Study on the Competitiveness of the Electrical and Electronic Engineering Industry

Final Report

Client: DG Enterprise and Industry

Munich, 18 December 2013

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Within the Framework Contract for Industrial Competitiveness and Market Performance – ENTR/90/PP/2011/FC

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Compiled by the following partners of the ECSIP consortium:

- Ifo Institute (Project lead)
- Cambridge Econometrics
- Danish Technological Institute
- Decision
- IDEA Consult

18 December 2013, Munich

About ECSIP

The **E**uropean **C**ompetitiveness and **S**ustainable **I**ndustrial **P**olicy Consortium, **ECSIP** Consortium for short, is the name chosen by the team of partners, subcontractors and individual experts that have agreed to work as one team for the purpose of the Framework Contract on 'Industrial Competitiveness and Market Performance'. The Consortium is composed of Ecorys Netherlands (lead partner), Cambridge Econometrics, CASE, CSIL, Danish Technological Institute, Decision, ECIS, Euromonitor, Fratini Vergano, Frost & Sullivan, IDEA Consult, IFO Institute, MCI, and wiiw, together with a group of 28 highly skilled and specialised individuals.

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Table of contents

Tables

Figures

Section I: Report

1 Introduction

1.1 Study context and objectives

The Ifo Institute, core member of the ECSIP Consortium, lead the Study on the Competitiveness of the EU Electrical Engineering Industry. The Final Report is presented on behalf of the project team.

The Electrical Engineering Industry (EEI) is one of the most competitive European manufacturing industries. It is a strong competitor in international markets and has benefited from global growth in the past decade. The industrialisation of emerging economies has been the most important driver for expansion. In 2008 the outbreak of the global financial crisis caused a fall in demand and EEI as well as other manufacturing industries suffered a severe recession. The subsequent recovery has been fragile; the previous level of output has not been reached yet.

In recent years emerging economies' manufacturing output has gained market share in global output, whereas the developed world has lost importance. Moreover, the European manufacturing sector remains affected by the European economic crisis. The EU-27 EEI is one of the most important manufacturing industries, a driver of innovation, provider of key-enabling technologies (KET) and largest employer within the EU. The aim of this study is the assessment of the EU's EEI competitiveness in comparison with major competing economies: the US, Japan, China, South Korea, Taiwan, India and Brazil.

The EEI is a heterogeneous industry. Its sub-sectors show large differences in their supply-side structure, business models and market environment. In information and communication technologies fast moving technological progress has lead to strong growth in labour and capital productivity. In power generation, environmental concerns and the expected scarcity of resources are pushing the development of new technologies. As a consequence of the diversity of the EEI a detailed analysis of numerous sub-sectors is asked for by the Request for Services (RfS).

In the EU-27 the EEI is located in traditionally industrialized regions and a division of labour has evolved over time. In particular, the Member States that joined the EU in 2004 and were integrated into European value chains, remain vulnerable to global competition. More generally, there exist regional strengths and weaknesses for the EU-27 EEI that are analysed in this report.

The EEI as a supplier of electrical and electronic products is strongly affected by European policies, regulations, and in particular climate change regulation with its "20-20-20" targets:

- A 20 % reduction of EU greenhouse gas emissions from 1990 levels,
- Raising the share of EU energy consumption produced from renewable resources to 20 %,
- A 20 % improvement in the EU's energy efficiency.

As the EEI supplies products for power generation, distribution and consumption it is an important enabler for the technical change required to reach these targets. It will benefit from the replacement of energy inefficient plants machinery and equipment overtaken by technological progress and investment in new, more efficient technology.

Beyond this growth-enhancing demand EEI is affected by EU provisions on energy efficiency, resource efficiency and recyclability. These policy targets are pursued with EU legislation. In this respect the Ecodesign Directive, the Restriction of Hazardous Substances Directive (RoHS), the Registration, Evaluation, Authorisation and Restriction of Chemicals Directive (REACH) and the Waste Electrical and Electronic Equipment Directive (WEEE) are of great importance for EEI. Other provisions relevant for the EEI concern the functionality and compatibility of products, such as the Electro-Magnetic Compatibility Directive (EMC) and Radio and Telecommunications Terminal Equipment Directive (R&TTE). Legislation directed towards consumers' health, safety and security in the workplace, as well as emissions is also relevant. The EU regulatory framework is supported by standardization work carried out by the ESOs[1]. This report analyses the impact of all of these policies on EEI's performance within the Single Market and globally.

