsobservatory/
[21] The graphs on KET specialisation can be retrieved from the KETs Observatory website.



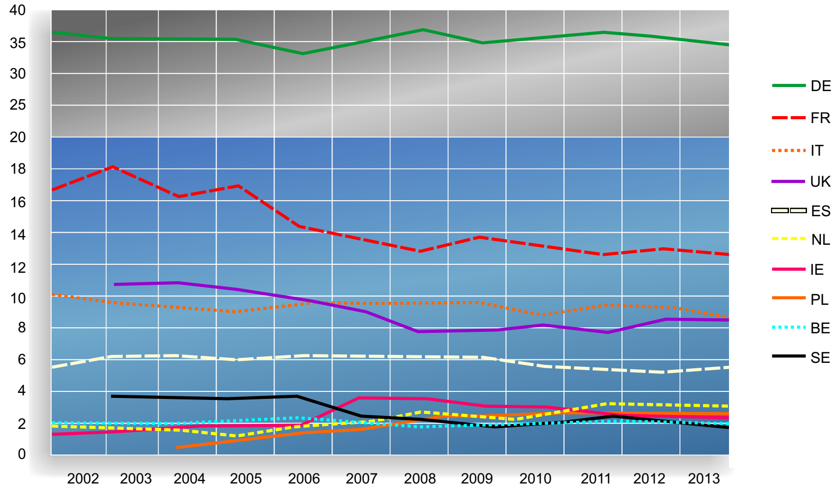
In this chapter, the share in production and share in demand are discussed. The first indicator is measured by dividing the share of production of a KET for a certain country by the total production of all European countries considered. The second indicator provides insights in the share of demand of a KET for a certain country in total demand of all European countries considered. Both indicators are influenced by the size of a country as larger countries tend to have a higher production and demand. To mitigate the size effect, the KETs Observatory also includes indicators like country significance, KET specialisation, and export and import quotient, which are available on the KETs Observatory website. The absolute production figures for each KET are available in Appendix III.

4.1 All six KETs

Production performance

The production performance of the TOP 10 EU Member States with the highest share of production for all six KETs is displayed in Figure 4-1. The results do not equal the sum of the individual KETs as they are adjusted to avoid double counts. **Germany, as the largest economy, is the country with the highest production share, followed at a large distance by France, Italy and the UK. Spain and the Netherlands follow at a fifth and sixth position. Ireland, Poland, Belgium and Sweden complete the TOP 10 European countries with respect to share of production**. While Germany has been able to increase its share of production in the last decade, France experienced a decline. This decline is mainly caused by the fact that the growth in production in France is slower compared to other EU-28 countries. Also with regard to KET specialisation - which informs about whether a country puts more or less focus on a certain KET than other countries do- Germany takes a prominent position and occupies the third position. **Ireland is the country with the highest KET specialisation in 2013, closely followed by Slovakia**. This implies that Ireland devotes on average a higher share of its resources to the production of all six KETs than other countries do[21].

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



Source: PRODCOM database and Eurostat – TNO calculation.

Demand performance

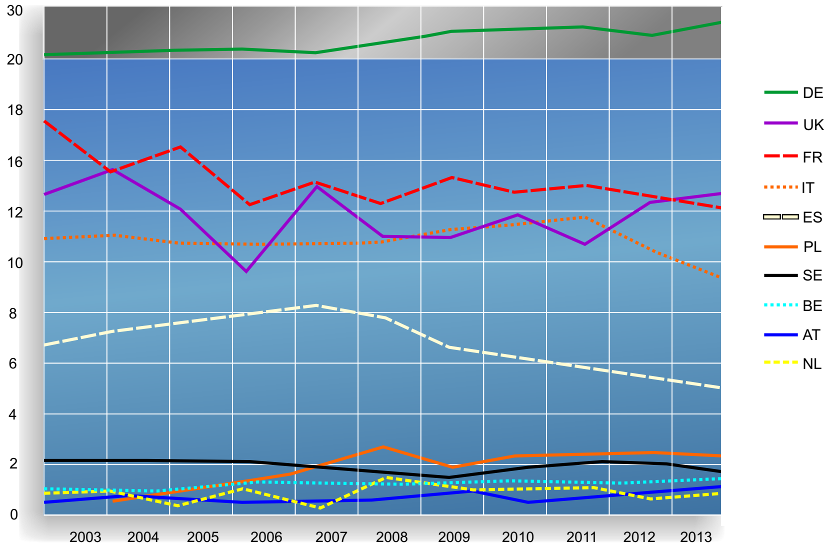
Looking at the share in total demand for all six KETs, **Germany clearly heads the ranking**. The number two position has been shared among the UK, France and Italy. Especially the UK has witnessed a considerably increase since 2011 onwards, resulting in a second position in 2013. Italy has experienced a decrease since 2011 which is due to a quite constant production, along with an increase in export and a decrease in import. "Photosensitive semiconductor devices[22]" and "Solar cells" are a few products that contributed to the decrease in import for Italy, while the Prodcom code "Electronic integrated circuits (excluding multichip circuits): other memories[23]" contributed, among others, to the increase in export for Italy. Spain follows at a fifth position although it is experiencing an ongoing decrease in share in total demand since 2008. **Due to its rather strong industrial base, Poland secures the sixth place for all 6 KETs**. Sweden, Belgium and Austria follow, while the Netherlands closes the TOP 10.

[22] This code includes photovoltaic cells assembled in modules or made up into panels incorporating bypass diodes (but no blocking diodes). The bypass diodes are not elements which supply the power directly to, for example, a motor.

[23] This code includes content addressable memories (CAMs) and ferroelectric memories. Content addressable memories (CAMs) are content associative storage devices. Storage locations of these devices are identified by their contents or by part of their contents, rather than by their names or positions (addresses). Ferroelectric memories are non-volatile memories obtained by combining ferroelectric and semiconductor material. The ferroelectric material is able to retain electric polarisation in the absence of an applied electric field. These devices are both electrically programmable and erasable.

[24] The graphs on KET specialisation can be retrieved from the KETs Observatory website.

Figure 4-2: Share in total demand for the TOP 10 EU-28 countries in all six KETs (in %)



Source: PRODCOM database and Eurostat – TNO calculation.

The results for **all six KETs** show that both in terms of share of production and share in total demand, Germany is leading, well before France, the UK and Italy. Ireland, Slovakia and Germany are the three countries that lead the ranking in terms of KET specialisation, implying that these countries devote a higher share of their resources to the production of all six KETs compared to other countries.

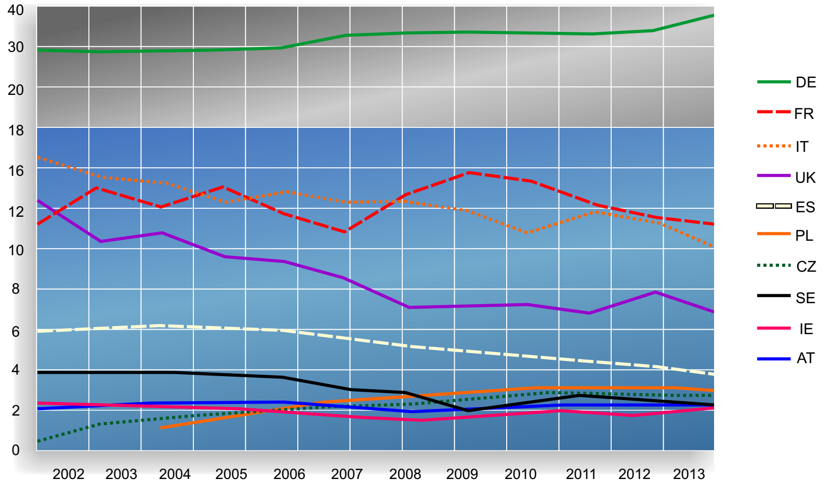
4.2 Advanced Materials

Production performance

The production performance shows significant gaps between EU-28 countries: **Germany dominates the market with 38% of shares of production in 2013, followed by France and Italy who rank second and third with scores of 12.6% and 11.4% in 2013** (Figure 4-3). Over the last decade, France and Italy alternate in occupying the second and third place. Although the share in production of the UK has decreased over the years, it still maintains the fourth position, just before Spain and Poland. The most relevant Prodcom codes that influence the results are related to “Manufacturing of other parts and accessories for motor vehicles” and “Parts of aircrafts and spacecraft”. Also “Contact lenses” represent an important share. In the case of France and Italy, the Prodcom code “Other parts and accessories, n.e.c., for vehicles of HS 87.01 to 87.05, parts thereof” is partly responsible for the decrease in share of production in the latest years. For Italy, also “Sunglasses” contributed somewhat to the decrease in 2013.

Countries that perform well with regard to KET specialisation are the Czech Republic, Slovakia, Germany and Ireland. This implies that these countries devote a higher share of their resources to the production of Advanced Materials compared to other countries[24].

Figure 4-3: Share of KETs-enabled production for the TOP 10 EU-28 countries in Advanced Materials (in %)

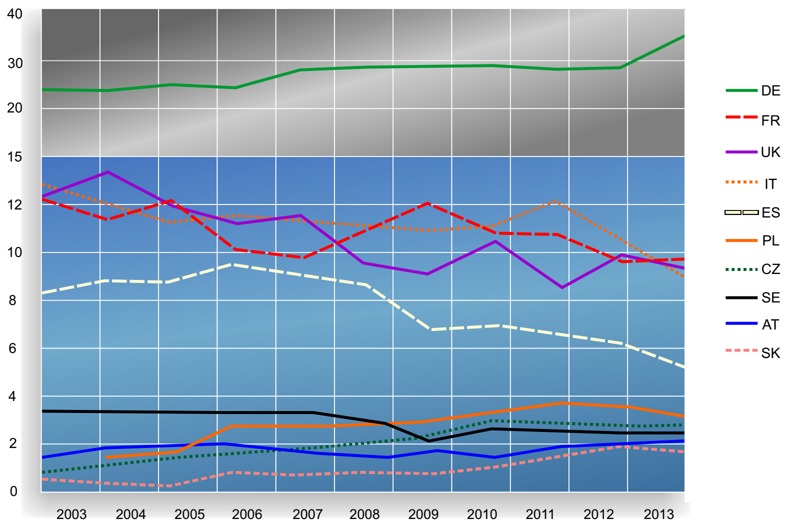


Source: PRODCOM database and Eurostat – TNO calculation.

Demand performance

The share in demand is dominated by **Germany that accounts for almost 35% of the European total in 2013** (Figure 4-4). The good performance is caused by a high production, and an export that exceeded the import in 2013. This is not surprising as Germany is a large and export-oriented economy. Other large Member States like France, the UK and Italy only achieve considerably lower shares in demand of around 10%. While the demand in most countries is constant or declining, Germany is the only country with a clear increase in share of total demand.

Figure 4-4: Share in total demand for the TOP 10 EU-28 countries in Advanced Materials (in %)



Source: PRODCOM database and Eurostat – TNO calculation.

In Advanced Materials, high shares of production correlates with high shares in total demand with the same leading countries for both performance indicators. The only exception is Ireland which is present in the TOP 10 EU-28 countries with regard to share of production, but that drops out of the TOP 10 concerning share in total demand. Ireland does perform well with regard to KET specialisation as well as Czech Republic, Slovakia and Germany.

[25] The graphs on KET significance can be retrieved from the KETs Observatory website.

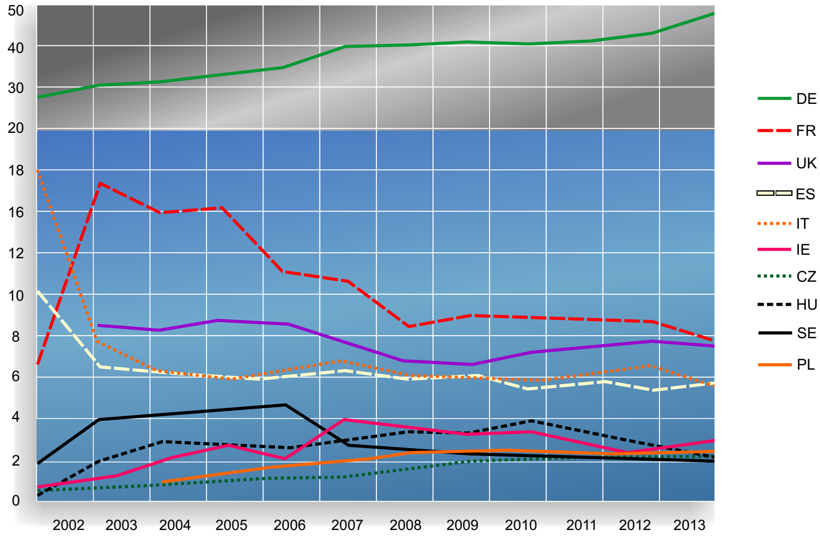
4.3 Nanotechnology

Production performance

Germany also holds the largest share of production in Nanotechnology (Figure 4-5). Several Prodcom codes are driving this good result. In 2013, its share of production reaches 45.6% while all other Member States have a share of production below 10%. Also the absolute production is significantly higher for Germany (see Appendix III, Figure 9-3). While the absolute production rose to 32.1 billion Euros in 2013, France and the UK only have an absolute production of respectively 6.3 billion Euros and 6.1 billion Euros.

Hungary has been able to increase its share of production continuously till 2010, but recently experienced some decline. **Hungary remains on top of the ranking concerning Nanotechnology specialisation, but also here, there is a decline since 2010. The Czech Republic could continue to increase its share of production till 2012 and only recently shows a small decrease**. Among others, the Prodcom code "Parts of silencers and exhaust pipes" experienced a decline in production in the Czech Republic. A similar picture is visible in the KET significance indicator, namely an increase for Hungary till 2010, followed by a decline in the subsequent years[25].

Figure 4-5: Share of KETs-enabled production for the TOP 10 EU-28 countries in Nanotechnology (in %)

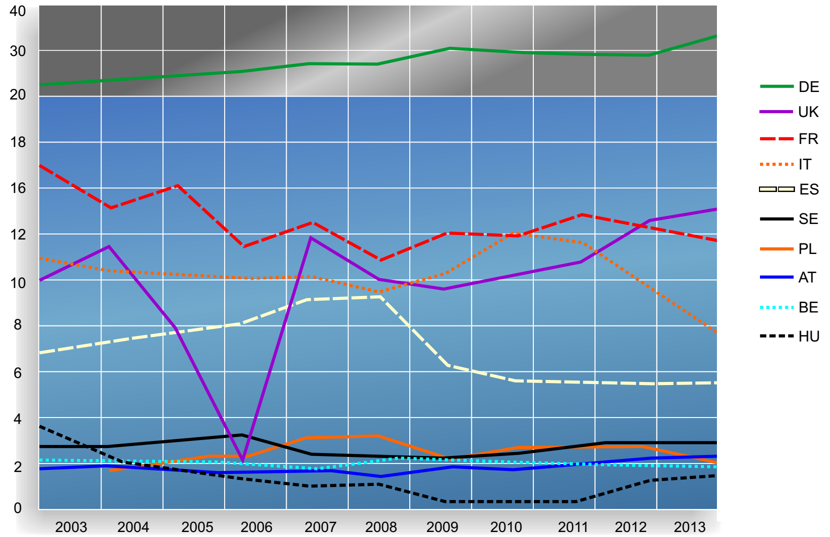


Source: PRODCOM database and Eurostat – TNO calculation.

Demand performance

Regarding demand performance, **Italy and Spain have experienced a decrease in demand in the latest years, while Germany, the UK and Sweden witnessed an increase** (Figure 4-6). Spain and Germany export more than they import, while Italy, the UK and Sweden tend to import more Nanotechnology products than they export. The decline in share in total demand of the UK in 2005 and 2006 is mainly linked to the Prodcom code "Radio transmission apparatus with reception apparatus". The decrease in share in total demand since 2011 of Italy is due to an increase in export (partly caused by "Other medicaments of mixed or unmixed products" and "Sunglasses") associated with a decrease in import (partly caused by "Photosensitive semiconductor devices, solar cells, photo-diodes, photo-transistors"), while production remains more or less constant. The share in total demand of Spain decreased quite significantly in 2009 and has not yet recovered to its position before the financial crisis. This is mainly due to the Prodcom code "Photosensitive semiconductor devices, solar cells, photo-diodes, photo-transistors", which is driven by the reduction of public subsidies of solar photovoltaics (PV) in several EU countries. **Sweden and Austria could increase their share in total demand, while Poland and Belgium show a decrease in recent years**.

Figure 4-6: Share in total demand for the TOP 10 EU-28 countries in Nanotechnology (in %)



Source: PRODCOM database and Eurostat – TNO calculation.

In Nanotechnology, Germany heads the rankings both in terms of share of production and share in total demand. Especially with regard to share of production, the difference with the rest of the TOP 10 countries is considerable. It is likely that this will even increase as the absolute production volume of Germany in the area of Nanotechnology rose significantly over the past years. Hungary leads in terms of Nanotechnology specialisation, implying that Nanotechnology is rather important compared to the overall industrial activities taking place in Hungary.

4.4 Micro- and Nanoelectronics

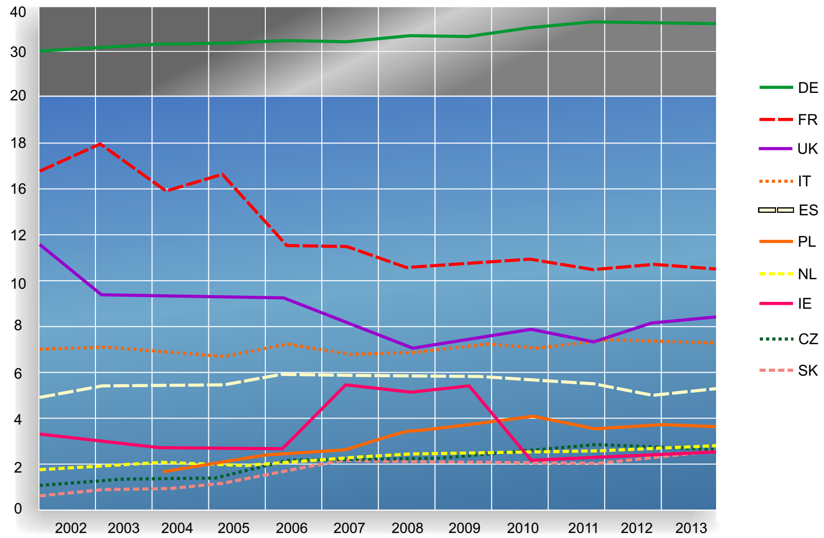
Production performance

With respect to the share of production (Figure 4-7), **the share of Germany increased over the last decade, and is rather stagnating since 2011 onwards. Also Poland shows a similar behavior in its share of production**. The share of France and the UK declined in the period 2003-2008 and is more or less constant since. Ireland shows a strong increase from 2007 till 2009, but fell back in 2010 to a similar level as 2006. After 2009, production moved abroad. The **Czech Republic and Slovakia show an increase in share of production, while Hungary has not been able to continue increasing its share of production and demonstrates a decrease since 2008 onwards**. A similar decrease can be seen in the country significance indicator for Hungary, indicating that Hungarian production is becoming less specialized in Micro- and Nanoelectronics . This country significance indicator reveals the share of production in Micro- and Nanoelectronics over the country's total production.

[26] The graphs on country significance can be retrieved from the KETs Observatory website.

[27] This code includes telephones for cellular networks, so called 'mobile phones', and telephones for other wireless networks.

