**COUNCIL OF
THE EUROPEAN UNION**

**Brussels, 24 September 2013
(OR. en)**

**13966/13
ADD 4**

**IND 258
COMPET 673
RECH 416
ESPACE 67
TRANS 487
ENER 427
REGIO 207
ECOFIN 820
MI 793
EDUC 355
TELECOM 242**

COVER NOTE

From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	24 September 2013
To:	Mr Uwe CORSEPIUS, Secretary-General of the Council of the European Union
No. Cion doc.:	SWD(2013) 347 final Volume part 5/5
Subject:	COMMISSION STAFF WORKING DOCUMENT European Competitiveness Report 2013 : Towards knowledge driven reindustrialisation

Delegations will find attached document SWD(2013) 347 final Volume part 5/5.

Encl.: SWD(2013) 347 final Volume part 5/5

EUROPEAN
COMMISSION

Brussels, 23.9.2013
SWD(2013) 347 final

Volume part 5/5

COMMISSION STAFF WORKING DOCUMENT

European Competitiveness Report 2013 : Towards knowledge driven reindustrialisation

Contents

ANNEX 3
METHODOLOGY

Decomposition of manufacturing R&D intensity

The results for the decomposition of R&D intensities in **Error! Reference source not found.**4.6 are derived followings the approach of Eaton et al. (1998). The decomposition approach takes the following form:

$$R\&D_c^m - R\&D_w^m = \sum_i (va_{i,c} - va_{i,w}) \cdot R\&D_{i,w} + \sum_i (R\&D_{i,c} - R\&D_{i,w}) \cdot va_{i,w} + \sum_i (va_{i,c} - va_{i,w}) \cdot (R\&D_{i,c} - R\&D_{i,w})$$

where $R\&D^m$ denotes R&D intensity in the manufacturing sector and $R\&D_i$ denotes R&D intensity in industry *i*. Subscript *c* denotes countries and subscript *w* denotes the global average which for this purpose is the average of Finland, France, Germany, United Kingdom, Austria, Belgium and the Netherlands as well as the United States and Japan, i.e. the nine countries included in the decomposition exercise. The valued added shares of manufacturing are denoted by va.

Therefore the first term represents the composition effect, i.e. the differences in industry specialisation across countries and the second term captures the differences in the industry level R&D intensities. The last term is an interaction term between those two which has no particular economic interpretation.

Calculation of value added exports

The concept of value added exports used throughout this Report is that of Johnson and Noguera (2012). The value added exports approach requires global input-output data. In this chapter the world input-output database (WIOD) is used for this purpose. The WIOD contains information on 40 countries plus the rest of the world (ROW) for 35 industries. The global input-output table in the WIOD that summarises the inter-industry linkages is therefore of dimension 1435 x 1435.

The starting point for calculating value added exports (VAX) is the basic input-output identity

$$q = (I - A)^{-1} \cdot f$$

where q denotes a vector of gross output for each country and industry (i.e. of dimension 1435x1), A is a matrix of intermediate inputs per unit of gross output (of dimension 1435x1435) and f is a vector of final demand by country and sector and therefore again of dimension (1435x1). A final product, e.g. a car, is made of many other parts produced in other industries maybe even in other countries.

The calculation of VAX consists of decomposing the output vector *q* of each country *r* in $(q^{1,r} \quad q^{2,r} \quad \cdots \quad q^{N,r})'(q^{1,r} \quad q^{2,r} \quad \cdots \quad q^{N,r})'$ where $q^{1,r}$ denotes the output absorbed in country *r* that was sourced from partner country 1 and likewise for the other partner countries. The elements of *q* are also referred to as output transfers. These output transfers are in turn used to calculate the value added produced in a source country *i* and absorbed in another country *r* which constitutes the bilateral value-added exports *($VAX_{i,r}$)*.

Bilateral value added exports are defined as $VAX_{i,r} = \frac{VA_i}{q_i} \cdot q_{ir}$,$VAX_{i,r} = \frac{VA_i}{q_i} \cdot q_{ir}$ where $\frac{VA_i}{q_i}$ is the ratio of value added to gross output in country *i* and q_{jr} is the output produced in country *i* that is absorbed in *r* (see Johnson and Noguera, 2012). The global value-added exports of country *r* (VAX_r) are obtained by summing up the bilateral value added exports for all partner countries. The market share of each country in global value added exports used in the text is then simply $\frac{VAX_r}{\sum VAX_r} \cdot 100$.

Quantitative analysis of State aid

Section 4.13 uses three types of approaches to estimate the relationship between the provision of state aid by Member States and export market shares, value added and value added growth respectively. The empirical approaches are briefly outlined below.

Aghion, Boulanger and Cohen (2011) type equation: In its basic form the following panel data equation is being estimated:

$$lnEX_{it} = \beta_1 lnSA_{it} + \beta_2 ln^2SA_{it} + \beta_3 lnPC_{it} + \beta_4 ln^2PC_{it} + \beta_5 lnPC_{it} lnSA_{it} + \gamma_i + \delta_t + \varepsilon_{it},$$

where $lnEX_{it}$ represents the log of the overall share of extra-EU manufacturing and services exports of an EU Member State *i* in the sample to total EU exports in year *t*. The variable *SA* covers total sectoral state aid to industry and services (also all the other types and sub-groups of state aid are being controlled for) and *PC* is a proxy for financial development, measured by the ratio of private credit by deposit-taking banks and other financial intermediaries to GDP (similarly also indicators of governance, competition and tariff protection are being checked). The squared terms control for non-linearity and the interaction term checks whether the two explanatory variables are substitutes or complements. Finally, γ_i and δ_t are country and time fixed effects respectively, while ε_{it} is the error term and the β's are the coefficients to be estimated. The rationale of this estimation exercise is to find out whether state subsidies can act as a promoter of international competitiveness, especially in those cases where access to private finance is limited. (It is important to note that this analysis is of a general nature and does not imply a specific link between a certain type of aid and the trade performance of any particular product or sector.) While the original sample of Aghion, Boulanger and Cohen (2011) included EU-15 data for the years 1992-2008, here EU-27 data for the period 1995-2011 are exploited.

Haraguchi and Rezonja (2011) type equation: The following modified base-line equation is being estimated:

$$lnVA^j_{it} = \beta_1 lnDP_{it} + \beta_2 ln^2DP_{it} + \beta_3 lnPD_{it} + \beta_4 lnNR_{it} + \beta_5 lnSA_{it} + \gamma_i + \delta_t + \varepsilon^j_{it},$$

where $lnVA^j_{it}$ is the log of the real value added per capita of the respective manufacturing sector *j* in country *i* and year *t*. The variable *DP* accounts for the per capita gross domestic product, *PD* stands for population density and *NR* is an indicator for natural resource endowment. Following Haraguchi and Rezonja (2011), the modified natural resource proxy variable can be calculated as the ratio between exports and imports of crude natural resource commodities. The commodities included are those categorised under SITC Rev. 1 in Code 2 (crude materials, inedible, except fuels), 32 (coal, coke and briquettes), 331 (petroleum, crude and partly refined) and 3411 (gas, natural).

These three explanatory variables are seen as mostly exogenous for the specific sample analysed. Here, SA is state aid per capita, and the β's, γ_i and δ_t are defined as in the earlier equation. ε^j_{it} is the error term. The value added data was taken from Eurostat's intermediate ISIC aggregation Rev. 2. GDP and population density data stems also from Eurostat. Data for constructing the natural resource endowment indicator were taken from the Comtrade database. In the preferred regressions the single manufacturing sectors have been aggregated in two groups – export-oriented industries and industries focusing on the domestic markets, based on an exportability measure, in order to make the results better interpretable. In following Rajan and Subramanian (2011) the exportability of an industry is assumed if the respective industry has a ratio of exports to value added that exceeds the industry median. For each industry, the median ratio of exports to value added was calculated using data from all EU-27 countries. The industries above the median are manufacturers of petroleum products, chemicals, pharmaceuticals, electronics, machinery and cars. Those below are manufacturing food, textiles, paper, plastics, metals, electric and other equipment.

Rajan and Subramanian (2011) type equation: The basic equation estimated is the following:

$$MG_{ij} = \beta_1 IS_{ij} + \beta_2 SA_i ED_{ij} + \gamma_i + \zeta_j + \varepsilon_{ij},$$

where the MG_{ij} variable depicts the average annual real growth rate of manufacturing value added of industry *j* in country *i* over the period 2000-2010. A country- and industry-specific indicator of the initial manufacturing share (*IS*) is added to the regression in order to control for convergence. Most importantly an interaction term of state aid as a share of GDP (*SA*) and a manufacturing sector-specific exportability dummy variable (*ED*) is included as well. Similarly to the regression before and following Rajan and Subramanian (2011) the exportability dummy takes a value of 1 if the respective industry has a ratio of exports to value-added that exceeds the industry median. For each industry, the median ratio of exports to value added was calculated using data from all the EU-27 countries. The aim of this regression equation is to check in what way public subsidies influence the growth of the export-oriented manufacturing sectors in Europe. All the data used have the same origin as in the second approach.

Estimation of commercialisation output model specification

The estimation procedure below for the commercialisation output model specification (used in 4.14) follows a so called CDM-approach (see Crepon et al. (1998) and Griffith et al. (2006) for more detail) towards estimating the innovation-driven economic performance of firms based on the CIS data. The CDM procedure uses a multiple equation econometric model estimate the economic outcomes from the firms' innovation efforts.

When estimating the R&D intensity equation using Heckman procedure, the firm's decision to perform/report R&D has been considered as depending on such specific factors as: the firm's size represented by the logarithm of total sales ($\log(S_i)$) in the previous period, whether or not the firm is a member of a group (GR_i):

$$RDperformer_i = \alpha_i + \beta_1 \log(S_i) + \beta_2 GR_i + \varepsilon_{it}$$

The first equation has the logarithm of the firm's R&D expenditures as dependent variable and is estimated conditional on the firm's decision to perform/report R&D above:

$$\begin{aligned} \ln(RD_i) &= \alpha_i + \beta_1 exRD_i + \beta_2 VCoop_i + \beta_3 HCoop_i + \beta_4 GCoop_i \\ &\beta_5 LPS_i + \beta_6 NPS_i + \beta_7 EUS_i + \beta_8 FSize_i + \varepsilon_i \end{aligned},$$

where the explanatory variables are the following[1]:

- **Extramural R&D indicator**, $exRD_i$ (1/0);
- **Vertical Cooperation indicator**, $VCoop_i$ (1/0);
- **Horizontal Cooperation indicator**, $HCoop_i$ (1/0);
- **Cooperation inside the group indicator**, $GCoop_i$ (1/0);
- **Local public funding indicator**, LPS_i (1/0);
- **National Public funding indicator**, NPS_i (1/0);
- **EU funding indicator**, EUS_i (1/0)
- **Firm size class,** $FSize_i$ (0: <50 employees, 1: >=50).

The second equation is estimated by the means of the tobit regression where the dependent variable is the share of the turnover from products and services new to the market (Y_i):

$$\begin{aligned} \ln(Y_i) &= \alpha_i + \beta_1 exRD_i + \beta_2 \ln(RD_i) + \beta_3 \log(S_i) + \beta_4 VCoop_i + \beta_5 HCoop_i \\ &+ \beta_6 GCoop_i + \beta_7 LPS_i + \beta_8 NPS_i + \beta_9 EUS_i + \varepsilon_{it} \end{aligned}$$

The additional explanatory variables are the following:

- **Predicted value of the logarithm of total R&D**, $\ln(RD_i)$;
- **The logarithm of total sales in the previous period,** $\log(S_i)$.

The estimations also take into account the country-specific intercepts and industry class dummies in order to correct for individual effects.

[1] The innovation activities and funding indicators are taking the value one if they engaged in the past three years in some innovation activities respectively if they received public funding for innovation activities and the value zero if not. The dummy variables for co-operation partner takes the value one if the firm indicated a certain type of collaboration in their country or other countries in Europe or the US or China/India or all other countries and the value zero if not.

Table A8. Results of the R&D regressions with CIS2006

	All firms	EU-15	EU-12	Small firms	Medium and large firms	All manuf. firms	Low-tech	Medium-low tech	Medium-high and high tech
R&D expenditures equation									
extramural R&D	0.367***	0.266***	0.504***	0.275***	0.414***	0.365***	0.375***	0.455***	0.253**
	(8.48)	(5.88)	(6.07)	(4.68)	(6.65)	(6.96)	(3.66)	(5.58)	(2.84)
vertical collaboration	0.429***	0.328***	0.557***	0.436***	0.398***	0.370***	0.455***	0.385***	0.242*
	(7.82)	(5.52)	(5.51)	(5.69)	(5.17)	(5.59)	(3.49)	(3.71)	(2.19)
horizontal collaboration	0.276***	0.349***	0.176	0.238*	0.306***	0.215*	0.129	0.409**	0.103
	(4.08)	(4.13)	(1.58)	(2.40)	(3.34)	(2.53)	(0.72)	(3.06)	(0.77)
intra-group collaboration	0.468***	0.507***	0.384**	0.283*	0.372***	0.541***	0.626***	0.449***	0.579***
	(6.52)	(6.09)	(3.12)	(2.24)	(4.16)	(6.22)	(3.30)	(3.33)	(4.20)
local public funding	0.381***	0.354***	0.707**	0.464***	0.317***	0.333***	0.211	0.308**	0.453***
	(6.19)	(6.69)	(2.84)	(5.96)	(3.32)	(4.57)	(1.44)	(2.73)	(3.76)
national public funding	0.986***	0.954***	1.003***	1.076***	0.853***	1.006***	0.915***	1.031***	1.037***
	(18.30)	(17.50)	(9.13)	(14.31)	(11.22)	(15.82)	(6.87)	(10.45)	(10.24)
EU funding	0.589***	0.666***	0.491***	0.444***	0.715***	0.561***	0.570**	0.466**	0.678***
	(7.58)	(7.17)	(3.77)	(3.86)	(6.85)	(5.67)	(2.94)	(2.88)	(4.26)
firm size class	0.984***	0.858***	1.104***			0.919***	0.773***	0.913***	1.045***
	(20.01)	(17.01)	(11.07)			(15.30)	(6.59)	(9.72)	(10.23)
R&D selection equation									
log 2004 sales	0.0370***	0.0230***	0.0646***	0.00322	0.111***	0.0442***	0.0502***	0.0374***	0.0450***
	(21.32)	(10.68)	(21.03)	(1.62)	(22.91)	(19.56)	(12.83)	(10.09)	(10.67)
member of a group	0.424***	0.418***	0.441***	0.357***	0.246***	0.501***	0.545***	0.505***	0.447***
	(33.72)	(24.65)	(23.17)	(18.15)	(13.37)	(29.47)	(19.21)	(17.54)	(14.14)
chi2 for model's significance	4895.0***	2832.6***	1591.3***	2861.4***	1743.0***	2216.9***	680.3***	892.3***	734.4***
observations	85281	38172	47109	53940	31341	43916	21686	13089	9141

*Note: t statistics appear in parentheses. ***, *, * indicate statistical significance at the 0,1%; 1% and 5% level respectively. Regressions include country and industry fixed effects as well as a constant term which are not reported.*
Source: Community Innovation Survey (CIS)

Table A9. Results of the R&D regressions with CIS2008

	All firms	EU-15	EU-12	Small firms	Large firms	All manuf. firms	Low-tech	Medium-low tech	Medium-high and high tech
R&D expenditures equation									
extramural R&D	0.619***	0.556***	0.729***	0.510***	0.633***	0.702***	0.745***	0.765***	0.542***
	(13.70)	(11.64)	(7.81)	(8.67)	(9.41)	(11.99)	(7.31)	(8.31)	(4.80)
vertical collaboration	0.559***	0.437***	0.769***	0.540***	0.567***	0.492***	0.807***	0.302**	0.424**
	(9.98)	(7.26)	(6.82)	(7.34)	(6.87)	(6.78)	(6.24)	(2.64)	(3.11)
horizontal collaboration	0.121	0.170*	-0.000436	0.162	0.0841	0.129	-0.117	0.364*	0.0484
	(1.74)	(2.10)	(-0.00)	(1.66)	(0.86)	(1.35)	(-0.67)	(2.46)	(0.27)
intra-group collaboration	0.514***	0.686***	0.23	0.267*	0.454***	0.588***	0.553**	0.571***	0.600***
	(7.30)	(8.55)	(1.79)	(2.30)	(4.97)	(6.42)	(3.16)	(3.97)	(3.66)
local public funding	0.219***	0.228***	0.218	0.250**	0.209*	0.157	0.0257	0.158	0.292*
	(3.44)	(4.01)	(0.78)	(3.26)	(2.05)	(1.93)	(0.17)	(1.24)	(1.97)
national public funding	1.032***	1.004***	1.098***	0.953***	1.044***	1.011***	1.080***	1.037***	0.890***
	(19.08)	(18.19)	(9.05)	(13.22)	(13.19)	(14.75)	(8.44)	(9.70)	(7.17)
EU funding	0.716***	0.960***	0.440**	0.740***	0.693***	0.666***	0.766***	0.533**	0.748***
	(8.77)	(9.61)	(3.12)	(6.25)	(6.14)	(6.20)	(4.08)	(3.04)	(3.76)
firm size class	0.957***	0.819***	1.151***			0.907***	0.722***	1.075***	0.923***
	(18.40)	(15.24)	(9.96)			(13.22)	(6.12)	(10.13)	(6.76)
R&D selection equation									
log 2006 sales	0.0380***	0.0253***	0.0880***	0.00792***	0.108***	0.0532***	0.0649***	0.0436***	0.0533***
	(23.99)	(14.27)	(23.92)	(4.37)	(24.77)	(22.83)	(15.69)	(11.99)	(11.63)
member of a group	0.450***	0.431***	0.451***	0.390***	0.289***	0.529***	0.543***	0.562***	0.462***
	(40.14)	(29.65)	(24.88)	(22.19)	(17.63)	(33.32)	(20.80)	(21.69)	(14.58)
chi2 for model's significance	4794.1***	3828.8***	1004.0***	2795.5***	1862.0***	2322.88***	829.8***	958.0***	596.3***
observations	98345	48831	49514	60845	37500	47306	23667	15152	8487

*Note: t statistics appear in parentheses. ***, *, *indicate statistical significance at the 0,1%; 1% and 5% level respectively. Regressions include country and industry fixed effects as well as a constant term which are not reported.*
Source: Community Innovation Survey (CIS)

Chapter 5.
EU PRODUCTION AND TRADE BASED ON KEY ENABLING TECHNOLOGIES

BACKGROUND

Previous chapters have discussed the specialisation, complexity and sophistication of economies basing their output on key enabling technologies (KETs). This chapter takes an in-depth look at the specialisation, strengths and weaknesses of the EU in the global production and trade in products based on KETs.

Two years ago, the High-Level Group on Key Enabling Technologies published its final report which estimated that the global market potential for products based on KETs would grow from USD 832bn around 2008 to USD 1 282bn around 2015 (HLG KETs 2011).

It was followed by the European Commission Communication 'A European strategy for Key Enabling Technologies – A bridge to growth and jobs' (European Commission 2012a) which outlined a strategy to boost the industrial production of KETs-based products and enable maximum exploitation of the EU's potential in competitive markets.

In addition, in its Communication 'A stronger European Industry for Growth and Economic Recovery' (European Commission 2012b), the Commission identified six priority action lines, one of which was the creation of markets for KETs. The European Commission expressed its intention to implement the European Strategy for KETs, ensuring better co-ordination of EU and Member State technology policies; funding of essential demonstration and pilot lines and cross-cutting KET projects; and the timely development of the internal market for KETs-based products (Calleja 2013). Moreover, the industrial deployment of KETs will be considered in future European Innovation Partnerships, while a 'knowledge and innovation community on added-value manufacturing' has been proposed as a forum for integration and promotion of skills and competences (European Commission 2013c).

OBJECTIVES

The overall objective of this chapter is to analyse the current position of the EU in the global production of KETs-based products in order to assess upcoming challenges for the competitiveness of the EU. The chapter aims to:

- Provide a narrative overview of most recent technological and industry developments in each KET since 2009;
- Update estimations on future market potentials in each KET, building on the analyses of recent trends in 'market shares' in the production of KET-related technologies;
- Assess the EU position in the value chain by studying two promising KETs-based products;
- Analyse the EU position in international trade for certain subfields of KETs-based products, including changes in the competitiveness of the EU over time;
- Determine the EU position in value chains (in terms of 'technology content') within certain subfields of KETs-based products based on unit value analysis of exports and imports;
- Analyse the specialisation of a selection of EU Member States in production and trade of KETs-based products by combining production and trade statistics.

This chapter applies the following definition of KETs-based products (European Commission 2012a). A KETs-based product is: (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.

STRUCTURE OF THE CHAPTER

This chapter is structured as follows: Section 5.1 presents an update of market share calculations and market potential estimates. Section 5.2 analyses the position of the EU in international trade in KETs-based products. In Sections 5.3 to 5.5, the value chain of two KETs-based products is analysed, namely lipase enzymes and the accelerometer. Section 5.6 summarises the main conclusions and potential policy implications.

5.1. TECHNOLOGY POSITIONS AND MARKET POTENTIAL

5.1.1. Introduction

Key Enabling Technologies (KETs) are defined as knowledge-intensive technologies associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration.

The following technologies are identified as KETs: micro- and nanoelectronics, nanotechnology, photonics, advanced materials, industrial biotechnology and advanced manufacturing technologies for other KETs (HLG KETs 2011).

The objective of this section is to provide an overview of the competitive position of the EU in the generation of technology and to estimate the future market potential for KETs-based products and applications. As such, it provides an update of the analysis undertaken in the background study to the 2010 European Competitiveness Report (European Commission 2010). The calculation of technology market shares is based on the number of international patent applications. KETs-relevant patent activities are identified through a list of IPC codes developed for the 2010 report and recently updated in the 'Feasibility study for a KETs Observatory' commissioned by DG Enterprise and Industry (Van de Velde et al. 2013). In order to estimate the market potential of each KET, an analysis of existing studies, reports and reviews has been conducted. For each KET, several market segments have been selected, depending on KETs-based applications.

5.1.2. Approach

An important measure of a country's competitive position in KETs is its ability to produce new, commercially relevant technological knowledge. One way to measure this ability is to look at patent data. Patent data have certain advantages when it comes to measuring technological performance. Patents represent new technological knowledge that has a particular potential for economic application. Each patent is linked to technological areas through an internationally standardised system (International Patent Classification (IPC)) which enables patents to be 'linked' to KETs. Since patents are essential for the production and protection of new technologies and innovative products and processes, they are a commercial good which serves as an input to production and can be traded on technology markets (through licensing or by selling and purchasing patent rights). In contrast to many other goods, most patents are produced and used in-house while only a small part is actually traded between firms (see Gambardella et al. 2007; Arora et al. 2002; Serrano 2005; Lamoreaux and Sokoloff 1999).

When using patent applications to assess the competitive strength and weakness of an economy, some limitations need to be pointed out. First, not all new technological knowledge needed for innovations is represented by patents, while a number of patents will never be used for innovations. Secondly, the economic value represented by one patent can vary substantially. Thirdly, not all patents seek legal protection of new technological knowledge but some are used to block competitors from patenting activities or to keep strategic information away from competitors. For these reasons, patents represent only a fraction of the technology market.

As with any other market, one can analyse the technology market performance of individual actors as well as of countries. Here, for each country a 'market share' of the technology market for each KET is calculated based on the number of international patent applications. International patent applications are patents applied for at the European Patent Office (EPO) or through the Patent Cooperation Treaty (PCT) procedure at the World Intellectual Property Organization. Using international patent applications reduces the risk of an overly strong home-country bias and excludes patents of low (expected) commercial value since applying at the EPO or via the PCT is comparatively costly.