The assessment of the EU-27 EEI's performance in the domestic and global markets has been carried out by an in-depth investigation of the evolution of price competitiveness, financial performance, comparative advantages, performance in foreign trade, technological competitiveness and the labour market. These evaluation criteria have been applied as basis for a quantitative assessment of the EU EEI's perspectives up to 2020, differentiated by domestic demand and exports to third countries.

1.2 Structure of the report

The focus of Chapter 2 is on the EU EEI. It provides a comprehensive description of the industry that consists of the electrical engineering sector (EE1), the electronic engineering sector (EE2) and the electrical and electronic components sector (EE3). All of these sectors show major differences in their structure and their products. To a large extent EE1 comprises capital goods and key components delivered to a broad range of industries, many of them dedicated to machinery and equipment and, transport equipment. The EU-27 commands a strong position in international markets for these products. The sector EE2 comprises information, communication and telecommunication (ICT) equipment. In several markets the EU-27 commands a strong position in international competition, in particular markets for medical equipment and communication infrastructure technologies. However, in consumer electronics the EU-27 is largely dependent on imports, predominantly from Asian countries. As compared to both EE1 and EE2, EE3 is small, despite being of crucial importance for technological progress. It comprises intermediary products, among them semiconductors that are key-enabling products not only for EE1 and EE2, but for a broad range of downstream industries. Hence, EE3 is a driver of innovation in downstream industries.

All of the three sectors are investigated in detail. For this purpose numerous sub-sectors are considered separately, as they differ strongly in the structure of the supply side, the pace of technological progress and innovation as well as their performance in international markets. The first part provides a description of EE1, based on a detailed analysis of its sub-sectors. The second and third parts are dedicated to EE2 and EE3 including sub-sectors. This sectoral differentiation is kept throughout the report. The assessment of the EEI's competitiveness is carried out for the sectors, EE1, EE2 and EE3, separately and summed up in an overall evaluation. Most of Chapter 2 is dedicated to a sectoral and sub-sectoral analysis of EU EEI. The final section tackles smart grids, a cross-sectoral technology that is of outstanding importance for the EU energy policy.

[1] CEN and CENELEC develop a specific program to support SMEs. URL: http://www.cencenelec.eu/sme/pages/default.aspx.

Chapter 3 is dedicated to an in-depth investigation of the relative competitiveness of the seven non-European economies. As for the EU EEI a qualitative description and a quantitative analysis of the EEI and its three sectors are carried out. The assessment of each competing economy's EEI performance is examined by two dimensions. First, the competing economy's domestic economic development is compared to the competing economy's total manufacturing as a benchmark. Second, the competing economy's EEI is compared to the EU EEI. The results provide insights into the evolution of comparative advantages or disadvantages.
Chapter 4 discusses in detail the different aspects that have been mentioned in the RfS as basis for the assessment of the EU EEI's competitiveness. Those are

- factor prices and productivity,
- performance in international trade and important sales markets,
- state of technology and the EU's position in global competition,
- availability and quality of input factors,
- companies' financial performance, liquidity and solvency and
- intra-EU division of labour, competitive clusters and coherence, structural elements of crucial importance for the long-time performance of the EU EEI.

Chapter 4.1 analyses the price competitiveness and its evolution over the period under investigation for the EU and the seven competing economies, differentiated by EE1, EE2 and EE3. Chapter 4.2 investigates the performance of the EU and its competing economies in international markets. Chapter 4.3 analyses the technological competitiveness with a focus on EU and US patent statistics. The evaluation is carried out for the EU, the US and a group of Asian economies. The analysis shows that the strength of Asia in high-tech industries has increased remarkably.

Chapter 4.4 investigates the availability and quality of labour supply. It concludes that demography and qualifications will be challenges for EEI if it wants to maintain its strong technological position in international competition. Mathematics, natural sciences and engineering have lost some of their former attractiveness, which is reflected in the subjects young people are interested in.

Chapter 4.5 investigates the financial performance of the EU and the competing economies. The results have been mixed. Although EU EE1 turns out to be competitive internationally in technology and international trade, the microeconomic analysis unveils a below average profitability. However, profitability has improved over the period under investigation. In contrast, EE2's profitability was remarkably good during the early years of the period under investigation, but it has worsened thereafter. In parallel, liquidity and solvency have deteriorated. For EE3 profitability was poor during the early years of the investigation, but has improved remarkably. Nevertheless, liquidity remains poor and long-term debt is higher than in competing economies. This poses a significant challenge for investment in future production technologies.

Chapter 4.6 investigates in the intra-EU division of labour. During the period under consideration, the employment record of the northern economies and central European economies (CEE) has been significantly better than for southern economies. The results of our investigation suggest that changes of price competitiveness had an impact on employment.