Figure 4-7: Share of KETs-enabled production for the TOP 10 EU-28 countries in Micro- and Nanoelectronics (in %)



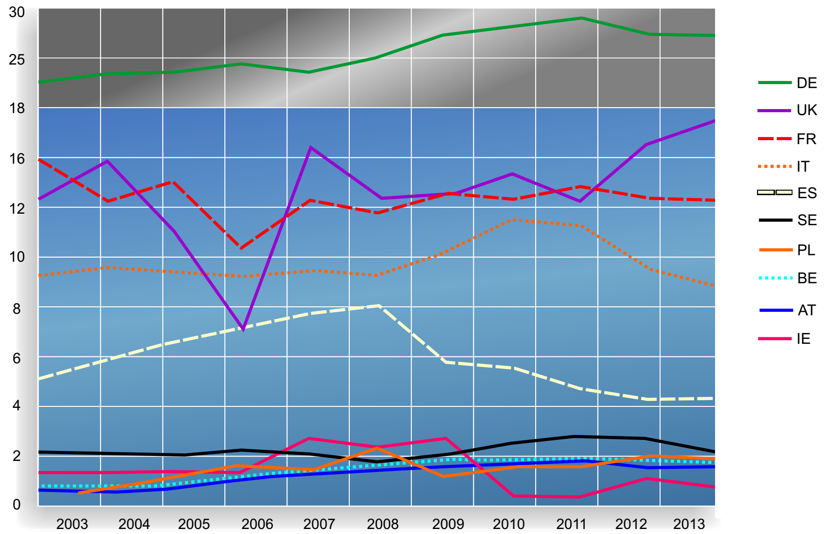
Source: PRODCOM database and Eurostat – TNO calculation.

Demand performance

Germany holds the highest share in total demand, after an increase since 2007 onwards, the share in total demand declined in 2012 and 2013 (Figure 4-8). The UK shows a serious decline in 2006 but recovered quickly in 2007 to occupy the second place in 2013. Again, the decline is mainly linked to the Prodcom code “Radio transmission apparatus with reception apparatus[27]”. The increase in “Production and import of motor vehicles with a diesel or semi-diesel engine” and the increase in “Import of laptop PCs and palm-top organisers and telephones for cellular networks or for other wireless networks” are driving the increase in share in total demand of the UK.

Italy increased its share in total demand in the years following the financial crisis, but could not maintain this growth. On the contrary, its share dropped in 2013 to 10.1% which is even lower than the 2008 value namely 10.5%. Sweden follows a similar, although less pronounced trend. Spain has continued to decrease its share in total demand since 2008 onwards. Interestingly, **the Prodcom code “Photosensitive semiconductor devices, solar cells, photo-diodes, photo-transistors” that contributes significantly to the decline in share in total demand of Italy is the same code that caused a decline in Spain a few years earlier**. This is mainly driven by the reduction of public subsidies of solar photovoltaics (PV) in several EU countries.

Figure 4-8: Share in total demand for the TOP 10 EU-28 countries in Micro- and Nanoelectronics



Source: PRODCOM database and Eurostat – TNO calculation.

In Micro- and Nanoelectronics, Germany, France, the UK and Italy hold the top positions in terms of share of production and share in total demand. Spain and Poland also show considerable activity in this area. Slovakia heads the ranking of country significance, implying that Micro- and Nanoelectronics is rather important compared to the overall industrial activities taking place in Slovakia.

4.5 Industrial Biotechnology

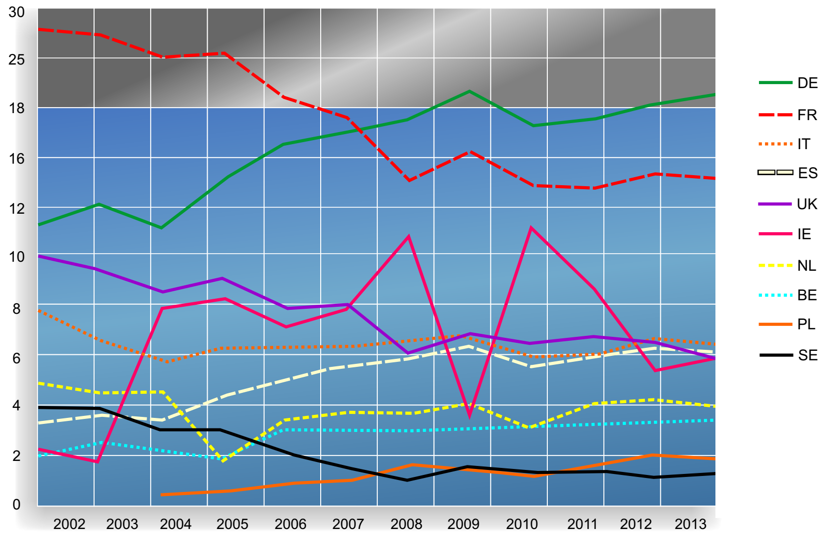
Production performance

From 2002 till 2007, France had the highest share of production of all EU-28 countries (Figure 4-9). **However, with exception of a small increase in 2009 and 2012, its share of production continuously declined.** Germany on the other hand, has increased its share of production in the last decade, except for 2004 and 2010. The increase in share of production of Germany is due to many Prodcom codes like “Polyamide in primary forms” and “Polyurethanes in primary forms”. France also experienced an increase in the production value of several Prodcom codes like “Polyamide in primary forms” and “Polypropylene in primary forms”, but as this occurred hand in hand with a significant drop in the production value of some specific Prodcom codes like “Other medicaments or mixed or unmixed products”, this partly neutralized the increase of the other products.

Worth mentioning is the **third position of Ireland in 2008, that was followed by a serious decline in 2009 to 5.4%. In 2010 however, the share of production mounted up to 14.0% to fall again in 2011 to 11.2%**[28]. A similar picture can be seen in the KETs specialisation indicator of Ireland[29]. Ireland heads the ranking of KET specialisation, which indicates that the country devotes a higher share of its resources to the production of Industrial Biotechnology compared to other countries. The share of production of Italy, Spain and the UK remained more or less constant in the past years.

[28] Single products are responsible for these fluctuations.
[29] The graphs on KET specialisation can be retrieved from the KETs Observatory website.

Figure 4-9: Share of KETs-enabled production for the TOP 10 EU-28 countries in Industrial Biotechnology (in %)

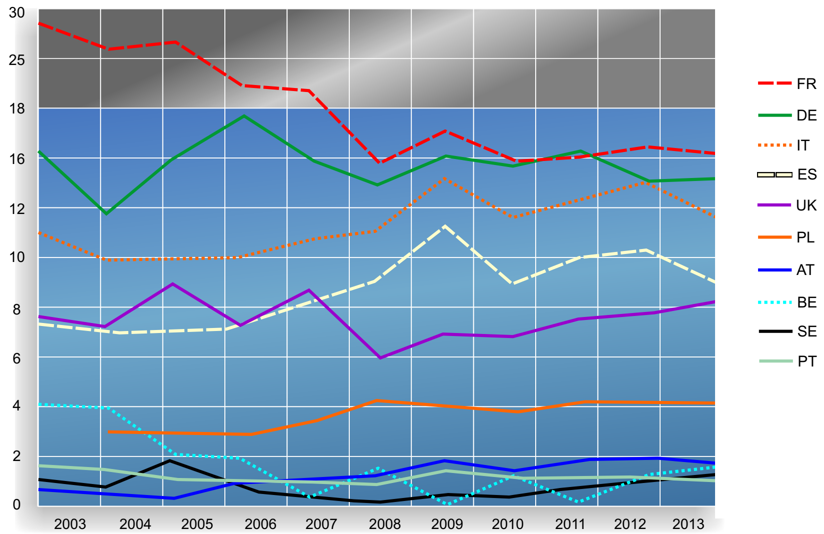


Source: PRODCOM database and Eurostat – TNO calculation.

Demand performance

In contrary to the rankings of the other KETs, **Germany does not hold the number one position in share in total demand in Industrial Biotechnology. In 2003, the share in total demand of France was about twice as high compared to the share in total demand of Germany (Figure 4-10). Ten years later, the difference is only marginal namely 16% for France versus 14.8% for Germany**. From 2003 till 2008, the share in total demand of France decreased significantly, while recently, the fluctuations are less pronounced. The share in total demand of Germany has remained more or less constant since 2007. Belgium, that occupied a sixth position in 2003 till 2006, but shows a decrease in share in total demand since, has been able to increase its share in total demand again to reach a seventh position in 2013, just behind Austria.

Figure 4-10: Share in total demand for the TOP 10 EU-28 countries in Industrial Biotechnology (in %)



Source: PRODCOM database and Eurostat – TNO calculation.

Industrial Biotechnology, is the only KET where Germany does not hold the top position in terms of share in total demand. In 2003, the share in total demand of France for Industrial Biotechnology-based products was almost twice as high as the share in total demand for Germany. Ten years later, there is only a small difference between the share in total demand for France and Germany i.e. respectively 16.0% versus 14.8%. Although Germany has the highest share of production in Industrial Biotechnology, it only surpassed France from 2008 onwards. Ireland has a strong specialisation in Industrial Biotechnology, implying that it devotes a higher share of its resources to the production of Industrial Biotechnology compared to other countries.

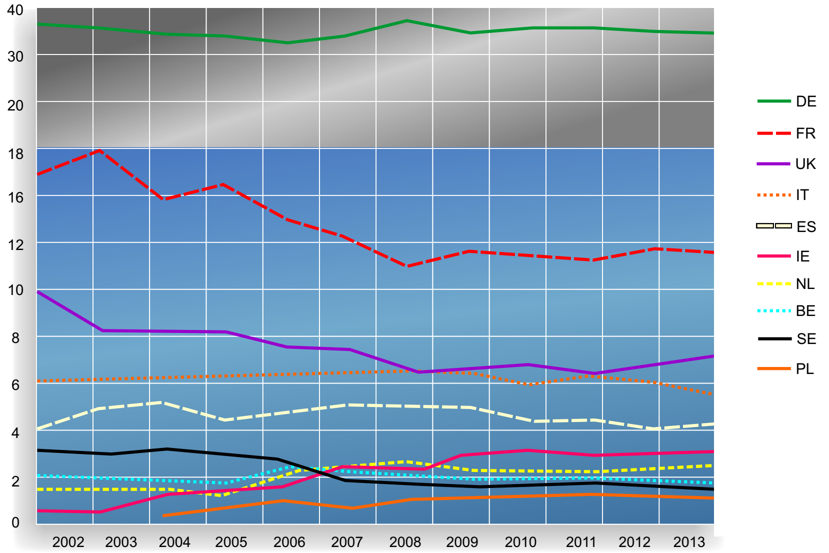
4.6 Photonics

Production performance

The share of production is dominated by Germany that holds a share of 36.5% in 2013 (Figure 4-11). Also with regard to country significance, Germany scores well and occupies the third position . This implies that a significant part of Germany's resources are used to manufacture products related to Photonics. France follows at a large distance with a share of production of 13.8% in 2013. Although the absolute production of France increased since 2009 onwards (see Appendix II Figure 9-6), its share of production declined since 2003 and is more or less constant in the latest years. **This can be explained by the fact that Germany, Ireland and Poland are growing at a faster rate compared to France**. All other countries have less than 10% of the share of production. In general, the share of production show limited fluctuations for all EU-28 countries of the top 10 in the last 5 years.

[30] The graphs on country significance can be retrieved from the KETs Observatory website

Figure 4-11: Share of KETs-enabled production for the TOP 10 EU-28 countries in Photonics (in %)



Source: PRODCOM database and Eurostat – TNO calculation.

Demand performance

The share in total demand shows more fluctuations in contrary to the share of production. For example, **Italy has witnessed a decrease in its share of total demand from 2011 onwards, leading to a share in total demand of 9.7% which is the lowest percentage in 10 years' time** (Figure 4-12). This is again mainly caused by the Prodcom code "Photosensitive semiconductor devices, solar cells, photo-diodes, photo-transistors". In 2013, Italy imported more Photonics products than it exported. The UK on the other hand has increased its share in total demand since 2011 to occupy the second position in 2013. This is partly due to an increase in demand for following products: "Telephones for cellular networks or for other wireless networks" and "Motor vehicles with a diesel or semi-diesel engine". In general, import, export and production are growing in the UK in the last years. However, import is growing faster since 2011. France and Germany also increased their absolute production, and continue to export more than they import. **Over the years, Poland has increased its share in total demand to occupy the sixth position in 2013.**

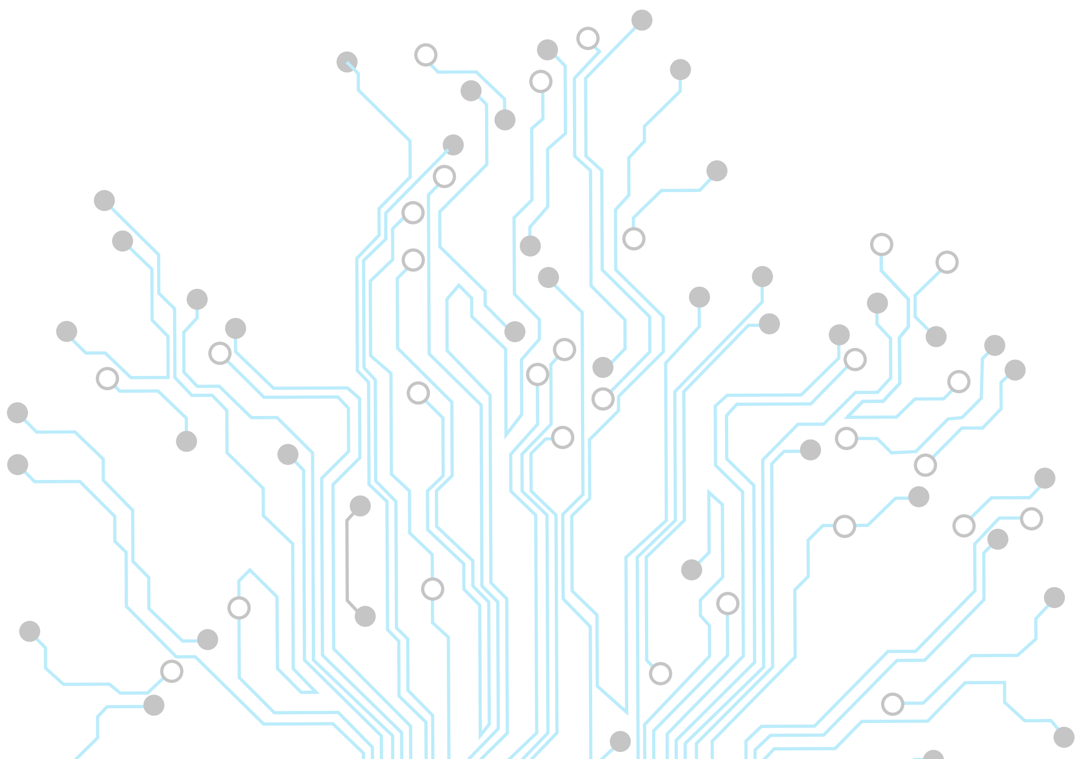
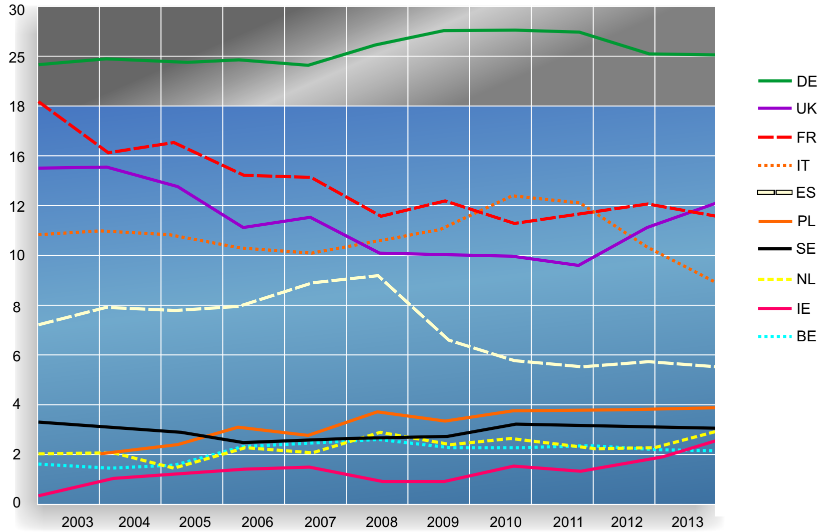


Figure 4-12: Share in total demand for the TOP 10 EU-28 countries in Photonics (in %)



Source: PRODCOM database and Eurostat – TNO calculation.

In Photonics, the share of production and share in total demand are dominated by Germany. It is the only country that has substantially increased its absolute production volume in the last decade. The share of production of France has declined since 2003 and remains about constant in recent years, although its absolute production volume and its country significance has increased since 2009 onwards.

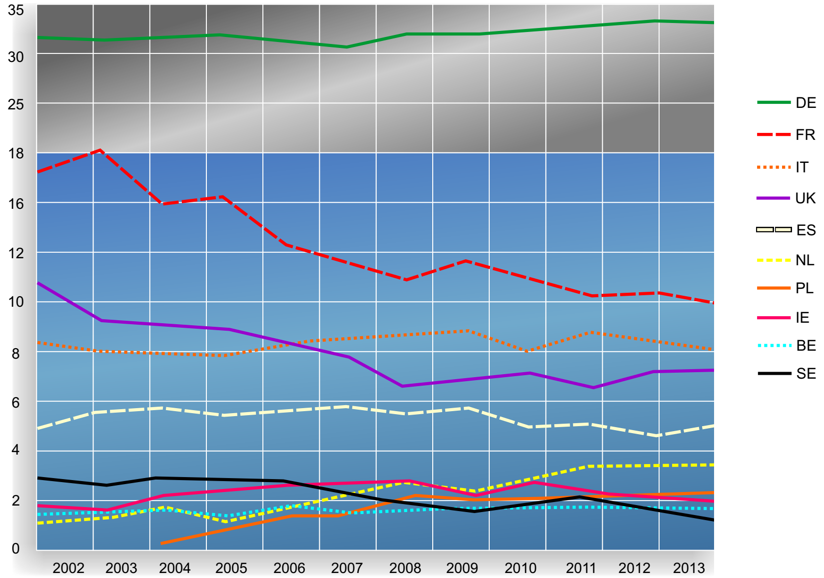
4.7 Advanced Manufacturing Technology

Production performance

Out of the EU-28 countries, it is again Germany that shows the highest share of production namely 33.4% in 2013 (Figure 4-13). Therewith, Germany's share is far above France, Italy and the UK. **Spain and the Netherlands are well positioned, being ranked fifth and sixth.** While the share of production of Germany and the Netherlands increased over the past five years, the share of France has decreased since 2003. While Ireland occupies the eight position with regard to share of production, it is positioned first in terms of country significance and KETs specialisation . Slovakia occupies the second position in the country significance rankings.

[31] The graphs on country significance and KET specialisation can be retrieved from the KETs Observatory website.