Technology market shares by KET are calculated using a conversion table that links IPC codes to KETs (see Van de Velde et al. 2013). Patent applications are assigned to countries using the country of the applicant and by applying 'fractional counting' in the event that a patent application is submitted by organisations from different countries. Patents are assigned to four regions: Europe (all EU Member States plus Albania, Andorra, Bosnia-Herzegovina, Former Yugoslav Republic of Macedonia, Iceland, Liechtenstein, Monaco, Montenegro, Norway, San Marino, Serbia, Switzerland); North America (US, Canada, Mexico); East Asia (Japan, China including Hong Kong, South Korea, Singapore, Taiwan); and the rest of the world (RoW). The April 2013 edition of the Patstat database published by EPO is used.

5.1.3. Industrial biotechnology

5.1.3.1. *Technology market share*

International patent applications in the field of industrial biotechnology have been decreasing over the past ten years. Globally, the number of patents fell by 33% between 2000 and 2010 (Figure 5.1). Europe and North America report even greater drops (–46%). East Asia and RoW increased the number of international patent applications in industrial biotechnology by 28% and 14% respectively. As a consequence, the market shares of Europe and North America are declining. Nevertheless, North America remains the region with the highest market share in 2010 (39%). Europe lost its second position in 2010 even though its market share in that year (27%) was above the low level reported for the mid-2000s (23% in 2006). East Asia gained market shares and contributed 28% to global patent applications in industrial biotechnology in 2010. Rest-of-the-world countries showed increasing market shares up to 2008 but no further growth afterwards, contributing 5% to total patenting in industrial biotechnology in 2010.

In Europe, Germany gradually lost market share, declining from 44% (2000) to 27% (2010). France gained market shares and by 2008 had replaced the UK as the second largest European patent producer in industrial biotechnology. The Netherlands showed high market shares in the mid-2000s (ranking second in 2005 with a European market share of 15%) but clearly lost ground in recent years. Switzerland and Denmark hold position five and six in European patenting in industrial biotechnology.

5.1.3.2. *Market potential*

Industrial biotechnology is used in the production of chemicals and derived biomaterials. The use of biotechnology for chemical production has increased over the past decade and is likely to continue increasing, driven by rising energy costs, new chemicals legislation and increasingly stringent environmental regulations (OECD 2009).

According to Festel Capital, the sales of products made by biotechnological processes in 2007 was around EUR 48bn, or 3.5% of total chemical sales, while by 2017 predicted sales of products made by biotechnological processes will be around EUR 340bn, or 15.4% of total chemical sales in 2017. Based on Festel Capital research, the most important sub-segments in 2017 are expected to be active pharma ingredients and polymers and fibres (Festel 2010). Other sources start from a market share of 9–13% in 2010 and predict further growth to 22–28% by 2025. Major growth is expected to take place in polymers and bulk chemicals (Kircher 2012).

The global market for industrial enzymes is forecast to reach USD 3.74bn by 2015. Important factors driving the market include new enzyme technologies with a view to enhanced cost efficiencies and productivity, and growing interest in substituting petroleum-based products. BCC projects the industrial enzymes market to grow to USD 6bn by 2016 (BCC Research 2011a). Major growth is expected in the segments of food and beverage enzymes and technical enzymes. Two other segments with high growth potential are carbohydrases and lipases (see also 5.4).

5.1.4. Photonics

5.1.4.1. *Technology market share*

Over the past ten years, East Asia has gained significantly in technology market shares in the field of photonics (Figure 5.2). Since 2003, East Asian organisations have become the largest group of applicants for photonics patents and have been able to strengthen their position continuously, increasing their market share from 27% in 2000 to 50% in 2010. North American applicants lost the leading position which they held in the early 2000s. Their market share fell from 40% (2000) to 19% in 2010. Europe did significantly better: its market share increased until 2008, when it reached 32%. In 2009 and 2010, Europe's contribution to photonics patenting fell back to 29%. Countries from outside the three main regions slightly lost market shares.

Changes in market shares in photonics took place against the background of expanding overall patenting. The total number of international patent applications grew by 25% between 2000 and 2010, almost four times the growth rate for all KET patent applications and equal to the growth rate of patenting across all fields of technology.

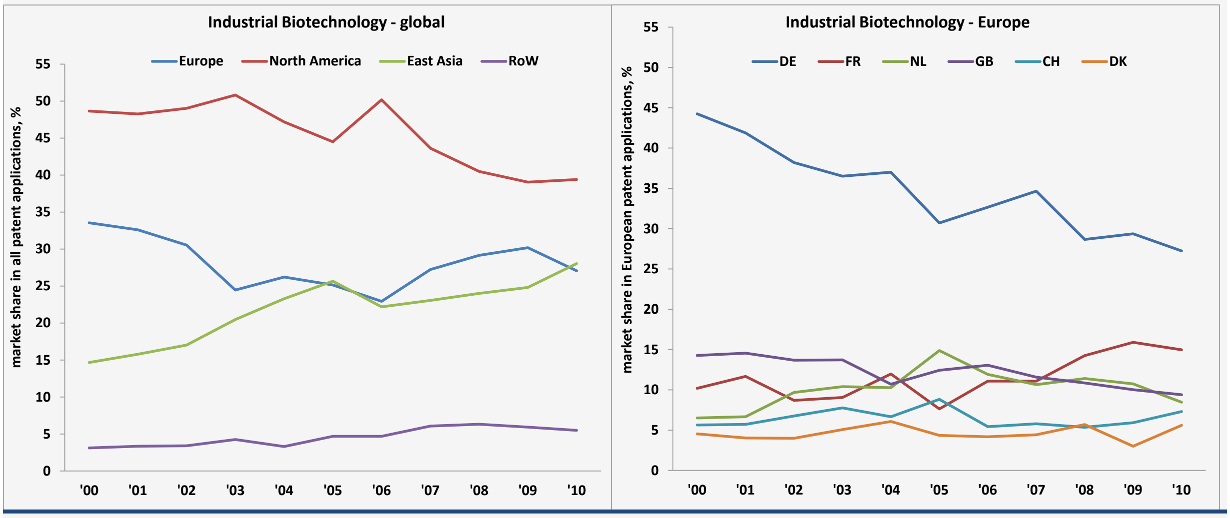
Germany further strengthened its position as the main producer of new technological knowledge in photonics within Europe over the past decade. Its share of total European patent applications was 43% in 2010, compared to 33% in 2001–2002. Among the other five main European applicant countries in 2010 – France, Netherlands, UK, Austria and Italy – Netherlands and the UK lost market shares while France and Italy maintained their positions within Europe. Austria recently increased patenting in photonics and overtook Swiss patents applicants.

5.1.4.2. *Market potential*

The photonics industry is expected to grow significantly in coming years. The global market for photonic components and systems forecast to be worth EUR 480bn by 2015, suggesting an annual growth rate of 8% (HLG KETs 2011).

Solar photovoltaic (PV) is the third most important renewable energy in terms of globally installed capacity. Its growth rate reached almost 70% in 2011. In terms of cumulative installed capacity, Europe leads the way worldwide with more than 51 GW installed as of 2011 (75% of world capacity). Internationally, significant market growth is expected until 2017, reflecting the large untapped potential of many countries (EPIA 2013).

Figure 5.1. Market shares in international patent applications in industrial biotechnology, 2000–2010 (percent)



Source: EPO: Patstat, ZEW calculations

By 2020, light emitting diodes (LEDs) are expected to account for around 95% of the market for light bulbs, currently estimated at EUR 11bn per year (J.P. Morgan Cazenove 2012). The expected growth in market demand for LEDs will be driven by product substitution. Other application areas of LEDs are: mobile applications including mobile phone notebooks and tablets; TV and monitor backlights; sign and automotive lighting. Japan accounts for the greatest portion of overall LED component revenues (30%) followed by South Korea (26%), Taiwan and Southeast Asia (19%).

The optical communication industry is experiencing a recovery from the economic downturn. In 2010 and 2011, the sales of data communication systems started to pick up again. The global market for lasers for communications (data and telecoms) was estimated to be worth USD 1.95bn in 2010 and USD 2.22bn in 2011 (+14%) (Overton et al. 2011). While Europe is experiencing a decline in demand, the construction of optical communication is at a peak in China.

5.1.5. Micro-/nanoelectronics

5.1.5.1. *Technology market share*

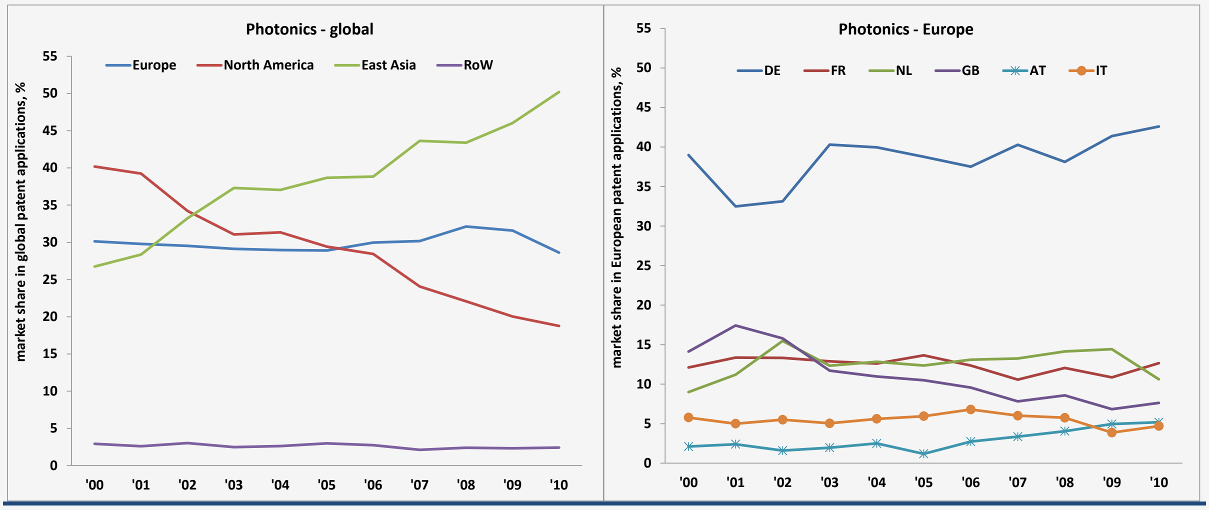
East Asia has since 2002 been the largest producer of international micro- and nanoelectronics patent applications (Figure 5.3). Its market share is gradually increasing over time. In 2010, 56% of global patent applications in this KET originated in East Asia. North America and Europe are both losing market shares. In 2010, North America reported a market share of 23%, while the figure for Europe was 20%. Countries from the rest of the world are of little importance in the technology market for micro- and nanoelectronics: their market share is 1% to 2%. Dynamics in micro- and nanoelectronics patenting are high. Globally, patent applications grew by 35% from 2000 to 2010. The number of European applications in 2010 was 2% higher than in 2000, while applicants from North America reported a 17% lower figure in 2010 than in 2000. The highest growth is in East Asia, where patent applications increased by 116% over the same ten-year period.

In Europe, Germany is clearly the largest patent producer in micro- and nanoelectronics and maintained a European market share of 42–45% from 2001 to 2010. France increased its European market share from 10% (2000) to 17% (2010), overtaking the Netherlands. The Dutch market share within Europe declined from 19% in 2003 to 8% in 2010. The UK is the fourth largest producer of micro-/nanoelectronics patent applications in Europe, followed by Switzerland and Italy.

5.1.5.2. *Market potential*

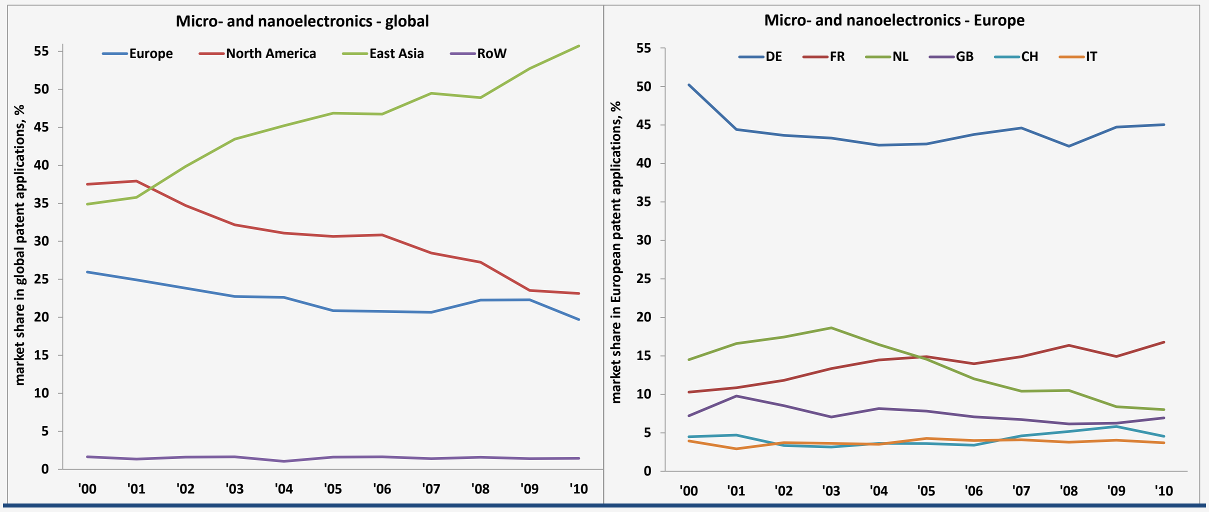
The global market for the semiconductor industry has increased significantly from USD 25bn in 1985 to USD 299.5bn in 2011 (SIA 2012). This growth is driven by the increasing need for microelectronic devices and smart sensors in intelligent products, such as smart phones, tablets, car driver assistance systems, smart grids, networked sensors, and other products. Smart sensors can also be used to detect and make risk assessments of disasters. That sort of risk management reduces the vulnerability of Member States, sectors and individual firms, thereby increasing competitiveness and sustainable growth.

Figure 5.2. Market shares in international patent applications in photonics, 2000–2010 (percent)



Source: EPO: Patstat, ZEW calculations

Figure 5.3. Market shares in international patent applications in micro and nanoelectronics, 2000–2010 (percent)



Source: EPO: Patstat, ZEW calculations

From a total investment of EUR 28bn in microelectronics in 2007, only 10% was in the EU, compared to 48% in Asia. Europe's semiconductor market share has declined from 21% to 16% since 2000 (Silicon Europe 2012). After the global economic crisis, the semiconductor market recovered quickly and global sales reached a record high in 2010. While billings fell by 11% from their peak in 2007 to 2009, sales subsequently recovered by 33% from 2009 to 2010, an unprecedented growth rate which more than compensated for previous losses (Ballhaus et al. 2011). PWC estimates that the semiconductor market will grow by 7.4% per year on average from 2010 to 2015.

According to IC Insights, worldwide processor sales are expected to regain strength in 2013 and grow 12% to USD 65.3bn, after a more modest increase in 2012 to USD 58.2bn (+5%). The slow growth in 2012 is attributed to weaknesses in the personal computer segment of the market and global economic uncertainty (Clarke 2013). The strongest growth is expected for microprocessor units, especially in the area of tablet computers and smartphones.

The total flash memory market grew by 2% to USD 30.4bn by end-2012, overtaking the DRAM [2] market for the first time, as the latter declined from USD 31.2bn to USD 28bn. This is because DRAM is used mostly in PCs while flash memory is used in smartphones, media tablets, and other personal media devices. IC Insights forecasts NAND [3] flash memory sales to increase by 14% annually from 2012 to 2017, growing to USD 53.2bn by 2017, while the DRAM market is forecast to grow by 9% over the same period.

2 Dynamic random-access memory.
3 The other main type of flash memory is NOR.

5.1.6. Advanced materials

5.1.6.1. *Technology market share*

East Asia is constantly increasing its market share in international patenting in the field of advanced materials (Figure 5.4). In 2010, 48% of all advanced materials patent applications originated in East Asia, compared to 28% from Europe and 21% from North America.

North America's share of global patent applications is declining much faster than the European share. Changes in market shares should be seen against the backdrop of low patent dynamics in advanced materials. Global patent applications fell by 4% between 2000 and 2010. While international patent applications in advanced materials are going down in Europe and North America, applicants from East Asian and the rest of the world are filing more applications each year.

Within Europe, the market shares of countries with the highest numbers of advanced materials patents have remained stable over time. Germany still accounts for more than 40% of European patent applications, followed by France (16% in 2010), Italy, Switzerland, the UK and Belgium. The Netherlands held third place in advanced materials patenting in Europe until 2008 but its patent activities have since decreased considerably.

5.1.6.2. *Market potential*

Advanced materials tend to outperform conventional materials with their superior properties such as toughness, hardness, durability and elasticity. The scope of advanced materials research is very broad. While some advanced materials are already well-known, like polymers, metal alloys, ceramics, semiconductors, composites and biomaterials, other advanced materials like carbon nanomaterials, activated carbon, titanium, are becoming increasingly important.

'Smart materials' are a class of materials that respond dynamically to electrical, thermal, chemical, magnetic, or other stimuli from the environment.

These materials are incorporated in a growing range of products, enabling these products to alter their characteristics or otherwise respond to external stimuli. The market for these materials was estimated to be worth USD 19.6bn in 2010 and was expected to approach USD 22bn in 2011 and exceed USD 40bn by 2016, a compound annual growth rate (CAGR) of 12.8% from 2011 to 2016 (BCC Research 2011b).

Lightweight materials are increasingly being used in the transportation industry as weight reduction is one of the most important ways of reducing fuel consumption. In 2010, the total global consumption of lightweight materials used in transportation equipment was worth USD 95.5bn. By 2015 this market is expected to reach USD 125.3bn, with a compound annual growth rate (CAGR) of 5.6% between 2010 and 2015.

Value-added materials (VAMs) are a group of advanced materials with strategic importance for economic growth, industrial competitiveness and societal challenges. Their market potential is estimated to reach EUR 1,000bn by 2050. In the environmental market segment, VAM growth will be driven by energy-efficient and carbon-capture technologies. VAMs in the ICT sector are expected to grow substantially in the coming years, with an average compound annual growth rate of 5%.

5.1.7. Nanotechnology

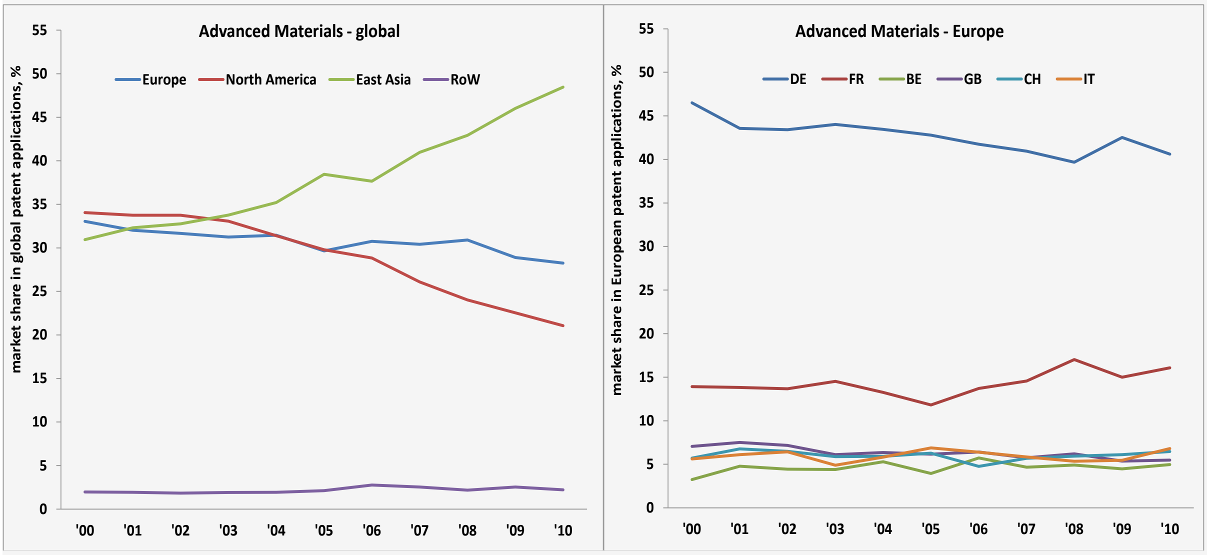
5.1.7.1. *Technology market share*

Trends in technology market shares in the field of nanotechnology significantly diverge from the general trends in KETs patenting. With a share of 39% of all applications in 2010, North America is still the most important origin of nanotechnology patent applications. While North America's share of all nanotechnology applications was falling until 2007 (when it reached 35%), the downward trend changed in 2008.

Europe and East Asia report similar market shares over the entire period. In most years, the East Asian share of applications exceeded the European share but in recent years Europe has taken a slightly higher share (28% in 2010, versus 27% for East Asia). The total number of nanotechnology patent applications grew by 31% between 2000 and 2010, with all four regions reporting growing nanotechnology patenting.

Within Europe, Germany has lost market shares over the past decade, from 41% in 2000 to 23% in 2010. At the same time, France substantially increased its nanotechnology patenting and gained market shares, catching up with Germany in 2010. The market share of the Netherlands dropped from 14% in 2004 to 6% in 2010, while the UK was able to maintain its share of total European patent applications in nanotechnology at around 10%. Switzerland filed about 5% of European nanotechnology patent applications over the entire period, while Italy has recently increased its share.

Figure 5.4. Market shares in international patent applications in advanced materials, 2000–2010 (percent)



Source: EPO: Patstat, ZEW calculations

5.1.7.2. *Market potential*

Nanotechnology has many applications in a broad range of industries. The global market for nanotechnology was valued at USD 20.1bn in 2011 and USD 20.7bn in 2012 (BCC Research 2012). Total sales are expected to reach USD 48.9bn in 2017 after increasing at a five-year compound annual growth rate of 18.7%. The US is the most prominent market and in 2011 accounted for an estimated share of around 35% of the global nanotechnology market – slightly less than its share of patent applications. Whilst it is expected to remain a major player, emerging economies such as China and South Korea as well as India and Brazil have started to catch up.

The global market for products based on the revolutionary new nanomaterial graphene is projected to reach USD 122.9 million in 2017 and USD 986.7 million in 2022, growing at a five-year compound annual growth rate of 51.7%. The segment made up of capacitors is projected to be the largest segment in 2022. Capacitors are expected to increase from USD 31 million in 2017 to USD 410 million in 2022, a CAGR of 67.6%. Others sources indicate a more conservative estimate of USD 100 million in 2018 and an annual growth rate of 40%, making the capacitors segment worth USD 216 million by 2020.

The global market for quantum dots, which in 2010 was generated revenues of USD 67 million, is projected to grow over the next five years at a compound annual growth rate of 58.3%, reaching almost USD 670 million by 2015 – a tenfold increase. MarketsandMarkets estimate the total market for quantum dots to be worth USD 7.5bn by 2022, the result of a compound annual growth rate of 55.2% from 2012 to 2022. The US has a leading position in the quantum dots technology market, followed by Europe and Asia-Pacific (MarketsandMarkets 2012).

5.1.8. Advanced manufacturing technologies

5.1.8.1. *Technology market share*

Trends in market shares for advanced manufacturing technologies for other KETs are quite similar to those for micro-/nanoelectronics and advanced materials, since many patents classified as advanced manufacturing technologies for other KETs relate to the former two KETs and a significant overlap exists.

East Asia is producing the highest number of patents in the field of advanced manufacturing technologies for other KETs (46% in 2010), while Europe and North America have about 25% each of global patent applications. North America's contribution to the global patent output has fallen sharper (from 40% in 2000) than Europe's share (31% in 2000). Rest-of-the-world countries increased their share marginally between 2000 and 2010, contributing 3% to global patent applications in 2010.

Patent dynamics in this KET are low. The total number of international patent applications in 2010 was 9% below the 2000 figure. Declining patent output in Europe (–25 %) and North America (–41%) are partly outweighed by significant increases in East Asia (+57%) and RoW (+11%).

In Europe, Germany has lost market shares but is still the largest patent producer in this KET with a European market share of 38% in 2010. France follows second with 17% to European patent output in in 2010. The Netherlands has fallen to rank 5 in 2010, overtaken by the UK and Switzerland. Sweden was the sixth largest patent producer in Europe in 2010, ousting Italy to rank 7.