Chapter 4.7 provides an in-depth assessment of the EU EEI's international competitiveness. The strength of the EU EEI is strongly dependent on EE1. This is reflected in its trade performance. EE1 commands a long-term trade surplus. Moreover, EU EE1 has gained share in global markets despite competition from emerging economies. For EE2 and EE3 the EU-27 the foreign trade balance is negative. The overall trade balance for EU EEI is balanced. Likewise, the technological position of the EU EEI in international competition is to a large extent dependent on EE1. The sectoral analysis of patents shows strong competition in EE2 and EE3 between Asia and the US.

Although the EU is leading globally in certain areas of technology, it is trailing behind Asia and the US in most sectors.

The EU EEI strengths are closely related to downstream industries, in particular the capital goods industries and transport equipment. The linkages are based on the delivery of intermediary products. Simultaneously, these value chains are innovation chains. Key-enabling technologies (KET) primarily supplied by EE3, are indispensable for innovation in downstream industries. The investigation in the evolution of employment has revealed that the employment effects of key-enabling technologies depend on downstream industries' ability to innovate. Generally speaking, all of the innovation and value chain is relevant for employment. For all of the competing economies it has turned out that the employment record of EE3, the KET-sector, was worse than for EEI overall.

EE3's performance in international trade is characterized by a growing focus of EU production in domestic markets, on strong downstream industries. In parallel, imports of EE3 products have declined. This development has been caused by a loss of production capacities for large scale manufactured consumer electronics and telecommunication terminals within the EU. In contrast to the general tendency of growing international division of labour, a specialization of the EU EE3 on domestic clients has taken place with the production of more specialized and customized products as asked for by domestic clients.

Chapter 5 investigates European policies and their impact on the performance of EEI in global competition. It focuses on the most relevant policies for EEI. Market access barriers are of importance for the EU EEI, an industry that exports roughly one third of its production. The chapter provides insight on trade barriers, in particular non-tariff barriers, for five of the seven competing economies plus three economic areas with which the EU maintains close trade relations. The EU industry – via its standardization bodies CEN, CENELEC and ETSI – is strongly involved in initiatives to develop technical standards that are internationally recognised and contribute to a reduction of non-tariff barriers.

As mentioned above EEI is a technology driven industry which is of pivotal importance for the EU to reach the EU "20-20-20" energy targets. Hence, numerous EU R&D policies in Horizon 2020 focus on technologies applied and developed by EEI. The chapter analyses schemes on electro-mobility, semiconductors, photonics, renewables power generation, smart grids and advanced production technologies.

Chapter 5 investigates EU regulations. The legal framework set by selected EU directives is assessed as regards a coherent, less bureaucratic regulatory system so as to ease compliance for companies placing products on the Single Market. With the New Legal Framework, which came into effect in 2010, the EU strives for a more consistent regulation. This is a challenge because simultaneously legislative initiatives are taken that will lead to new requirements. An initiative launched by the Commission is the Product Safety and Market Surveillance Package (PSMSP) that is dedicated to overcome the deficiencies of market surveillance in the Single Market and to warrant competition on eye level for economic operators.

Chapter 6 provides an outlook for the EU EEI up to 2020 based on the Ifo Institute's latest medium-term economic outlook (as of October 2013). The EU's macroeconomic perspectives are muted and impact EU EEI strongly. Domestic demand will stagnate over the forecasting period, whereas third country demand is the driver of growth. The foreign markets importance as measured by the export ratio will continue to increase. While it was only 26 % in the period 1998 – 2005, it increased to 31 % for 2005 – 2012, and is forecast to reach 37% for 2012 – 2020. Beyond stagnant domestic demand an on-going increase of the international division of labour – as in the past – will contribute to this development.

Chapter 6 highlights the more important framework conditions and provides some recommendations. They are subsumed under two categories: Supply side economics comprise:

- Public policies on R&D;
- Regulation;
- Competitive advantages based on manufacturing and research clusters;
- Access to third countries;
- Qualification and the supply of labour.

Demand side economics focus on EU climate and energy policies built upon the EU "20-20-20" Targets. They affect EEI as the supplier of products for power generation, distribution and consumption. Policies pose high requirements on resource and energy efficiency, but simultaneously incorporate the potential for growing demand.