Figure 4-13: Share of KETs-enabled production for the TOP 10 EU-28 countries in Advanced Manufacturing Technology (in %)

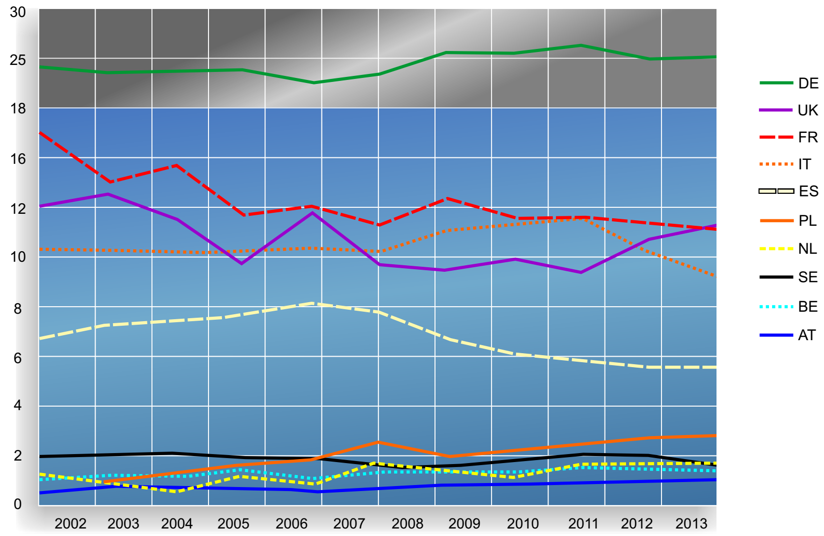


Source: PRODCOM database and Eurostat – TNO calculation.

Demand performance

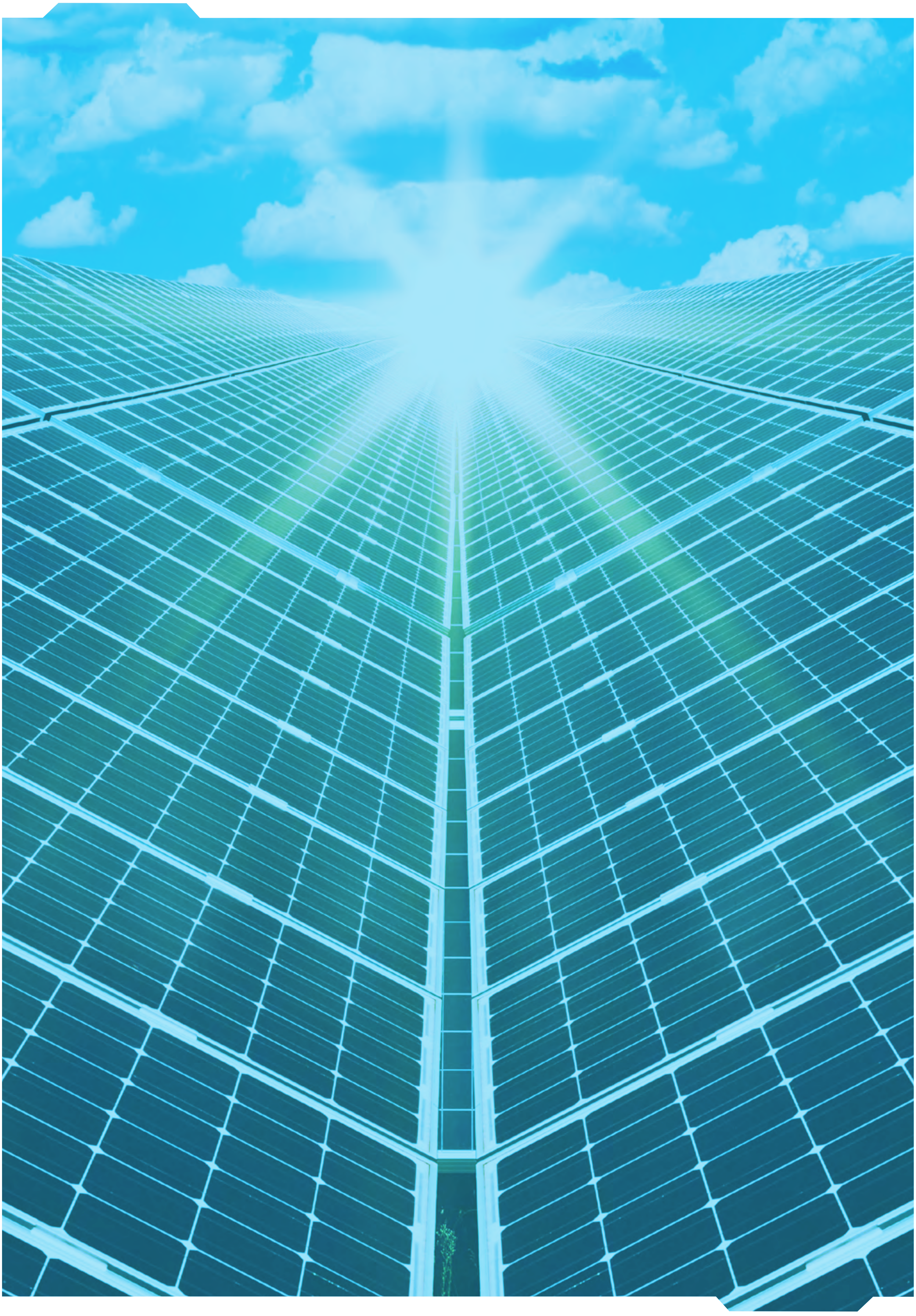
The share in total demand in Advanced Manufacturing Technology is again dominated by Germany, as its share is twice as high as the share of the UK or France. **Poland is the only country that continued to increase its share in total demand in the last five years. All other countries experienced one or more rather limited declines in recent years**. In general, import is slowing down since 2010, while export and production are growing at a faster rate.

Figure 4-14: Share in total demand for the TOP 10 EU-28 countries in Advanced Manufacturing Technology (in %)



Source: PRODCOM database and Eurostat – TNO calculation.

In Advanced Manufacturing Technology, the share of production is dominated by Germany, which has a leading position with 33.4% of production shares in 2013. France, Italy and the UK follow at a distance with 11.5%, 9.4% and 8.5% respectively. While most countries experienced a limited decline in share in total demand, Poland is the only country that continued to increase its share in total demand in the last five years. Ireland leads in terms of country significance, followed by Slovakia.



5. Overall performance of Member States throughout the deployment value chain

5.1 Introduction

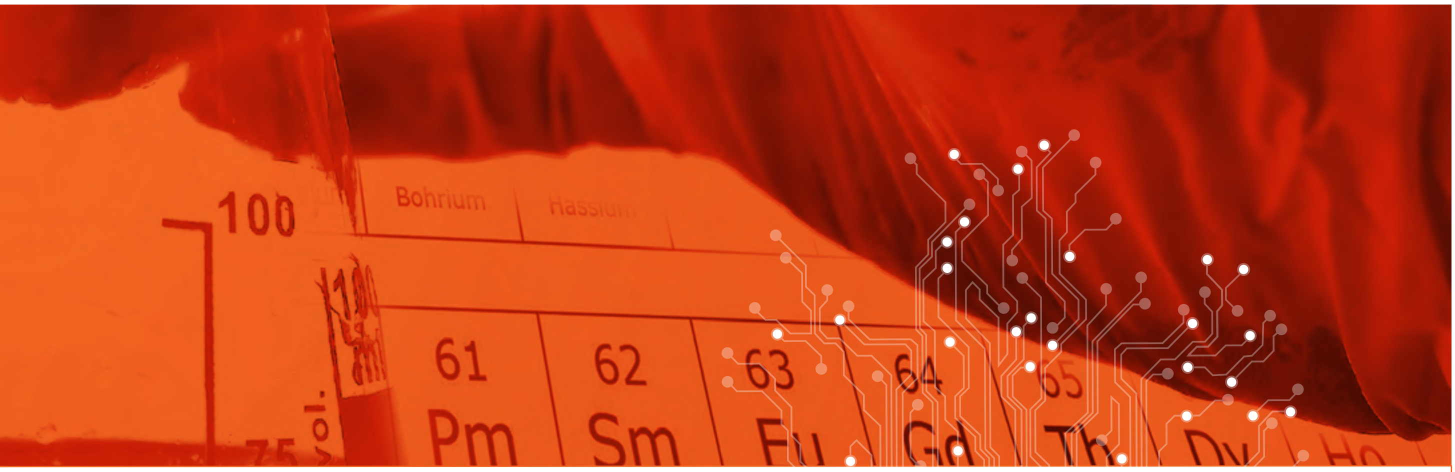
In this chapter we present the results of the composite indicators. Composite indicators measure the ability of countries to cover the KETs deployment value chain from technology development to commercialisation. The composite indicator builds upon all group of indicators of the technology generation and exploitation approach (technology, production, trade, and turnover)[32]. **It enables a meaningful interpretation as it informs about how a certain country performs in a certain KET regarding the different stages of technology maturity and closeness to market application**. One could easily identify whether a certain country is e.g. highly competitive in new technologies and competitive innovations but relatively not successful in its wide application. For example, in Advanced Materials, Belgium is ranked first

[32] https://ec.europa.eu/growth/tools-databases/ketsobservatory/sites/default/files/library/kets_1st_annual_report.pdf

[33] A composite indicator is a single real-valued metric which is derived from a set of indicator components by some (mostly linear) aggregation method (see Grupp, H., Schubert, T. (2010): Review and new evidence on composite innovation indicators for evaluating national performance. In: Research Policy, Vol. 39, pp. 67-78 or the methodology report for more details).

[34] In Micro- and Nanoelectronics, several countries perform well for production (e.g. Denmark (9th), Poland (11th), Romania (8th), Hungary (5th) and Slovakia (10th)), but not for trade (e.g. Denmark (18th), Poland (24th), Romania (27th), Hungary (15th) and Slovakia (20th)).

[35] The time series for production and trade are based on index values. The index value does not have an exact maximum due to different normalization rules. The values for trade are higher due to the addition of more variables to come to the composite indicator compared to production. The data in each table of this chapter concerns 2011 data for technology and 2013 data for production and trade as this is the most current year of data availability.



in the production, trade and technology composite indicator. This implies that Belgium has a strong innovation-industry-ecosystem for this KET, bringing together strong skills in technology deployment. The methodology is designed such that the resulting set provides comparable statistics on the deployment of different KETs over time[33].

The results indicate that in general, Middle and Western European countries dominate the rankings, with a few exceptions of some Eastern European countries that are performing well such as the Czech Republic for Photonics and Hungary for Advanced Materials. Overall, while the country ranking for production and trade shows high similarities for almost all KETs (with exception of Micro- and Nanoelectronics[34]), the link between performances in technology on the one hand and production and trade on the other hand differs between the KETs. For example, in Advanced Materials, Ireland is positioned 5th for production and 3rd for trade, while it is only ranked 14th with regard to technology. Similarly, in Nanotechnology, no clear connection can be found between technology and production/trade performance e.g. Sweden is positioned 5th for production and 7th for trade, while it only occupies the 14th position for technology. The results of the composite indicators show that only in a few cases, countries have been able to significantly and sustainably increase their performance during the past years which might be due to certain KETs related policy efforts. Examples are Poland for production in Advanced Materials or Spain for trade in Industrial Biotechnology.

In the following sections the main findings for the composite indicator for each KET are presented and discussed. As previous KETs studies have mainly focused on the technology dimension, the discussion of the composite results will concentrate on the aspects of “production” and “trade”, and therefore concentrate on the indicators that represent a higher level of technological maturity in terms of market readiness. We present the same TOP 10 countries for production and trade for time series to allow for comparisons of countries’ performance[35].

5.2 Advanced Materials

Table 5-1 shows the findings for the rankings of countries' performance in Advanced Materials across three different composite indicators. **Belgium and Germany perform strong in all indicators. However, the tables also reveal that a high performance in one dimension (e.g. technology) is not necessarily accompanied by a high performance in other dimensions (e.g. trade).** Some countries such as the Netherlands and Luxembourg perform well for technology taking a fifth or six position, while they are less successful for trade and especially for production. This points towards a specialisation pattern that can be found in the performance profile of different countries. **While some countries are specialised on early technology development, others take up this technology knowledge and implement it along their industrial value chains.** Such knowledge-spillovers from technology into production or trade are also taking place due to international companies that transfer the technological know-how from one country (where they perform their R&D activities) to their production establishments in another country.

Vice versa, **Ireland and Hungary are characterised by a rather weak technology performance, however they show top-level performance in production and trade**. Hence, when designing KETs policies, **these different patterns of country specialisation with regard to different performance dimensions should be taken into account when identifying future potentials for strengthening the respective country's performance level in a given KET.** Moreover, **such individual country profiles can also be a starting point for designing cross-country value chains for KETs in the EU.**

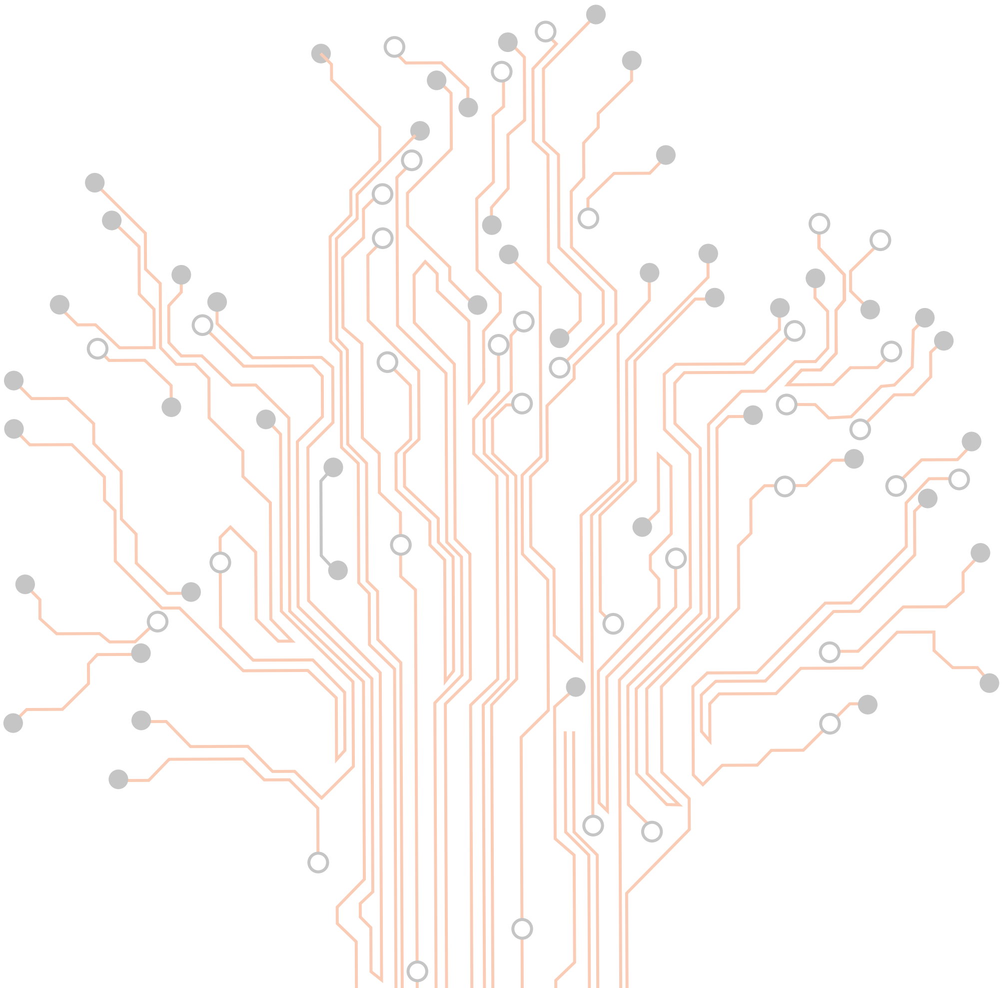


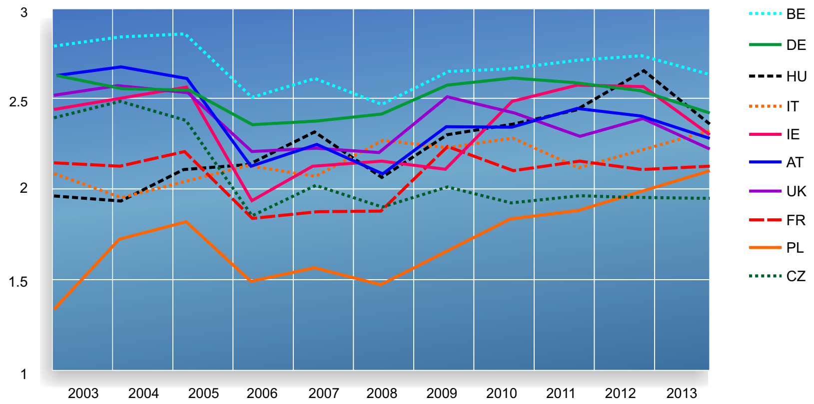
Table 5-1: Country ranking in composite analysis for Advanced Materials

Advanced Materials Country rankings			
Country	**Production**	**Trade**	**Technology**
BE	1	1	1
DE	2	4	4
HU	3	8	20
IT	4	11	7
IE	5	3	14
AT	6	16	3
UK	7	10	10
FR	8	14	2
PL	9	5	13
CZ	10	2	19
EE	11	6	22
ES	12	15	12
NL	13	7	5
PT	14	21	16
FI	15	9	8
SE	16	13	17
SK	17	22	9
LT	18	19	28
BG	19	20	26
RO	20	25	15
HR	21	27	25
MT	22*	17	23
CY	23*	28	24
LU	24*	12	6
DK		23	18
GR		24	21
LV		26	27
SI		18	11

Source: Fraunhofer ISI calculations based on the different indicators of the technology generation and exploitation approach
Table is sorted in descending order by "production"; empty cells = composite could not be calculated due to data confidentiality
* The reported production value for these countries is zero

The time series of TOP 10 countries in the field of production of Advanced Materials show some dynamics since mid-2000. **Some countries managed to improve their performance in this dimension in the past years such as Italy and Poland**. Other countries like Germany, the UK or Hungary show a decline between 2012 and 2013. Noteworthy is the second position of Hungary in 2012 and its third position in 2013.

Figure 5-1: Advanced Materials – time series of EU TOP 10 countries' performance (index-values) in the field of production

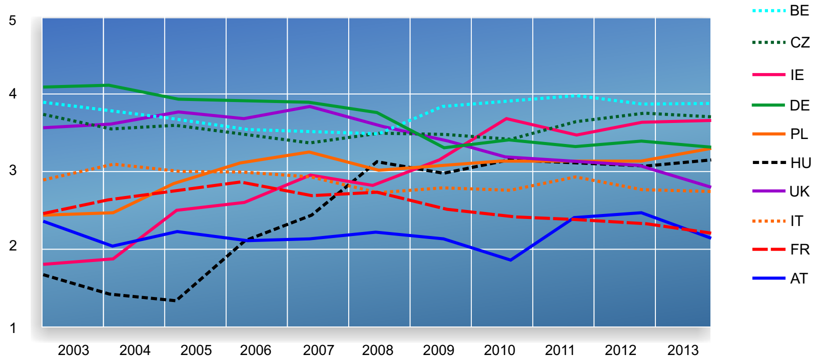


Source: Fraunhofer ISI calculations based on the production indicators of the technology generation and exploitation approach.

Regarding the trade dimension, some countries managed to increase their trade performance in Advanced Materials in a certain time period: Hungary, Poland and Ireland in the time period between around 2004/2005 and 2007/2008 and the Czech Republic since 2010. Especially the case of the Czech Republic appears to be interesting, as with regard to the production performance this country is only ranked at the 10th position and even at the 19th position for technology in this comparative analysis. This finding is mainly due to "wedding, gauze, bandages and similar articles" produced in subcontracting for multinational companies (see First Report of the KETs Observatory).

In contrast, since 2007 the UK shows a constant decreasing trade performance. Along with the also decreasing performance in production and stagnant development in technology, one can state that the UK runs the risk to significantly lose its competitive edge in Advanced Materials.