5.1.8.2. *Market potential*

Manufacturing is an essential step to bring technological innovations to the market. The global manufacturing economy is estimated to be worth GBP 6.5 trillion (TSB 2012). In the 2013 Global Manufacturing Competitiveness Index, China was found to be the most competitive manufacturing nation, followed by Germany, US, India and South Korea. Five years from now, the report predicts China to maintain the first ranking, followed by India, Brazil, Germany and US (Deloitte 2013).

Additive manufacturing is a layer-by-layer technique of producing three-dimensional objects directly from a digital model. With markets such as prototyping, tooling, direct part manufacturing, and maintenance and repair, the industry has grown significantly to USD 1.3bn of materials, equipment, and services in 2010. The additive manufacturing market, including consumer products, business machines, medical, and aerospace industries, is expected to grow at a compound annual growth rate (CAGR) of 13.5% from 2012 to 2017.

In 2011, BCC Research estimated the global market for robots and robot-related products to grow to nearly USD 22bn in 2011 and USD 30bn by 2016, a compound annual growth rate (CAGR) of 6.7%. In a more recent report (BCC Research 2013), BCC forecast a slightly lower compound annual growth rate (CAGR) of 5.9% between 2013 and 2018. The Asian market is expected to see the fastest growth in the coming years, while growth in the European Union is anticipated to be concentrated in the latter part of the forecast period, when robotic development initiatives now being undertaken on an EU-wide basis will result in commercialised products.

5.1.9. North American decline, East Asian rise

The preceding analysis of shares of patent applications for KETs reveals a steady strengthening of East Asia as the main producer of new technological knowledge in KETs. Over the past ten years, East Asian organisations have increased their share in total patent activity in each of the six KETs. In four KETs – photonics, advanced materials, micro-/nanoelectronics, advanced manufacturing technologies for other KETs – East Asian applicants were the most important patent producers by 2010. At the beginning of the 2000s, North America held the leading position in all six KETs: nowadays industrial biotechnology and nanotechnology are the only two areas that still show North America as the region with the largest share of patent applications. While North America has lost market shares in all six KETs, Europe has performed relatively better. In photonics and nanotechnology, Europe has remained stable during the past decade, while in the other four KETs losses were less severe compared to North America. The decline in North America and general stability in Europe occurred despite productivity gains in North American manufacturing which have tended to be greater than in Europe.

These trends in KET patenting are very similar to the overall trend in international patenting: an increasing East Asian share and a declining contribution by North America, while Europe reports moderate losses in market shares. The main difference with respect to KETs is the speed with which East Asia captures market shares, giving this region a leading position globally. By contrast, the shift from West to East in general international patenting is taking place more slowly, with Europe still holding the largest share in 2010.

In Europe, Germany and France were the main sources of patent applications in 2010 in each of the six KETs. While Germany maintained its dominant position during the past ten years, France increased its share of total European patent applications in all six KETs. The UK and Netherlands both show decreasing market shares.

A more disaggregated analysis at the level of subfields within each KET reveals that Europe is the leading KET patent applicant in some subfields and has been able to gain market shares. In photonics, European strengths are in the fields of measurement and electro-optics as well as lasers. In nanotechnology, Europe is the leading source of patent applications in nano-analytics and has increased its market share in nano-materials. In micro- and nanoelectronics, Europe has been able to maintain its market share in the field of devices and shows an increasing market share in the small area of testing and amplifiers. In advanced manufacturing technologies for other KETs, Europe has a very high market share in the subfield of instruments and has been able to maintain its share in the global technology output of advanced manufacturing technologies for biotechnology and materials production.

The analysis of the market potential of KETs reveals that substantial market growth is expected in all six KETs over the coming years. Depending on the KET, growth potentials of 10–20% per year can be expected. For particular submarkets, the growth potential is even larger. The position of Europe with respect to market size differs for the various KETs, but in general the increasing importance of East Asia and the higher pace of market share gains can be seen here as well.

5.2. THE POSITION OF EUROPE IN THE PRODUCTION AND TRADE OF KETS-RELATED PRODUCTS

5.2.1. Introduction

Analysing the position of countries and regions within value chains of a certain production process typically requires information on input and output links between the countries or regions. Input-output tables, however, offer such information only at a highly aggregated level of industries, not for individual products which can be linked to KETs. For that reason, this section uses an alternative approach. In order to identify Europe's position in global value chains within each KET in relation to North America and East Asia, characteristics of production and trade and their relation to technology inputs are examined. The following metrics are complementary and will be used jointly:

1. The technology content of manufactured goods, i.e. whether products are more technologically advanced;

2. The type of competition of Europe's exports in KET-related products, distinguishing between quality and price competition;

3. The links between the creation of new technological knowledge (measured by patent applications) and the technology content of manufactured goods.

By combining these three approaches, a comprehensive picture of Europe's competitive advantage vis-à-vis its main competitors in each KET will emerge. The analysis is based on data for individual products related to one of the six KETs, in the sense that the products represent certain technological features which are directly linked to a KET (a certain new material, a photonics element, a semiconductor, a biochemical entity or a machine tool) but which do not use KETs as an input for more complex goods (such as batteries, measuring instruments, medical devices, information and communication devices). The notion of 'value chain' as used in this chapter therefore refers entirely to the division of labour within the production of KET products. In order to identify products linked to KETs, the results of a recent feasibility study on monitoring KETs are used (Van de Velde et al. 2013). In that study, KET products were defined at an 8-digit level of the Prodcom product classification system. For the purposes of this report, a narrow version of the definition is used in order to avoid analysis of products that are only partially linked to a certain KET.

5.2.2. Technology content of products related to key enabling technologies

The concept of technology content assumes that similar products can be produced by using different qualities and quantities of 'technology'. Technology may refer to the sophistication of production methods, the variety of different technologies used in the production, or how technologically advanced inputs are. Products with higher technology content are supposed to be positioned further along the value chain. As high technology content products should be superior to products with lower technology content, they should also reflect a higher unit price. Therefore a common trade indicator will be used to measure technology content: the unit value of exports. Based on the assumption that a country's exports of a certain product represent that country's total production of the product, export unit values give the average value of a product manufactured in a country. The assumption is somewhat unrealistic, since many studies have shown that exports tend to contain more innovative products than the average since it is the more innovative firms that engage in exports (see Wakelin 1998; Bleaney and Wakelin 2002; Beise and Rammer 2006; Wagner 1996; Ebling and Janz 1999; Roper and Love 2002; Lefebvre et al. 1998). Here though, the possible bias of exports towards innovative products can be seen as an advantage because it means the analysis will focus on the more innovative products within each KET.

A country or region's export unit value of a certain product is compared with the export unit value of the same product in global trade. A value greater than one indicates that the country (region) exports (and therefore manufactures) products of a higher value per unit, hence products with a higher technology content. Comparing export unit values over time provides information about the dynamics in technology content, in other words whether a country (region) moves away from the average unit value or converges towards it. Combining both dimensions – the level and dynamics of unit values – produces a matrix with four quadrants.

Figure 5.5. Measuring technology content of manufactured products

p=1: high and increasing technology content $UV^X_{ijt} > UV^X_{wjt}$ $\Delta UV^X_{ijt} > \Delta UV^X_{wjt}$	p=3: low but increasing technology content $UV^X_{ijt} < UV^X_{wjt}$ $\Delta UV^X_{ijt} > \Delta UV^X_{wjt}$
p=2: high but decreasing technology content $UV^X_{ijt} > UV^X_{wjt}$ $\Delta UV^X_{ijt} < \Delta UV^X_{wjt}$	p=4: low and decreasing technology content $UV^X_{ijt} < UV^X_{wjt}$ $\Delta UV^X_{ijt} < \Delta UV^X_{wjt}$

UV ... unit value ($/kg)
X ... exports
Δ ... change over time
i ... country/region ($i \in w$)
w ... world (total trade)
j ... KET-related product
k ... KET
t ... time
TC ... technology content
p ... position in quadrant

$$TC(p)_{ikt} = \Sigma_j X_{pij(k)t} / \Sigma_{ip} X_{pij(k)t}$$

For each KET-related product, a country (region) can be positioned in the following way:

1. High and increasing technology content.
2. High but decreasing technology content.
3. Low but increasing technology content.
4. Low and decreasing technology content.

Source: NIW/ZEW

The technology content (TC) of a country (region) *i* in a certain KET *k* is examined by determining the position *p* in the quadrants shown in Figure 5.5 ($p \in \{1,2,3,4\}$) of each individual product *j* belonging to KET area *k*, weighted by the product's share in total exports *X* of products related to KET area *k* of country (region) *i*.

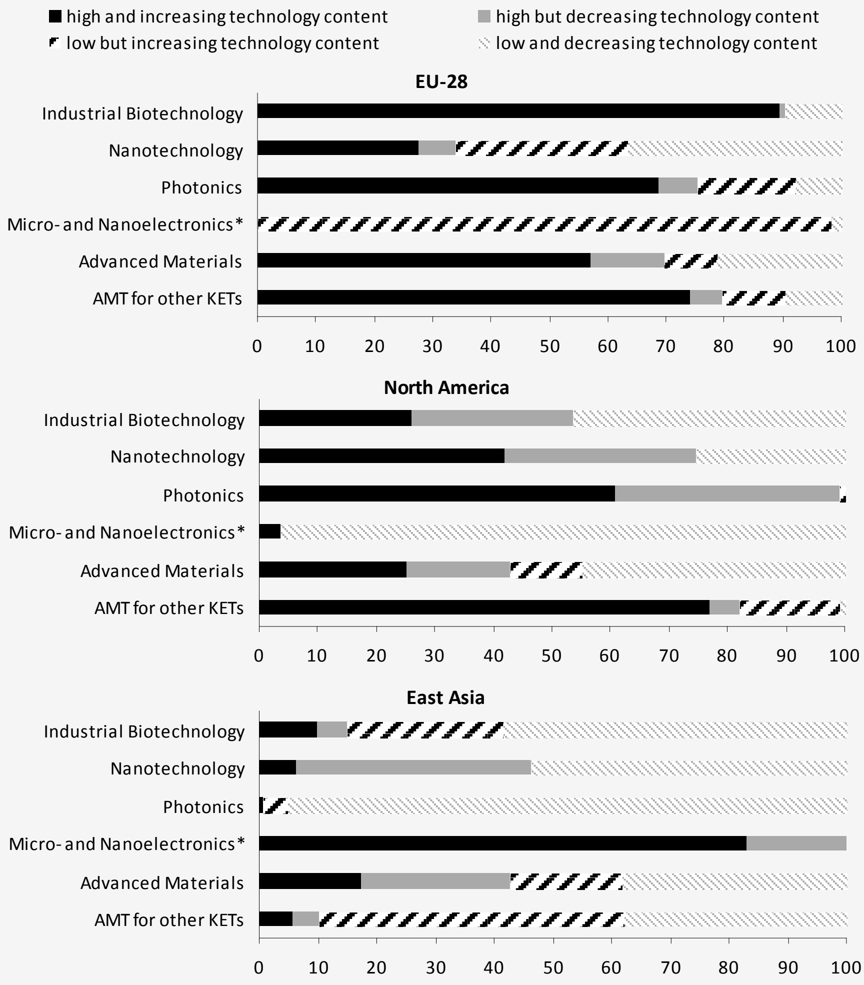
The analysis is conducted for three regions: EU-28 (EU Member States), North America (US and Canada) and East Asia (Japan, South Korea and China). The total exports of the three regions constitute 'total trade' *w*. Furthermore, separate analyses for 12 Member States (Germany, France, United Kingdom, Italy, Belgium, Netherlands, Austria, Sweden, Denmark, Poland, Czech Republic and Hungary) are carried out. The analysis is undertaken for individual KET-related products defined as 6-digit classes of the HS (harmonised system) product classification used in trade statistics. The 6-digit HS classes were identified using a conversion table from 8-digit Prodcom codes. Data on exports (in USD) and quantities (kg) were taken from the UN Comtrade database. The analysis covers the period from 2002 to 2011. Data for 2007 to 2011 rely on the HS 2007 classification while data for 2002 to 2006 are based on HS 2002. A conversion table was used to link the two classifications. To avoid picking up unit value fluctuations between single years, the analysis focuses on the development between two sub-periods, 2002–2006 and 2007–2011. In order to classify products by their technology content, changes in unit values between the average values for 2002–2006 and 2007–2011 are calculated.

The EU-28 reports a high and increasing technological content of its exports in four KETs. The strongest performance is found for industrial biotechnology. Here about 90% of the exports in the years 2007 to 2011 were generated by products with a higher unit value than in the main competitor regions and for which unit values increased more rapidly over time than in the other regions (Figure 5.6). In advanced manufacturing technologies (AMT) for other KETs, 74% of EU-28 exports were in products with high and increasing technology content. For photonics exports, the corresponding share was 69% and for advanced materials it was 57%.

Low technology content occurs for nanotechnology and micro- and nanoelectronics. In nanotechnology, 28% of the EU-28 export volume 2007–2011 was generated by products with high and increasing unit values, while 37% of exports were in products with low and decreasing technology content and another 30% with low but decreasing unit values. For micro- and nanoelectronics, because of limited data availability only the 2002–2006 period can be analysed. In this earlier period, the EU-28 exported products related to micro- and nanoelectronics with a lower unit value compared to the same products exported by the main competitor regions (East Asia in particular). However, for almost all of these products, unit values increased more strongly in the first half of the 2000s (from 2002–2003 to 2005–2006) than in the competitor regions.

Whilst North America shows a similar pattern of technology content of exports of KETs-related products as the EU-28, it performs significantly better (in terms of having a higher technology content of exports) in photonics and nanotechnology but less well in industrial biotechnology and advanced materials. In photonics, North America is the leading technology region with broad and constantly increasing technological content. In nanotechnology, 75% of the 2007–2011 exports were based on products with high technology content, and for most of these products, unit values increased more rapidly than in the competitor regions.

Figure 5.6. Technology content of KET-related products by KET and triadic region, 2007 – 2011 averages



* 2005–2006 average, change in unit values for 2002–2003 to 2005–2006.

Source: COMTRADE Database, NIW calculations

In AMT for other KETs, the composition of North America's exports by technology content is very similar to the EU-28. This result indicates that both regions specialise in trade in different products, each region specialising in those products for which it has superior unit values. Like the EU-28, North America's exports in micro- and nano-electronics were focused on low technology content products, at least in the first half of the 2000s. In contrast to the EU-28, almost all export products faced decreasing unit values compared with the export unit values of the same products in the competitor regions. In advanced materials, North American exported products of varying technology content.

East Asia exports KET-related products which are classified mainly as low technology content products. The main exception is micro- and nano-electronics, where all products exported by East Asia have technology content. In addition, 46% of nanotechnology exports in 2007–2011 were based on products with higher-than-average unit values, though most of these products reported decreasing export unit values compared with the same products in the competitor regions. In advanced manufacturing technologies for other KETs, most East Asian export products show an increasing technology content over time. In advanced materials, East Asia reports a similar pattern of technology content as North America: a mix of high and low technology content products. Photonics is clearly where East Asian exports focus on low technology content products, an indication of early stages in the value chains.

Within the EU-28, export performance with respect to technology content varies among Member States, though the main patterns for the EU-28 can be recognised for many of the largest Member States (Figure 5.7). In industrial biotechnology, a high share of exports with products showing a high and increasing technology content can be found for

Denmark, the Czech Republic, Belgium, Austria, France, Netherlands, the UK, Germany and Italy.

In nanotechnology, only the UK, Netherlands, Belgium and Italy report a share above 50% for products with high and increasing technology content. For photonics, the high share of EU-28 exports products with high and increasing technology content is due mainly to the export activities of France and Sweden.

5.2.3. Type of competition and competitive advantages in international trade

In addition to technology content, the type of competition a country's or region's products face in international trade provides further, complementary information on the position of the country/region in international value chains. To simplify: product market competition can be driven either by price or by quality. Price competition dominates if the price elasticity is high while at the same time product differentiation (differentiating similar products by quality characteristics such as durability, usability, flexibility, additional performance characteristics) is of little relevance. Price competition often indicates that products are positioned earlier in the value chain, while quality competition may be associated with more complex products further along the values chain.

Aiginger (1997, 2000) proposed a method to classify products according to quality and price competition based on the relation of a region's export unit values to its import unit values on the one hand, and its trade balance on the other. Products are price elastic (price competition dominates) if export unit values which are higher (lower) than import unit values lead to a negative (positive) trade balance.

Conversely, products for which higher (lower) export unit values than import unit values result in a positive (negative) trade balance are price inelastic, in other words quality competition dominates. For both types of competition, a positive trade balance is an indication that the region can build on a competitive advantage for that type of competition. Combining the relation of export unit values to import unit values with the trade balance produces four quadrants (Figure 5.8) in which a region can be positioned for each KET-related product:

1. Quality competition with a quality advantage: where export unit values exceed import unit values and the trade balance is positive – a country or region can export more of a certain product than it imports, despite higher prices.
2. Quality competition without quality advantage: export unit values are lower than import unit values while the trade balance is negative – a country or region imports more than it exports despite lower prices, indicating that quality is the main driver for trade.
3. Price competition with a price advantage: a country or region shows lower export unit values than import unit values and can translate lower prices into a positive trade balance.
4. Price competition without a price advantage: export unit values are higher than import unit values in combination with a negative trade balance.

As for technology content, the type of competition that dominates the exports of country or region *i* in a certain KET *k* is determined by the position *p* in the quadrants shown in Figure 5.8 ($p \in \{1,2,3,4\}$) that each individual product *j* belonging to KET area *k* occupies, weighted by the product's share in total exports *X* of products related to KET area *k* of country or region *i*. To calculate the type of competition, the same data source is used as for calculating the technology content of trade.

The results for the three main regions are reported in Figure 5.9. Exports of KETs-related products by the EU-28 face very different competition on international markets. In advanced manufacturing technologies for other KETs, most EU-28 exports (64%) concern products for which trade is characterised by quality competition. For almost all these products, the EU-28 has a quality advantage; in other words, it is able to gain a positive trade balance based on superior product quality. In nanotechnology, industrial biotechnology and advanced materials, only 23% to 34% of EU-28 exports are based on quality competition. Although the majority of EU-28 exports in these KETs is characterised by price competition, most of these exports benefit from price advantages. This means that Member States specialise in those price- sensitive products for which a cost-efficient production in the EU is possible. In photonics and micro-/nanoelectronics, most of the products exported by the EU-28 are in price competition (89% and 94% respectively), and for the majority of these products the EU has no price advantage.

North America reports a strong focus on exports which face quality competition: it relies on a quality advantage in international trade in the fields of photonics (78% of all exports in this KET) and nanotechnology (54%). In micro- and nano-electronics, 41% of North America's exports fall into this category, while 15% are characterised by quality competition, without having a quality advantage. In the other three KETs, exports from North America mainly face price competition, with a price advantage over their main competitors.

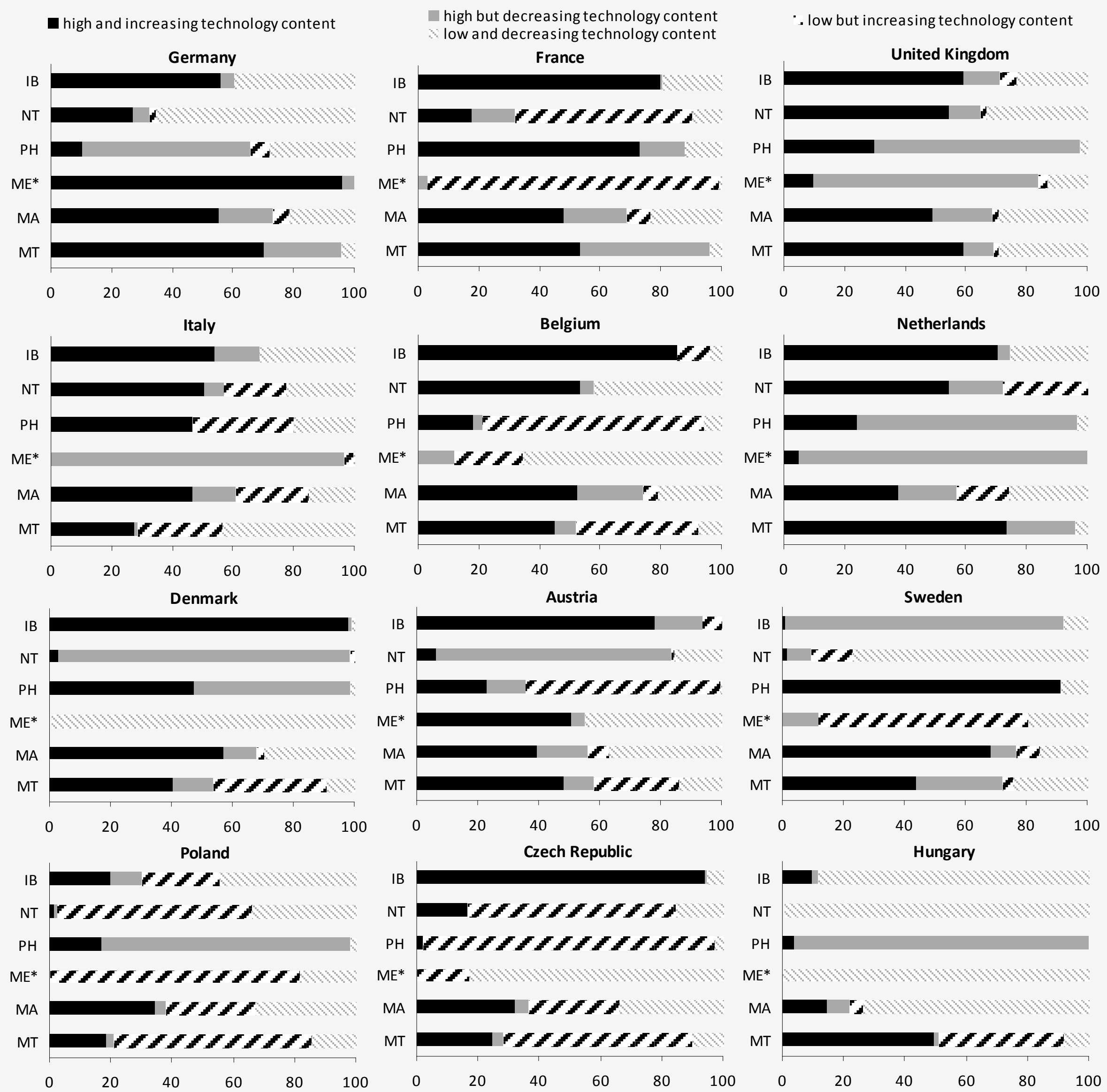
East Asia's trade in KET-related products is strongly focused on price competition. In five KETs –

industrial biotechnology, nanotechnology, micro- and nanoelectronics, advanced materials and advanced manufacturing technologies for other KETs – East Asia benefits from a price advantage, in other words a cost-efficient production. Photonics is the only area where East Asia's exports are under major pressure, as most of its products face price competition but cannot compete on a price advantage. In each KET, the share of KET-related products exported from East Asia which are in markets dominated by quality competition is lower than for North America, ranging from 10% (micro-and nanoelectronics) to 29% (photonics). The majority of these exports do not have a quality advantage.

When examining the development of competition types by KET over time, no clear trends for the EU-28 emerge. In advanced manufacturing technologies for other KETs, the share of EU exports based on quality competition and quality advantage increased during the 2000s, while the share of exports based on price competition and price advantage decreased. In photonics, the share of EU exports in markets with price competition which could profit from an EU price advantage has fallen substantially in the last ten years, while the share of exports facing price competition without a price advantage has increased.

At the level of EU Member States (Figure 5.10), most countries face price competition for the majority of their KETs-related exports. Interestingly, for products facing price competition some large Member States (Germany, France, UK, Italy) and the Netherlands do not appear to have any price advantage. By contrast, exports of price-sensitive KET-related products from

Figure 5.7. Technology content of KET-related products by KET for selected Member States, 2007 – 2011 averages



Notes: IB: Industrial biotechnology; NT: Nanotechnology; PH: Photonics; ME: Micro and nanoelectronics; MA: Advanced materials; MT: AMT for other KETs.
** 2005–2006 average, change in unit values for 2002–2003 to 2005–2006.*
Source: COMTRADE Database, NIW calculations

Sweden, Austria, Belgium, the Czech Republic and Hungary rely mostly on price advantages, though in each Member State there are also some KETs with products that predominantly feature price disadvantages.