2 Description of the EU electrical and electronic engineering industry

The scope of the investigation is illustrated in **Table 2.1.** The definition of the sub-sectors is based in NACE (Rev. 2) and the grouping into three sectors has been agreed upon during the Kick-off Meeting. This chapter contains a detailed description of the EU electrical and electronic engineering (EEI), differentiated by the sectors and sub-sectors. Most of the sub-sectors are defined by four digit NACE groups as shown below. One sub-sector "Insulated wire and cables" reported in this chapter consists of two NACE codes, C2731 and C2732. No analysis will be carried out on the following two sub-sectors: C2790 "Manufacture of other electrical equipment" is a conglomerate of quite different products and markets that does not allow meaningful analysis and assessment. C3250 "Manufacture of medical and dental instruments and supplies" is beyond the EEI and comprises a number of mechanical products without much linkages to the EEI production and value chain. This gives a total of 15 sub-sectors to be reported on in this chapter instead of the 13 requested in the RfS.

Table 2.1: Structure of the EU electrical and electronic engineering

	Electrical and Electronic Engineering (EEI)
EE1	**Electrical engineering**
	C2711 Manufacture of electric motors, generators and transformers
	C2712 Manufacture of electricity distribution and control apparatus
	C2651 Manufacture of instruments and appliances for measuring, testing and navigation
	C2720 Manufacture of batteries and accumulators
	C2731 Manufacture of fibre optic cables
	C2732 Manufacture of other electronic and electric wires and cables
	C2740 Manufacture of electric lighting equipment
	C2751 Manufacture of electric domestic appliances
	C2790 Manufacture of other electrical equipment
	C2931 Manufacture of electrical and electronic equipment for motor vehicles
	C3320 Installation of industrial machinery and equipment
EE2	**Electronic engineering**
	C2620 Manufacture of computers and peripheral equipment
	C2630 Manufacture of communication equipment
	C2640 Manufacture of consumer electronics
	C2660 Manufacture of irradiation, electromedical and electrotherapeutic equipment
	C3250 Manufacture of medical and dental instruments and supplies
EE3	**Electrical and electronic components**
	C2611 Manufacture of electronic components
	C2612 Manufacture of loaded electronic boards

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The EEI is one of the large sectors of the EU-27. In 2012 its **gross output**[2] was € 703.3 billion. This equals a share of 9.6 % of all manufacturing industries' gross output. In 2000, its share was 10.0 %, showing a slight but steady decline over the period under consideration. In spite of this decrease, the number of workplaces declined only at an annual average rate of 0.7 % to 3,389,000 in 2012, whereas employment in the manufacturing industry as whole declined at a rate of 1.6 % per year. (**Table 2.2**)

[2] Gross output ~ Turnover +/- changes in inventories ~ production + sale of services and merchandise goods +/- changes in inventories.

The **EEI** – as measured by **value added in constant prices** – increased at an average annual rate of 2.7 % between 1998 and 2012. It accounted for € 212.4 billion in 2012 and had grown at a fast pace, whereas total manufacturing suffered some losses. The better development of the EEI in real terms rather than in nominal terms is explained by falling prices in the EE1 and EE2 sectors. Moreover, the increasing manufacturing depth of EEI had also contributed to a certain extent. This indicator – measured by the ratio of nominal value added divided by gross output – hovered around 30 % for the EEI over the period under consideration. In recent years it increased slightly. In contrast, for total manufacturing the depth of manufacturing declined from 28 % to only 23 %. This indicates that the value creation within the EU-27 has retained its importance in the EU EEI's global manufacturing production networks. For all other manufacturing industries with the EU-27 as a location for production lost some of their former importance on average within the global production networks.

Labour productivity of the EEI increased much stronger than value added at an annual average rate of 3.5 % over the period under consideration. Simultaneously, labour costs per employee only increased by 2.3 % per annum and caused a decline of unit-labour costs (ULC) by 1.1 % (a noteworthy improvement of price performance). In contrast, for total manufacturing price performance had worsened. Labour costs increased at a higher pace at 3.1 % annually and exceeded labour productivity by far, which expanded by a meagre 0.9 %. As a consequence, unit-labour costs (ULC) worsened annually by 2.2 %.

The sectors of the EEI developed quite differently. **EE1** accounts for around 52.9 % of the EEI's gross output. Its pattern of growth was broadly in line with traditional industries. Product prices did not change much over the period under consideration, only increasing by an average of 0.4 % per annum. Improvement of labour productivity by 2.5 % p.a. was well above total manufacturing, but lagged behind the other sectors in the EEI. By 2012, manufacturing depth increased and contributed to a relatively good employment record, compared to the other sectors. The number of workplaces declined only by around 0.3 % p.a.