Figure 5-2: Advanced Materials – time series of selected EU countries' performance (index-values) in the field of trade



Source: Fraunhofer ISI calculations based on the trade indicators of the technology generation and exploitation approach

In Advanced Materials, Belgium and Germany perform strong in the technology, production and trade composite indicators. In contrast, the performance of other EU-28 countries varies between the different indicators. Overall, there are indications that a kind of specialisation takes place within Member States: while some countries are specialized on early technology development (e.g. France, Austria, and the Netherlands), others take up this technology knowledge and implement it along their industrial value chains (e.g. Hungary, Ireland). Hungary occupies in 2013 the third position in the production composite indicator. The trade composite indicator show a strong performance of the Czech Republic (second position), while the UK shows a constant decreasing trade performance. Along with the also decreasing performance in production and stagnant development in technology, one can state that the UK runs the risk to significantly lose its competitive edge in Advanced Materials.

5.3 Nanotechnology

The composite analysis for Nanotechnology shows that Spain is the leader in the country rankings. As was indicated in the First Report of the KETs Observatory, 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. **On the other hand, a lot of countries that perform well for production and trade are less successful for technology (e.g. Poland, the Netherlands, Sweden, and Austria) and the other way around (e.g. the Czech Republic and Romania). This might be due to the fact that new potential products in this technology with less industrial maturity have not yet been commercialised**.

The ranking also reveals that middle-eastern European countries like Lithuania, Croatia, Estonia and Bulgaria are characterised by a low level of activities in the field of Nanotechnology. Here it is interesting to consider if this indicates a need to stimulate technology development activities by dedicated science, technology, and innovation (STI) policy, or if it would be advisable to focus on technological knowledge-spillovers from more advanced countries to middle-eastern European countries in terms of fostering production, trade, and business activities in more mature stages.

Table 5-2: Country ranking in composite analysis for Nanotechnology

Nanotechnology Country rankings			
Country	Production	Trade	Technology
ES	1	1	1
PL	2	9	15
FR	3	12	3
NL	4	3	11
SE	5	7	14
AT	6	10	19
IT	7*	13	13
DE	8	5	12
UK	9	6	5
PT	10*	23	9
SK	11	11	25
CZ	12	2	4
RO	13*	24	2
HU	14	15	17
HR	15	26	23
FI	16	19	8
DK	17	16	18
LT	18	17	27
MT	19**	18	10
LU	20**	25	20
EE	21**	21	21
CY	22**	28	24
BE		8	6
BG		27	22
GR		20	28
IE		4	16
LV		22	26
SI		14	7

Source: Fraunhofer ISI calculations based on the different indicators of the technology generation and exploitation approach

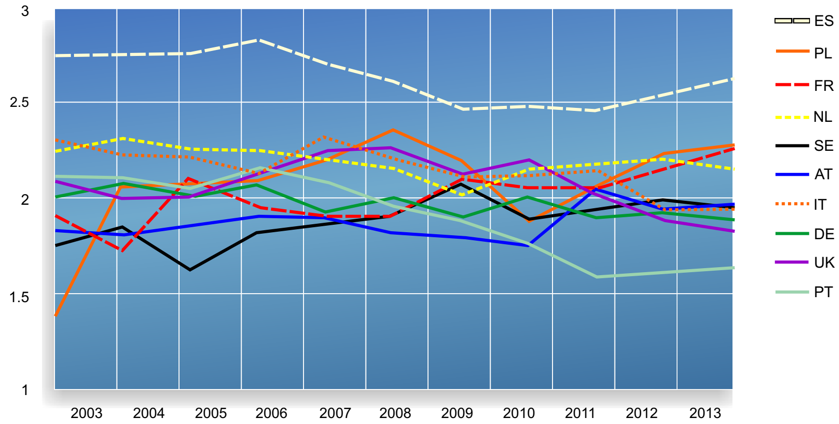
Table is sorted in descending order by “production”; empty cells = composite could not be calculated due to data confidentiality

* Production data for 2013 is confidential. For the calculation of the rankings the 2012 production data is used for Italy and Portugal and 2011 production data for Romania

** The reported production value for these countries is zero

When looking at the dynamics of production in the field of nanotechnology (Figure 5-3), the composite analysis shows quite a lot of changes in the country ranking behind Spain. This is because most of these countries are on a rather equal level and thus small changes in performance leads to a change in ranking. One possible reason could be that the amount of technological solutions ready for industrial production is still limited and countries do not show a clear specialisation profile yet. So far, only three countries have a positive trend in the recent years considering their production activities: Spain, France, and Poland.

Figure 5-3: Nanotechnology – time series of EU TOP 10 countries' performance (index-values) in the field of production*

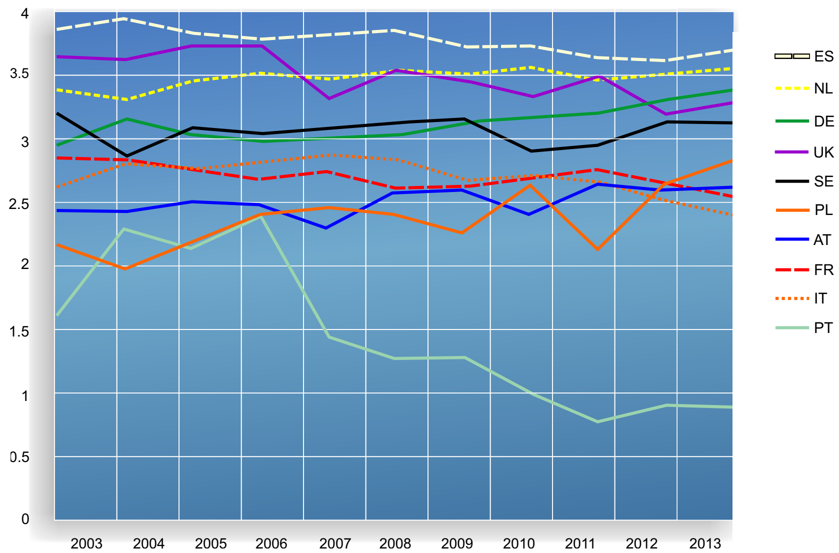


Source: Fraunhofer ISI calculations based on the production indicators of the technology generation and exploitation approach

* For Italy some years are confidential, therefore missings have been imputed. For Portugal, production data for 2013 is confidential, for the calculation of the rankings the 2012 data is used.

Figure 5-4 summarizes the selected countries' trade performance in Nanotechnology between 2003 and 2013. It can be seen that trade activities are characterised by a rather low dynamic. In particular, **Spain and the Netherlands show a constantly high level of trade performance in Nanotechnologies**. Germany and Poland succeeded in a rather steady improvement in trade activities. Finally, countries like Italy and Portugal have reduced their trade activities in recent years.

Figure 5-4: Nanotechnology – time series of selected EU countries' performance (index-values) in the field of trade



Source: Fraunhofer ISI calculations based on the trade indicators of the technology generation and exploitation approach.

In Nanotechnology, Spain is the leading country for technology, production and trade composite indicators across time. This is noteworthy as a lot of countries performing well for production and trade are generally less successful for technology (e.g. Poland, the Netherlands, Sweden, and Austria) and the other way round (e.g. the Czech Republic and Romania). This might be due to the fact that new potential products in this technology with less industrial maturity have not yet been commercialised. Only three countries have a positive trend in their production activities over the last few years: Spain, France, and Poland.

5.4 Micro- and Nanoelectronics

The country ranking across all three composite indicators in Micro- and Nanoelectronics (Table 5-3) reports **a clear divide between a set of leading countries, e.g. France, Germany, Italy, the Netherlands, Austria and the UK with top 10 positions in Micro- and Nanotechnologies, and another set of lower performing countries (e.g. Estonia, Lithuania, Latvia and to some extent Finland).** Interestingly, the performance for trade correlates more to technology than to production. Among others, Romania, Hungary and Slovakia perform well for production, but not for trade and technology. An explanation might be that these countries possess production capacities for some steps of the value chain, but do neither trade the MNE components and systems nor perform significant research for leading-edge products and processes.

These findings highlight that **the EU landscape of Micro- and Nanoelectronics is quite condensed. In order to diffuse micro- and nanotechnological solutions in industrial applications on an EU-wide scale, one could further strengthen the technology leaders in their performance and support countries in the low performing group in developing production and trade activities in order to establish some kind of EU-wide specialisation patterns**. Countries like Germany, Italy and Austria thereby could act as leaders initiating knowledge- spillovers on technology, production and trade. As stated in the First Report of the KETs Observatory, the 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.

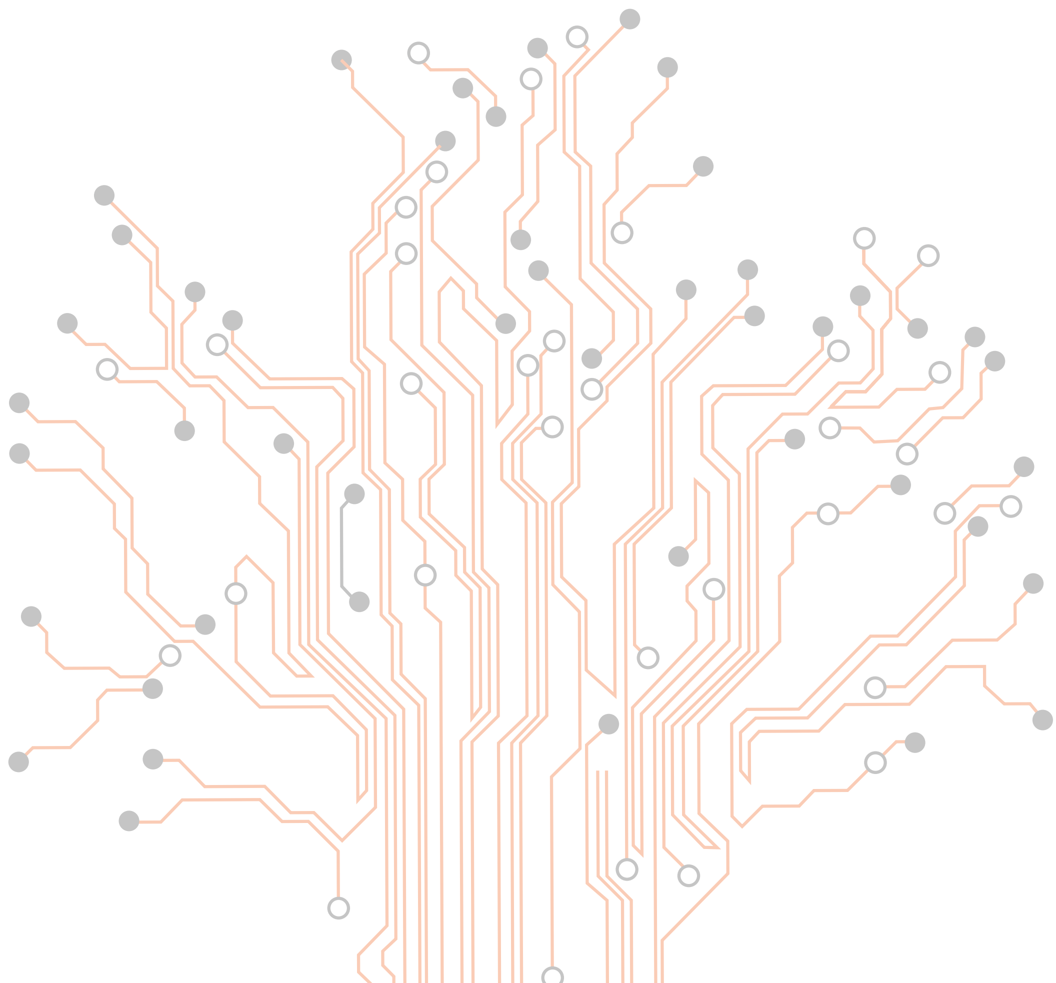


Table 5-3: Country ranking in composite analysis for Micro- and Nanoelectronics

Micro- and Nanoelectronics Country rankings			
Country	**Production**	**Trade**	**Technology**
IT	1	9	9
FR	2	1	1
DE	3	3	2
AT	4	4	5
HU	5	15	17
NL	6	6	4
UK	7	7	6
RO	8	27	28
DK	9	18	12
SK	10	20	27
PL	11	24	18
HR	12	8	23
SE	13	13	13
CZ	14	11	19
BG	15	10	20
ES	16	19	11
PT	17*	16	14
LT	18	23	24
FI	19	17	10
LV	20	21	25
EE	21	25	15
LU	22**	14	16
MT	23**	2	26
CY	24**	28	22
BE		12	3
GR		26	8
IE		5	7
SI		22	21

Source: Fraunhofer ISI calculations based on the different indicators of the technology generation and exploitation approach

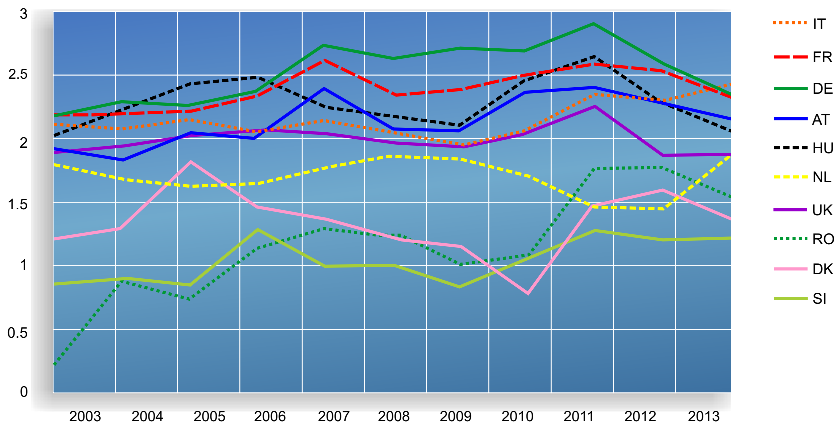
Table is sorted in descending order by "production"; empty cells = composite could not be calculated due to data confidentiality

* Production data for Portugal for 2013 is confidential. For the calculation of the rankings the 2012 production data is used.

** The reported production value for these countries is zero.

The findings from the country ranking are also supported by looking at the development of production performance in the last decade (Figure 5-5). **Germany, Italy, France, and Austria started quite equally in 2003 and, after some divergences in the subsequent years, have again assembled at a similar level of production performance in 2013, hereby building the leading group in EU Micro- and Nanoelectronics**. Instead, the UK lost the connection to the leading group in the recent past. Besides, Romania and Denmark have recently improved their production performance, but stagnated in 2013.

Figure 5-5: Micro- and Nanoelectronics – time series of EU TOP 10 countries' performance (index-values) in the field of production*



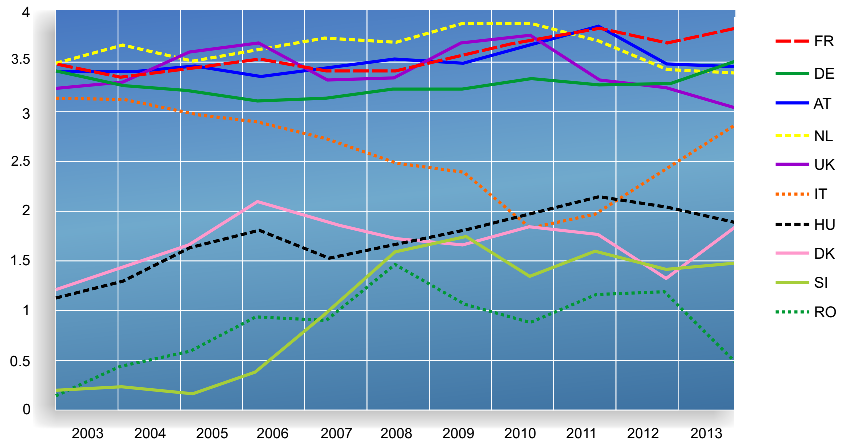
Source: Fraunhofer ISI calculations based on the production indicators of the technology generation and exploitation approach.

* For Portugal, production data for 2013 is confidential, for the calculation of the rankings the 2012 data is used

The analysis of the trade performance along the years 2003 to 2013 confirms this picture (Figure 5-6). France, Austria, Germany, the Netherlands and the UK are the leading countries in Micro- and Nanoelectronics' trade. All of them have more or less stabilized their performance on a certain (high) level. Instead, Italy shows a continually decreasing performance between 2003 and 2010, but almost catches up to the leading group again in 2013 (mainly thanks to the production of other electronic integrated circuits).

Next, Denmark, Hungary and Romania increase their performance between 2003 and 2006, but cannot catch-up to the leading group later on. Slovenia shows a strong growth between 2006 and 2009, but stagnates later on. **Hence, the picture of high divergence between countries for MNE is confirmed in the time series.**

Figure 5-6: Micro- and Nanoelectronics – time series of selected EU countries' performance (index-values) in the field of trade



Source: Fraunhofer ISI calculations based on the trade indicators of the technology generation and exploitation approach

In Micro- and Nanoelectronics, France, Germany, the Netherlands, Austria, Italy and the UK perform well in all three dimensions of Micro- and Nanotechnology indicators, with a similar performance. These findings highlight that the EU landscape of Micro- and Nanoelectronics is quite compact. In contrast, there is a set of lower performing countries (e.g. Estonia, Lithuania, Latvia and to some extent Finland) that show a rather low performance for all dimensions of the composite indicators. In order to diffuse micro- and nanotechnological solutions in industrial applications on a EU-wide scale, one could further strengthen the technology leaders and support countries in the low performing group in developing production and trade activities in order to establish some kind of EU-wide specialisation patterns. Countries like Germany, France, Italy and Austria could thereby act as leaders initiating knowledge-spillovers to production and trade in other European countries.

5.5 Industrial Biotechnology

The composite analysis' findings for Industrial Biotechnology draw a similar picture than for Nanotechnology. It shows a clear winner in the country rankings: Denmark (Table 5-4). This is not surprising as Denmark has been among the EU leading countries in this technology for a long time. The findings of this analysis clearly confirm this leading position with Denmark reaching the top score in all three dimensions. **However, high technology performance is not necessarily connected with high performance levels in production and trade**. Hungary (6), Portugal (9), Poland (7) are in the top 10 for technology but haven't been able yet to transfer the technology development in industrial application and trade. Vice versa, a lower performance in technology development is not correlated with higher performance levels in production and trade, e.g. Germany or Austria. From the innovation systems perspective, this implies rather low correlations between technology development and industrial application and trade. Again **this opens potentials for developing specialisation patterns of different countries or regions by science, technology and innovation (STI) policy.**

Comparably to the previous KETs, the countries in the middle-east of the EU show the weakest performance (e.g. Romania, Estonia, and the Czech Republic) in Industrial Biotechnology with regard to all three dimensions. This result points out that Industrial Biotechnology is far from broadly diffused in the EU industrial value chains.