Quality competition dominates for only a few KETs in each Member State. In Germany and Austria, most exports in advanced manufacturing technologies for other KETs rely on quality advantages and compete on quality. In Denmark and Sweden, the same is true

Figure 5.8. Measuring the type of competition and competitive advantages of manufactured products

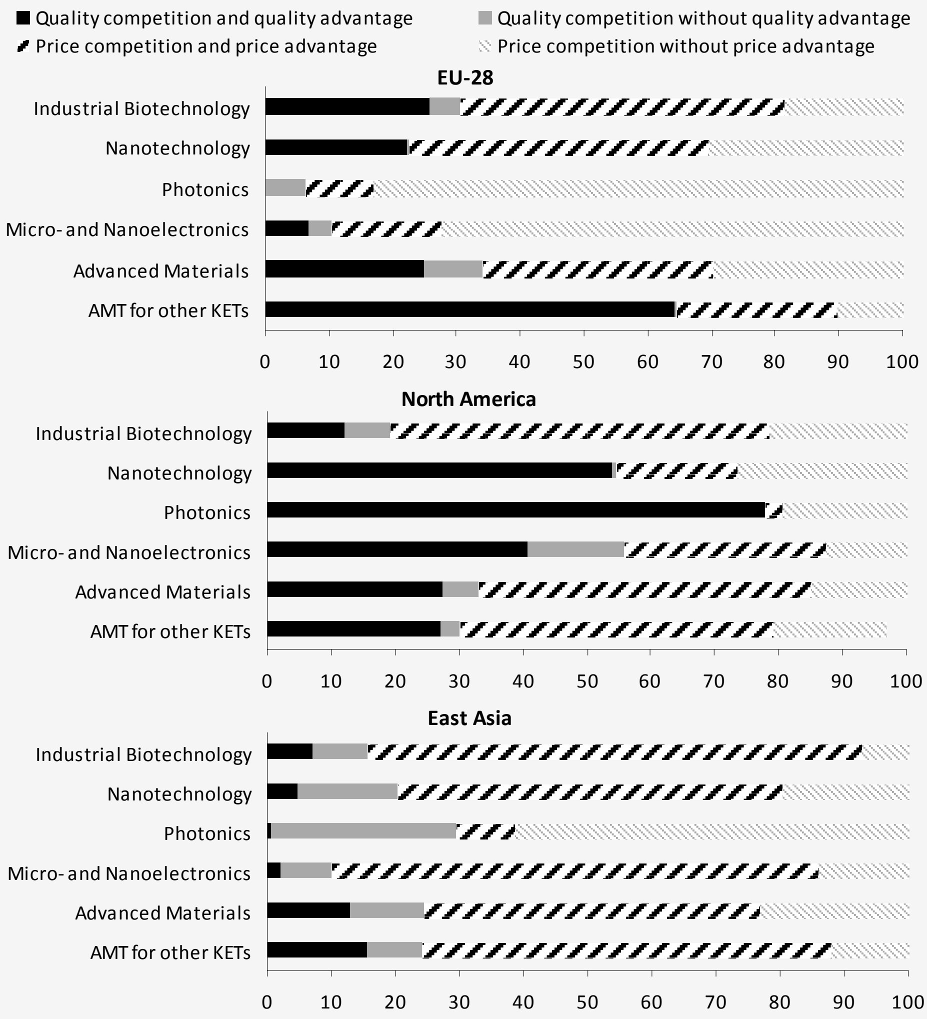
p=1: quality competition and quality advantage $UV^X_{ijt} > UV^M_{ijt}$ $Q^X_{ijt} > Q^M_{ijt}$	p=3: price competition and price advantage $UV^X_{ijt} < UV^M_{ijt}$ $Q^X_{ijt} > Q^M_{ijt}$
p=2: quality competition, no quality advantage $UV^X_{ijt} < UV^M_{it}$ $Q^X_{ijt} < Q^M_{ijt}$	p=4: price competition, no price advantage $UV^X_{ijt} > UV^M_{ijt}$ $Q^X_{ijt} < Q^M_{ijt}$

$$CP(p)_{ikt} = \Sigma_j X_{pij(k)t} / \Sigma_{ip} X_{pij(k)t}$$

UV ... unit value ($/kg)
X ... exports
M ... imports
Q ... quantity (kg)
Δ ... change over time
i ... country/region (i ∊ w)
w ... world (total trade)
j ... KET-related product
k ... KET
t ... time
CP ... Type of Competition
p ... position in quadrant

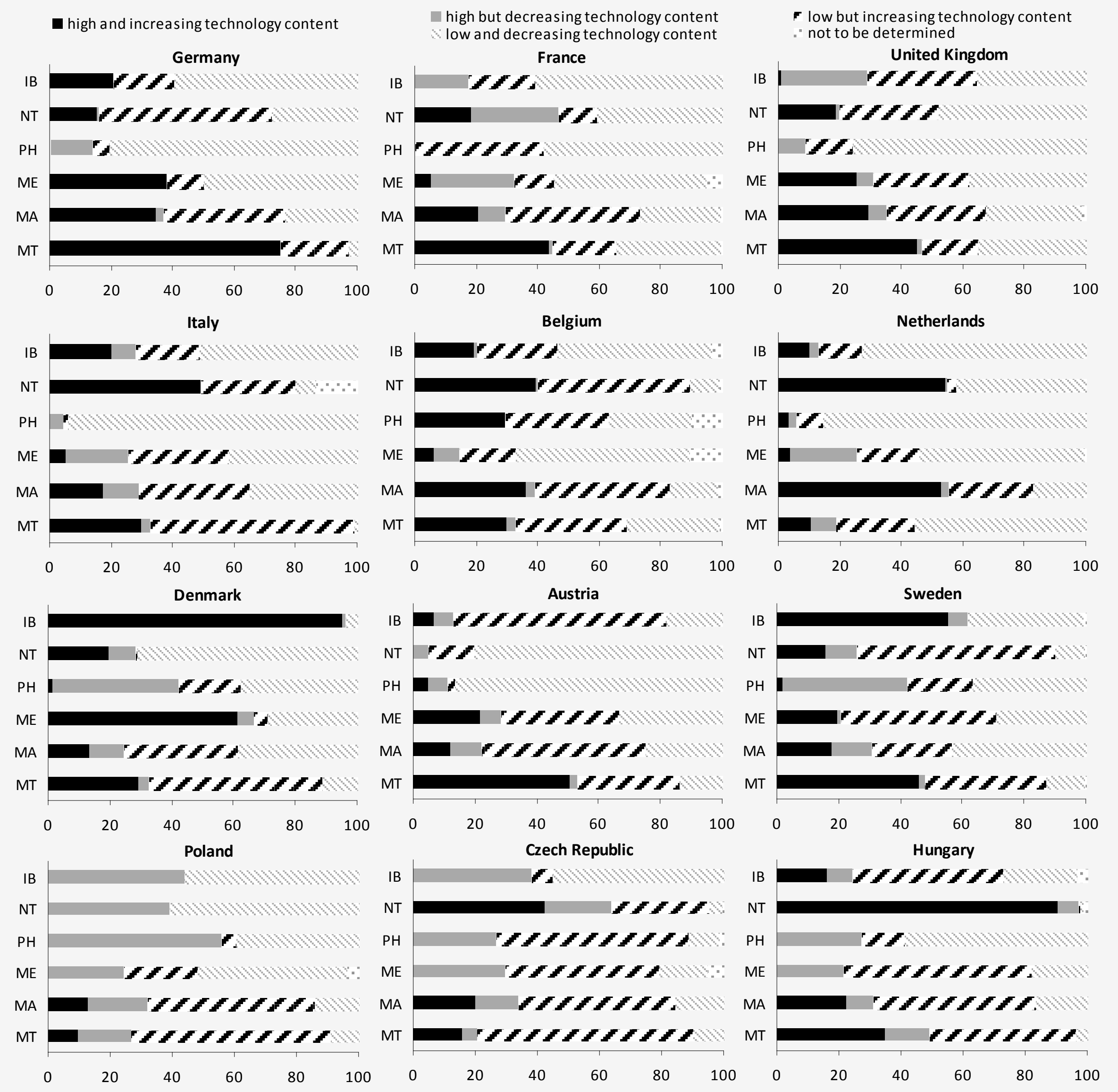
Source: NIW/ZEW based on Aiginger (1997)

Figure 5.9. Type of competition in trade with KET-related products, 2002 – 2011 averages



Source: COMTRADE Database. NIW calculations for industrial biotechnology. Exports from the Netherlands and Hungary in products related to nanotechnology are also predominantly based on a quality advantage in markets where they face quality competition. In micro- and nanoelectronics, Denmark is the only Member State considered here which exports most of its products based on quality competition and quality advantage. In advanced materials, only the Netherlands is in the same situation. In photonics, for all Member States considered here apart from Poland, most export markets are characterised by price competition, but most Member States do not possess a price advantage for these exports.

Figure 5.10. Type of competition in trade with KETs-related products for selected Member States, 2002–2011 averages



IB: Industrial biotechnology; NT: Nanotechnology; PH: Photonics; ME: Micro and nanoelectronics; MA: Advanced materials; MT: AMT for other KETs
Source: COMTRADE Database, NIW calculations

5.2.4. Link between patenting and technology content of products related to key enabling technologies

The link between patenting activities and the technology content of products provides another indication of a country's position in the value chains of KET-related products. If the production of new technological knowledge (as revealed through patent applications) has a direct impact on the technology content of traded products, one may conclude that these products are closer to the technological frontier and depend on a direct technology input from recent efforts in developing new technology. In order to examine this link, a country's unit values of exports of products based on a certain KET are regressed are regressed on the patent activities of that country in the same KET.

The level of export unit values (UV) for each product *j* belonging to a KET *k* in country *i* in period *t* are explained by the country's patent activity in the respective KET area *k* in a previous period $t-n$. Since unit values do not depend on country size, while patent activity does, the latter is divided by country population to derive a size-adjusted patent intensity (PINT). Country-specific variables such as size (GDP) and productivity (GDP per capita, PROD) are used to control for the effects of market size and the sophistication of the production system, while time dummies are used to capture changes in prices over time:

$$ln(\mathrm{UV}^X)_{ij,t} = \alpha + \beta_1\ ln(\mathrm{PINT})_{ik,t-n} + \beta_2\ ln(\mathrm{GDP})_{i,t} + \beta_3\ ln(\mathrm{PROD})_{i,t} + \Sigma_t\ \chi_t\ d_t + \varepsilon_i \qquad \text{with } j \in k$$

The patent intensity indicates to what extent a country produces new technological knowledge in a certain subfield of KETs given the total resources available in that country. All variables are measured in logarithms. The model is estimated for each KET separately as well as across all KETs for the period 2002 to 2011 for 39 countries (EU-28, US, Canada, China, Japan, South Korea, Switzerland, Norway, Iceland, Israel, Former Yugoslav Republic of Macedonia, and Russia).

The estimation results confirm a positive link between lagged patent intensity and unit values. Across all six KETs, a 10% increase in patenting results in a 1.2% increase in export unit values (Figure 5.11). The impact of patenting on the technology content of exports is largest in advanced manufacturing technologies for other KETs (2.4% increase in unit values, or twice as high as for all KETs) and micro-/nanoelectronics (2.3% increase). In industrial biotechnology, the elasticity of unit values on patent intensity is 1.5%, in nanotechnology 1.4%, in advanced materials 1.0% and in photonics 0.8%.

The main findings also hold when only EU Member States are considered. For the EU, the link between patent intensity and unit values of exports is of similar magnitude as for the entire set of countries. A 10% increase of patent intensity would transfer into an increase of export unit values of 1.0%. For three KETs, the link between patenting and technology content of exports is stronger in the EU than for all 39 countries considered in this analysis. In micro-/nanoelectronics, a 10% increase in patent intensity in the EU-28 results in a 2.7% increase in export unit values.

In photonics, the elasticity in the EU-28 is 1.0% and 1.6% in industrial biotechnology. In advanced manufacturing technologies for other KETs, the EU Member States report the same elasticity for patenting as the total group of 39 countries. In nanotechnology and advanced materials, the EU-28 elasticity of patenting is somewhat lower (0.9% and 0.8% respectively).

5.3. VALUE CHAIN ANALYSIS OF PROMISING KETS-BASED PRODUCTS

5.3.1. Introduction

How do these general observations hold when focusing on a number of product-specific value chains? In this section, the value chains of two promising products based on key enabling technologies are analysed and discussed. First, the selection of the two products, lipase enzymes and accelerometers, is explained. A more detailed analysis of the value chain of lipase enzymes and the accelerometer is then provided.

The analysis begins with a detailed description of the value chain, after which all relevant players in each part of the value chain are identified, thereby analysing the position of EU companies vis-à-vis non-EU companies. The information and analyses are based on expert interviews, articles, news sites and market reports. The methodology used to analyse the value chain is the same methodology as in the feasibility study for an EU monitoring mechanism on KETs (Van de Velde et al. 2013).

The analysis points out that EU firms play an important role in essential parts of the value chain even though the exact proportions of value added captured by EU firms could not be retrieved.[4]

5.3.2. Selection of products

The economic importance and growth potential of the candidate product has been the main selection criterion. Furthermore, whether a candidate product constitutes a relatively new application or is well-established is another factor to consider. The value chain analysis aims to focus on upcoming products that are driven by technological innovation, and to analyse how the EU performs in developing and

[4] A major difficulty here is the possibility of estimating the value added of a KETs-based product in the total product range of a company. For example, in the case of foundries, no information is disclosed on the share of the accelerometer production versus total production. Moreover, this share tends to change over time, particularly due to rapid shifts in market demand. There is also often a problem of corporate confidentiality to overcome.

marketing new high technology products in the KETs area and how EU policies support this process. On the basis of an extensive literature review, the enzyme class lipases in industrial biotechnology and the accelerometer in micro- and nanoelectronics were chosen. The overall selection process is presented in Figure 5.12.

Figure 5.11. Different steps in the selection of products for the value chain analysis

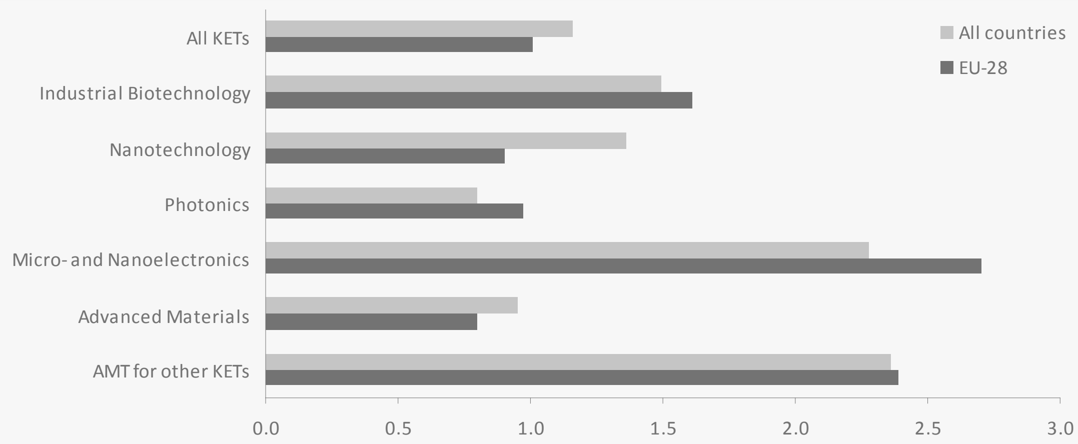
Source: IDEA Consult

5.3.2.1. *Lipase enzymes*

The first key enabling technology selected is industrial biotechnology because of its fundamental role in the development of a bio-based economy. Bio-based products are one of the six priority action lines in the Communication 'A stronger European Industry for Growth and Economic Recovery' (European Commission 2012b). Within industrial biotechnology, enzymes have been selected as the product segment. Enzymes are one of the major promising areas in industrial biotechnology. They enable a broad range of applications and provide several advantages over traditional chemistry, including high selectivity, lower energy use and mild reaction conditions. The market for enzymes has grown rapidly over the past decade, and both households and industry are becoming more dependent on enzymatic catalysis. Even so, there remains a vast untapped potential in the enzyme market (Sarrouh et al. 2012). In 2010, the market for industrial enzymes was worth USD 3.3bn and is expected to grow to USD 4.4bn by 2015, a compound annual growth rate of 6% over those five years (BCC Research 2011a).

Within enzymes, lipases are, together with carbohydrases, considered to have the highest growth prospects (Global Industry Analysts 2012). Lipases – enzymes that catalyse chemical conversions of fats – have traditionally been used in detergents to remove fat and oily stains. In addition, they are increasingly used in the food industry, for instance in applications involving dairy products and baking. In recent years, lipases have also received more attention as highly effective, versatile and flexible biocatalysts for organic synthesis. This has opened up a whole new range of possibilities, including the production of basic chemicals, specialty chemicals, pharmaceuticals, cosmetics and biodiesel. Lipases have the potential to impact positively on several industries, both in terms of competitiveness and environmental friendliness (lower energy use, fewer unwanted side-products). Therefore this product is selected to analyse the position of the EU in the value chain of this class of enzymes.

Figure 5.12. Link between patent output and unit values of exports, 2002 – 2011, change in unit values from a 10 % change of patent output, by KET, 2002 – 2011

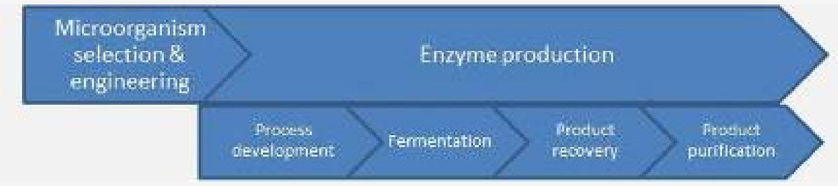


Source: COMTRADE and PATSTAT data, ZEW calculations

5.3.2.2. *Accelerometer*

Micro and nanoelectronics provide knowledge and technologies which generate some 10% of GDP. The expected market size for this key enabling technology is estimated to be USD 300bn in 2015, with an expected compound annual growth rate of 13% (HLG MNE 2011). It has enabled the rise of the information age, impacts deeply on everyday life and is expected to continue to do so. Given the increasing importance of 'More-than-Moore' (MtM) applications, a product within MtM and more specifically in the segment of micro-electro mechanical systems (MEMS) was chosen. MEMS are products elementary for many types of interactions of electronics with the outside world, and provide a good example of the continued integration of digital and non-digital functions over time (the MtM trend). This integration has enabled MEMS to grow rapidly in recent years. The MtM trend is a major evolution with potential for radical innovations, and the relative weight of MtM in the industry is expected to increase (ITRS 2010).

Figure 5.13. Value chain decomposition for enzymes



Source: IDEA Consult

In the MEMS segment, rapid growth is expected for inertial sensors (Yole Développement 2012). One example of fast-growing inertial sensors is the accelerometer, which is the chosen product based on this key enabling technology. It is a motion sensor which measures the acceleration of a given object. It was first introduced on a large scale in the automotive sector but has since found its way into many consumer electronics applications. In mobile devices such as smartphones, accelerometers are key sensors as they enable gesture recognition, user interface control and activity monitoring. Other consumer electronics applications include measuring motion in gaming and sports applications. The accelerometer has been an important sensor in the evolution towards more 'intelligent' consumer electronics – devices becoming increasingly aware of the environment and the conditions of the device (Ryhänen 2010). As the accelerometer is representative of two major evolutions in micro- and nanoelectronics – the trend towards mobile, intelligent devices and the integration of heterogeneous functions – this product has been selected.

5.4. VALUE CHAIN ANALYSIS OF LIPASE ENZYMES

5.4.1. Value chain decomposition

Figure 5.13 shows the value chain of lipase enzymes, consisting of two broad phases. First there is the selection and genetic engineering of an appropriate microorganism capable of producing the enzyme of interest. Then there is the actual production of the enzyme. The latter phase can be subdivided into four major steps. The first step is the development of the production process, which entails discerning the right conditions for fermentation (the following step) and the up-scaling of production from laboratory scale to commercial scale. Once the production process is optimised, large-scale fermentation can occur. During fermentation, the microorganisms grow on a substrate and produce the enzyme of interest. Once fermentation is complete, the next step is to separate the enzymes from the fermentation mass (product recovery). In the final step, the enzyme product is purified. The necessity of this final step depends on the application.

The value chain in Figure 5.13 applies not only to lipase enzymes but to enzymes in general, and to a large extent even to industrial biotechnology in general.

5.4.2. EU activity along the value chain

In what follows, the key players in the lipase enzymes value chain will be identified and discussed. First, the lipase enzyme producers – companies selling lipase enzymes – will be described. Next, companies that do not sell lipases directly but contribute to the value added of this product by executing a specific step in the value chain will be discussed. The focus will be on the companies providing services for the selection and engineering of the microorganism, followed by companies active in the second part of the value chain, namely enzyme production. Table 5.1 provides an overview of identified companies along the value chain.

5.4.2.1. *Lipase producers*

Fifteen companies selling lipases have been identified, almost half of them located in Europe. In Denmark-based Novozymes, Europe hosts the world's largest player in the overall enzyme industry with a market share of about 47% of global enzyme sales in 2011. With regard to lipase enzymes, the company offers a broad portfolio of enzymes for various applications, including as detergents and food processing, but also more recent applications such as biocatalysis for the pharmaceutical, cosmetics and chemicals industry. Netherlands-based DSM is larger than Novozymes in terms of revenue but has a lower market share in enzymes (6% compared with 47% for

Novozymes [5]). DSM is active particularly in lipases for food applications and has recently underlined its interest in this field by acquiring lipase technology from US-based Verenium, primarily to extend its activities in food applications. However, its lipase portfolio is not as broad as that of Novozymes.

The other European companies active in the lipase segment are generally an order of magnitude smaller than DSM and Novozymes. Many of them focus on a number of specific applications. For example, AB Enzymes (owned by the UK-based ABF) produces lipases predominantly for food (baking) purposes, while Biocatalysts focuses on dairy applications. Eucodis Bioscience is a relatively young company with a high share of lipases in its product portfolio, targeting mainly pharmaceutical applications. Germany-based C-lecta is also a relatively young company, offering enzymes for a limited number of applications. With its lipase products it focuses notably on the production of specialty chemicals.

Outside the EU, the main emerging country is the US, where the largest player is Dupont, due to its recent acquisition of Genencor. Genencor is the second largest enzyme producer in the world, with about half the sales of Novozymes. While Genencor holds a strong position in the food enzyme market, it has so far not been able to play a leading role in the lipase segment of the food market. In addition, unlike Novozymes it is much less present in the emerging markets for lipases, such as pharmaceutical and chemical market applications. The other US companies are significantly smaller than Genencor. Codexis produces enzymes used to improve production processes in the pharmaceutical industry and is currently developing its lipase activities. Verenium has achieved some success in the commercial development of lipases, as illustrated by the recent acquisition of its enzyme technology including lipases by DSM. Dyadic is another rather small company which owns a revolutionary technology platform for the discovery and production of enzymes, but it does not have a specific focus on lipases.

Japan has two companies in Table 5.1. Amano Enzymes has a long history as a specialty enzyme developer, with key strengths in hydrolases. One of its most successful products is a lipase which has been widely produced in the past. However, Amano does not serve the wide range of applications Novozymes does. The other Japanese company, Meito-Sangyo, is smaller than Amano but is also a recognised player in the field of lipases, especially in applications involving chiral transformations.

Two companies from India also appear in the list, both offering a broad portfolio of lipases. This reflects the emergence of India in the enzyme industry as one of the countries with the highest level of commitment to the development of industrial biotech in Asia.

European companies are well represented in each segment. In the detergent segment, Genencor and Novozymes are the two companies with the highest market shares. The food segment is dominated by Novozymes and DSM. Novozymes is the clear market leader in the biocatalysis segment.