EE2 accounts for around 40 % of the EEI's gross output. The sector is directly driven by technological progress in microelectronics and discloses the typical pattern of high-tech industries. Labour productivity improved by 4.5 % annually and exceeded by far price adjusted growth of value added, which increased only at an annual rate of 2.9 %. Falling prices let companies' revenues stagnate and companies shed workforce on average by 1.6 % p.a.

EE3 contributes almost 7 % to the EEI's gross output. This upstream industry provides intermediary products to EE1, EE2 and a broad range of different industries. It is even more affected by technological progress than EE2. This is indicated by a **technology driven improvement of labour productivity** of 7.9 % p.a. Although the growth rate of real value added reached an annual rate of 6.5 %, it was not sufficient to prevent a reduction of staff that was lower than for EE2.

Table 2.2: Key figures for the EU electrical and electronic engineering

Indicator	Units		1998 Values	2012 Values	1998 - 2012 Aagr[1)]	2012
Total manufacturing						
Gross output	in current prices	bn. €	5049.2	7343.1	2.7%	-
Value added	in 2010 prices	bn. €	1756.3	1610.3	-0.6%	-
Employees	1,000	1,000	37320	29985	-1.6%	-
Labour costs	per employee	1,000 €	25.1	38.8	3.1%	-
Labour productivity	in 2010 prices	1,000 €	47.1	53.7	0.9%	-
Unit-labour costs	in 2010 prices	€ per €	0.53	0.72	2.2%	-
Electrical and electronic engineering (EEI)						**Shares[2)]**
Gross output	in current prices	bn. €	537.1	703.3	1.9%	9.6%
Value added	in 2010 prices	bn. €	146.1	212.4	2.7%	13.2%
Employees	1,000	1,000	3762	3389	-0.7%	11.3%
Labour costs	per employee	1,000 €	31.4	43.3	2.3%	111.8%
Labour productivity	in 2010 prices	1,000 €	38.8	62.7	3.5%	116.7%
Unit-labour costs	in 2010 prices	€ per €	0.81	0.69	-1.1%	96.0%
Electrical engineering (EE1)						*Shares[3)]*
Gross output	in current prices	bn. €	283.9	424.1	2.9%	60.3%
Value added	in 2010 prices	bn. €	96.9	130.7	2.2%	61.5%
Employees	1,000	1,000	2306	2210	-0.3%	65.2%
Labour costs	per employee	1,000 €	30.1	43.4	2.6%	100.1%
Labour productivity	in 2010 prices	1,000 €	42.0	59.2	2.5%	94.4%
Unit-labour costs	in 2010 prices	€ per €	0.72	0.73	0.2%	106.1%
Electronic engineering (EE2)						*Shares[3)]*
Gross output	in current prices	bn. €	214.9	214.4	0.0%	30.5%
Value added	in 2010 prices	bn. €	40.6	60.6	2.9%	28.5%
Employees	1,000	1,000	1099	882	-1.6%	26.0%
Labour costs	per employee	1,000 €	34.2	43.2	1.7%	99.8%
Labour productivity	in 2010 prices	1,000 €	36.9	68.8	4.5%	109.7%
Unit-labour costs	in 2010 prices	€ per €	0.93	0.63	-2.7%	91.0%
Electrical and electronic components (EE3)						*Shares[3)]*
Gross output	in current prices	bn. €	38.2	64.8	3.8%	9.2%
Value added	in 2010 prices	bn. €	8.7	21.1	6.5%	9.9%
Employees	1,000	1,000	357	298	-1.3%	8.8%
Labour costs	per employee	1,000 €	30.7	43.2	2.5%	99.7%
Labour productivity	in 2010 prices	1,000 €	24.3	70.8	7.9%	112.9%
Unit-labour costs	in 2010 prices	€ per €	1.26	0.61	-5.0%	88.3%
1) Annual average growth rates; 2) of total manufacturing in 2012; 3) of electrical and electronic engineering.						

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Despite a slight decline in the number of workplaces, the EEI's share of total manufacturing increased from 10.1 % in 1998 to 11.3 % in 2012. This relatively positive development was driven above all by EE1. This sector's contribution to EEI's employment increased from 61.3 % to 65.2 % over the period under investigation. For EE2 and EE3, the shares declined from 29.2 % to 26.0 % and from 9.5 % to 8.8 %, respectively.

It is of crucial importance to understand that – as measured by the number of workplaces – the reduced weight of EE2 and EE3 does not indicate a loss of relevance. Technological progress drives labour productivity strongly, exceeding output growth by far. As a result, employment could be reduced. EE3 is an upstream industry and provides many key enabling technologies to client industries. It has become an important driver for innovation throughout the period under investigation. The growing interdependencies between EE3 and downstream industries – fuelled by an accelerated pace of technological progress and the delivery of high-tech components – are pivotal to client industries' long-term competitiveness. The tendency of a growing interrelation between EE3 and EE2 as well as EE1 is highlighted in the following chapters.