Table 5-4: Country ranking in composite analysis for Industrial Biotechnology

Industrial Biotechnology Country rankings			
Country	Production	Trade	Technology
DK	1	1	1
FR	2	3	8
ES	3*	11	2
IE	4	15	12
DE	5	8	17
NL	6	5	4
AT	7	6	15
IT	8	9	19
BE	9	2	3
UK	10	10	5
HU	11	14	6
LT	12	12	14
SK	13	21	13
SE	14	18	22
BG	15	7	28
PT	16*	20	9
PL	17	16	7
CZ	18	17	23
HR	19	24	10
EE	20	27	20
MT	21**	28	26
CY	22**	22	24
LU	23**	25	21
FI		4	16
GR		23	18
LV		19	25
RO		26	27
SI		13	11

Source: Fraunhofer ISI calculations based on the different indicators of the technology generation and exploitation approach

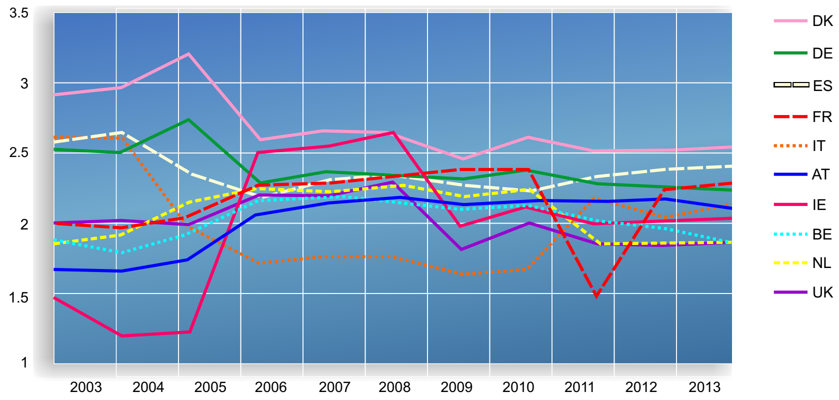
Table is sorted in descending order by "production"; empty cells = composite could not be calculated due to data confidentiality

* Production data for 2013 for Spain and Portugal is confidential. For the calculation of the rankings the 2012 production data is used for Spain and the 2011 production data for Portugal.

** The reported production value for these countries is zero

With regard to the composite's time series analysis in the field of production (Figure 5-7), only limited dynamics during the past decade can be observed. Between 2003 and 2006, Denmark's performance slightly decreases, but the country remains at a top position. In contrast, Ireland catches up with other countries after a strong improvement in 2006. But since 2006, almost all countries show a stable performance. **One reason could be that many ongoing product developments in Industrial Biotechnology are still in an early stage, implying that increasing dynamics can be expected in the upcoming years.**

Figure 5-7: Industrial Biotechnology– time series of EU TOP 10 countries' performance (index-values) in the field of production

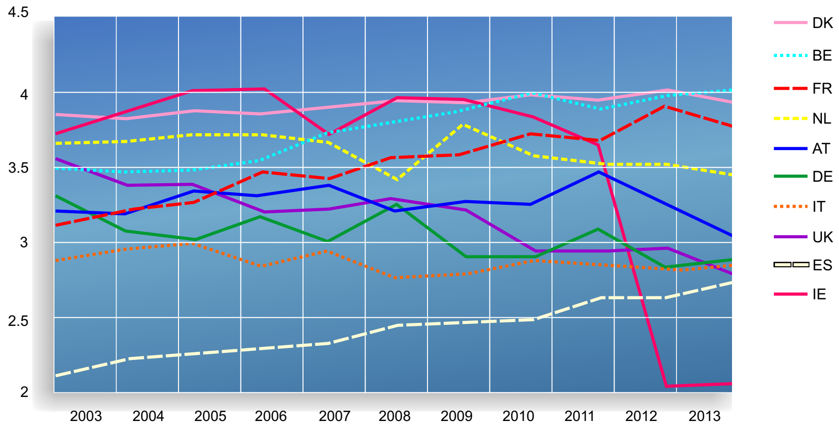


Source: Fraunhofer ISI calculations based on the production indicators of the technology generation and exploitation approach

* For Spain, production data for 2013 is confidential, for the calculation of the rankings the 2012 data is used.

A similar result can be seen for the trade performance's time series (Figure 5-8). The dynamics are characterised by punctual ups and downs instead of middle to long term trends making them difficult to interpret. **Only Belgium and Spain were able to significantly increase their trade performance**. On the other end of the scale, Ireland and to some extent Austria show a decline since 2011.

Figure 5-8: Industrial Biotechnology – time series of selected EU countries' performance (index-values) in the field of trade



Source: Fraunhofer ISI calculations based on the trade indicators of the technology generation and exploitation approach

In Industrial Biotechnology, Denmark is the leading country for the technology, production and trade composite indicator. France shows a strong performance for production and trade, but to a lower extent for technology. Respectively, high technology performance is not necessarily connected with high performance levels in production and trade. Hungary, Portugal, and Poland are in the TOP 10 for technology, but have not yet been able to transfer their technology developments in industrial applications and trade. Comparably to the previous KETs, some countries like Romania, Estonia, and the Czech Republic show the weakest performance in Industrial Biotechnology with regard to all three dimensions. This result indicates that Industrial Biotechnology is not yet broadly diffused in the EU industrial value chains.

5.6 Photonics

The country ranking for Photonics reveals a small group of leading countries with good performance in all three dimensions: Austria, Germany, the Czech Republic, the Netherlands and the UK. On the other side, the group of low performers across all dimensions mainly consists of countries like Malta, Cyprus, and Romania. Compared to the other KETs, the rather small group of high performance countries might indicate that countries' activities in Photonics appear to be driven by the specialisation in certain specific industry structure that favours the use of photonic applications (e.g. laser welding, laser cutting, process-integrated quality control or the information transport via light). This would imply for innovation policy to focus on the development of new application fields for this technology in industrial manufacturing.

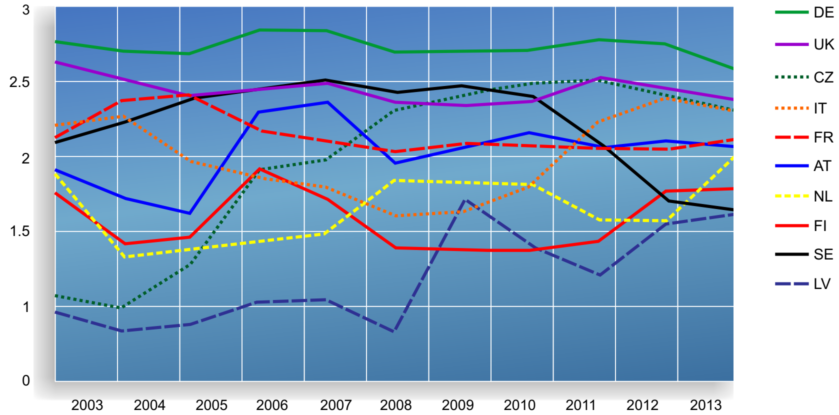
Table 5-5: Country ranking in composite analysis for Photonics

Photonics Country rankings			
Country	Production	Trade	Technology
DE	1	1	3
UK	2	6	4
CZ	3	5	9
IT	4	18	11
FR	5	10	7
AT	6	2	2
NL	7	7	1
FI	8	20	19
SE	9	4	16
LV	10	8	25
EE	11	21	24
DK	12	14	13
BG	13	17	28
BE	14	13	5
ES	15	22	15
HU	16	19	6
IE	17	3	12
PL	18	15	20
PT	19	23	17
SK	20	24	14
HR	21	11	18
RO	22	27	27
CY	23*	26	23
MT	24*	28	26
LU	25*	16	21
GR		25	22
LT		9	8
SI		12	10

Source: Fraunhofer ISI calculations based on the different indicators of the technology generation and exploitation approach
Table is sorted in descending order by "production"; empty cells = composite could not be calculated due to data confidentiality
* The reported production value for these countries is zero.

As Figure 5-9 depicts, production show significant dynamics since 2003. **While a few countries like Germany, the UK and France show a widely stable performance level over the time span considered, other countries like the Czech Republic, Latvia or Austria have been catching-up**, however each in different time periods. On the contrary, Sweden shows a strong decline since 2010.

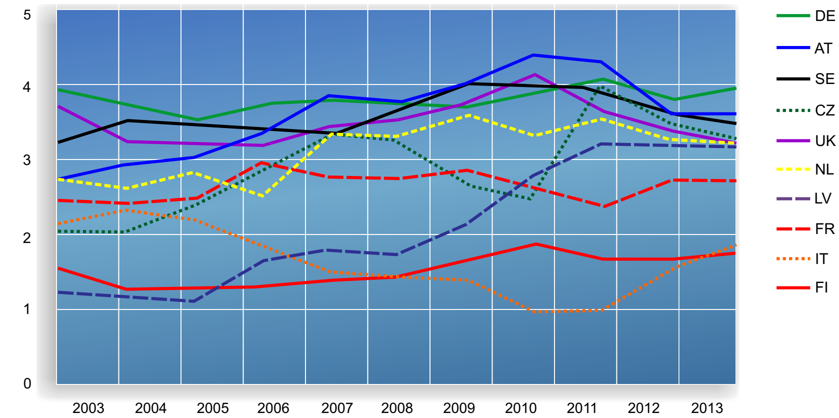
Figure 5-9: Photonics– time series of EU TOP 10 countries' performance (index-values) in the field of production



Source: Fraunhofer ISI calculations based on the production indicators of the technology generation and exploitation approach

The countries' trade activities in Photonics also show rather high dynamics, particularly in the time period between the years 2005 and 2011. Looking at the present situation, it can be argued that the trade performance of the TOP 10 countries has been moving closer together in the past years between the top countries. **Germany and in particular Italy recently succeeded in revitalising their trade activities. Both countries are important for the manufacturing of high performance machinery of the most modern generation that frequently includes photonics technology**. Again, the Czech Republic and Latvia show a strong catching up during the regarded time period, although the Czech Republic shows decreasing values again since 2011.

Figure 5-10: Photonics – time series of selected EU countries' performance (index-values) in the field of trade



Source: Fraunhofer ISI calculations based on the trade indicators of the technology generation and exploitation approach

In Photonics, there is a small group of leading countries with good performance in all three dimensions: Austria, Germany, the Czech Republic, the Netherlands and the UK. This rather small group of high performing countries indicates that their activities in Photonics might be driven by specialised industrial structures favouring the use of photonic applications. For instance, Germany and -in particular- Italy recently succeeded in revitalising their trade activities. Both countries are important for the manufacturing of high performance machinery of the most modern generation that frequently includes photonics technology. This would imply for innovation policies to focus on the development of new application fields of photonics in industrial manufacturing. Finally, the Czech Republic and Latvia show a strong catching up, although the Czech Republic shows decreasing values since 2011. In production, Sweden shows a strong decline since 2010.

5.7 Advanced Manufacturing Technology

Finally, the composite country rankings for Advanced Manufacturing Technology are in line with expectations with Germany and Italy being among the leaders in all three dimensions of this KET. **Countries like Austria, Sweden, France and the UK are following at a certain distance, still showing a somehow coherent performance across all three dimensions**. However, the picture is a bit different for the Netherlands, which performs less in the field of technology (14), but relatively better in production (1) and trade (1). The latter might also be due to the “harbour effect” of Rotterdam. **Given the high maturity of Advanced Manufacturing Technology and its strong technology bases in some EU countries, the findings again point to some regional specialisation patterns in production and/or trade that could serve a fruitful starting point for both strengthening the technological competences (in already good performing countries) and shaping some regional specialisation patterns.**

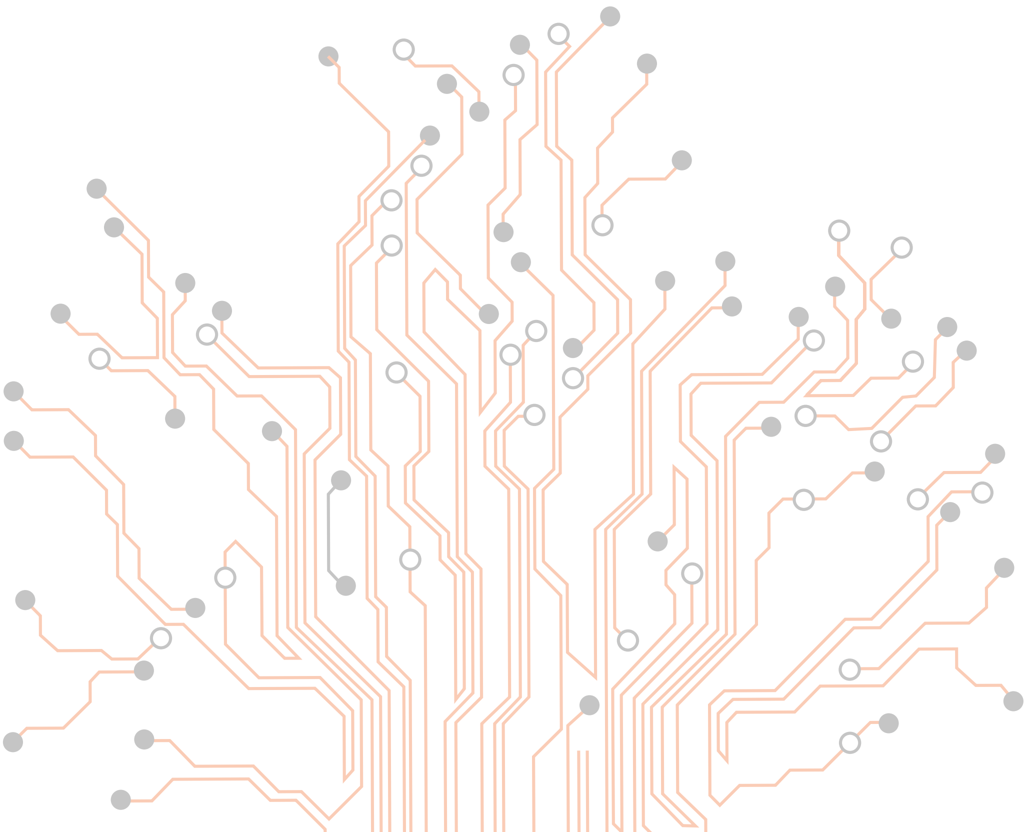


Table 5-6: Country ranking in composite analysis for Advanced Manufacturing Technology

Advanced Manufacturing Technology Country rankings			
Country	Production	Trade	Technology
NL	1	1	14
DE	2	2	1
IT	3	3	4
UK	4	7	6
AT	5	4	3
FI	6	5	10
FR	7	9	2
CZ	8	10	13
SE	9	11	5
ES	10	8	7
SK	11	12	9
PL	12	20	18
EE	13	19	8
RO	14	16	11
BE	15	13	20
HU	16	14	23
PT	17	21	19
LT	18	17	27
IE	19	23	22
HR	20	25	26
BG	21	28	15
LV	22	26	21
LU	23*	18	24
CY	24*	22	28
MT	25*	27	17
DK		6	16
GR		24	25
		15	12

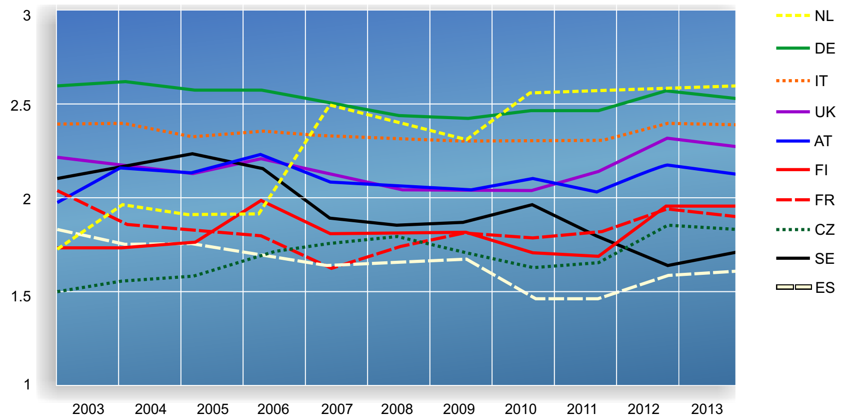
Source: Fraunhofer ISI calculations based on the different indicators of the technology generation and exploitation approach

Table is sorted in descending order by "production"; empty cells = composite could not be calculated due to data confidentiality

* The reported production value for these countries is zero.

The time series analysis of the composite indicator on production widely confirms the previous findings (Figure 5-11). Germany and Italy are maintaining their top-level performance along the whole time span considered, followed by the UK and Austria. Additionally to the rankings before, time series analysis reveals that the Netherlands have managed to increase their production performance since 2007. This underlines that this finding can be considered as a sustainable dynamic. **In the second half of the TOP 10, Spain and Finland show a positive trend in the recent past.**

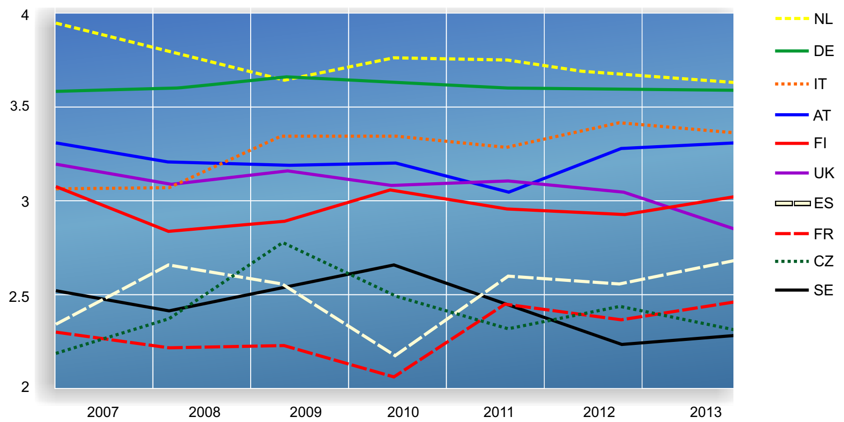
Figure 5-11: Advanced Manufacturing Technology – time series of EU TOP 10 countries' performance (index-values) in the field of production



Source: Fraunhofer ISI calculations based on the production indicators of the technology generation and exploitation approach

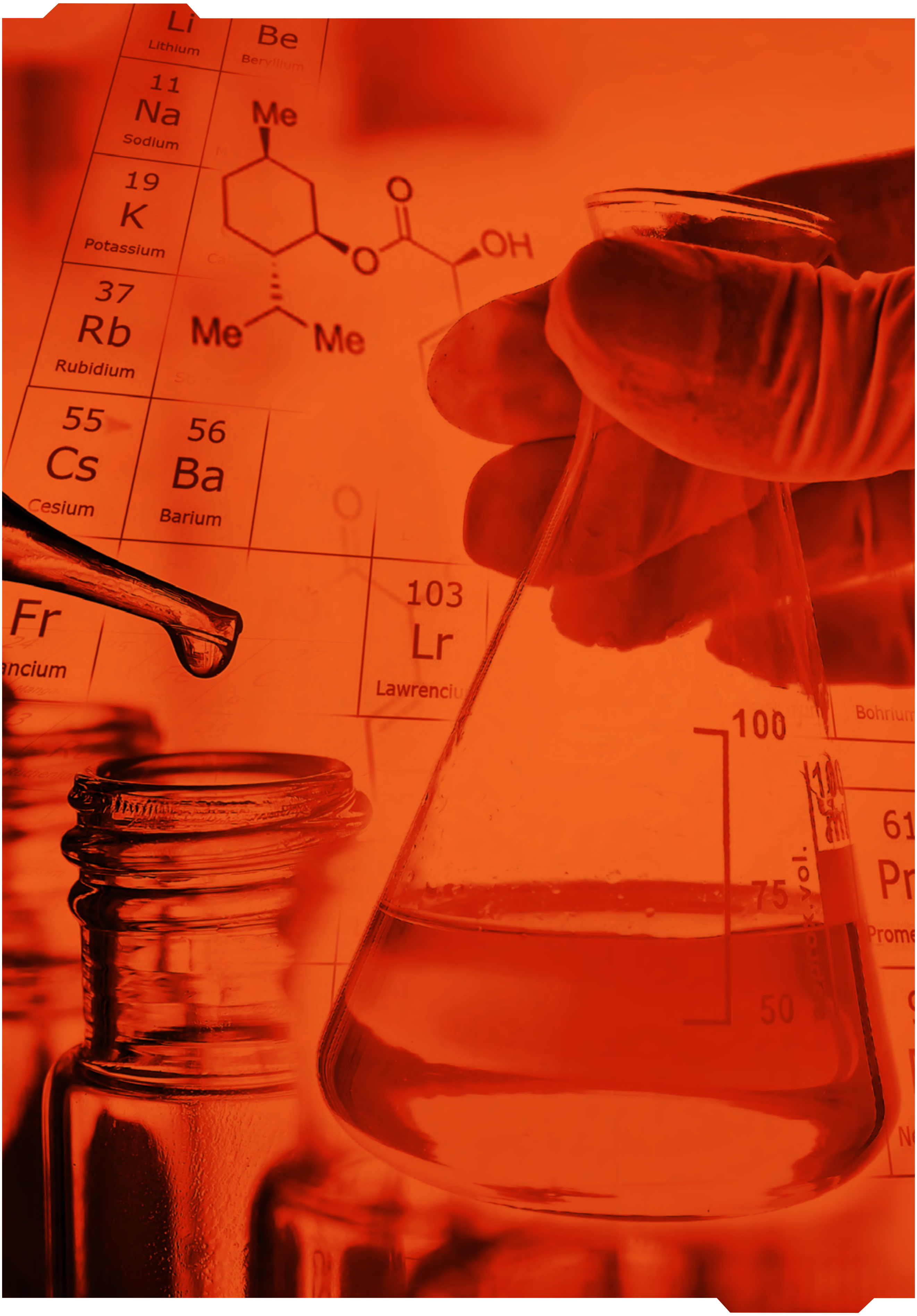
Also the composite analysis on the TOP 10 countries trade performance supports the previous findings (Figure 5-12) with the Netherlands, Germany, Austria, and Italy still being part of the leading group. During the past years, the **UK seems to have lost touch with the leading group**. With Sweden, it is the sole country showing a clear negative dynamic in its trade performance in Advanced Manufacturing Technology. On the contrary, a group of countries (Spain, France, and Belgium) are characterized by a slight, but steady growth in trade performance.