5.4.2.2. *Companies active in microorganism selection and engineering*

Lipase producers are not necessarily active in all parts of the value chain. Other companies can be active in specific segments. Only three companies have been identified as providers of services for microorganism selection and engineering services, the first part of the value chain. This can be explained by the fact that the first step of the value chain can be considered as a core competence of most lipase producers. One example of a company offering such services is DSM, which provides guidance to other companies in the development of their technologies. For example, when a lipase producer is working on the commercialisation of its products, DSM can propose other microorganisms for expressing the gene of interest in order to facilitate the up-scaling of enzyme production. Similarly, Lonza possesses so-called 'expression platforms' – in-house engineered microorganisms enabling high enzyme production levels.

5.4.2.3. *Companies active in enzyme production*

The large-scale production of enzymes requires considerable investment in infrastructure, which often creates a hurdle, especially for smaller (start-up) companies. Outsourcing enzyme production can deliver specific benefits to enzyme companies, not only by reducing the financial risk, but also by gaining access to the fermentation service provider's know-how. In this respect, it is important to note that in industrial biotechnology, the scaling up of the production of a given product (such as enzymes or vitamins) from laboratory to commercial scale is more difficult than in classical chemical production processes (Wydra 2012). Therefore the fermentation service providers often guide enzyme producers through the gradual up-scaling of production of a new enzyme, a service primarily used by smaller companies, whereas large industrial players typically organise the whole production in-house.

5 Source: Novozymes

The companies identified as active in enzyme production are shown in the lower part of Table 5.1. These companies are known to be engaged in contract production of enzymes for industrial purposes. However, it should be noted that the importance of lipase production in their production services may vary over time, and is not fully disclosed by these companies. This list therefore applies to industrial enzyme production in general. Four companies are located in Europe. DSM, by far the largest company involved, is present also in the list of lipase producers. Apart from producing enzymes under its own brand name, it also offers a broad range of fermentation services to other companies. Two other companies, Eucodis Bioscience and Biocatalysts, are also identified as lipase producers. Finland-based Galilaeus is a small company focusing on fermentation services for various fields.

Table 5.1. Overview of companies active along the lipase value chain

Region	Country	Company name	Total revenue 2011 (USD million)
Lipase producers			
EU	**Netherlands**	**DSM**	**9 048**
	Denmark	**Novozymes**	**1 891**
	UK	**ABF (AB Enzymes)**[a]	**16 650 (127)**
	Germany	**C-lecta**	n.a.
	UK	**Biocatalysts Ltd**	n.a.
	Austria	**Eucodis Bioscience**	n.a.
Non-EU	US	Dupont (Genencor)[a]	38 000 (835b)
	US	Codexis	124
	US	Verenium	61
	US	Dyadic	10
	Japan	Amano	1 074c
	Japan	Meito-Sangyo	176
	India	Advanced Enzymes	34
	India	Aumgene Bioscience	n.a.
	China	Syncozymes	n.a.
Companies active in microorganism selection and engineering			
EU	**Netherlands**	**DSM**	**9 048**
Non-EU	Switzerland	Lonza	2 019
	India	Aumgene Bioscience	n.a.
Companies active in enzyme production			
	Netherlands	**DSM**	**9 048**
EU	**Finland**	**Galilaeus Oy.**	**1.9**[b]
	Austria	**Eucodis Bioscience**	n.a.
	UK	**Biocatalysts Ltd**	n.a.
	Switzerland	Novartis (Sandoz)[a]	58 566 (10 700)
	Switzerland	Lonza	2 019
Non-EU	Israel	Biodalia	n.a.
	Mexico	Fermic	n.a.
	India	Aumgene Bioscience	n.a.

Source: IDEA Consult. Company turnover and main production sites are based on corporate annual reports and company website information
Notes: a: in case the relevant activities are performed by a specific subsidiary, this subsidiary is listed in parentheses behind the parent company. b: total revenue 2010; c: total revenue 2012; n.a. = not available

Outside the EU, Switzerland hosts two companies. However, the presence of the large pharmaceutical company Novartis is due to its ownership of Sandoz, which offers a broad range of fermentation services to its facilities in Germany, Austria and Italy. Lonza is also a large company with a broad range of activities. Given that the main fermentation site of this company is located in the Czech Republic, it can be concluded that many activities of interest here of the two Swiss companies take place in Europe, particularly the fermentation services accessible to European firms.

Fermic, based in Mexico, has an agreement with US-based Verenium for the manufacturing of all of the latter's enzymes.

Table 5.2. Dominant companies per lipase application field

Application field	Companies with highest market shares
Detergent	Genencor, Novozymes
Food	DSM, Novozymes
Biocatalysis	Novozymes

Source: IDEA Consult [6]

The world enzyme market is dominated by a select number of companies (Novozymes, Genencor, DSM). In a market where product innovation is very important, their extensive R&D capabilities allow these companies to remain at the forefront. However, a second important element in the enzyme industry is the capability to produce enzymes on a large scale (and therefore at a moderate cost). This is because the scaling of manufacturing processes in industrial biotech is far less straightforward than in classical chemistry. Currently Novozymes, Genencor and DSM (and to a lesser extent AB Enzymes) distinguish themselves in the large-scale effective production of enzymes. While many smaller firms are good at the discovery of new enzymes with interesting properties, the step to large-scale manufacturing is not easy to take. As a consequence, the technology of the smaller companies is often acquired by larger companies who then set up large-scale production of the enzyme. Europe is well-placed in this regard and should foster its capabilities in large-scale enzyme production since it gives an important competitive advantage.

5.4.3. EU position in the value chain of lipase enzymes

With Novozymes (the world's leading enzyme supplier) and DSM, Europe has leading companies in all lipase application fields. In addition, Europe hosts a group of smaller companies which tend to specialise in certain applications. There is considerable competition from US companies, primarily Genencor. However, this company only has a leading market position in detergent lipases. Japan, on the other hand, hosts two recognised players which are strong in emerging applications such as pharmaceutical and chemical applications. However, the lipase activities of these companies do not have the scale of the large EU players.

Looking at more specific parts of the value chain, a significant share of fermentation services is provided within Europe, especially when taking into account several EU-based activities of companies with Swiss headquarters. No other major region emerges in this segment. As for the first step of the value chain, microorganism selection and engineering, only a few companies were identified, one of which is based in the EU. This represents a smaller segment though. The analysis – largely expert-driven – confirms that Europe is a key player in the global enzyme market and holds a strong position in the subfield of lipases.

It has not been possible to calculate the value added captured by European firms in the value chain of lipases. In order to assess the performance of EU companies, industry experts were asked to list the companies with the highest market shares for each of the three major application fields of lipases in order to gain insight into which regions lead in the segment. For companies not selling lipases but focusing on specific parts of the value chain, information on the relevance of lipases in their activities is typically more difficult to find since these activities are more remote from the end-product.

5.5. VALUE CHAIN ANALYSIS OF THE ACCELEROMETER

5.5.1. Value chain decomposition

The accelerometer consists of two main functional units: a mechanical component which senses the acceleration (the sensor) and an electronic unit which receives and translates the signals coming from the mechanical component. The electronic unit is often referred to as an application-specific integrated circuit (ASIC), as its sole purpose is to receive and translate signals from the mechanical component. Figure 5.14 is a schematic representation of the value chain of the accelerometer. It covers two major phases, the design and manufacturing of the ASIC and of the sensor. In the design phase, a complete plan of the ASIC and sensor is drawn, detailing all functional structures and how they will be interconnected. These plans will be translated into a format that can be used for manufacturing. The manufacturing process can be divided into four steps. The first step is the fabrication of the ASIC and sensor on a large silicon substrate (or wafer). The next step, wafer probing, is to inspect the wafer for malfunctioning ASICs and sensors. Then the two components are integrated into one package, followed by a final phase of tests of the accelerometer. Each step will be discussed in more detail below.

The value chain of the accelerometer consists of many steps. A company can opt to cover the whole value chain itself or focus on a specific number of steps. Companies covering the entire chain are integrated device manufacturers (IDMs) and are responsible for the design, manufacturing and sale of their own products. However, other business models

[6] Table 5.2 important players in each application field.

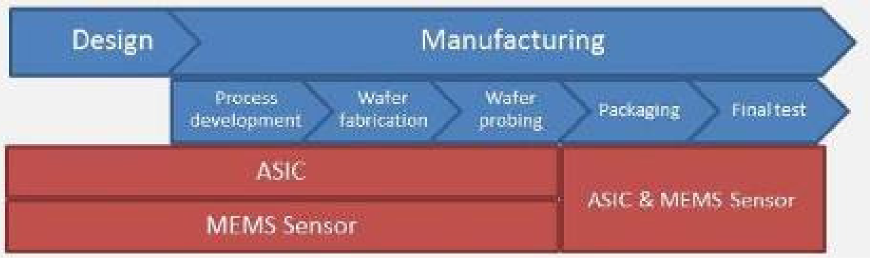
exist as well. A company can focus on design but leave manufacturing to another firm (a 'fabless' company). Companies focusing exclusively on manufacturing chips commissioned by 'fabless' companies are referred to as foundries. Intermediate forms can also exist: a company can manufacture part of its products and outsource the rest to a foundry, or be active only in the design phase by providing design services to other companies.

This illustrates that the value added from creating an accelerometer is divided among several companies, each covering particular stages of the value chain. It is therefore important to look not only at the end-producers of this product but at all parts of the value chain when assessing the competitiveness of the EU in this product. In the following paragraphs, the key players will be identified for each step of the value chain. First the end-producers of accelerometers (companies selling accelerometers) will be discussed, followed by companies active in the first part of the value chain (design) and then those active in the second part of the value chain (manufacturing).

The interest of consumer electronics manufacturers in accelerometers (and other MEMS) has grown gradually as a result of their drive to give electronics 'intelligent' attributes. This posed a number of technical challenges – smaller chips, higher production volumes and extreme cost consciousness. STMicroelectronics was one of the first sensor producers to spot the potential of the consumer electronics market and develop large-scale production facilities for that market. This has brought the company solid growth and a strong position in this segment. Robert Bosch is another key player in the consumer electronics market. Strength in both the automotive and consumer segments provides an opportunity to operate at a large scale, thus reducing costs. The main competition in the accelerometer market comes from US-based companies. Analog Devices and Freescale are two well-established competitors, while Memsic and Invense are two young, promising and innovative companies with strong growth rates over the past years.

The accelerometer market was worth around USD 1.5bn in 2011 and dominated by companies such as STMicroelectronics and Bosch (around 20% each), Freescale (around 10%), Analog Devices, Denso and VTI. The success of STMicroelectronics and Bosch in both automotive and consumer electronics makes them the two largest players in the accelerometer market. The EU represents almost half of the market in this segment, making it the leading region. Two US companies, Freescale and Analog Devices, also capture a significant share of the market, although less than STMicroelectronics or Bosch. Together with other US companies with smaller market shares, the US has the second largest market share after the EU. The third player, Japan, has been able to capture a considerable share of the market with Denso and the acquisition of VTI and Kionix.

Figure 5.14. Value chain decomposition for the accelerometer



Source: IDEA Consult

5.5.1.1. *Accelerometer producers*

Table 5.3 lists the most important players in the accelerometer industry. It is clear that Germany, the US and Japan are the three countries covering the majority of the market (in case of multinational companies, the country assigned is the location of the parent company).

Europe has a small group of large companies, while in the US there is a larger group of somewhat smaller companies. Japan has three major players on the market, but two are the result of recent acquisitions (Rohm Semiconductor acquired US-based Kionix, while Murata Electronics acquired Finland-based VTI). The widespread use of accelerometers started in the automotive industry, which remains an important market. All large companies in Table 5.3 have a strong presence in the automotive sector. In this respect it has been an advantage for companies in Europe to have a strong domestic automotive market.

5.5.1.2. *Companies active in design*

Companies specialising in support for MEMS producers in the design phase are often referred to as 'design houses'. Their task involves helping other companies with the design and prototyping of a new product. Design houses can help deliver a faster 'time-to-market' (which tends to be quite long for MEMS in general) and ensure a good match of the design with more conventional manufacturing techniques.

Table 5.3 also lists companies active as design houses for MEMS. It should be noted that the importance of accelerometer design in the activities of these companies varies over time and is not disclosed. Therefore, the list applies to MEMS more generally. Of the four identified actors, three are US-based. France-based Movea is a young, innovative company specialised in motion sensing. Design houses are a relatively small segment (much smaller than the foundry segment) since design is a core competence of most accelerometer end-producers and is often undertaken to a significant extent by these companies themselves.

5.5.1.3. *Companies active in manufacturing*

Companies active in accelerometer manufacturing are those which manufacture accelerometer products on behalf of a second party. Most of the large companies in Table 5.3 (Bosch, STMicroelectronics, Freescale, Analog Devices) are IDMs covering the whole value chain. However, this is not true for all accelerometer producers. The US-based company Invensense, for example, operates a fabless model by operating a simplified and innovative manufacturing process.

Outsourcing is not unique to small companies such as Invensense. Companies like Analog Devices also outsource part of their MEMS manufacturing. The main rationale behind outsourcing is cost reduction. The manufacturing equipment for integrated circuits is capital intensive and cost-competitive production is only possible if done on a large scale. A high-volume, quick-turnaround consumer segment can often be better served by dedicated large-scale foundries. An exception is the automotive market, where strict compliance requirements are in place and production is in most cases done internally. Another reason to use foundry services is the expertise these companies have in the successful up-scaling of production to large volumes.

Table 5.3 lists the most important foundries active in accelerometer manufacturing. This list consists of companies that undertake manufacturing of accelerometer products on behalf of a second party. It should be noted that while the companies listed in the table are known to have accelerometer production capabilities, the importance of accelerometer production in their total activities varies over time and is not disclosed. Two types of foundries can be distinguished: those making only MEMS products and those active also in the regular electronics markets (memory, microprocessors). The latter category of firms is referred to as silicon foundries. Foundries (whether MEMS-exclusive or not) often develop their own technological (manufacturing) competences and hold a number of patents on in-house manufacturing technology. MEMS foundries also tend to offer a number of services aimed at facilitating the translation of design into a successful product, going from co-design to custom-specific process development and packaging and testing.

In Europe there is considerable foundry activity in four countries. Silex Microsystems has grown strongly in MEMS and has become a strong player thanks to its in-house manufacturing technology which allows close integration of the ASIC and the sensor. However, the EU foundry companies are relatively small; and as only a part of their revenues stems from accelerometer production their weight is much smaller than accelerometer producers such as STMicroelectronics and Robert Bosch.

Outside the EU, US companies are somewhat less present in the foundry segment than the end-product market. Global Foundries is a leading silicon foundry, but in MEMS it is currently a small player as it has only recently moved into this field (including accelerometers), attracted by the good market prospects. Taiwanese companies have a stronger presence on the foundry list than on the list of accelerometer producers. The less prominent presence of US companies and the strong emergence of Taiwanese companies might be interrelated, as a number of US companies employ Taiwanese foundries for their manufacturing. For example, Invensense operates as a fully fabless company, with all the manufacturing done in Taiwan by TSMC.

In addition, Analog Devices also outsources the manufacturing of the electronic component (ASIC) of its accelerometer to TSMC.

The Taiwanese foundry giants TSMC and UMC are two examples of the successful development of the semiconductor industry in Taiwan, particularly of the foundry segment. These firms make the large majority of their sales in the mainstream semiconductor segments but are increasingly used by other companies for MEMS production because the large foundries are able to produce at low cost and in large volumes. The positive growth prospects of the MEMS segment have caught their attention, and both have been active in developing skills needed for mechanical sensor production in recent years. Other silicon foundries are also entering, or planning to enter, the MEMS segment. Germany-based Xfab has invested heavily in MEMS production capacities in recent years and has recorded positive growth figures in this segment. The competition from foundries in the mainstream semiconductor industry is expected to grow in the near future.

A possible future competitive threat for Europe is its low level of investments over the past decade in semiconductor production capacity. European companies have followed a strategy of prolonging the life of 150 mm and 200 mm fabs by using them for MEMS production. Investments in 300 mm fabs have been low compared to US and Asia. Europe currently has a very limited market share in the mainstream semiconductor segments, where production in most cases is done on 300 mm wafers and with advanced technology. On the other hand, MEMS production can be achieved competitively on 150 mm or 200 mm wafer fabs and without using the latest technology. However, with the ongoing depreciation of the older 150 mm and 200 mm fabs and the expected move of the mainstream semiconductor industry to 450 mm technology, it is expected that within five to ten years all MEMS production will take place on 300 mm wafer fabs. Given that there is currently little 300 mm production technology in Europe, there is a risk that manufacturing of MEMS (and the associated value added and employment) will increasingly move out of Europe. Moreover, the increasing dependence on foreign countries for enabling technologies such as micro- and nanoelectronics may at some point also give rise to strategic concerns.

A study for the European Commission in 2012 suggests that Europe needs to take advantage of the shift to 450 mm production technology to catch up with its investment deficit in production capacity. Indeed, once the new 450 mm technology is installed, significant spare 300 mm capacity will become available in other regions, and it will not make economic sense for the EU to invest massively in 300 mm capacity. One of the proposed scenarios is to install 450 mm capacity initially to safeguard the current strong position in 'More than Moore' (including MEMS and the accelerometer) and later to expand the scope to more advanced technology for 'More Moore' (mainstream semiconductor) production. The investment costs will be so high that they will need to be spread over several years, which means that early commitment is needed.

5.5.2. The EU position in the value chain of the accelerometer

The analysis shows that EU companies have a solid position in the end-producers segment of the accelerometer market. The EU is represented by a relatively small group of large companies that have a strong base in the automotive market. These companies have also been able to take significant shares of the fast-growing consumer market. The strongest competition in the end-producers segment comes from US-based companies which consist of a mixture of well-established companies and some younger, more innovative companies. In the smaller design segment, only a few companies have been identified, all of which are located in the EU or the US. In the foundry segment the EU is also well represented, with four companies active in four different countries. Here the main competition comes from the US, Canada and Taiwan, where regular silicon foundries as well as MEMS foundries are increasingly used by producers.

EU companies perform well thanks to a strong background in the automotive industry, good R&D competence and – particularly in the case of the two large IDMs – a rapid understanding of the possibilities of new markets and the advantage of large-scale production. However, an important future competitive threat exists as investments in new (300 mm wafer) production capacity have been low in Europe in recent years. Currently this is not a problem for MEMS (accelerometer) production, but as the mainstream semiconductor industry migrates to 450 mm wafers, manufacturing of MEMS (accelerometers) will occur on 300 mm within five to ten years. Therefore there is a risk that manufacturing of these products will move to other regions, primarily Asia. For Europe it seems that the transition to 450 mm should be taken as an opportunity to safeguard its leading position in accelerometers, but also in MEMS as a whole.

Again, in the case of the accelerometer it has not been possible to calculate the value added captured by European firms in the value chain. For accelerometer producers however, market reports contain information on the market share of each company, providing insights into how different regions are performing in the accelerometer market. For companies focusing on specific parts of the value chain, information on the relevance of the accelerometer in their activities is typically more difficult to find since these activities are more remote from the end-product and is therefore not included in this chapter.

5.6. CONCLUSIONS AND POLICY IMPLICATIONS

The results of the analysis show that Europe holds varying positions in the different KETs. Asia is gaining ground as a main producer of new technological knowledge in KETs, thereby demonstrating fast market share gains.

Europe has a strong technological capacity, a substantial production base, is specialised in (mature) products with high technology content, but has to compete mainly on price. Moving to the higher end of the value chain is a real challenge.

Table 5.3. Overview of companies active along the value chain of the accelerometer

Region	Country	Company name	Total revenue 2011 (USD million)
Accelerometer producers			
EU	**Germany**	**Robert Bosch**	**70 539**
	Netherlands	**STMicroelectronics**	**9 735**
	Germany	**Infineon**	**5 479**
	France	**Sagem (Colibrys)[a]**	**16 438 (16)**
Non-EU	US	Freescale Semiconductor	4 572
	US	Analog Devices	2 993
	US	Invensense	96
	US	Honeywell	36 529
	US	MEMSIC	68
	US	Endevco	n.a.
	Japan	Denso	37 660
	Japan	Murata Electronics (VTI)[a]	7 130b (76c)
	Japan	Rohm Semiconductor (Kionix)	3 187 (n.a.)
Companies active in design			
EU	**France**	**Movea**	n.a.
	US	A.M. Fitzgerald	n.a.
Non-EU	US	Nanoshift	n.a.
	US	SVTC Technologies	n.a.
Companies active in manufacturing			
EU	**Sweden**	**Silex Microsystems**	**47**
	France	**Tronics**	**15.2**
	Germany	**Xfab**	n.a.
	UK	**Semefab**	n.a.
Non-EU	Norway	Sensonor	7.5
	Israel	TowerJazz	611
	US	Global Foundries	3 480
	US	Teledyne (Dalsa Semiconductor)[a]	1 941 (212c)
	US	IMT	24
	Canada	Micralyne	15
	Taiwan	Asia Pacific Microsystems	n.a.
	Taiwan	TSMC	12 914
	Taiwan	UMC	3 855
	Malaysia	MEMSTech	n.a.
	US/Japan	UT - SPP (Silicon Sensing Systems)[a]	n.a.

Source: IDEA Consult. Company turnover is based on corporate annual reports and company website information.
Notes: a= in case the relevant activities are performed by a specific subsidiary, this subsidiary is listed in parentheses behind the parent company; b= total revenue 2012; c= total revenue 2010; n.a. = not available

Looking at its position in the production and trade of KETs, Europe has both a strong technological capacity and a substantial production base in all KETs. Europe is, in contrast to emerging competitors from East Asia, specialised in key enabling technology products with high technology content. However, most of these products seem to be mature as they compete mostly on price, less on quality. There are, however, differences between and within KETs.

- **Industrial biotechnology: high and increasing technology content of exports, and a price advantage.** In industrial biotechnology, Europe specialises in products with high technology content, in other words products with higher quality or further along the production chain. During the past decade, Europe has been able to further strengthen its position. Despite Europe's technological advance, exports predominantly face price competition. However, Europe tends to have a price advantage in international trade in industrial biotechnology products which could point to a more efficient production. Patenting is a major driver for the technology content of industrial biotechnology products.

- **Nanotechnology: low and decreasing technology content of exports but with a price advantage.** In the nanotechnology sector, the EU position is less favourable. The technology content of most products is lower than in the two main competitor regions (North America and East Asia) and going down, indicating a specialisation in less complex products. EU exports in nanotechnology compete mainly on price and in most cases EU products enjoy a price advantage. Patenting is important to achieve high technology content but this effect is less pronounced in Europe than in North America and East Asia.

- **Micro- and nanoelectronics: low and decreasing technology content of exports with no price advantage.** The technology content of products is low and decreasing, accompanied by strong price competition for exports and no sign of a price advantage for Europe. To maintain high levels of technology content, patenting is extremely important, having an even stronger impact in Europe than in the other two regions. Patent activities in Europe have not been sufficient to improve its trade position, though.

- **Photonics: high and increasing technology content of exports and a price advantage.** In photonics, EU exports show high and increasing levels of technology content, which primarily face price competition. Most of its exports do not show a price advantage relative to competitors. The role of patenting is lower for the technology content of photonics products than for most other KETs. A conclusion could be that Europe is specialised in high-end products in photonics, while global markets are increasingly characterised by price erosion.

- **Advanced materials: high and increasing technology content of exports and a price advantage.** Advanced materials are in a similar position as industrial biotechnology products in Europe. The technology content is high and increasing for most of Europe's exports. International competition is driven by price competition and Europe can build on price advantages for most of its export products. Patenting is of secondary relevance for the technology content of products.

- **Advanced manufacturing for other KETs: Europe is leading; high technology content of exports; a clear quality advantage**. Advanced manufacturing for other KETs is the KET area in which Europe holds the most advanced position in production and trade. The technology content of exports is high, increasing and strongly based on patenting. Most of Europe's exports compete on quality and Europe holds quality advantages for most of its export products. Europe is the leading region in this KET, which is also confirmed by a high positive specialisation and a high positive trade balance.

The EU position in each of the key enabling technology value chains is summarised in Table 5.4.