The **EU EEI**'s **regional concentration** is measured as its employment **share in total manufacturing** (TM) employment. In 2012, the EEI's share of the total workforce in manufacturing was 11.3 %. Member States with a strong focus on EEI are the more developed economies, Finland (16.2 %), Germany (14.6 %) and Austria (13.6 %), followed by Sweden (12.3 %) and France (12.2 %). Another group of countries with a strong focus on EEI are characterised by lower wages and beneficial framework conditions for large enterprises. Ireland is in the lead with around one quarter, followed by Hungary at one fifth of TM's workplaces in the EEI, and then Slovakia and Slovenia. For southern EU Member States, such as Spain and Portugal, the EEI less important with lower shares of 7.0 % and 5.6 % of domestic total manufacturing, respectively. During the early phase of the period under investigation (1998), the concentration was less pronounced. At the time, the EU EEI's share in total manufacturing employment was 10.1 %. For instance, the EEI's share in Germany's total manufacturing employment was 12.1 %, whereas the share in Portugal and Spain was 7.6 % and 6.0 %, respectively.

The regional shift of employment within each of the industries is highlighted by a comparison of Northern, Southern and Central Eastern European (CEE) economies as depicted in **Table 2.3 for TM, EEI, EE1, EE2 and EE3**. Northern economies provided 32.9 % to TM's workplaces in 2012. This share increased by 4.3-percentage points since 1998, while the share of CEE economies had also increased by 1.5-percentage points. Simultaneously, the southern and other Member States lost some of their former importance throughout the period under investigation.

For the EEI, the increase in weight was of similar magnitude for northern economies as in TM, while for CEE economies it was even more pronounced. Their share of employment increased from 11.2 % in 1998 to 14.8 % in 2012. The southern economies lost 1.8-percentage points over the whole period under consideration and in 2012 only had 16.8 % of EEI's workplaces. The losses of other Member States were of similar size. **It is important to note that most of the shifts in employment took place before 2009 and cannot be attributed to the Euro Area public debt and banking crises. Northern and CEE economies gained shares above all in EE1.** In EE2, only the CEE economies gained significant shares as measured by the number of workplaces, whereas the northern economies lost their former weight. The southern economies maintained their weight in this sector. However, EE2 is most challenged by global competition and the EU-27 lost much of their former importance, in particular in markets for mass manufactured electronics.

Table 2.3: Changes in the regional distribution of employment within the EU-27

Industry / sector	Northern economies[1)]	Southern economies[2)]	CEE economies[3)]	Other Member States
	2012			
Total manufacturing	32.9%	21.6%	15.7%	29.8%
Electrical and electronic engineering	40.7%	16.8%	14.8%	27.7%
Electrical engineering	41.2%	16.9%	13.9%	28.1%
Electronic engineering	41.4%	16.8%	17.2%	24.5%
Electrical and electronic components	34.4%	16.1%	14.7%	34.8%
	2010			
Total manufacturing	32.0%	22.5%	15.8%	29.8%
Electrical and electronic engineering	39.3%	17.4%	14.6%	28.7%
Electrical engineering	8.5%	17.5%	13.7%	60.2%
Electronic engineering	41.5%	17.3%	16.6%	24.6%
Electrical and electronic components	32.4%	16.3%	15.1%	36.2%
	1998			
Total manufacturing	28.6%	22.2%	14.2%	35.0%
Electrical and electronic engineering	36.6%	18.6%	11.2%	33.6%
Electrical engineering	31.9%	19.9%	11.2%	37.0%
Electronic engineering	47.5%	16.4%	11.8%	24.4%
Electrical and electronic components	33.5%	17.4%	9.7%	39.4%
1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia.				

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.1 The EU electrical engineering sector

This chapter begins with an assessment of EE1 compared to its benchmark EEI and highlights the sector's specifics and the evaluation of its price and trade performance. Moreover, it provides a synopsis of the major results derived from the investigation into the sub-sectors. The presentation of the detailed sub-sectoral results follows.

EE1 is an industry with a broad product programme that comprises capital goods, durable consumer goods and intermediary products. Parts, components and complex systems that are crucial for the quality and performance of final goods are also manufactured. Intermediary goods are delivered to other companies in the sector, such as for the construction of power generation plants, electricity grids, and also to a broad range of downstream industries. EE1 products provide essential functions in all kinds of transport equipment, airplanes, trains and cars. Industrial automation and process control in all manufacturing companies are based on EE1 products. Building automation, heating, air-conditioning and access authorisation as well as the equipment of private households with domestic appliances are similarly dependent on the supply of EE1.