Figure 5-12: Advanced Manufacturing Technology – time series of selected EU countries' performance (index-values) in the field of trade



Source: Fraunhofer ISI calculations based on the trade indicators of the technology generation and exploitation approach

In Advanced Manufacturing Technology, Germany and Italy are among the leaders in all three dimensions (technology, production, trade) of this KET's industrial deployment. Countries like Austria, Sweden, France and the UK are following at a certain distance, still showing a somehow coherent performance across all three dimensions. However, the picture is a bit different for the Netherlands, which performs less in the field of technology, but holds the top position for trade and production. Regarding trade, the UK seems to have lost touch with the leading group. The UK and Sweden are the only countries that show a clear negative dynamic in their trade performance. In order to diffuse Advanced Manufacturing Technology, one could both strengthen the technological competences in already good performing countries as well as shape regional specialisation patterns in low performing countries identified by the KETs Observatory (e.g. Latvia and Bulgaria).


Li
Lithium
Be
11
Na
Sodium
19
K
Potassium
37
Rb
Rubidium
55
Cs
Cesium
56
Ba
Barium
Fr
103
Lr
Me
Me
Me
O
O
OH
100
75
50

6. Conclusions

The KETs Observatory provides EU, national and regional policy makers with information on the deployment of Key Enabling Technologies (KETs) both within the EU-28 and in comparison to other world regions (East Asia and North America). The data allows to compare the performance of countries in relation to the deployment of KETs. This second report focuses on the results of the technology diffusion approach. This approach captures to which extent the EU is using the potential of KETs to improve its competitiveness by manufacturing KETs based products and applying KETs in production processes. This approach covers both sectors that produce KETs and other industries applying KETs to improve their efficiency.

6.1 Absolute KETs enabled employment

Overall, the absolute employment enabled by all six KETs amounted to 3.3 million jobs in 2013 in EU-28 or 11% of all employment depending on manufacturing. The estimated size of KETs related employment is interpreted as employment that is dependent on the production and use of KETs based products. Hence, the employment figures cover direct employment linked to the manufacturing of KETs based products and indirect employment linked to research activities performed in companies, technical services and manufacturing of products strongly dependent on KETs innovation. The employment figures do not cover upstream R&D jobs of service providers and public R&D institutes.

In Europe, the absolute employment enabled by Advanced Manufacturing Technology exceeds 1.6 million people in 2013 (see Figure 6-1), experiencing a decline in 2008- 2009, and an increase from 2010 onwards. Micro- and Nanoelectronics enable an absolute employment of 1.4 million people in 2013. In 2003, this KET represented the highest absolute employment, but it lost its first position to Advanced Manufacturing Technology since 2005. Unlike Advanced Manufacturing Technologies, Micro- and Nanoelectronics enabled employment has not yet reached its pre-crisis level e.g. the absolute KETs enabled employment was associated with 1.44 million people in 2007.

Advanced Materials and Photonics enabled the employment of respectively 976.000 and 760.000 in 2013. Advanced Materials experienced a decline in its enabled employment in the period 2008-2010, while absolute employment started to increase again since 2011. Photonics also saw a decline in 2008-2009, but the growth started again in 2010. Both KETs however, have not yet recovered sufficiently to reach their pre-crisis peak of 2007.

Industrial Biotechnology and Nanotechnology are KETs that are less mature in terms of the potential that has already been realised. Contrary to the other four KETs, Industrial Biotechnology did not experience a decline in its enabled absolute employment as a result of the crisis. It succeeded in continuing to grow in the past decade to reach an absolute enabled employment of 236.000 people. Nanotechnology-enabled employment shows a small decline in 2009, to recover strongly from 2010 onwards. This growth resulted in an enabled absolute employment of 258.000 people.

It is important to note that when adding up the numbers mentioned in the previous paragraphs, one comes to a KETs enabled employment that is larger than the 3.3 million jobs mentioned. This is due to the fact that in compiling the figures for all six KETs, the data is adjusted for double counts. This is important as some KETs based products are linked to several KETs, due to their multi-KET dimension.

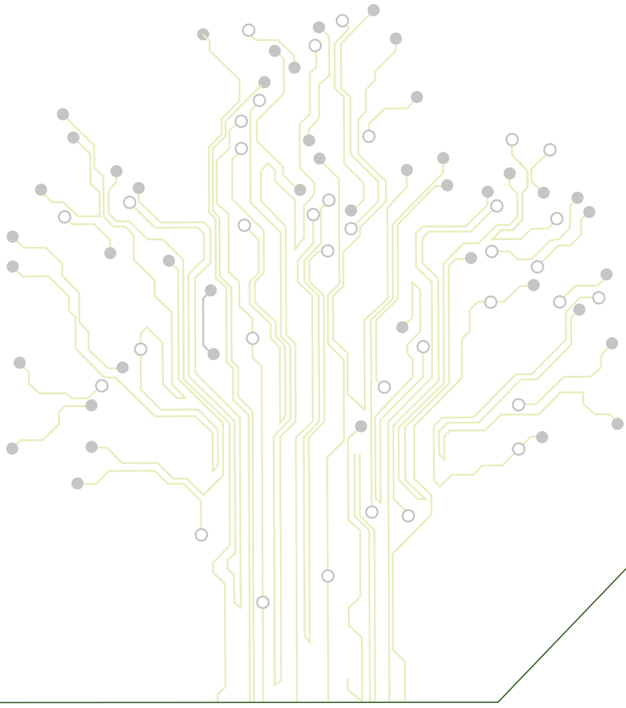
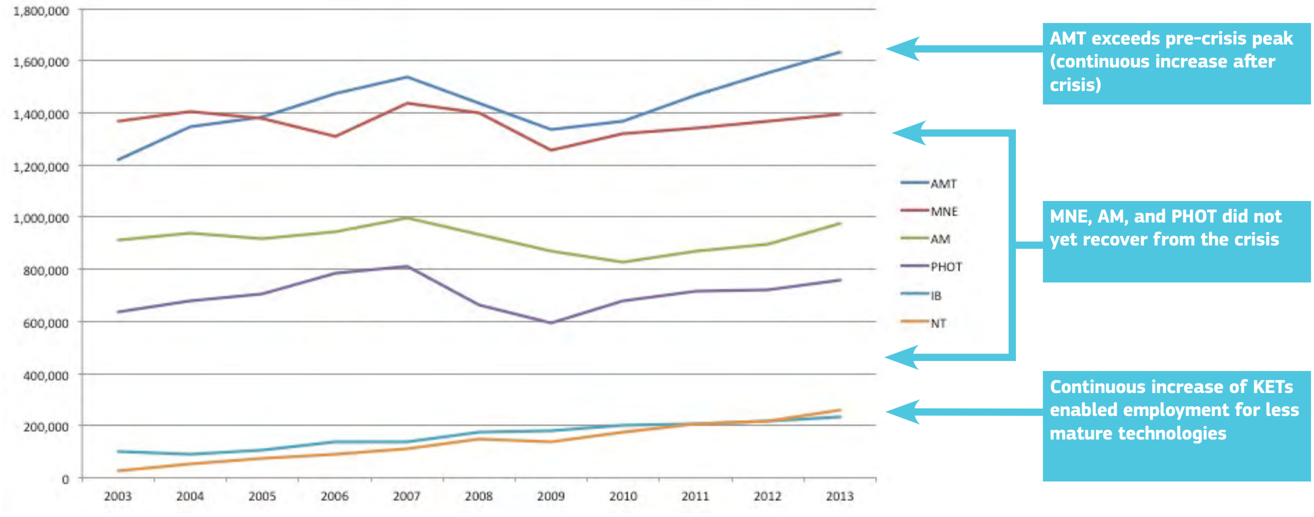


Figure 6-1: Absolute KETs enabled employment in EU-28



Source: PRODCOM database and Eurostat - Fraunhofer ISI calculations

6.2 Absolute KETs enabled production

Absolute KETs enabled production captures the production of goods that are highly dependent on KETs. The absolute production for all EU-28 countries enabled by all six KETs amounted 953.5 billion Euros in 2013 or 19.2% of total EU-28 production.

Figure 6-2 shows an uneven performance across KETs: a dynamic growth for Advanced Manufacturing Technology, Industrial Biotechnology, and Nano-technology-based production; and a modest growth for Micro- and Nanoelectronics, Photonics, Advanced Materials-based production.

Production enabled through Advanced Manufacturing Technologies represents the highest production volume (€561.3 billion in 2013), followed by Micro- and Nanoelectronics (€306.2 billion in 2013), Photonics (€294.2 billion in 2013) and Advanced Materials (€187.4 billion in 2013). As these technologies are more mature and used in many sectors, this translates into a higher production volume. Industrial Biotechnology and Nanotechnology represent a smaller production volume but they show a continuous increase in production volume over the last decade.

In contrast, production enabled through the other three KETs experienced a decline in 2008 and 2009, as a result of the financial crisis. Micro- and Nanoelectronics have still not recovered entirely as the production volume has risen since 2009, but is more or less constant since 2011, staying below the production volume of 2007. As regards Photonics-enabled production, the production volume recovered more easily, leading to an absolute production volume of €294.15 billion in 2013. The recovery in Advanced Materials took a bit longer and reached only in 2013 a similar production volume as in 2007.

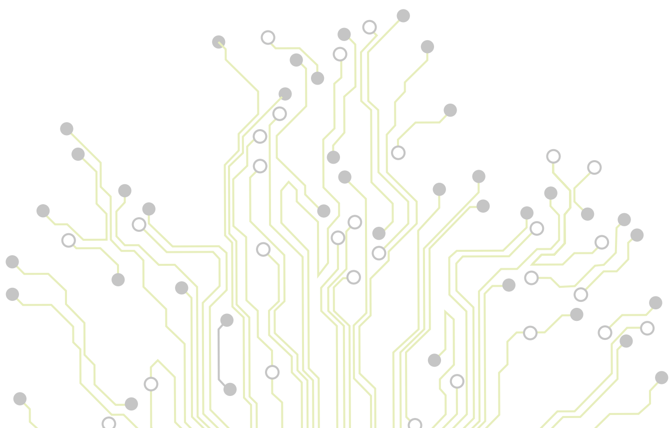
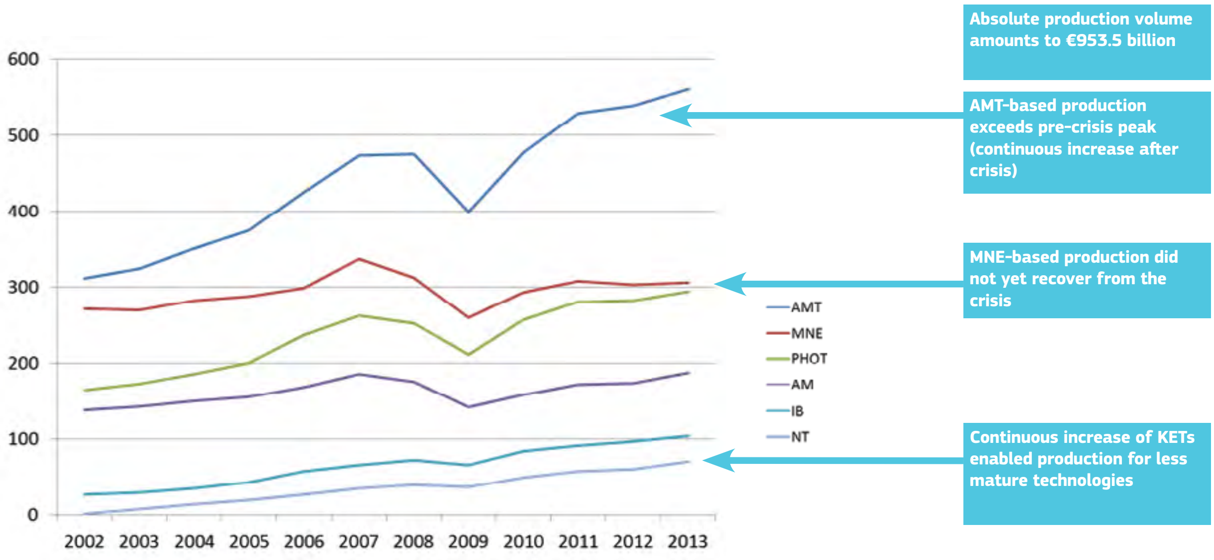


Figure 6-2: Absolute KETs enabled production in EU-28 (in billion Euros)



Source: PRDCOM database and Eurostat – TNO calculation

6.3 Link to smart specialisation

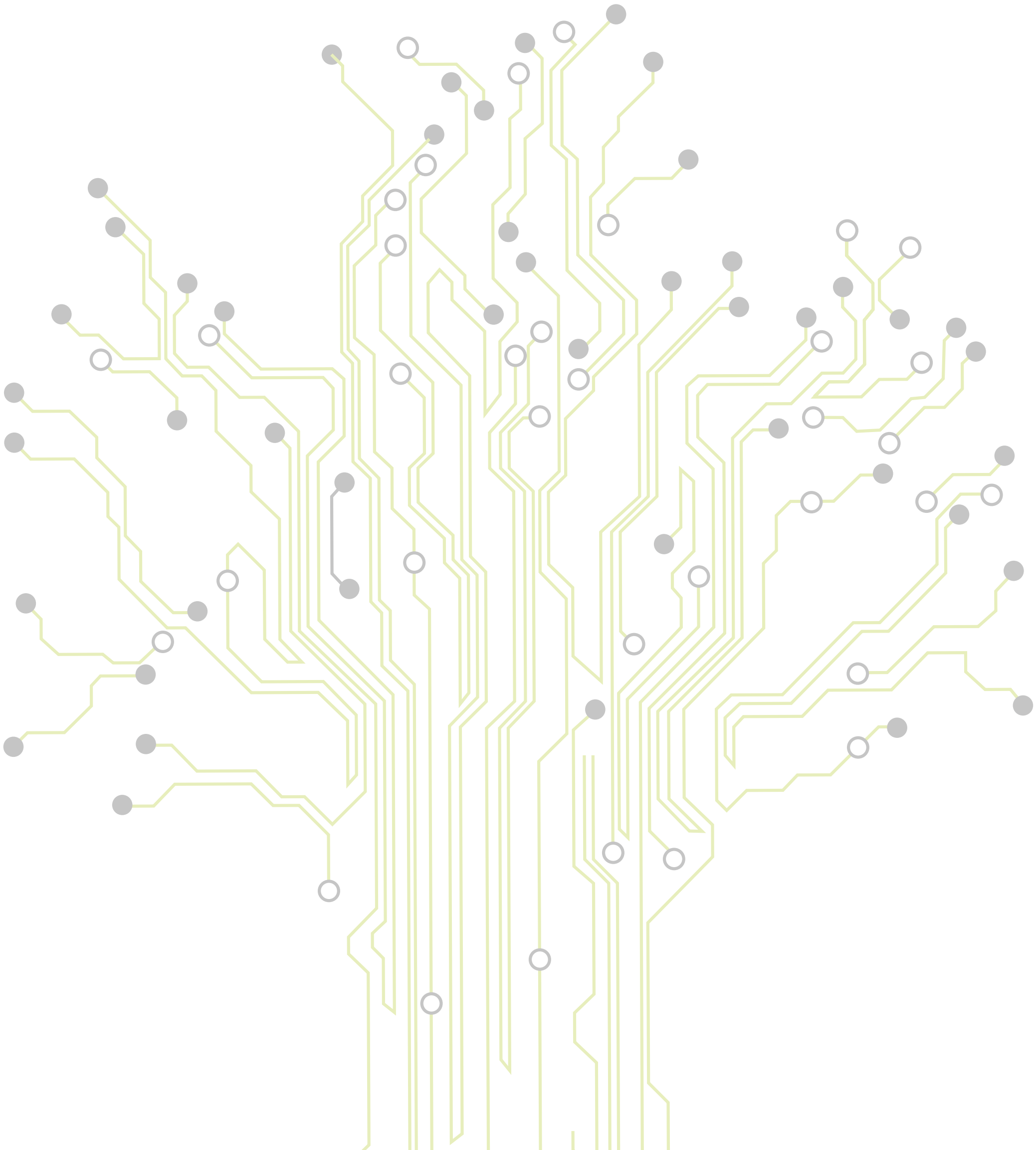
The data of the KETs Observatory provides interesting insights in the performance and specialisation of countries in specific KETs. For drafting smart specialisation strategies, the objective data of the KETs Observatory might help to identify tangible strengths of a region.