A key challenge for European competitiveness policy is to bring **European industry onto a competitive path that rests firmly on more innovative and more complex products**. In many KETs this would mean a focus on more integrated technologies, including those which link several KETs. Such a product portfolio would imply a shift of competitive pressure towards quality competition. In such an environment, EU industry could better exploit its competitive advantages and create real value on several levels.

In order to achieve this, various approaches may be followed:

- Improving the links between producers of basic technological elements with producers of components and final products;

- Strengthening cross-fertilisation of technology developments across key enabling technologies;

- Fostering and reinforcing the development of clusters along value chains in key enabling technologies, including knowledge producers (such as universities and research institutes) and knowledge users.

Although precise figures on the value added captured by European companies are unavailable (due to confidentiality issues and the lack of insight into the share of a particular technology in the overall valued added of a company) the results show that **the EU is a key player in the area of lipase enzymes and the global enzyme market**. **Europe also has a solid position in the end-producers segment of the accelerometer**, as some EU companies have taken a significant share of the automotive and consumer electronics markets, two markets where accelerometers are applied. Competition is nevertheless strong, especially in the foundry segment.

Table 5.4. The position of the EU in the production and trade of KET-related products: summary overview

Industrial biotechnology materials AMT for other KETs	Nano-technology	Micro-/nano-electronics		Photonics	Advanced
Technology content of exports high and increasing	high and increasing high and increasing		low, mostly decreasing high and increasing		low and decreasing
Type of competitionmostly price competition, price advantage no price advantageprice competition, no price advantage competition, quality advantage		price competition, mostly with price advantage price competition, mostly with price advantage			price competition, mostly quality
Impact of patentingmoderate	low	high	low	low	high

Source: ZEW and NIW

The strategy of moving European industry to the higher end of value chains could build on a strong base in each basic element within each key enabling technology. Policy should also consider the advantages of global cooperation in the development and deployment of new key enabling technologies and new applications. This could mean cooperation with specialised technology suppliers from other world regions. On the other hand, successful commercialisation of new applications often depends on cooperating with the right customers in those markets that set future trends ('lead markets'). It could be more beneficial for European industry to commercialise new key enabling technologies abroad – even if parts of the production will move to dynamic markets abroad – than to focus on European markets with less promising long-term prospects.

Moving to the higher end of the value chain is at the same time enormously complex and challenging. While monitoring the developments in the entire value chain, it is equally important to focus on promising segments and the position of the EU in the value chains of these segments. This is confirmed by the analysis of the two promising KETs products which have been analysed above.

Focusing on promising KET product segments: a starting point for moving up the value chain? On the basis of the analysis of the value chains of two products, lipase enzymes (industrial biotechnology) and the accelerometer (micro- and nanotechnology), a qualitative assessment has been made of the strength of the EU in these two selected value chains.

It is interesting to note that although the general EU position in the entire micro- and nanotechnology value chain is weak, its position with respect to the accelerometer value chain is good. This suggests that, even if the overall position in a particular key enabling technology is not optimal, there may always be segments – existing or emerging – where the EU is in a good position and where active policy support can make a difference in the longer run. **It is important to observe and monitor these specific segments closely, for instance through the future KETs Observatory, and act in time in order to stay ahead of the competition. A focused and intensified policy in this respect might, in the long run, lead to Europe moving up the global key enabling technology value chains.**

REFERENCES

Aiginger, K. (1997), 'The use of unit values to discriminate between price and quality competition', *Cambridge Journal of Economics*, 21, 571–592

Aiginger, K. (2000), 'Europe's position in quality competition, background report for the European competitiveness report 2000', Working Paper, DG Enterprise and Industry, European Commission

Arora, A., Fosfuri, A. and Gambardella, A. (2002), '*Markets for technology: the economics of innovation and corporate strategy*', Cambridge: MIT Press

Ballhaus, W., Pagella, A., Vogel, C., Wilmsmeier, C. (2011), 'Faster, greener, smarter – reaching beyond the horizon in the world of semi-conductors'. Published by Pricewaterhouse-Coopers AG Wirtschaftsprüfungs-gesellschaft

BCC Research (2011a), 'Enzymes in industrial applications: global markets'

BCC Research (2011b), 'Smart materials and their applications: technologies and global markets'

BCC Research (2012), 'Nanotechnology: a realistic market assessment'

BCC Research (2013), 'Robotics: technologies and global markets'

Beise, M. and Rammer, C. (2006), 'Local user-producer interaction in innovation and export performance of firms', *Small Business Economics*, 27, 207–222

Bleaney, M. and Wakelin, K. (2002), 'Efficiency, innovation and exports', *Oxford Bulletin of Economics and Statistics*, 64, 3–15

Calleja, D. (2013), 'The role of KETs (Key Enabling Technologies) in the 2020 European innovation strategy', *The European Files*, September 2013

Clarke, P. (2013), 'Processor market to surf tablet wave in 2013', *EE Times*, 21 January 2013

Deloitte (2013), '2013 global manufacturing competitiveness index'. Deloitte Touche Tohmatsu and U.S. Council on Competitiveness

Ebling, G. and Janz, N. (1999), 'Export and innovation activities in the German service sector: empirical evidence at the firm level', ZEW Discussion Paper No. 99–53, Mannheim: ZEW

ECSIP (2013), Study on the international market distortion in the area of KETs: a case analysis. Study for Directorate-General for Enterprise and Industry. Copenhagen: ECSIP

European Commission (2010), 'European Competitiveness Report 2010'. Luxembourg: Publications Office of the European Union

European Commission (2012a), 'A European strategy for key enabling technologies – a bridge to growth and jobs', COM(2012) 341, Brussels: European Commission

European Commission (2012b), 'A stronger European industry for growth and economic recovery', COM(2012) 582, Brussels: European Commission

European Commission (2012c), 'Innovating for sustainable growth: a bioeconomy for Europe', COM(2012) 60, Brussels: European Commission

European Commission (2013a), 'Public-private partnerships in Horizon 2020: a powerful tool to deliver on innovation and growth in Europe', COM(2013) 494, Brussels: European Commission

European Commission (2013b), 'Proposal for a Council Regulation on the bio-based industries joint undertaking', COM(2013) 496, Brussels: European Commission

European Commission (2013c), Monthly update on industrial policy indicators and analysis, Directorate-General for Enterprise and Industry, July 2013

European Parliament (2013), Resolution of 2 July 2013 on innovating for sustainable growth: a bioeconomy for Europe, Strasbourg: European Parliament

EPIA (2013), 'Global market outlook for photovoltaics 2013–2017'. Brussels: European Photovoltaic Industry Association

Festel (2010), 'Industrial biotechnology: market size, company types, business models, and growth strategies', *Industrial* Biotechnology, 6(2), 88–94

Gambardella, A., Giuri, P. and Luzzi, A. (2007), 'The market for patents in Europe', *Research Policy,* 36, 1163–1183

Global Industry Analysts (2012), 'Industrial enzymes – A global strategic business report', March 2012

HLG KETs (2011), Final report, June 2011

HLG MNE (2011), Interim thematic report by the micro-/nanoelectronics sherpa team, High Level Group (HLG) on Key Enabling Technologies

ICT MAN (2011), Exploring the potential of ICT components and systems manufacturing in Europe

ITRS (2010), 'More-than-Moore white paper', International Technology Roadmap for Semiconductors (ITRS)

J.P. Morgan Cazenove (2012), 'Electrical engineering and semiconductor equipment: Winners and losers in a radically changing lighting market driven by LED'

Kircher, M. (2012), 'How to turn industrial biotechnology into reality', *New Biotechnology,* 29(2), 243–247

Lamoreaux, N. and Sokoloff, K. (1999), 'Inventive activity and the market for technology in the United States, 1840–1920', NBER Working Paper 7107, Washington D.C.: NBER

Lefebvre, E., Lefebvre, L.A. and Bourgault, M. (1998), 'R&D-related capabilities as determinants of export performance', *Small Business Economics,* 10, 365–377

MarketsandMarkets (2012), 'Quantum dots (QD) market – global forecast & analysis (2012–2022)', May 2012

OECD (2009), 'The bioeconomy to 2030: designing a policy agenda'. Paris: OECD

Overton, G., Anderson, S.G., Belforte, D.A., Hausken, T. (2011), 'Skies may be clearing, but fog still lingers', *Laser Focus World*, January 2011, 40–42

Photonics21 (2012), 'Photonics technologies and markets for a low carbon economy', study prepared for the Photonics Unit, DG CONNECT, European Commission

Roper, S. and Love, J.H. (2002), 'Innovation and export performance: evidence from UK and German manufacturing plants', *Research Policy,* 32, 1087–1102

Ryhänen, T. (2010), 'Impact of silicon MEMS — 30 years after', in Lindroos, V., Tilli, M., Lehto, A. and Motooka, T. (eds.), 'Handbook of silicon based MEMS materials and technologies', pp. xv–xxxii

Sarrouh, B., Marcos Santos, T., Miyoshi, A., Dias, R. and Azevedo, V. (2012), 'Up-to-date insight on industrial enzymes applications and global market', *Journal of Bioprocessing & Biotechniques,* S4:002

Serrano, C.J. (2005), '*The market for intellectual property: evidence from the transfer of patents*', mimeo, University of Minnesota and Federal Reserve Bank of Minneapolis

SIA (2012), 'Semiconductor industry posts record-breaking revenues despite 2011 challenges', Semiconductor Industry Association, 6 February 2012

Silicon Europe (2012), 'Silicon Europe: cluster alliance for European micro- and nano-electronics industry', 8 October 2012

Technology Strategy Board (2012), 'A landscape for the future of high value manufacturing in the UK'. Swindon: Technology Strategy Board

Van de Velde, E., Rammer, C., de Heide, M., Pinaud, F., Verbeek, A., Gehrke, B., Mertens, K., Debergh, P., Schliessler, P., van der Zee, F. and Butter, M. (2013), '*Feasibility study for an EU Monitoring Mechanism on Key Enabling Technologies*', Brussels: European Commission

Wagner, J. (1996), 'Export performance, human capital, and product innovation in Germany: a micro view', *Jahrbuch für Wirtschaftswissenschaften,* 47, 40–45

Wakelin, K. (1998): 'Innovation and export behaviour at the firm level', *Research Policy*, 26, 829–841

Wydra, S. (2012). Overview of policy measures of biobased products. *Industrial biotechnology*, 8(1), 8–12

Yole Développement (2012), Status of the MEMS industry 2012

Chapter 6.
STATISTICAL ANNEX

6.1. SECTORAL COMPETITIVENESS INDICATORS

6.1.1. Explanatory notes

Geographical coverage: all indicators refer to EU-27

Production index[7]: The production index is actually an index of final production in volume terms.

Labour productivity: this indicator is calculated by combining the indexes of production and number of persons employed or number of hours worked[8]. Therefore, this indicator measures final production per person of final production per hour worked.

Unit Labour Cost: it is calculated from the production index and the index of wages and salaries and measures labour cost per unit of production. "Wages and salaries" is defined (Eurostat) as "the total remuneration, in cash or in kind, payable to all persons counted on the payroll (including homeworkers), in return for work done during the accounting period, regardless of whether it is paid on the basis of working time, output or piecework and whether it is paid regularly wages and salaries do not include social contributions payable by the employer".

Relative Trade Balance: it is calculated, for sector "i", as (Xi-Mi)/(Xi+Mi), where Xi and Mi are EU-27 exports and imports of products of sector "i" to and from the rest of the World.

Revealed Comparative Advantage (RCA): The RCA indicator for product "i" is defined as follows:

$$RCA_i = \frac{\dfrac{X_{EU,i}}{\sum_i X_{EU,i}}}{\dfrac{X_{W,i}}{\sum_i XW_{,i}}}$$

where: X=value of exports; the reference group ('W') is the EU-27 plus 109 other countries (see list below); the source used is the UN COMTRADE database. In the calculation of RCA, X_{EU} stands for exports to the rest of the world (excluding intra-EU trade) and X_W measures exports to the rest of the world by the countries in the reference group. The latter consists of the EU-27 plus the following countries: Albania, Algeria, Azerbaijan, Argentina, Australia, Bahamas, Bahrain, Armenia, Bermuda, Bhutan, Bolivia (Plurinational State of), Bosnia Herzegovina, Brazil, Belize, Belarus, Cambodia, Canada, Cape Verde, Central African Rep., Sri Lanka, Chile, China, Colombia, Costa Rica, Croatia, Dominican Rep., Ecuador, El Salvador, Ethiopia, French Polynesia, Georgia, Gambia, State of Palestine, Ghana, Greenland, Guatemala, Guyana, China, Hong Kong SAR, Iceland, Indonesia, Iran, Israel, Côte d'Ivoire, Japan, Kazakhstan, Jordan, Rep. of Korea, Kyrgyzstan, Lebanon, China, Macao SAR, Madagascar, Malawi, Malaysia, Maldives, Mauritania, Mauritius, Mexico, Other Asia, nes, Rep. of Moldova, Montenegro, Montserrat, Namibia, Nepal, Aruba, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, Qatar, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saudi Arabia, Senegal, Serbia, India, Singapore, Viet Nam, South Africa, Zimbabwe, Suriname, Switzerland, Thailand, Togo, Tonga, United Arab Emirates, Tunisia, Turkey, Turks and Caicos Isds, Uganda, Ukraine, Former Yugoslav Republic of Macedonia, Egypt, United Rep. of Tanzania, US, Burkina Faso, Samoa, Yemen, Zambia.

[7] The data are working-day adjusted for production.
[8] The data are working-day adjusted for hours worked.

Statistical nomenclatures: the indicators in Tables 6.1 to 6.6 are presented at the level of divisions of the statistical classification of economic activities in the European Community (NACE Rev.2[9]), while those in Tables 6.7 to 6.9.2 are presented in terms of divisions of the statistical classification of products by activity (CPA).

Table 6.10 uses extended balance of payments services classification. In terms of data sources: Tables 6.1 to 6.6 are based on Eurostat's short-term indicators data. Table 6.7, Table 6.8, Table 6.9.1 and Table 6.9.2 are based on United Nations' COMTRADE. Table 6.10 is based on IMF balance of Payments. Royalties and license fees were not included as it is not related to a special service activity.

[9] Compared to the statistical annexes of the previous publications, the new activity classification is used: NACE REV 2. The correspondence tables from NACE Rev. 2 – NACE Rev. 1.1 and from NACE Rev. 1.1 to NACE Rev. 2, are available on: http://epp.eurostat.ec.europa.eu/portal/page/portal/nace_rev2/introduction

Table 6.1. EU-27 - Industry production index, annual growth rate (%)

Code (NACE Rev. 2)	Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average 2007-2012
B	MINING AND QUARRYING	-2.8	0.5	-2.8	-1.9	-6.0	-3.8	-0.1	-3.6	-10.7	-0.3	-7.0	-5.8	-5.5
C	MANUFACTURING	0.1	-0.8	0.3	2.5	1.6	4.8	4.2	-1.9	-15.3	7.3	4.5	-2.2	-1.8
C10	Manufacture of food products	1.4	1.9	0.5	2.1	2.4	1.3	1.9	-0.5	-1.0	2.2	1.0	-0.7	0.2
C11	Manufacture of beverages	2.7	1.6	1.3	-2.3	0.9	3.7	1.2	-2.1	-3.2	-1.0	6.5	-2.8	-0.6
C12	Manufacture of tobacco products	-1.6	-2.1	-5.8	-11.4	-5.5	-4.7	1.5	-11.7	-0.7	-5.9	-6.2	-4.5	-5.9
C13	Manufacture of textiles	-2.9	-4.5	-3.4	-4.8	-5.9	-0.8	-1.1	-10.2	-18.0	7.8	-2.1	-6.0	-6.1
C14	Manufacture of wearing apparel	-4.7	-11.5	-7.3	-5.6	-10.4	-0.5	-0.6	-7.6	-14.0	-1.1	-4.1	-5.8	-6.6
C15	Manufacture of leather and related products	-5.7	-8.3	-6.8	-10.2	-9.0	-2.9	-5.7	-8.1	-14.1	2.1	5.4	-4.2	-4.0
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-4.2	0.7	2.3	3.2	0.2	4.2	0.7	-9.1	-14.9	2.9	2.6	-4.3	-4.8
C17	Manufacture of paper and paper products	-2.0	3.4	1.4	2.9	-0.1	3.9	2.6	-3.2	-8.7	6.0	-1.1	-1.5	-1.8
C18	Printing and reproduction of recorded media	-1.9	-0.6	-1.2	1.4	2.4	0.2	0.7	-2.2	-7.9	-0.3	-0.5	-6.6	-3.6
C19	Manufacture of coke and refined petroleum products	-0.9	0.9	1.3	4.6	0.7	-0.9	0.4	1.0	-8.0	-2.0	-1.7	-1.9	-2.6
C20	Manufacture of chemicals and chemical products	-1.9	1.9	-0.1	3.3	2.0	3.4	2.9	-3.3	-12.5	10.3	1.3	-1.6	-1.4
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	10.9	8.6	5.0	-0.2	4.7	5.9	0.4	0.6	2.9	4.9	1.6	0.2	2.0
C22	Manufacture of rubber and plastic products	-0.3	0.0	1.9	1.8	0.9	3.9	4.5	-4.6	-13.9	7.3	3.8	-3.4	-2.4
C23	Manufacture of other non-metallic mineral products	-0.6	-1.7	0.3	1.7	0.5	4.2	1.8	-6.7	-19.4	1.9	3.2	-8.4	-6.2
C24	Manufacture of basic metals	-1.2	-0.4	0.2	4.9	-0.7	6.3	1.3	-3.6	-27.1	18.1	3.6	-5.1	-4.0
C25	Manufacture of fabricated metal products, except machinery and equipment	0.4	-0.6	0.9	2.6	1.5	4.8	6.1	-3.0	-22.6	6.9	7.2	-3.3	-3.6
C26	Manufacture of computer, electronic and optical products	-6.3	-10.2	0.5	6.4	2.8	9.0	7.6	0.7	-17.2	7.2	5.1	-2.0	-1.6
C27	Manufacture of electrical equipment	-0.7	-4.1	-1.6	2.3	0.9	8.4	4.3	-0.7	-21.0	11.4	4.3	-2.3	-2.3
C28	Manufacture of machinery and equipment n.e.c.	1.3	-1.8	-0.8	4.1	3.9	8.4	8.4	1.4	-26.8	10.6	11.5	0.5	-1.7
C29	Manufacture of motor vehicles, trailers and semi-trailers	1.6	0.7	1.6	4.5	1.4	3.3	6.1	-5.9	-25.1	21.6	12.1	-3.1	-1.4
C30	Manufacture of other transport equipment	1.2	-3.5	0.5	0.4	2.0	7.8	4.8	3.9	-5.7	-0.7	4.1	2.8	0.8
C31	Manufacture of furniture	-2.3	-5.1	-2.5	0.3	1.1	3.8	3.3	-5.0	-16.7	-1.0	2.0	-5.6	-5.5
C32	Other manufacturing	3.6	3.0	-2.2	1.2	0.9	5.3	1.7	-1.5	-6.9	8.2	3.1	0.0	0.5
C33	Repair and installation of machinery and equipment	0.3	-4.0	-2.0	4.5	1.1	7.9	4.5	3.7	-10.2	2.2	4.5	-1.5	-0.4
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	2.0	0.9	3.0	2.3	2.0	0.9	-0.7	-0.1	-4.5	4.1	-4.1	0.3	-0.9
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	CONSTRUCTION	1.1	0.3	1.7	0.7	2.8	3.4	2.7	-2.9	-7.5	-4.7	0.2	-5.2	-4.1

N/A: Data not available, Source: Eurostat

Table 6.2. EU-27 - Number of persons employed, annual growth rate (%)

Code (NACE Rev. 2)	Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average 2007-2012
B	**MINING AND QUARRYING**	-3.4	-4.6	-4.5	-4.6	-3.1	-3.8	-3.5	-1.5	-3.8	-4.1	-3.4	-1.4	-2.9
C	**MANUFACTURING**	0.0	-1.9	-2.0	-1.9	-1.3	-0.8	0.5	-0.3	-7.3	-3.7	0.6	-0.3	-2.2
C10	Manufacture of food products	-0.6	-0.9	-0.5	-1.2	0.1	-0.2	0.0	-0.1	-1.9	-0.5	0.5	-0.3	-0.5
C11	Manufacture of beverages	-1.8	-1.1	-1.8	-1.2	-1.3	-1.4	-0.1	-1.2	-6.4	-1.9	-1.5	-1.6	-2.5
C12	Manufacture of tobacco products	-4.2	-0.3	-5.0	-5.2	-2.1	0.1	-11.1	-9.9	-6.0	-6.8	-2.4	-4.9	-6.0
C13	Manufacture of textiles	-3.2	-5.0	-7.2	-6.3	-4.3	-5.9	-5.3	-6.3	-12.9	-5.9	-2.7	-2.4	-6.1
C14	Manufacture of wearing apparel	-3.1	-3.6	-3.9	-6.2	-7.7	-5.8	-5.9	-6.7	-13.1	-8.5	-1.8	-2.7	-6.6
C15	Manufacture of leather and related products	-1.2	-0.6	-4.4	-6.7	-5.6	-2.7	-3.7	-5.9	-12.5	-3.6	4.1	0.4	-3.7
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-0.9	-1.5	-1.3	-1.4	-0.6	-1.3	0.6	-2.3	-12.6	-3.4	-0.1	-3.2	-4.4
C17	Manufacture of paper and paper products	-1.7	-0.7	-3.0	-1.6	-2.6	-2.6	-2.8	-2.2	-5.5	-2.3	-0.5	-1.9	-2.5
C18	Printing and reproduction of recorded media	-0.2	-2.1	-4.0	-1.9	-3.3	-1.6	-0.1	-2.3	-7.0	-4.8	-3.6	-3.6	-4.3
C19	Manufacture of coke and refined petroleum products	-1.9	-3.0	-3.2	-1.7	-2.9	-3.1	0.9	-0.7	-3.3	-2.8	-2.8	0.7	-1.8
C20	Manufacture of chemicals and chemical products	-0.8	-1.6	-2.6	-3.3	-2.2	-1.2	-0.6	-2.3	-4.5	-2.3	-0.2	-0.1	-1.9
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	1.8	2.2	-0.5	-2.4	-1.4	1.6	0.3	-2.5	-3.6	-1.0	-0.4	1.2	-1.3
C22	Manufacture of rubber and plastic products	1.0	-0.9	0.2	0.0	-0.8	-0.8	1.6	0.6	-7.0	-2.6	1.3	0.6	-1.5
C23	Manufacture of other non-metallic mineral products	-0.6	-2.3	-2.8	-2.1	-1.0	-0.7	1.2	-2.1	-10.7	-6.5	-1.9	-3.0	-4.9
C24	Manufacture of basic metals	-0.2	-4.0	-2.9	-4.2	-1.1	-1.0	-0.6	-0.6	-8.4	-5.4	1.0	-1.4	-3.0
C25	Manufacture of fabricated metal products, except machinery and equipment	1.0	-1.0	-1.1	0.2	-0.2	1.4	3.3	2.6	-8.4	-5.4	1.6	0.5	-1.9
C26	Manufacture of computer, electronic and optical products	1.9	-5.6	-4.4	-2.9	-1.3	-0.8	1.2	-1.8	-8.7	-3.9	1.2	-1.9	-3.1
C27	Manufacture of electrical equipment	0.5	-3.9	-4.1	-1.4	-0.6	0.9	2.5	1.1	-8.2	-2.0	3.3	0.5	-1.1
C28	Manufacture of machinery and equipment n.e.c.	1.0	-1.5	-2.2	-2.4	-0.9	0.7	3.0	1.9	-5.9	-5.0	2.7	1.9	-0.9
C29	Manufacture of motor vehicles, trailers and semi-trailers	1.7	-1.0	-0.4	0.2	-0.8	-1.0	-0.2	0.8	-8.9	-2.8	2.9	1.3	-1.4
C30	Manufacture of other transport equipment	0.0	-1.7	-2.7	-1.7	0.3	0.8	2.7	1.7	-1.5	-4.7	-0.3	1.0	-0.8
C31	Manufacture of furniture	0.5	-3.4	0.2	-2.6	-2.5	-1.3	0.3	-2.1	-9.6	-8.4	-1.7	-3.1	-5.0
C32	Other manufacturing	1.1	-1.6	-0.2	-1.0	-1.7	-0.5	0.3	-0.1	-3.1	-1.9	-0.9	0.8	-1.1
C33	Repair and installation of machinery and equipment	0.2	-2.3	-2.0	-0.5	-0.5	0.5	0.6	3.5	-1.8	-2.8	-1.4	1.0	-0.3
D	**ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY**	-2.7	-5.1	-4.9	-3.6	-2.4	-1.2	-1.6	-0.9	1.8	-0.2	0.4	-1.8	-0.1
E	**WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES**	-0.4	-0.3	0.5	-1.0	-1.8	1.9	0.7	-1.0	-0.3	-0.3	-0.3	1.1	-0.2
F	**CONSTRUCTION**	1.9	0.6	1.7	2.1	3.7	3.8	4.8	-0.3	-7.1	-5.5	-3.0	-3.9	-4.0