For a long time – compared to EE2 and EE3 – EE1 was understood as a more conventional branch of total manufacturing with a moderate pace of innovation. However, throughout the past decade there have been changes across many of EE1's sub-sectors and the pace of technological progress has accelerated. In some sub-sectors, dramatic shifts have been taking place that have not only affected product innovation, but also the structure of sub-sectors and upstream linkages, such as in the sub-sector "Lighting equipment and electric lamps". These trends have to be taken into account when assessing the performance and future perspectives of the whole industry under investigation.

The EE1's increasing importance as a supplier of innovations for downstream industries can be highlighted, above all, by deliveries into the automotive industry. During the early stages of the electronification of vehicles, the electro-mechanical motor control was replaced by electronic control and management systems. Throughout the past two decades, more electronic features have been integrated into vehicles to increase the comfort of drivers and passengers and to improve active and passive safety by anti-lock braking systems (ABS), Electronic Stability Program (ESP) etc. Self-driving cars – once just a utopic dream - have now been realised with the help of electrical and electronic engineering. Electro-mobility is another more recent trend driven by electric and electronic innovations. However, insufficient battery capacity has remained the Achilles heel for a widespread dissemination, despite all public incentives. While the more traditional electric components – such as starters, lamps etc. – delivered to the automotive industry are aggregated in a separate sub-sector of EE1, the high-tech electronic components have not been allocated to this sub-sector. They cannot be easily spotted because they are not subsumed in a product group, or a single sub-sector.

Notably, the sub-sector "Lighting equipment and electric lamps" has been affected by new technology based on upstream deliveries from EE3. The dissemination of the SSL-technology with LEDs has become a driver for product innovation and structural change of the sub-sector. LEDs provide a number of additional opportunities for the design of lighting and will lead to an enormous increase in energy efficiency compared to traditional light sources, which will be substituted to a large extent in the medium-term. A more application-driven (rather than standardisation-driven) design of light sources will lead to an intensification of the interaction between companies along the value chain and will provide leeway for companies at the lower end to open up new business opportunities. The semiconductor industry will become the most important supplier of key components for this sub-sector. This means supply relationships between the industry's sub-sectors EE1 and EE3 have been intensified by this innovation and will further deepen. This technology push highlights the **growing importance of upstream key-technology dependency**.

In the area of SSL-technology, Asian manufacturers are globally in the lead by volume and they have long-standing experience in the production of LEDs. This strength eases Asian manufacturers' access to the EU market, although EU manufacturers of light sources are the global leaders in this market. These large manufacturers have always been leading the market for traditional light sources and command a strong position in LEDs with technologically advanced and high-quality products. Their knowledge of specific applications and system engineering gives them an edge in competition with Asian suppliers who build on their ability to raise scale effects. The strengths of US companies in the area of SSL-technologies are especially based on innovations concerning the light spectrum. This underscores the necessity to investigate the international competitiveness along value chains in order to understand and assess the potential long-term perspectives of EU industries.

Photovoltaic – not a new technology, but one that has gained in importance for power generation – is another good example for the intra-industrial division of labour of the EEI. Photovoltaic cells are semiconductors mentioned under EE3 as products of NACE 26.1. Solar panels are delivered for the production of photovoltaic systems for the direct generation of electricity to manufacturing sites that are subsumed under the EE1 sub-sector "Electric motors, generators and transformers" (NACE 27.1). The manufacture of photovoltaic plants is subsumed under the EE1 sub-sector "Other electrical equipment n.e.c." (NACE 27.90). As for lighting equipment, the supply relationships between EE1 and EE3 have become closer. This product group has grown over the past decade and will remain one of the growth drivers stimulated by public funding dedicated to reducing the CO_2 footprint.

Likewise, the sub-sector "Accumulators and batteries" has undergone significant changes. In particular Lithium-ion batteries (LiB) have gained importance. Market penetration of these types of batteries has started in consumer electronics and with these applications they dominate the market. Here Asia has, once again, longstanding experience in R&D and in the production of small LiBs due to the region's focus on the manufacture of consumer electronics. Asian manufacturers have become global market leaders. However, Asian manufacturers are challenged by the growing demand for batteries with high capacities. It has become evident that it is not sufficient to simply put together a large number of LiBs. Of crucial importance to the development of batteries with large capacities and high energy density is a sophisticated battery management process for longevity and safe handling.[3] These technologies are urgently needed for a widespread dissemination of electro-mobility and for back-up storages necessary for smoothing fluctuating power generation by renewables. In these technologies the EU EE1 commands a strong position, to a certain extent based on European strengths in power electronics and interdisciplinary research.