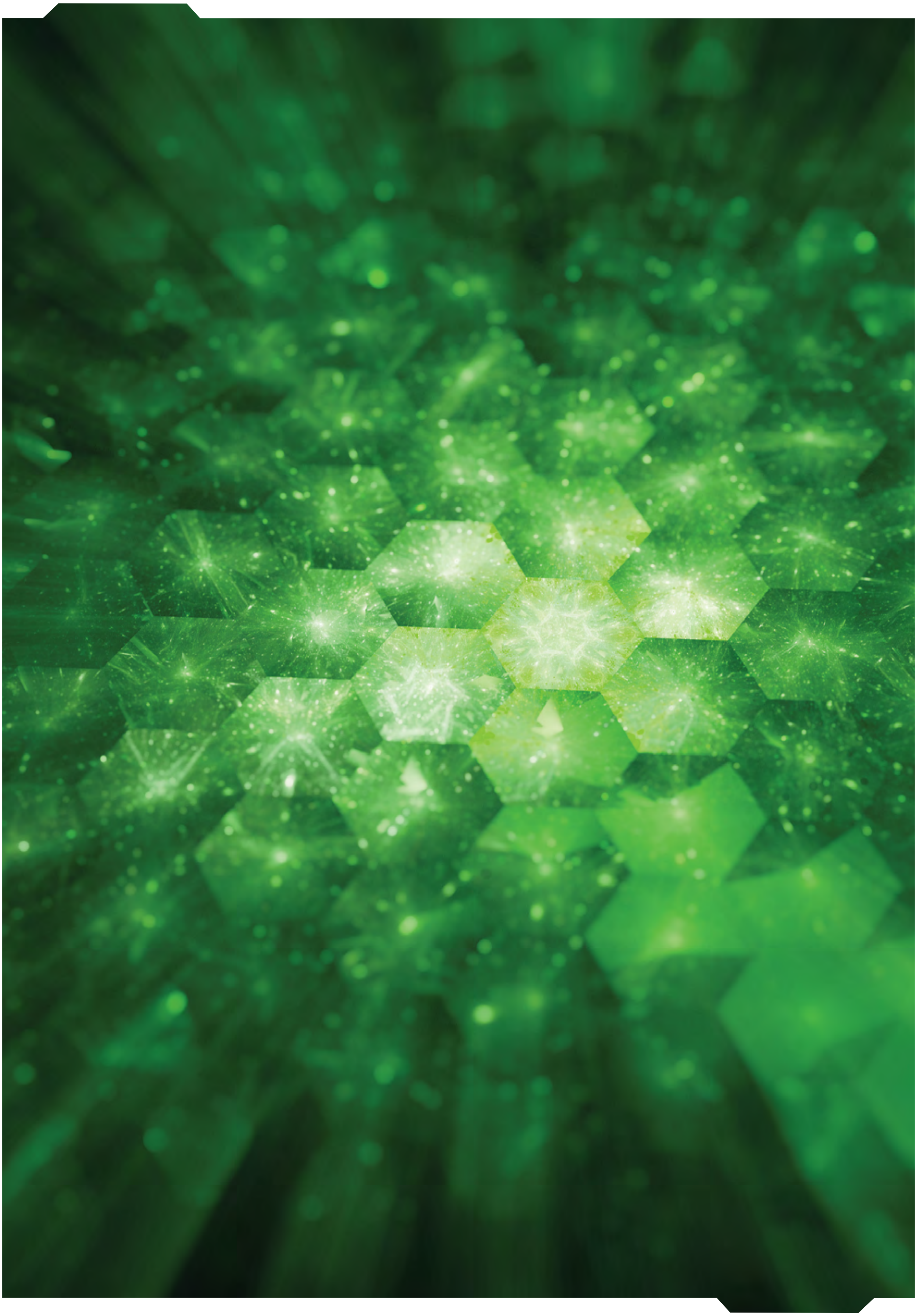
First, the KETs Observatory points out that KETs have in many cases a significant impact on the Member States' economies, which may grow considerably due to further technological diffusion and a potential increase of the competiveness of countries. As KETs are – per definition- "enabling" and form the building blocks of many products, they are important to modernize the industry and to drive regions in their smart specialisation strategies. KETs can foster the innovation of "moderate performing" regions as every region can identify particular niches in the deployment value chain. In this chain, it is not only important to master a technology, but also to encourage the uptake of these technologies – for instance to use it to produce more efficient machine tools. Hence, a region or a Member State can smartly position itself and assess whether its performance is more 'supply-based' (strong community of technology suppliers leading to relatively strong technology performance), 'demand-based' (strong lead-users, integrators of KETs based products or systems) leading to a relatively strong performance in terms of KETs based products), or a combination of both. Clear-cut and comparative evidence provided by the KETs Observatory can help policy-makers in their strategic choices (e.g. reinforcing the science and technology community to keep up with their leading-edge position, attracting specific activities and lead-user companies to link them with the existing ecosystem of technology suppliers).

Second, the KETs Observatory highlights the specialisation and performance of a country in a certain KET over time. Time-series are available, providing policy analysts with clear-cut evidence on trends such as a growth in patented inventions in the field of Advanced Materials, an increase in trade performance in Nanotechnology, a decline in production of Photonics, etc. **This information may help policy makers to check whether the drawn assumptions of particular strengths of a country when working out smart specialisation strategies and setting priorities can be verified by objective data.**

Third, the KETs Observatory entails **information on the position and specialisation of a country in the innovation and value chain**. The composite indicators show that some countries perform well in production, but not in trade or technology. This might be explained by the fact that these countries possess production capacities for some parts of the value chain, but lack capabilities in other parts. For example, in Advanced Materials, some countries are specialised on early technology development (e.g. France, Austria, and the Netherlands), while others take up this technology knowledge and implement it along their industrial value chains (e.g. Hungary, Ireland). In order to deploy KETs in industrial applications on an EU-wide scale, innovation policies could strengthen leading countries in their performance and support emerging countries in developing activities to complement cross-country KETs value chains, hereby leading to the establishment of EU-wide specialisation patterns.

In conclusion, the KETs Observatory provides useful indications for which KETs and stages in the deployment value chain a country performs well and what kind of overall policy approach may be concluded (e.g. foster cross-border collaboration, support for certain domestic activities in innovation and value chains). The KETs Observatory and its detailed data are a strong complement to regional and national strategies' development as the worldwide scope of the KETs Observatory allows for a unique comparison and positioning. Combined with other sources of information such as the JRC smart specialisation platform (which contains useful information on the Member States and regions' innovation priorities), it presents an important complementary database for informed decision making with regard to smart specialisation strategies.





7. Appendix I: Methodological background

7.1 Introduction

This section contains a description of the methodologies used to collect data on production, demand and employment indicators. It describes the methodologies in a comprehensive way. More detailed information on the methodology applied can be found in the methodology report that is published on the KETs Observatory website. The methodologies developed in this project are the result of extensive consultations with a diversity of technological, statistical and business experts. Several workshops have been organised to consult these experts. The consortium has worked hard to formulate a robust methodology to measure the deployment of KETs. Retrieving KETs-specific data from existing databases is not straightforward as each database has its own rationale and the PRODCOM database does not differentiate between different KET technologies. Eurostat provided substantial support to collect and interpret the data.

The objective of this study is to come up with indicators to compare the performance of countries with regard to specific KETs. In addition, the technology diffusion approach also provides absolute number on production and employment.

7.2 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 7-1). While the technology generation and exploitation approach looks at the ability of countries to generate and commercialise 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 commercialise internationally competitive products based on new technological knowledge. Here, export shares or specialisation 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-enabled employment.

Figure 7-1 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 7-1: 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 commercialising new technology. While technology indicators report the production of new technology, production and trade indicators help to identify the extent of successful commercialisation 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 commercialised 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 Harmonised 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.

- **Production and demand data** is calculated based on the Eurostat Prodcom statistics and International trade statistics. The Prodcom 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 7-1). 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 7-1).

- **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), using Eurostat Structural Business Statistics.

[36] Depending on the availability of appropriate data.
[37] A European strategy for Key Enabling Technologies – A bridge to growth and jobs, European Commission, COM (2012
[38] Note that only (a) and (b) are selective criteria for the selection of KETs based Prodcom entries.

The KETs Observatory covers the following countries[36]:

- 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 Prodcom database only contains data for EU-28, Iceland and Norway, hence no production data is available for non-EU countries. For production data, some data is confidential and therefore not included in the analyses. Appendix II provides an overview of the data availability. The KETs Observatory project covers European data for production, demand and employment indicators.

The second report focuses on the technology diffusion approach while the first report discussed the results of the technology generation and exploitation approach.

7.3 Indicators of the technology diffusion approach

This report contains a concise overview of the methodology applied in the KETs Observatory for the technology diffusion approach. More detailed information on this approach or the technology generation and exploitation approach can be found in the methodology report that is published on the KETs Observatory website. The KETs Observatory works with four production and employment indicators; and with six demand indicators to monitor EU-28 performance and measure the value created by the deployment of KETs.

Four indicators are available for production and employment: (1) country significance (i.e. how important a certain KET is in a country's total production activity, demand and employment), (2) share of production, share in demand or share in employment (i.e. how important a country is for European production activity, demand and employment in the relevant KET), (3) medium-term dynamics (i.e. how KETs activities have changed over the past decade), and (4) KET specialisation, indicating the relative significance of a particular KET. The second indicator is discussed in this report. All other indicators are available on the website.

In addition, demand indicators also cover the import and export quotient of a country per KET. The first indicator informs about the global import per country per KET at a certain time, while the second indicator informs about the global export per country per KET at a certain time.

7.4 Methodology for production and demand indicators

This section discusses the methodology for the production and demand indicators. It details the conceptual approach of selecting KETs-relevant Prodcom codes for the technology diffusion approach. More detailed information can be found in the methodology report.

7.4.1 Identification of relevant Prodcom entries

In order to link KETs to statistics, we adopt the concept of a KETs based product as introduced by the EC[37](see Box 2).

Box 2: KETs based product

In its 2012 communication, the EC defines a KETs based products as (EC, 2012a)[38]:
(a) an enabling product for the development of goods and services enhancing their overall commercial and social value;
(b) induced by constituent parts that are based on nanotechnology, micro-nanoelectronics, industrial biotechnology, advanced materials and/or photonics;
and, but not limited to
(c) produced by advanced manufacturing technologies.

This definition does not suffice as a tool to consistently include or exclude KETs based Prodcom entries, and subsequently weight them. The approach for the selection of relevant Prodcom entries has therefore been extended (in line with the definition of Box 2), distinguishing between three different types of KETs based products, such that a uniform and practical approach for the selection of relevant Prodcom entries is created (see Table 7-1)[39]. This categorization subsequently has been used to identify relevant Prodcom entries by the experts.

Table 7-1: Categorisation of KETs based products

Category 1:	**Products in which a KET is deployed that enables their functionality (i.e. a product "with a KET in it")**
Category 2:	**Products that are produced by deploying a KET in the manufacturing stage. (i.e. a product manufactured with a KET).**
Category 3:	**Production equipment that deploys a KET (i.e. production equipment "with a KET in it"): In practice this implies that this category covers AMT equipment.**

7.4.2 Assessment of the value created by the deployment of KETs for the selected Prodcom entries.

Assessing the contribution of a technology to the value of production, import or export of a product is not straightforward. Hence, KETs experts were asked to assess the contribution of the deployment of a KET to the competitiveness of a selected Prodcom code. Prodcom entries are subsequently scored with the help of a semi-qualitative scale. The corresponding quantified scores are than used in a later stage to calculate the share of the production value of a Prodcom entry resulting from deployment of KETs.

Scoring contribution to the increase in competitiveness as a measure to estimate value creation might seem like a laborious and time-consuming approach. But the starting point of the KETs strategy is that it is crucial for EU economic growth. The deployment of KETs is subsequently about enabling innovation and increasing competitiveness. The methodology therefore refers to the increase in competitiveness as it addresses (i.e. captures) the innovative capacity / aspects of KETs.

In the technology diffusion approach, we look at the contribution of a KET to the increase in competitiveness as a measure to estimate value creation. The list of relevant Prodcom codes for each KET was established in the following way:

- For each KET, a demarcation of the individual KETs took place[40].
- Next, a pre-selection of relevant Prodcom codes per KET was made by TNO experts.
- KETs experts were identified from Fraunhofer, CEA and TNO
- The KETs experts assessed the pre-selection of Prodcom entries and the impact of the deployment of the different KETs not only for the current situation (i.e. 2012) but also with respect to the situation 10 years ago (i.e. 2002).
- Two workshops were organised with these KETs experts to consolidate the input resulting from the preparatory work.

7.4.3 Production and demand data

The production data is taken from the Prodcom database of Eurostat, in close collaboration with Eurostat. Eurostat has organised a consultation round with Member States experts to make production data available. As a result, almost all production data is available per KET per country, with only a few exceptions (see Appendix II).

[39] We refer to products (including components and end-products) as most of the value created / added by KETs will take place in the end user product stage (actual deployment). We include all these different types of KETs based products because some KETs are more process related than others (specifically IB, and to a lesser extent AM). With these KETs, the innovative element is not so much in the end-product, but rather in the equipment or the process to manufacture this product. Taking only the first category into account would exclude relevant Prodcom entries, and ultimately lead to a wrong estimation of the value created by the deployment of KETs.

[40] See Appendix II: KETs taxonomy in the methodology report

Prodcom provides statistics on the production of manufactured goods and is updated annually. For the KETs Observatory, production data for the period 2002-2013 is considered. The database covers EU-28, 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. We have taken the 2009 classification of Prodcom as a reference year. As the PRODCOM entries are subject to change over time, the selected codes and corresponding weighting factors as defined by the experts, are valid just for the year 2009 itself. For the computation of the weighting factors for the whole period of our analysis, the 2009 codes were subsequently converted using coding details from linkage tables, which are available from the EU Ramon database.

Demand is calculated as production minus export plus import. The data for the production, import and export values have been calculated and provided by Eurostat. Demand, as defined within our framework, results sometimes in negative values. This is not caused by our methodology but is a known problem within the framework of economic analysis. Basis for this is twofold:

1) Production, import and export value are provided by different sources (manufacturers and customs authorities). It is subsequently possible that a product is clustered in different Prodcom entries for manufacturing and import/ export.

2) Especially for smaller countries with limited manufacturing capacity, but large harbour facilities, demand tends to be negative for specific product groups that are widely traded. The large transit of goods involving limited but significant adding of value (such as repackaging) results in a positive trade balance (i.e. export value exceeds import value). Combined with limited domestic production, this results in negative demand for these specific goods.

7.5 Methodology for employment indicators

This section gives a short overview of the methodology developed for the employment indicators. More detailed information can be found in the methodology report.

7.5.1 Defining KETs-enabled firm employment

In order to calculate the employment effects, we use the production data of the technology diffusion approach (see previous section) and multiply it 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 calculating an average of the values of the respective sectors of a KET using the Eurostat Structural Business Statistics. More precisely, the related NACE sectors to the PRODCOM codes are identified on a 4-digit level and the employment per Euro of gross output is estimated for each relevant sector. As the PRODCOM codes belong to many different sectors, we only use data from those sectors, which produce at least 5% of the European production value in the specific KET in the EU-28. Hence, we take the following approach:

a. First, the related NACE sectors on a 4-digit level of the PRODCOM codes are identified. As the Prodcom codes belong to many different sectors, we only use data from those sectors, which produce at least 5% of the European production value in the KET in the EU-28.

b. Where possible, the remaining few data missing are filled by data imputation using the values or time trends for the respective countries in other years or in case of missing data for a few sectors in a country for a KET, we use the average of the EU-28 for the sector.

c. We estimate an average for this indicator for a KET in a certain country and year by taking the weight of the respective PRODCOM codes of a KET according to the production data for the EU-28 for the year 2013. These assumptions for weights can be justified as no meaningful weights for countries are available and the variation of the weights over time can be assumed as modest. As some deviations between the sum for the single EU-countries and EU-28 total arise because of missing imputations and weights of sub-sectors, we use a correction factor, if the countries sum exceeds the EU-28 total.

7.5.2 Employment data

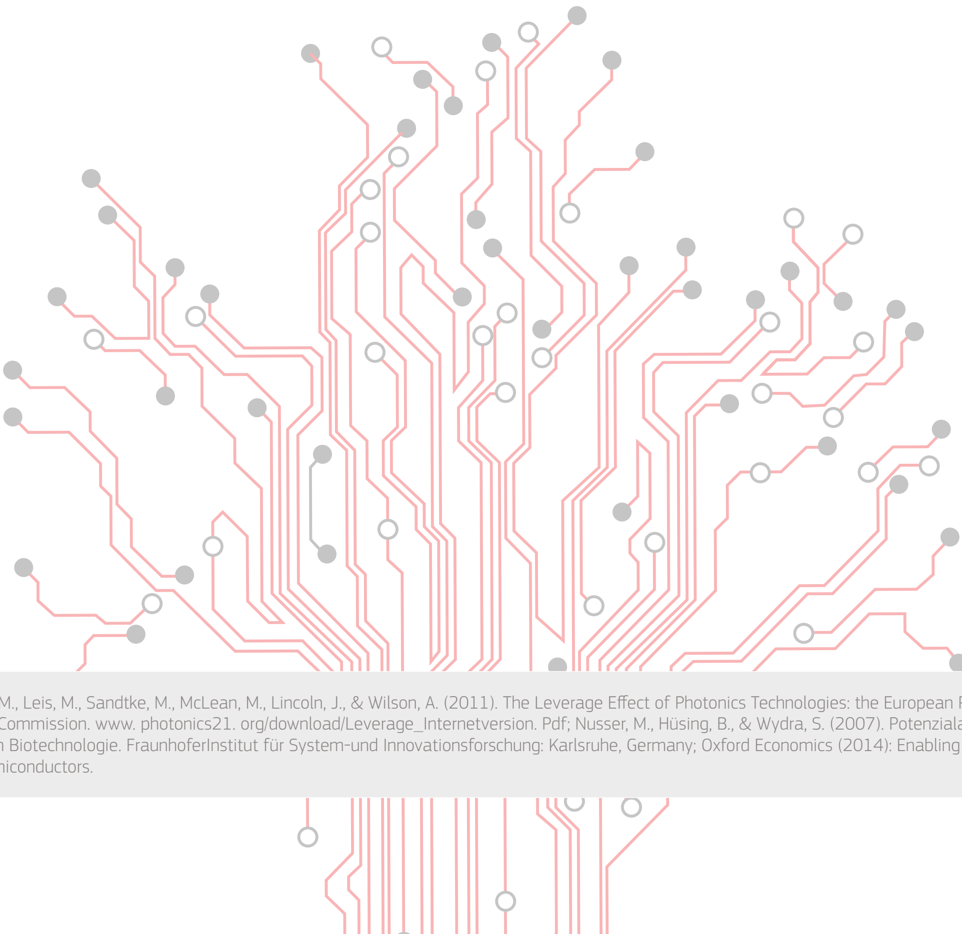
As stated in the previous section, production data is taken from the Prodcom database of Eurostat. The employment per Euro of gross output for a KET is taken from the Eurostat Structural Business Statistics. As the Prodcom database only covers EU-28, no employment data of non-European countries is available. For the KETs Observatory, the time period 2003-2013 is considered.

In general, it can be observed that the employment per production value usually does not dominate the results, but the respective production data does. The differences between countries and the variations over time in production data usually exceed the differences and developments in productivity.