N/A: Data not available, Source: Eurostat

Table 6.3. EU-27 - Number of hours worked, annual growth rate (%)

Code (NACE Rev. 2)	Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average 2007-2012
B	**MINING AND QUARRYING**	-2.7	-4.7	-5.3	-3.8	-3.0	-4.8	-3.6	-1.3	-5.4	-2.5	-2.3	-0.1	-2.3
C	**MANUFACTURING**	-1.2	-2.4	-2.5	-1.4	-1.5	-0.1	0.1	-0.7	-9.6	-0.7	1.5	-0.7	-2.1
C10	Manufacture of food products	-1.1	-1.8	-2.0	-0.3	-0.5	-0.2	-0.5	0.2	-2.6	0.3	0.2	-0.7	-0.5
C11	Manufacture of beverages	-0.2	-3.5	-0.3	0.5	-2.9	-4.0	-1.2	-1.7	-4.6	-4.5	-0.3	-1.4	-2.5
C12	Manufacture of tobacco products	2.0	-2.3	-10.3	-1.9	-3.8	-8.7	-2.5	-10.6	-6.1	-4.1	-1.3	-1.2	-4.7
C13	Manufacture of textiles	-4.4	-5.6	-7.4	-7.2	-5.4	-5.7	-3.2	-5.7	-15.3	-0.6	-0.3	-1.4	-4.8
C14	Manufacture of wearing apparel	-3.5	-2.3	-3.1	-3.7	-4.1	-3.7	-5.8	-6.9	-15.3	-8.3	0.3	-3.1	-6.8
C15	Manufacture of leather and related products	-1.9	-0.6	-1.8	-2.6	-4.1	-0.9	-4.7	-7.1	-12.0	-0.6	3.9	0.4	-3.2
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-3.3	-1.2	-1.9	-1.1	-2.2	-0.4	-0.3	-3.0	-13.6	0.1	0.2	-2.1	-3.8
C17	Manufacture of paper and paper products	-1.8	-0.4	-2.9	-1.9	-2.0	-0.9	-1.3	-4.1	-7.7	-0.5	0.2	-1.6	-2.8
C18	Printing and reproduction of recorded media	-1.2	-3.5	-4.4	-2.9	-2.3	-0.1	0.2	-2.0	-6.1	-3.7	-2.4	-5.1	-3.9
C19	Manufacture of coke and refined petroleum products	-1.9	-3.9	-2.1	-0.4	0.0	-3.7	0.4	2.0	-9.0	-2.2	-1.8	1.0	-2.1
C20	Manufacture of chemicals and chemical products	-2.3	-2.2	-2.7	-2.0	-3.2	-0.9	-1.6	-1.9	-5.5	-1.5	0.8	0.8	-1.5
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.4	1.9	-0.2	-0.7	-1.6	0.0	0.9	0.0	-1.9	-0.8	-0.1	1.8	-0.2
C22	Manufacture of rubber and plastic products	-0.3	-1.8	-1.5	-0.2	-1.4	1.6	0.6	-0.4	-9.4	0.9	2.2	0.3	-1.4
C23	Manufacture of other non-metallic mineral products	-2.6	-3.3	-3.2	-1.3	-1.0	-0.5	0.4	-2.7	-12.4	-2.4	-0.4	-3.5	-4.4
C24	Manufacture of basic metals	-1.6	-3.2	-4.7	-2.1	-2.1	0.0	-0.5	-0.9	-13.1	1.8	2.6	-2.1	-2.5
C25	Manufacture of fabricated metal products, except machinery and equipment	-0.5	-1.3	-2.0	-0.3	-1.0	1.7	2.2	2.9	-11.7	-0.7	1.9	0.4	-1.6
C26	Manufacture of computer, electronic and optical products	-0.3	-5.0	-4.4	-2.9	-1.5	-0.7	0.3	-1.0	-12.2	-2.4	-0.1	-1.7	-3.6
C27	Manufacture of electrical equipment	-1.2	-2.9	-3.8	-1.6	-1.9	2.5	1.7	0.6	-13.4	3.4	3.3	-1.2	-1.7
C28	Manufacture of machinery and equipment n.e.c.	-0.6	-2.3	-2.2	-1.2	-1.3	1.5	2.5	1.7	-11.2	-0.2	4.3	0.7	-1.1
C29	Manufacture of motor vehicles, trailers and semi-trailers	0.4	-1.8	-0.9	0.4	-0.3	-0.6	0.8	-1.4	-14.2	4.1	4.5	-0.2	-1.7
C30	Manufacture of other transport equipment	-1.4	-2.0	-1.8	-2.3	-0.4	1.0	0.9	1.3	-1.9	-3.8	-0.4	2.1	-0.6
C31	Manufacture of furniture	0.7	-4.6	-3.3	-0.5	-3.4	0.8	0.3	-2.9	-11.9	-5.5	-0.8	-2.8	-4.9
C32	Other manufacturing	0.2	-3.2	-2.5	0.3	-2.8	-0.8	0.6	0.4	-5.7	0.2	2.4	1.5	-0.3
C33	Repair and installation of machinery and equipment	-1.5	-3.0	-3.4	-2.7	0.0	0.9	0.6	1.6	0.1	-3.7	-0.1	0.6	-0.3
D	**ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY**	-1.8	-4.9	-4.6	-2.0	-0.3	-1.4	-1.0	-0.1	-0.9	-0.5	1.2	-2.7	-0.6
E	**WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES**	-1.2	-1.4	-0.9	1.2	-2.2	-0.2	0.2	0.7	-2.8	0.5	0.3	1.6	0.0
F	**CONSTRUCTION**	0.6	-1.7	0.7	1.0	7.2	2.9	2.7	-1.3	-9.3	-7.2	-0.8	-1.7	-4.1

N/A: Data not available, Source: Eurostat

Table 6.4. EU-27 - Labour productivity per person employed, annual growth rate (%)

Code (NACE Rev. 2)	Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average 2007-2012
B	**MINING AND QUARRYING**	0.6	5.4	1.8	2.8	-3.0	0.0	3.5	-2.1	-7.1	4.0	-3.7	-4.4	-2.7
C	**MANUFACTURING**	0.1	1.2	2.3	4.5	3.0	5.6	3.7	-1.6	-8.7	11.4	3.9	-1.9	0.4
C10	Manufacture of food products	2.0	2.8	1.0	3.3	2.3	1.5	1.9	-0.4	0.9	2.7	0.5	-0.4	0.7
C11	Manufacture of beverages	4.6	2.7	3.2	-1.2	2.3	5.2	1.3	-0.9	3.5	1.0	8.1	-1.3	2.0
C12	Manufacture of tobacco products	2.7	-1.8	-0.8	-6.6	-3.5	-4.8	14.1	-2.0	5.7	1.0	-3.9	0.4	0.2
C13	Manufacture of textiles	0.3	0.5	4.1	1.6	-1.7	5.4	4.5	-4.1	-5.8	14.5	0.6	-3.7	0.0
C14	Manufacture of wearing apparel	-1.7	-8.2	-3.5	0.6	-2.9	5.7	5.6	-1.0	-1.0	8.1	-2.4	-3.2	0.0
C15	Manufacture of leather and related products	-4.5	-7.8	-2.5	-3.7	-3.7	-0.2	-2.1	-2.3	-1.8	6.0	1.2	-4.6	-0.4
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-3.3	2.2	3.7	4.7	0.8	5.6	0.1	-7.0	-2.7	6.5	2.7	-1.2	-0.4
C17	Manufacture of paper and paper products	-0.3	4.1	4.5	4.6	2.6	6.6	5.5	-1.0	-3.4	8.5	-0.6	0.4	0.7
C18	Printing and reproduction of recorded media	-1.8	1.5	2.9	3.3	5.8	1.9	0.8	0.1	-0.9	4.7	3.2	-3.1	0.7
C19	Manufacture of coke and refined petroleum products	1.0	4.0	4.7	6.4	3.7	2.2	-0.5	1.7	-4.9	0.8	1.1	-2.6	-0.8
C20	Manufacture of chemicals and chemical products	-1.1	3.6	2.6	6.8	4.2	4.7	3.5	-1.1	-8.4	12.9	1.5	-1.5	0.5
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	8.9	6.3	5.5	2.3	6.2	4.2	0.1	3.2	6.7	6.0	2.0	-1.0	3.3
C22	Manufacture of rubber and plastic products	-1.3	0.9	1.7	1.8	1.7	4.7	2.9	-5.2	-7.4	10.1	2.5	-4.0	-1.0
C23	Manufacture of other non-metallic mineral products	0.0	0.6	3.2	3.9	1.5	4.9	0.6	-4.7	-9.7	9.0	5.2	-5.6	-1.4
C24	Manufacture of basic metals	-1.0	3.7	3.2	9.5	0.4	7.4	1.9	-3.0	-20.5	24.8	2.6	-3.8	-1.0
C25	Manufacture of fabricated metal products, except machinery and equipment	-0.6	0.4	2.0	2.4	1.7	3.4	2.7	-5.5	-15.5	13.0	5.5	-3.8	-1.7
C26	Manufacture of computer, electronic and optical products	-8.1	-4.8	5.2	9.6	4.2	9.8	6.3	2.6	-9.3	11.5	3.8	-0.1	1.5
C27	Manufacture of electrical equipment	-1.2	-0.2	2.6	3.7	1.5	7.4	1.8	-1.8	-14.0	13.7	1.0	-2.8	-1.2
C28	Manufacture of machinery and equipment n.e.c.	0.2	-0.3	1.5	6.7	4.8	7.6	5.3	-0.5	-22.2	16.4	8.5	-1.4	-0.7
C29	Manufacture of motor vehicles, trailers and semi-trailers	-0.1	1.7	2.0	4.3	2.2	4.3	6.4	-6.7	-17.8	25.1	8.9	-4.4	0.0
C30	Manufacture of other transport equipment	1.2	-1.8	3.3	2.1	1.7	7.0	2.0	2.2	-4.3	4.2	4.4	1.7	1.6
C31	Manufacture of furniture	-2.7	-1.7	-2.6	3.0	3.7	5.1	3.0	-3.0	-7.8	8.1	3.7	-2.5	-0.5
C32	Other manufacturing	2.4	4.7	-2.0	2.2	2.7	5.8	1.4	-1.4	-3.9	10.3	4.0	-0.8	1.5
C33	Repair and installation of machinery and equipment	0.1	-1.7	0.0	5.0	1.6	7.4	3.8	0.2	-8.6	5.1	5.9	-2.4	-0.1
D	**ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY**	4.8	6.3	8.3	6.1	4.5	2.1	0.9	0.8	-6.2	4.3	-4.5	2.1	-0.8
E	**WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	**CONSTRUCTION**	-0.8	-0.3	0.0	-1.4	-0.9	-0.4	-2.0	-2.6	-0.4	0.8	3.3	-1.4	-0.1

N/A: Data not available, Source: Eurostat

Table 6.5. EU-27 - Labour productivity per hour worked, annual growth rate (%)

Code (NACE Rev. 2)	Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average 2007-2012
B	**MINING AND QUARRYING**	-0.1	5.4	2.6	2.0	-3.1	1.0	3.7	-2.3	-5.6	2.2	-4.8	-5.7	-3.3
C	**MANUFACTURING**	1.3	1.6	2.9	3.9	3.2	4.9	4.1	-1.2	-6.3	8.0	3.0	-1.5	0.3
C10	Manufacture of food products	2.5	3.8	2.6	2.4	2.9	1.5	2.4	-0.7	1.6	1.9	0.8	0.0	0.7
C11	Manufacture of beverages	2.9	5.3	1.6	-2.8	3.9	8.0	2.4	-0.4	1.5	3.7	6.8	-1.4	2.0
C12	Manufacture of tobacco products	-3.6	0.2	5.0	-9.7	-1.8	4.3	4.1	-1.2	5.7	-1.9	-4.9	-3.3	-1.2
C13	Manufacture of textiles	1.6	1.1	4.3	2.5	-0.6	5.2	2.2	-4.8	-3.2	8.5	-1.8	-4.7	-1.3
C14	Manufacture of wearing apparel	-1.2	-9.4	-4.3	-2.0	-6.5	3.3	5.5	-0.7	1.5	7.8	-4.4	-2.8	0.2
C15	Manufacture of leather and related products	-3.8	-7.7	-5.1	-7.8	-5.1	-2.0	-1.1	-1.1	-2.4	2.7	1.4	-4.6	-0.8
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-0.9	1.9	4.2	4.4	2.4	4.6	1.0	-6.3	-1.5	2.8	2.4	-2.3	-1.0
C17	Manufacture of paper and paper products	-0.2	3.8	4.4	4.9	2.0	4.8	3.9	0.9	-1.0	6.6	-1.3	0.1	1.0
C18	Printing and reproduction of recorded media	-0.7	3.1	3.3	4.5	4.8	0.3	0.5	-0.2	-1.9	3.5	1.9	-1.6	0.3
C19	Manufacture of coke and refined petroleum products	1.0	4.9	3.5	5.0	0.7	2.9	0.0	-0.9	1.1	0.2	0.1	-2.9	-0.5
C20	Manufacture of chemicals and chemical products	0.5	4.2	2.7	5.5	5.4	4.4	4.6	-1.4	-7.4	12.0	0.5	-2.4	0.0
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	10.4	6.5	5.2	0.5	6.4	5.9	-0.5	0.6	4.8	5.8	1.7	-1.6	2.3
C22	Manufacture of rubber and plastic products	0.0	1.9	3.5	2.0	2.3	2.2	3.9	-4.2	-5.0	6.4	1.6	-3.7	-1.1
C23	Manufacture of other non-metallic mineral products	2.1	1.7	3.6	3.1	1.5	4.7	1.4	-4.1	-8.0	4.4	3.6	-5.1	-1.9
C24	Manufacture of basic metals	0.4	2.8	5.2	7.2	1.4	6.3	1.9	-2.8	-16.1	16.0	1.0	-3.1	-1.5
C25	Manufacture of fabricated metal products, except machinery and equipment	0.9	0.7	3.0	2.9	2.5	3.1	3.8	-5.7	-12.4	7.6	5.2	-3.7	-2.1
C26	Manufacture of computer, electronic and optical products	-6.0	-5.4	5.1	9.5	4.4	9.7	7.3	1.7	-5.7	9.9	5.2	-0.4	2.0
C27	Manufacture of electrical equipment	0.5	-1.3	2.3	3.9	2.9	5.8	2.6	-1.3	-8.8	7.7	1.0	-1.1	-0.6
C28	Manufacture of machinery and equipment n.e.c.	1.9	0.6	1.4	5.3	5.3	6.8	5.8	-0.3	-17.5	10.9	7.0	-0.2	-0.5
C29	Manufacture of motor vehicles, trailers and semi-trailers	1.2	2.5	2.6	4.1	1.7	3.9	5.3	-4.6	-12.7	16.8	7.3	-2.9	0.3
C30	Manufacture of other transport equipment	2.7	-1.6	2.4	2.8	2.4	6.7	3.8	2.5	-3.9	3.3	4.6	0.7	1.4
C31	Manufacture of furniture	-3.0	-0.5	0.8	0.8	4.6	3.0	3.0	-2.2	-5.4	4.8	2.8	-2.9	-0.7
C32	Other manufacturing	3.4	6.4	0.3	0.9	3.8	6.2	1.0	-1.8	-1.3	8.0	0.7	-1.5	0.7
C33	Repair and installation of machinery and equipment	1.9	-1.1	1.4	7.4	1.1	6.9	3.9	2.1	-10.3	6.2	4.6	-2.1	-0.1
D	**ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY**	3.8	6.1	8.0	4.3	2.3	2.4	0.3	0.0	-3.6	4.6	-5.2	3.1	-0.3
E	**WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	**CONSTRUCTION**	0.5	2.0	1.0	-0.3	-4.1	0.5	0.0	-1.6	2.0	2.7	1.0	-3.6	0.1

N/A: Data not available, Source: Eurostat

Table 6.6. EU-27 - Unit labour cost, annual growth rate (%)

Code (NACE Rev. 2)	Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average 2007-2012
B	**MINING AND QUARRYING**	7.1	-0.7	6.4	4.2	-0.4	7.4	4.8	10.7	11.7	1.6	10.2	9.1	8.6
C	**MANUFACTURING**	3.0	1.7	0.3	-1.2	-0.5	-2.2	-0.1	6.0	10.6	-6.4	-0.6	4.5	2.7
C10	Manufacture of food products	2.1	0.9	2.1	-0.7	-0.7	0.4	1.4	4.9	1.2	-0.2	0.5	2.3	1.7
C11	Manufacture of beverages	1.3	-1.1	2.8	3.5	-1.2	-3.8	1.0	4.5	2.2	-0.7	-4.0	3.1	1.0
C12	Manufacture of tobacco products	5.2	2.2	5.8	19.1	6.8	2.2	-1.7	9.2	-3.1	0.9	1.3	4.2	2.4
C13	Manufacture of textiles	2.0	3.0	0.5	0.8	2.9	-2.3	0.4	9.6	6.3	-8.7	2.2	5.2	2.7
C14	Manufacture of wearing apparel	1.6	10.8	4.1	2.1	5.4	-0.9	2.1	8.2	4.9	-3.9	4.7	4.4	3.6
C15	Manufacture of leather and related products	9.8	8.2	4.1	8.1	5.7	5.8	9.2	10.9	5.5	-0.2	0.6	8.6	5.0
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	5.2	-1.4	-1.9	-0.6	0.7	-0.3	5.0	12.0	5.5	-3.9	-0.4	1.6	2.8
C17	Manufacture of paper and paper products	4.9	-2.5	-1.5	-1.5	0.7	-3.5	-1.3	3.6	3.8	-5.0	2.2	1.7	1.2
C18	Printing and reproduction of recorded media	4.8	0.3	-1.6	-1.5	-2.3	-0.5	0.4	4.2	2.4	-4.6	-2.5	3.0	0.4
C19	Manufacture of coke and refined petroleum products	1.7	4.8	-4.4	-0.5	2.2	3.8	2.2	5.1	6.4	3.5	3.2	4.0	4.4
C20	Manufacture of chemicals and chemical products	3.8	-1.1	1.7	-3.4	-0.9	-3.5	0.0	5.4	11.2	-9.1	4.5	3.7	2.9
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-6.1	-2.6	-0.1	1.6	-2.6	-2.7	5.7	-0.1	-2.5	-3.6	0.2	4.1	-0.4
C22	Manufacture of rubber and plastic products	3.3	1.3	-0.1	0.6	0.1	-2.3	-0.6	7.7	8.3	-4.8	0.9	5.9	3.5
C23	Manufacture of other non-metallic mineral products	2.0	2.7	0.4	-0.8	0.5	-1.7	2.8	9.2	13.1	-3.0	-2.6	7.3	4.6
C24	Manufacture of basic metals	-2.6	-0.8	-0.2	-3.6	3.1	-3.0	2.9	7.2	23.7	-13.8	1.4	6.4	4.3
C25	Manufacture of fabricated metal products, except machinery and equipment	4.2	1.8	-0.2	0.0	0.1	-0.9	0.9	10.5	16.1	-6.5	-2.6	5.9	4.3
C26	Manufacture of computer, electronic and optical products	12.9	7.9	-4.7	-6.4	-2.6	-7.6	-4.1	1.7	11.3	-8.1	-2.7	4.4	1.1
C27	Manufacture of electrical equipment	3.4	3.3	-0.5	-0.5	-0.4	-4.2	1.2	5.8	12.6	-8.4	2.3	4.5	3.1
C28	Manufacture of machinery and equipment n.e.c.	3.1	2.5	1.7	-1.9	-2.5	-3.7	-1.5	4.3	27.9	-8.9	-3.6	3.9	4.0
C29	Manufacture of motor vehicles, trailers and semi-trailers	1.7	1.0	0.9	-2.1	0.2	-0.1	-5.2	9.2	17.6	-15.5	-3.5	7.3	2.4
C30	Manufacture of other transport equipment	3.4	7.7	1.5	-1.2	1.0	-4.1	0.1	2.4	8.1	2.1	-1.2	3.8	3.0
C31	Manufacture of furniture	6.0	4.7	-0.7	-0.9	-0.7	-0.8	0.3	7.4	10.5	-3.6	-2.5	4.4	3.1
C32	Other manufacturing	1.0	-1.2	3.3	1.1	-1.3	-3.0	4.2	3.7	4.4	-5.5	0.6	2.9	1.2
C33	Repair and installation of machinery and equipment	4.6	5.2	1.9	-2.7	1.6	-4.5	-0.2	3.8	14.0	-5.7	-3.9	4.1	2.2
D	**ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY**	0.6	1.6	-1.7	-1.4	0.0	4.0	4.9	4.5	8.4	-1.7	6.1	1.5	3.7
E	**WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	**CONSTRUCTION**	7.2	5.8	2.6	3.5	9.3	3.0	6.5	6.7	0.4	-1.3	1.0	4.4	2.2

N/A: Data not available, Source: Eurostat

Table 6.7. EU-27 - Revealed comparative advantage index

Code (NACE Rev. 2)	Sector	2007	2008	2009	2010	2011
C10	Manufacture of food products	1.20	1.12	1.10	1.09	1.06
C11	Manufacture of beverages	1.61	1.59	1.61	1.70	1.72
C12	Manufacture of tobacco products	1.52	1.56	1.61	1.67	1.72
C13	Manufacture of textiles	0.81	0.76	0.69	0.67	0.66
C14	Manufacture of wearing apparel	0.76	0.76	0.76	0.74	0.75
C15	Manufacture of leather and related products	0.96	0.91	0.91	0.87	0.91
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.15	1.18	1.18	1.16	1.15
C17	Manufacture of paper and paper products	1.28	1.30	1.35	1.35	1.34
C18	Printing and reproduction of recorded media	1.20	1.62	1.79	1.88	1.87
C19	Manufacture of coke and refined petroleum products	0.84	0.84	0.77	0.79	0.78
C20	Manufacture of chemicals and chemical products	1.13	1.13	1.16	1.16	1.13
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	1.47	1.53	1.54	1.65	1.62
C22	Manufacture of rubber and plastic products	1.18	1.21	1.18	1.19	1.19
C23	Manufacture of other non-metallic mineral products	1.22	1.19	1.18	1.15	1.13
C24	Manufacture of basic metals	0.92	0.88	0.82	0.85	0.86
C25	Manufacture of fabricated metal products, except machinery and equipment	1.18	1.19	1.16	1.20	1.20
C26	Manufacture of computer, electronic and optical products	0.60	0.60	0.57	0.57	0.58
C27	Manufacture of electrical equipment	0.98	0.99	0.98	0.97	0.99
C28	Manufacture of machineryand equipment n.e.c.	1.14	1.18	1.18	1.17	1.18
C29	Manufacture of motor vehicles, trailers and semi-trailers	1.22	1.22	1.30	1.28	1.32
C30	Manufacture of other transport equipment	0.85	0.88	1.15	1.21	1.15
C31	Manufacture of furniture	1.27	1.24	1.20	1.13	1.15
C32	Other manufacturing	0.80	0.78	0.75	0.77	0.72

Note: there was a transition from NACE REV 1 to NACE REV 2, therefore the data are only available from 2007
Source: own calculations using Comtrade data

Table 6.8. EU-27 - Relative trade balance (X-M)/(X+M)

Code (NACE Rev. 2)	Sector	2007	2008	2009	2010	2011
C10	Manufacture of food products	-0.03	-0.03	-0.02	-0.01	-0.01
C11	Manufacture of beverages	0.21	0.20	0.20	0.22	0.24
C12	Manufacture of tobacco products	0.03	0.06	0.06	0.05	0.08
C13	Manufacture of textiles	0.00	-0.01	-0.02	-0.02	-0.03
C14	Manufacture of wearing apparel	-0.19	-0.19	-0.21	-0.22	-0.21
C15	Manufacture of leather and related products	-0.07	-0.07	-0.08	-0.08	-0.06
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.00	0.02	0.04	0.03	0.04
C17	Manufacture of paper and paper products	0.04	0.04	0.06	0.06	0.06
C18	Printing and reproduction of recorded media	0.08	0.05	0.04	0.08	0.09
C19	Manufacture of coke and refined petroleum products	-0.03	-0.01	-0.05	-0.05	-0.05
C20	Manufacture of chemicals and chemical products	0.03	0.03	0.06	0.04	0.03
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.07	0.08	0.08	0.10	0.10
C22	Manufacture of rubber and plastic products	0.04	0.04	0.04	0.05	0.05
C23	Manufacture of other non-metallic mineral products	0.08	0.08	0.09	0.08	0.08
C24	Manufacture of basic metals	-0.06	-0.03	0.01	-0.01	0.00
C25	Manufacture of fabricated metal products, except machinery and equipment	0.09	0.09	0.10	0.10	0.10
C26	Manufacture of computer, electronic and optical products	-0.11	-0.11	-0.11	-0.13	-0.10
C27	Manufacture of electrical equipment	0.07	0.08	0.08	0.07	0.07
C28	Manufacture of machineryand equipment n.e.c.	0.16	0.17	0.20	0.19	0.19
C29	Manufacture of motor vehicles, trailers and semi-trailers	0.06	0.08	0.08	0.12	0.13
C30	Manufacture of other transport equipment	0.13	0.11	0.11	0.10	0.14
C31	Manufacture of furniture	0.04	0.04	0.03	0.02	0.05
C32	Other manufacturing	-0.04	-0.04	-0.04	-0.02	-0.02

Note: there was a transition from NACE REV 1 to NACE REV 2, therefore the data are only available from 2007
Source: own calculations using Comtrade data

Table 6.9.1. Revealed comparative advantage index in manufacturing industries in 2011 - EU countries, Japan and Brazil, China, India and Russia.

	Food	Bevarages	Tobacco	Textiles	Clothing	Leather & footwear	Wood & wood products	Paper	Printing	Refined petroleum	Chemicals	Pharma-ceuticals	Rubber & plastics	Non-metallic mineral products	Basic metals	Metal products	Computers, electronic & optical	Electrical equipment	Machinery	Motor vehicles	Other transport	Furniture	Other manufacturing
	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32
Austria	0.87	2.24	0.28	0.68	0.55	0.70	4.49	2.19	1.30	0.24	0.47	1.52	1.30	1.36	1.34	2.16	0.43	1.35	1.40	1.34	0.70	1.19	0.71
Belgium	1.28	1.00	1.10	0.78	0.72	0.93	0.85	0.92	7.34	1.21	2.20	3.17	1.00	1.06	1.11	0.68	0.22	0.42	0.70	1.09	0.16	0.49	1.26
Bulgaria	1.31	0.81	4.94	1.14	2.87	1.18	1.63	0.76	0.22	1.55	0.55	0.90	0.92	2.20	2.83	0.86	0.27	1.11	0.93	0.36	0.24	1.31	0.35
Cyprus	2.16	1.22	27.96	0.13	0.32	0.82	0.20	0.34	0.00	0.00	0.97	7.44	0.30	0.34	0.78	0.68	0.72	0.71	0.41	0.27	1.15	0.47	1.20
Czech Rep.	0.44	0.57	1.57	0.88	0.31	0.46	1.42	0.94	1.74	0.20	0.53	0.32	1.67	1.63	0.64	2.14	1.11	1.66	1.16	2.00	0.39	1.52	0.73
Denmark	3.05	1.29	1.34	0.68	1.75	0.77	1.00	0.69	0.84	0.67	0.64	1.65	1.09	0.97	0.34	1.69	0.56	0.95	1.56	0.34	0.79	2.51	0.84
Estonia	1.00	2.10	0.20	1.17	1.04	0.86	7.71	0.83	0.73	2.33	0.64	0.10	1.29	1.38	0.49	1.79	0.95	1.40	0.75	0.61	0.24	2.74	0.53
Finland	0.35	0.49	0.04	0.26	0.19	0.25	5.28	9.87	0.74	1.60	0.85	0.62	0.92	0.77	1.66	1.04	0.47	1.32	1.46	0.27	0.37	0.23	0.46
France	1.18	4.63	0.59	0.54	0.70	1.18	0.63	1.03	1.80	0.51	1.30	1.70	1.10	0.99	0.75	0.90	0.48	0.88	0.87	1.15	3.97	0.52	0.76
Germany	0.74	0.65	2.05	0.53	0.50	0.39	0.81	1.20	2.49	0.21	1.00	1.34	1.29	1.02	0.76	1.31	0.58	1.22	1.60	1.91	1.30	0.85	0.57
Greece	2.16	1.52	4.89	1.08	1.47	0.55	0.55	0.58	1.14	4.56	0.71	1.26	0.98	1.33	1.93	0.84	0.22	0.65	0.29	0.09	0.50	0.31	0.32
Hungary	0.85	0.40	0.62	0.35	0.27	0.50	0.74	0.88	0.08	0.42	0.58	1.11	1.44	1.18	0.33	0.80	1.68	1.89	0.86	1.78	0.17	1.00	0.27
Ireland	1.44	1.76	0.53	0.10	0.15	0.09	0.41	0.11	0.00	0.23	2.85	9.43	0.32	0.22	0.08	0.28	0.65	0.24	0.31	0.03	0.41	0.09	1.49
Italy	0.87	2.30	0.03	1.35	1.58	3.09	0.53	1.03	0.98	0.70	0.70	1.10	1.35	1.90	1.09	1.68	0.23	1.05	1.82	0.73	0.75	2.38	0.95
Latvia	1.48	6.43	1.67	0.99	1.07	0.32	19.91	0.95	1.92	0.96	0.55	1.17	0.98	2.04	1.26	1.55	0.50	0.63	0.48	0.73	0.32	2.31	0.40
Lithuania	1.64	1.58	7.16	0.94	1.22	0.34	3.42	1.08	0.23	4.21	1.32	0.39	1.05	0.86	0.20	0.98	0.24	0.51	0.56	0.78	0.21	5.67	0.40
Luxembourg	0.89	1.02	6.08	2.17	0.32	0.45	2.24	1.79	0.01	0.01	0.49	0.15	4.16	2.51	3.86	1.20	0.28	0.74	0.74	0.63	1.09	0.12	0.21
Malta	0.53	0.31	0.69	1.05	0.10	0.12	0.01	0.02	0.93	4.67	0.13	2.04	1.12	0.33	0.05	0.23	1.87	0.92	0.24	0.03	1.64	0.08	1.78
Netherlands	1.94	1.29	5.35	0.45	0.61	0.66	0.31	0.86	0.29	2.02	1.62	0.95	0.79	0.49	0.61	0.79	1.05	0.54	1.07	0.39	0.32	0.40	0.80
Poland	1.46	0.45	4.79	0.60	0.71	0.41	2.33	1.66	0.54	0.59	0.76	0.32	1.85	1.61	0.92	1.79	0.60	1.35	0.57	1.64	1.29	5.03	0.27
Portugal	1.12	3.70	4.25	1.86	2.15	3.08	4.15	3.22	0.77	0.60	0.76	0.46	1.85	3.19	0.69	1.77	0.32	1.01	0.43	1.46	0.19	2.80	0.28
Romania	0.49	0.28	5.73	1.04	2.18	2.40	4.18	0.31	1.90	0.85	0.53	0.47	1.61	0.54	0.98	1.12	0.61	1.48	0.77	1.82	0.91	3.61	0.23
Slovakia	0.50	0.47	0.00	0.35	0.57	1.38	1.19	1.07	0.40	0.82	0.45	0.17	1.53	1.09	1.05	1.56	1.22	1.01	0.74	2.49	0.17	1.52	0.27
Slovenia	0.51	0.59	0.00	0.80	0.37	0.61	2.93	1.87	0.27	0.45	0.86	2.54	1.84	1.59	1.02	2.07	0.22	2.28	0.95	1.46	0.19	2.78	0.46
Spain	1.55	2.27	0.46	0.76	1.21	1.19	0.82	1.43	0.51	0.79	1.09	1.28	1.26	2.10	1.06	1.25	0.17	0.95	0.65	2.17	1.15	0.73	0.36
Sweden	0.49	0.84	0.28	0.29	0.36	0.21	3.54	5.49	0.22	1.06	0.67	1.37	0.85	0.60	1.11	1.11	0.82	1.01	1.25	1.34	0.31	1.55	0.43
United Kingdom	0.67	3.99	0.60	0.50	0.63	0.48	0.18	0.66	1.88	1.27	1.17	2.51	0.92	0.72	0.80	0.73	0.65	0.72	1.11	1.30	1.61	0.42	1.01
EU-27	1.06	1.72	1.72	0.66	0.75	0.91	1.15	1.34	1.87	0.78	1.13	1.62	1.19	1.13	0.86	1.20	0.58	0.99	1.18	1.32	1.15	1.15	0.72
USA	0.88	0.76	0.24	0.52	0.15	0.20	0.61	1.19	0.56	1.29	1.41	0.99	0.97	0.73	0.72	0.89	1.00	0.86	1.36	1.04	0.41	0.48	1.52
Japan	0.07	0.06	0.08	0.43	0.02	0.02	0.02	0.26	0.18	0.32	0.94	0.17	1.09	1.04	1.11	0.73	1.08	1.09	2.09	2.01	1.35	0.14	0.45
Brazil	5.17	0.11	0.47	0.37	0.04	1.74	1.73	2.99	0.34	0.38	0.94	0.39	0.72	0.98	1.75	0.73	0.10	0.43	0.82	1.04	1.42	0.52	0.17
China	0.37	0.09	0.15	2.54	2.72	2.52	0.93	0.43	0.23	0.21	0.53	0.23	1.00	1.53	0.53	1.34	1.88	1.47	0.74	0.28	0.86	2.12	1.29
India	1.35	0.10	0.47	2.82	1.94	1.18	0.11	0.23	0.74	3.07	0.93	1.02	0.61	0.74	0.77	0.94	0.19	0.38	0.39	0.32	1.23	0.32	5.37
Russia	0.49	0.22	1.07	0.05	0.02	0.11	3.45	0.99	0.15	7.83	1.50	0.05	0.22	0.35	2.61	0.27	0.10	0.17	0.13	0.10	0.46	0.12	0.03

Source: Own calculations using COMTRADE data

Table 6.9.2 Relative trade balance (X-M)/(X+M) in manufacturing industries in 2011 - EU countries, Japan and Brazil, China, India and Russia.

	Food	Bevarages	Tobacco	Textiles	Clothing	Leather & footwear	Wood & wood products	Paper	Printing	Refined petroleum	Chemicals	Pharma-ceuticals	Rubber & plastics	Non-metallic mineral products	Basic metals	Metal products	Computers, electronic & optical	Electrical equipment	Machinery	Motor vehicles	Other transport	Furniture	Other manufac-turing
	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32
Austria	-0.06	0.53	-0.71	-0.03	-0.42	-0.20	0.42	0.23	-0.37	-0.55	-0.27	0.03	-0.04	-0.01	0.03	0.11	-0.09	0.11	0.06	0.02	0.15	-0.21	-0.10
Belgium	0.12	-0.02	0.08	0.23	-0.01	0.22	-0.01	-0.05	0.04	0.02	0.13	0.13	0.04	0.11	0.18	-0.04	-0.19	-0.06	0.05	-0.04	-0.12	-0.21	0.03
Bulgaria	-0.12	-0.19	0.49	-0.43	0.56	0.09	0.25	-0.34	-0.75	0.07	-0.34	-0.21	-0.23	0.21	0.40	-0.14	-0.38	-0.01	-0.04	-0.27	-0.23	0.27	-0.16
Cyprus	-0.67	-0.87	-0.32	-0.92	-0.93	-0.82	-0.96	-0.92	-1.00	-1.00	-0.62	0.03	-0.91	-0.95	-0.55	-0.80	-0.54	-0.78	-0.77	-0.89	-0.52	-0.93	-0.61
Czech Rep.	-0.20	0.02	0.32	0.09	-0.20	-0.17	0.34	-0.06	0.01	-0.22	-0.20	-0.39	0.01	0.21	-0.20	0.18	-0.04	0.15	0.16	0.34	0.34	0.28	0.18
Denmark	0.25	-0.16	0.29	-0.03	-0.02	-0.20	-0.37	-0.36	-0.24	-0.22	-0.09	0.21	-0.08	-0.12	-0.34	0.13	-0.12	-0.06	0.26	-0.38	0.06	0.21	-0.04
Estonia	-0.04	-0.25	-0.73	0.06	0.12	0.05	0.44	-0.13	-0.55	-0.11	-0.19	-0.72	-0.11	0.04	-0.28	0.21	0.01	0.04	-0.07	-0.10	-0.32	0.61	0.04
Finland	-0.44	-0.39	-0.95	-0.37	-0.67	-0.43	0.56	0.80	-0.54	0.21	-0.05	-0.18	0.01	-0.12	0.32	0.03	-0.18	0.12	0.20	-0.50	0.08	-0.61	-0.10
France	-0.05	0.62	-0.60	-0.15	-0.38	-0.10	-0.34	-0.19	0.20	-0.37	0.02	0.04	-0.12	-0.17	-0.08	-0.15	-0.20	-0.06	-0.05	-0.06	0.25	-0.51	-0.16
Germany	0.05	-0.06	0.51	0.02	-0.32	-0.27	0.06	0.14	0.40	-0.38	0.12	0.13	0.20	0.18	0.00	0.23	-0.02	0.21	0.39	0.39	0.07	-0.08	0.05
Greece	-0.31	-0.24	0.08	-0.15	-0.31	-0.65	-0.50	-0.68	-0.49	0.25	-0.50	-0.57	-0.25	-0.24	0.17	-0.24	-0.62	-0.35	-0.52	-0.79	-0.69	-0.73	-0.63
Hungary	0.15	0.04	-0.14	-0.18	-0.06	-0.09	0.12	-0.04	-0.83	0.04	-0.09	0.04	0.05	0.15	-0.31	-0.14	0.14	0.15	-0.07	0.41	0.18	0.42	0.05
Ireland	0.28	0.22	0.05	-0.32	-0.61	-0.59	0.06	-0.69	-0.95	-0.49	0.67	0.76	-0.23	-0.29	-0.26	-0.05	0.28	-0.10	0.15	-0.75	-0.46	-0.55	0.55
Italy	-0.13	0.62	-0.98	0.17	0.12	0.27	-0.41	-0.05	-0.04	0.24	-0.22	-0.12	0.24	0.42	-0.06	0.42	-0.41	0.20	0.47	-0.12	0.22	0.64	0.14
Latvia	-0.23	0.31	-0.30	-0.11	-0.07	-0.48	0.79	-0.37	-0.45	-0.50	-0.32	-0.19	-0.30	0.02	-0.04	-0.04	-0.13	-0.24	-0.40	-0.22	-0.30	0.33	-0.35
Lithuania	0.11	-0.15	0.54	-0.11	0.26	-0.22	0.26	-0.15	-0.70	0.75	0.04	-0.39	0.01	-0.15	-0.42	0.05	-0.23	-0.08	-0.12	-0.10	-0.35	0.82	0.04
Luxembourg	-0.29	-0.54	-0.06	0.61	-0.53	-0.32	0.14	-0.07	-0.98	-0.99	-0.46	-0.68	0.27	0.04	0.32	-0.15	-0.31	-0.12	-0.01	-0.48	-0.50	-0.89	-0.47
Malta	-0.60	-0.77	-0.63	0.41	-0.80	-0.73	-0.98	-0.98	-0.54	-0.39	-0.79	0.26	-0.07	-0.72	-0.78	-0.63	0.10	-0.01	-0.46	-0.88	-0.48	-0.91	0.43
Netherlands	0.24	0.15	0.62	0.07	-0.12	-0.05	-0.51	-0.05	-0.30	0.12	0.21	0.08	-0.01	-0.17	-0.03	0.03	0.03	-0.04	0.23	-0.15	0.11	-0.31	0.01
Poland	0.17	-0.09	0.78	-0.30	-0.06	-0.32	0.39	-0.03	-0.30	0.07	-0.24	-0.47	0.07	0.15	-0.05	0.10	-0.16	0.12	-0.24	0.25	0.23	0.75	-0.24
Portugal	-0.35	0.43	0.47	0.06	0.15	0.22	0.39	0.27	-0.11	-0.20	-0.34	-0.54	0.12	0.38	-0.19	0.18	-0.32	-0.04	-0.27	-0.05	-0.15	0.30	-0.48
Romania	-0.40	-0.45	0.68	-0.47	0.53	0.08	0.59	-0.64	-0.14	0.09	-0.38	-0.52	-0.18	-0.47	-0.09	-0.28	-0.19	-0.11	-0.25	0.25	0.57	0.63	-0.27
Slovakia	-0.10	-0.11	-1.00	-0.16	0.02	0.23	0.28	0.16	-0.05	0.40	-0.08	-0.53	0.16	0.11	0.23	0.06	0.12	0.03	0.08	0.32	0.10	0.26	0.01
Slovenia	-0.35	-0.14	-1.00	0.03	-0.36	-0.34	0.17	0.09	-0.63	-0.61	-0.17	0.41	0.15	0.03	-0.12	0.20	-0.24	0.33	0.12	0.05	-0.01	0.33	-0.07
Spain	0.03	0.25	-0.75	-0.05	-0.28	-0.11	-0.02	0.02	-0.42	-0.22	-0.11	-0.11	0.04	0.37	0.13	0.11	-0.57	0.01	-0.07	0.16	0.38	-0.22	-0.38
Sweden	-0.32	-0.13	-0.40	-0.25	-0.41	-0.47	0.51	0.71	-0.62	0.15	-0.13	0.32	-0.07	-0.23	0.13	0.09	-0.01	0.02	0.14	0.11	-0.09	0.09	-0.09
United Kingdom	-0.44	0.14	-0.47	-0.31	-0.57	-0.55	-0.81	-0.47	0.44	0.09	-0.06	0.13	-0.21	-0.27	-0.08	-0.24	-0.24	-0.21	0.01	-0.14	0.16	-0.63	-0.16
EU-27	-0.01	0.24	0.08	-0.03	-0.21	-0.06	0.04	0.06	0.09	-0.05	0.03	0.10	0.05	0.08	0.00	0.10	-0.10	0.07	0.19	0.13	0.14	0.05	-0.02
USA	-0.04	-0.48	-0.18	-0.33	-0.88	-0.82	-0.39	0.04	0.48	0.00	0.13	-0.26	-0.17	-0.25	-0.20	-0.15	-0.26	-0.25	-0.03	-0.30	-0.46	-0.69	-0.19
Japan	-0.87	-0.83	-0.96	-0.18	-0.97	-0.95	-0.98	-0.29	0.38	-0.46	0.15	-0.64	0.35	0.28	0.30	0.18	0.12	0.30	0.63	0.76	0.60	-0.66	-0.26
Brazil	0.78	-0.81	0.91	-0.51	-0.81	0.54	0.82	0.54	-0.29	-0.69	-0.46	-0.59	-0.29	-0.08	0.33	-0.22	-0.85	-0.45	-0.38	-0.22	0.02	0.30	-0.53
China	0.07	-0.43	0.66	0.72	0.95	0.81	0.26	-0.12	0.40	-0.20	-0.22	0.14	0.42	0.61	-0.03	0.62	0.24	0.35	-0.02	-0.15	0.41	0.91	0.73
India	0.32	-0.15	0.83	0.65	0.95	0.65	-0.47	-0.54	-0.31	0.56	-0.30	0.51	0.14	0.03	-0.65	0.15	-0.61	-0.29	-0.44	0.15	0.24	0.03	0.38
Russia	-0.61	-0.81	0.31	-0.89	-0.97	-0.89	0.61	-0.20	-0.89	0.91	0.15	-0.95	-0.75	-0.65	0.49	-0.73	-0.82	-0.82	-0.88	-0.91	-0.51	-0.83	-0.92

Source: Own calculations using COMTRADE data

Table 6.10. Revealed comparative advantage index in service industries in 2011 - EU countries, US, Japan, Brazil, China, India and Russia.

Country name	Telecom., computer and information	Construction	Finance	Insurance and pension	Other business services	Personal, cultural and recreational	Transport	Travel
Austria	0.56	0.52	0.41	0.81	1.10	0.43	1.17	1.25
Belgium	0.86	1.17	0.70	0.65	1.62	0.69	1.29	0.45
Bulgaria	0.89	0.42	0.20	0.98	0.52	0.74	0.97	2.00
Cyprus	0.13	0.27	2.20	0.28	1.14	0.49	1.23	1.22
Czech Republic	0.90	1.44	0.07	0.64	1.23	0.89	1.08	1.21
Denmark	0.36	0.21	0.21	0.21	0.88	0.72	2.78	0.37
Estonia	0.76	2.28	0.27	0.07	0.78	0.29	1.73	0.81
Finland	2.51	1.17	0.50	0.10	0.78	0.30	0.65	0.54
France	0.47	1.81	0.59	1.32	1.23	1.67	1.00	0.97
Germany	0.78	1.85	1.04	1.17	1.19	0.33	1.08	0.53
Greece	0.23	1.28	0.08	0.72	0.26	0.46	2.26	1.38
Hungary	0.66	0.76	0.16	0.08	1.08	5.64	0.96	0.92
Ireland	4.06	0.00	1.67	5.63	0.93	0.00	0.26	0.16
Italy	0.79	0.05	0.47	1.16	1.29	0.25	0.67	1.52
Latvia	0.53	0.75	1.29	0.28	0.71	0.40	2.26	0.62
Lithuania	0.26	0.87	0.17	-0.01	0.34	0.32	2.56	0.90
Luxembourg	0.45	0.22	11.17	2.30	0.69	3.34	0.24	0.25
Malta	0.28	0.00	1.02	0.35	0.49	35.88	0.39	0.95
Netherlands	1.07	1.01	0.26	0.34	1.66	0.62	1.28	0.50
Poland	0.68	1.70	0.24	0.57	1.28	1.18	1.35	1.06
Portugal	0.43	1.23	0.23	0.30	0.68	1.10	1.30	1.65
Romania	1.35	1.53	0.30	0.56	1.00	0.86	1.20	0.44
Slovak Republic	0.92	1.49	0.10	0.20	0.75	1.09	1.48	1.37
Slovenia	0.74	1.34	0.13	0.88	0.70	0.91	1.29	1.55
Spain	0.61	1.23	0.69	0.51	1.14	1.28	0.77	1.56
Sweden	1.51	0.54	0.44	0.72	1.39	0.75	0.81	0.78
United Kingdom	0.76	0.35	4.16	3.16	1.52	1.14	0.58	0.45
EU27	1.11	0.75	1.28	1.19	1.13	1.10	1.06	0.88
United States	0.44	0.20	2.34	1.33	0.76	0.40	0.61	0.92
Japan	0.13	3.20	0.57	0.62	1.29	0.10	1.29	0.30
Brazil	0.13	0.02	1.33	0.69	2.50	0.12	0.71	0.64
China	0.71	3.19	0.09	0.85	1.23	0.06	0.89	0.98
India	4.33	0.24	0.87	0.98	0.77	4.52	0.59	0.48
Russian Federation	0.51	3.04	0.36	0.30	1.23	0.72	1.38	0.73

Source: Own calculations based on IMF and OECD data