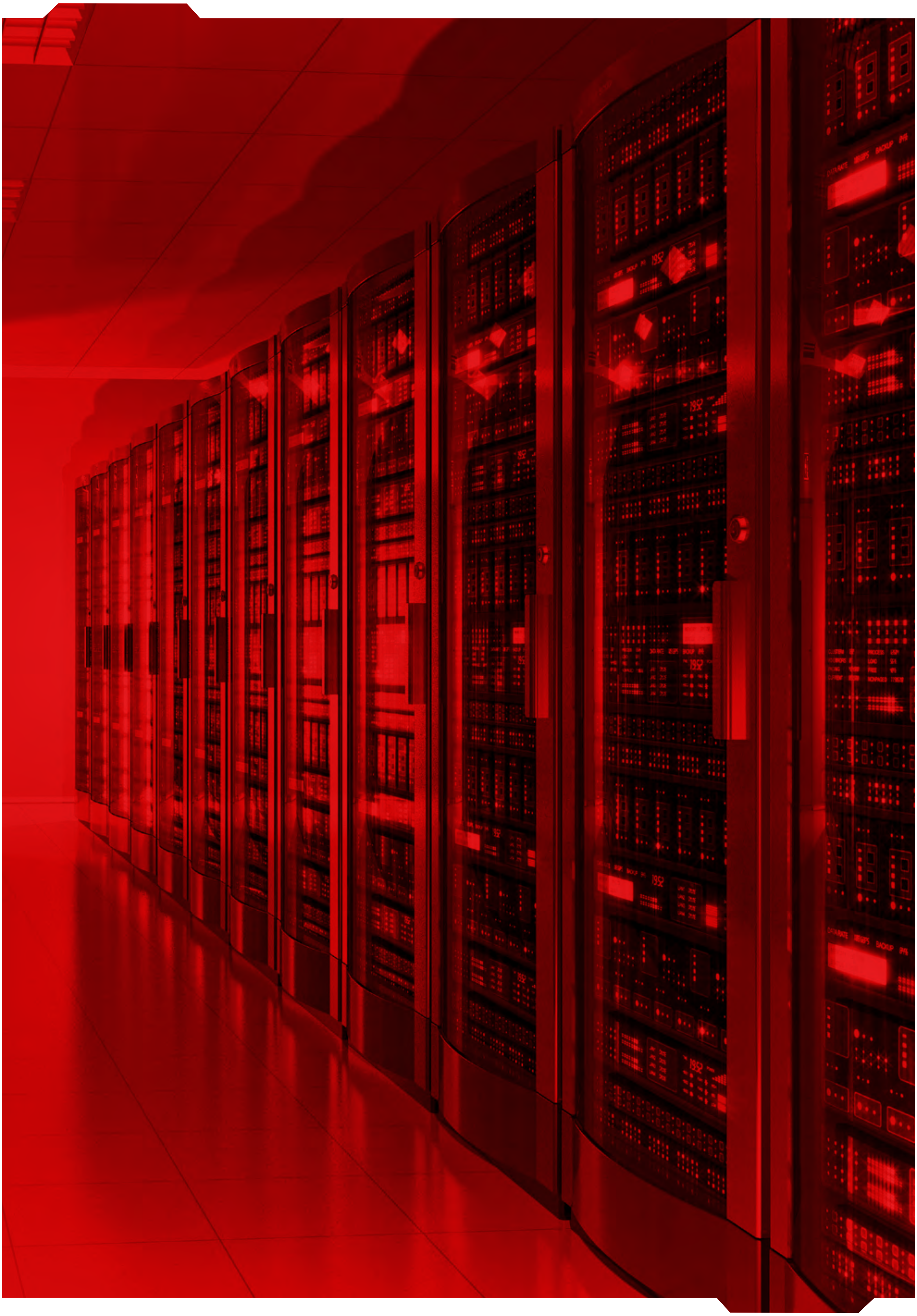
There is no standard methodology to include downstream effects of technologies in user industries. In the past, there have been different attempts with varying methodologies and results to capture those effects of various KETs for production or employment (e.g. Oxford Economics 2014 for semiconductors, Nusser et al. 2007 for industrial biotechnology; Butter et al. 2011 for photonics). An important methodological difference to the mentioned studies is that in the KETs Observatory, expert opinions for the attribution of effects are integrated on a highly detailed level. This approach should (in principle) be more accurate than estimations for whole (sub-) industries. It tends to lead to lower results compared to expert judgments for sub- industries, as the experts usually tend to overestimate the impact on a higher aggregation level, as they don't have all different products of a sector in mind and hence tend to neglect those products, which are hardly affected by those technologies.

In interpreting the employment indicators, it is important to keep in mind that the related Prodcom lists is looking at products that rely, at least to some extent, on the use of KETs, i.e. innovations in one of the six technology areas considered as key enablers for manufacturing. The list incorporates substantial KETs-related innovations even though not all single products belonging to these individual codes can be considered to be innovative. The resulting employment indicators should be interpreted more as employment enabled by the production or use of KETs based products (including for instance production equipment that deploys a KET.

Moreover, as we take the inverse of productivity for whole industries as a multiplier, we principally include all different employees' occupations in an industry, from R&D to production or sales. However, we do not cover employment from activities from firms, which do not perform any production in a country and i.e. firms that performs solely R&D or other services. This is because those firms are attributed to other NACE codes in the respective country.



[41] References: Butter, M., Leis, M., Sandtke, M., McLean, M., Lincoln, J., & Wilson, A. (2011). The Leverage Effect of Photonics Technologies: the European Perspective‹. Brussels: European Commission. www. photonics21. org/download/Leverage_Internetversion. Pdf; Nusser, M., Hüsing, B., & Wydra, S. (2007). Potenzialanalyse der industriellen, weißen Biotechnologie. FraunhoferInstitut für System-und Innovationsforschung: Karlsruhe, Germany; Oxford Economics (2014): Enabling the Hyperconnected Age: The role of semiconductors.



8. Appendix II: Data availability for production indicators

Figure 8-1: Data availability for production indicators for the technology diffusion approach for 2013

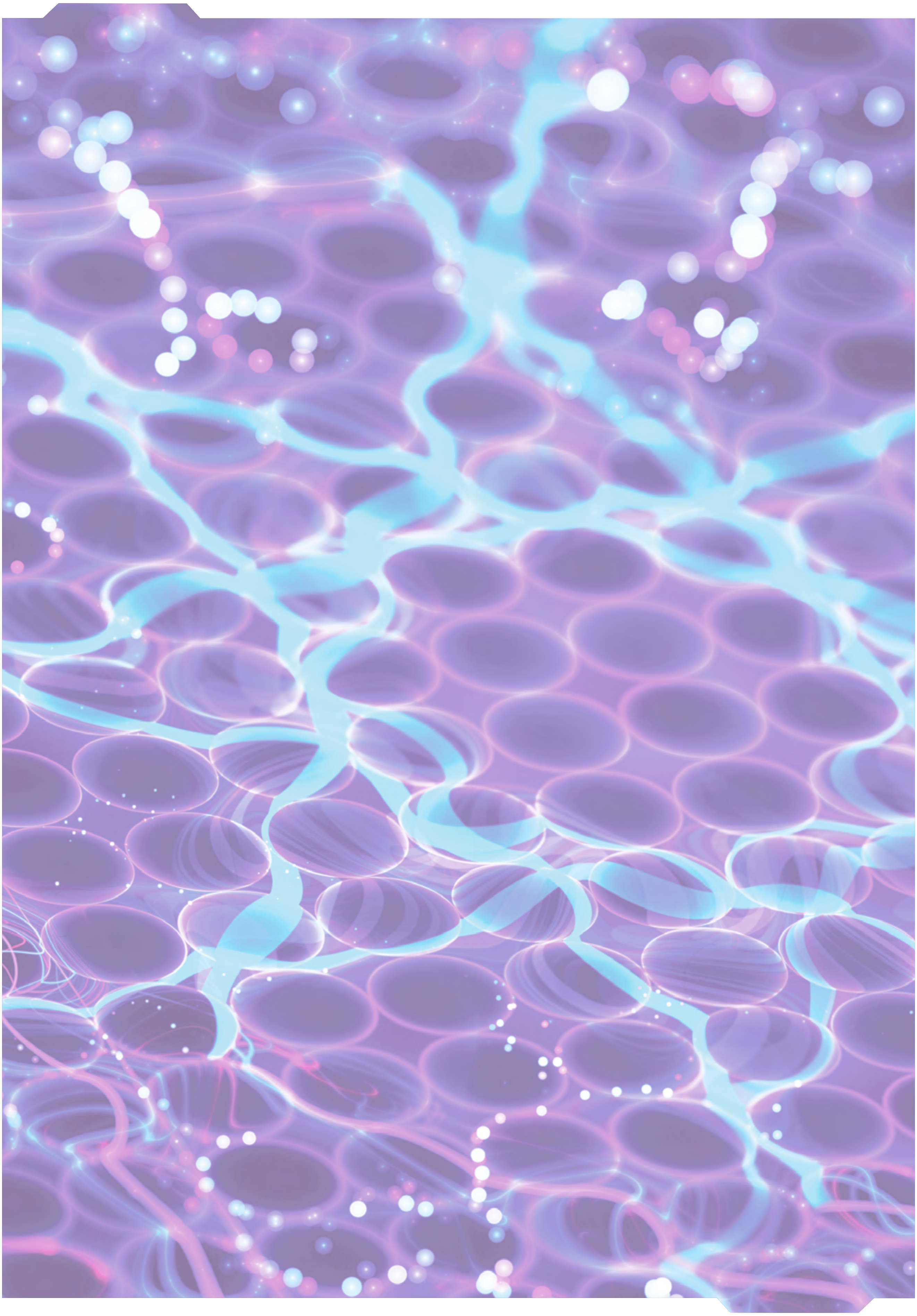
Country	Advanced Materials	Nano-technology	Micro- and Nano-electronics	Industrial Bio technology	Photonics	Advanced Manufacturing Technology
AT	A	A	A	A	A	A
BE	A	A	A	A	A	A
BG	A	A	A	A	A	A
CY	0	0	0	0	0	0
CZ	A	A	A	A	A	A
DE	A	A	A	A	A	A
DK	C	A	A	C	A	A
EE	A	A	A	A	A	A
ES	A	A	A	A	A	A
FI	A	A	A	A	A	A
FR	A	A	A	A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

A: data is available

C: data is confidential

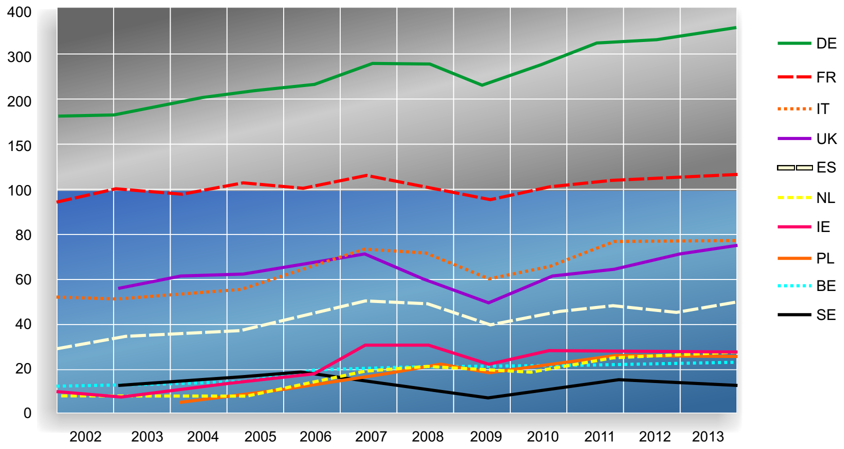
0: zero production is recorded for Cyprus, Luxembourg, and Malta as according to the terms of the PRODCOM Regulation, these countries are exempted from reporting PRODCOM data to Eurostat.

Source: Prodcom -Database. – Eurostat calculation.



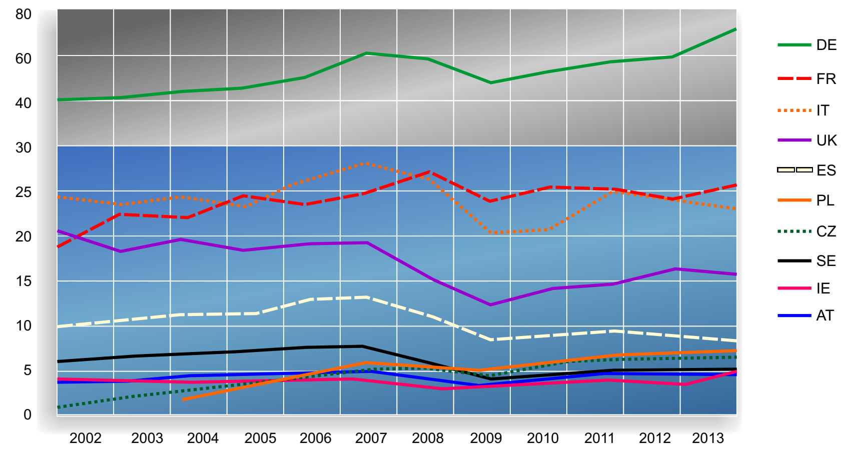
9. Appendix III: Absolute KETs enabled production figures

Figure 9-1: Absolute KETs enabled production for the TOP 10 EU-28 countries in all six KETs (in billion Euros)



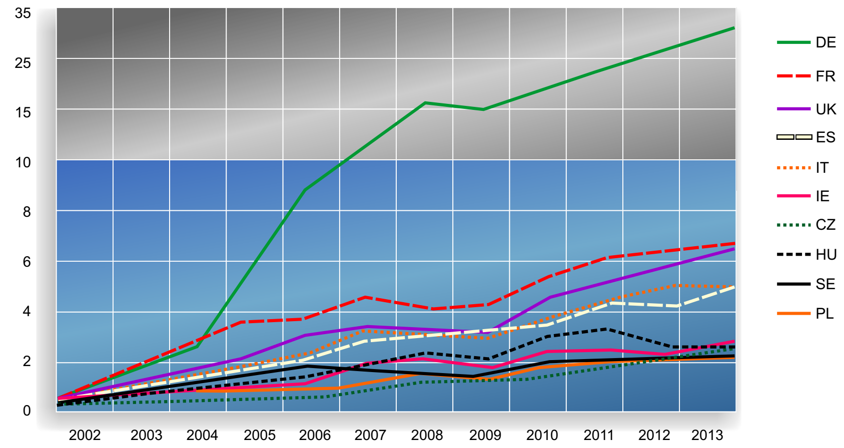
Source: PRODCOM database and Eurostat – TNO calculation

Figure 9-2: KETs enabled production for the TOP 10 EU-28 countries in Advanced Materials (in billion Euros



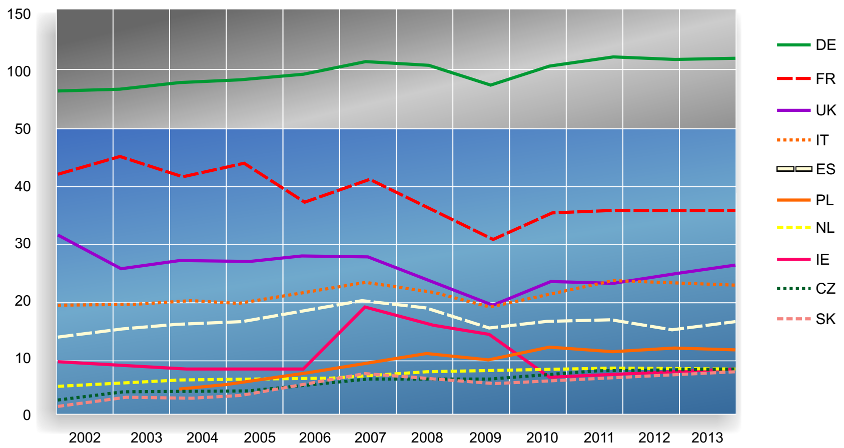
Source: PRODCOM database and Eurostat – TNO calculation

Figure 9-3: Absolute KETs enabled production for the TOP 10 EU-28 countries in Nanotechnology (in billion Euros)



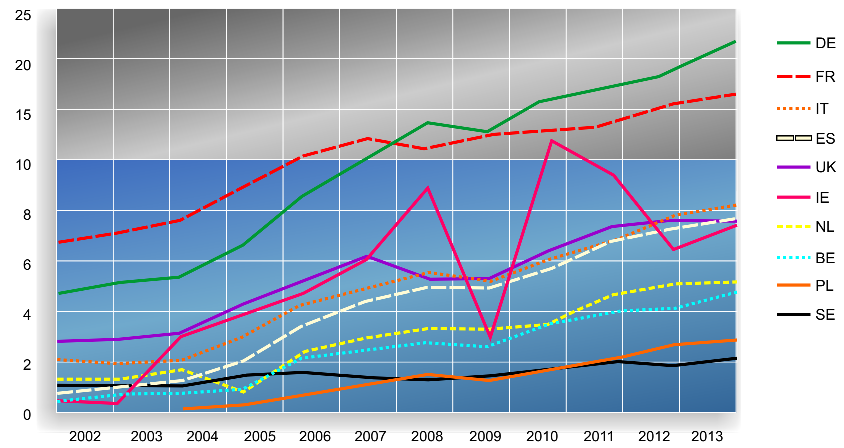
Source: PRODCOM database and Eurostat – TNO calculation

Figure 9-4: Absolute KETs enabled production for the TOP 10 EU-28 countries in Micro- and Nanoelectronics (in billion Euros)



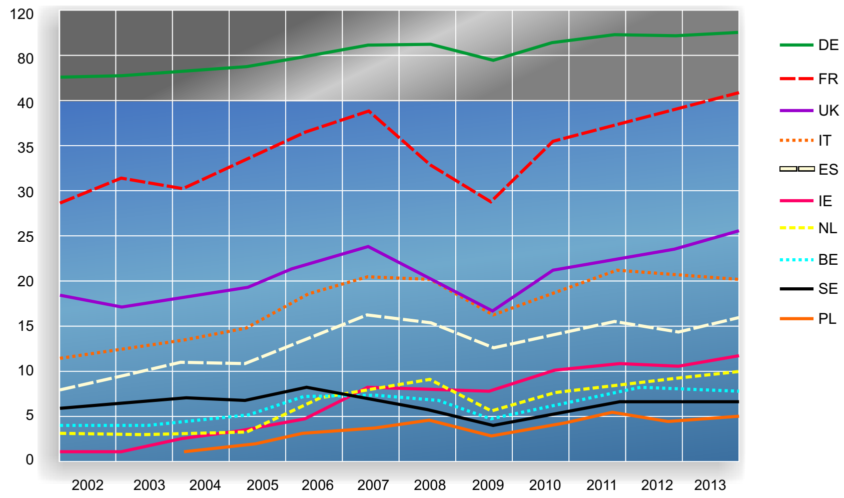
Source: PRODCOM database and Eurostat – TNO calculation

Figure 9-5: Absolute KETs enabled production for the TOP 10 EU-28 countries in Industrial Biotechnology (in billion Euros)



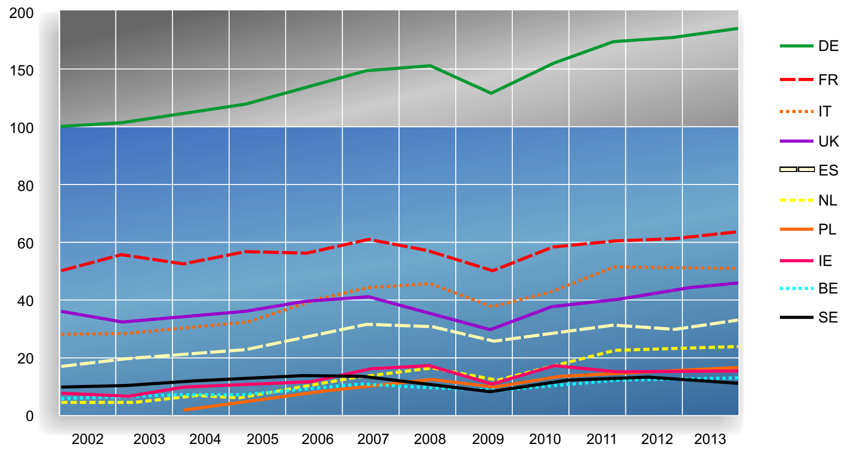
Source: PRODCOM database and Eurostat – TNO calculation

Figure 9-6: Absolute KETs enabled production for the TOP 10 EU-28 countries in Photonics (in billion Euros)



Source: PRODCOM database and Eurostat – TNO calculation

Figure 9-7: Absolute KETs enabled production for the TOP 10 EU-28 countries in Advanced Manufacturing Technology (in billion Euros)



Source: PRODCOM database and Eurostat – TNO calculation