For more than a decade another tendency has been observed: a growing **integration of different technologies and services towards complex systems**. One striking example is smart grids. New technological opportunities and escalating efforts to shift from fossil power generation to renewables have required a more flexible adjustment of both power supply and electricity demand. Power engineering has to be developed further, with problems to be solved for the technical implementation of long-distance DC transmission, such as high-voltage breakers, where a European player has made a breakthrough development of worldwide importance. Simultaneously, wide area monitoring, regulation and control systems based on computers, sensors and software tools for data processing have to be combined for a well-functioning and flexible power supply that enables the final consumer of electricity to adjust their demand on the basis of price information received from advanced metering infrastructure. Smart grids is a type of technology that reaches beyond traditional sectoral or sub-sectoral boundaries and cannot be aggregated into one sub-sector of the EEI. The different parts and components are scattered over different product groups of EEI. However, a separate analysis of this technology is provided within the sub-sector "Electrical distribution and control apparatus" to provide a comprehensive overview.

Production automation is another cross-sectoral area of technology that cannot be assigned to a single industry. It is a combination of products from the majority of EEI's sub-sectors and reaches beyond the industry under investigation – in particular mechanical engineering and related software service providers. The integration of hardware, software and related services has become one of the characteristics of advanced technologies, which is of particular importance to companies with a stake in production automation. This trend provides **new business opportunities** that can be used to substitute the loss of workplaces in the course of globalisation by a growing international division of labour whereby the manufacture of simple parts and intermediary products is relocated to emerging economies. Beyond maintenance and repair, more comprehensive after-sales-services and even the operation of complete power generation plants, grids and production systems for clients have become promising business areas. These services not only provide opportunities for employment but also allow companies to run steadier businesses, such as the marketing of capital goods with its volatile demand cycles. Machinery and equipment for production automation are widespread throughout numerous sub-sectors but will be tackled in a subsection on installation of industrial machinery and equipment (2.1.11).

[3] Boeing's problems with LIBs used in its latest and most advanced airliner indicate yet existing difficulties in new applications.

Assessment of the economic performance

The EU EE1's gross output reached € 370.4 billion (2012). The sector commands around 60 % of the EEI's production (**Table 2.4**). It gained importance throughout the period under investigation. In 1998, its contribution to EEI's production was only 50 %. EE1's improved development has also been observed for the years after the breakdown caused by the global financial crisis in 2009. In 2012, it toppled the peak output recorded in 2008, while the EEI did not regain the former output level.

While EE1's output increased at a nominal annual average rate of 2.5 % for the years 1998 to 2012, employment declined. But losses of workplaces were less pronounced than in the other two sectors of the EEI. As a consequence, the share of EE1 in EEI's total employment increased to 65 %. **Table 2.4** highlights the cyclical development over the whole period under consideration, driven by the "New Economy Bubble" during 1998 and 2000, the consolidation from 2000 to 2005, the final years of the global boom from 2005 to 2008, and the last period with its meltdown of global production followed by a quick and dynamic recovery from 2008 until 2012.

Table 2.4: Key indicators for the EU electrical engineering sector (EE1)

Sector	Indicator	2012		Annual average growth rate in % 1998 – 00	2000 – 05	2005 - 08	2008 – 12
EEI[1]	Production, in current prices	bn. €	635.8	9.5	-0.2	4.6	-1.2
Electrical engineering			370.4	8.3	1.1	5.9	-1.1
EEI[1]	Production, in 2010 prices	bn. €	651.1	9.7	0.8	7.2	-0.1
Electrical engineering			362.6	10.0	0.6	4.9	-1.9
EEI[1]	Value added, in 2010 prices	bn. €	212.4	8.9	0.1	5.3	1.2
Electrical engineering			130.7	10.2	-0.3	2.6	1.0
EEI[1]	Employees	1,000	3389	2.2	-1.7	0.5	-1.9
Electrical engineering			2210	2.4	-1.2	0.6	-1.2
EEI[1]	Labour costs per employee	1,000 €	43.3	3.4	1.6	2.1	2.8
Electrical engineering			43.4	3.5	2.1	2.5	3.0
EEI[1]	Productivity[2]	1,000 €	62.7	6.5	1.7	4.8	3.2
Electrical engineering			59.2	7.7	0.9	2.0	2.2
EEI[1]	Unit labour costs[3]	€ / €	0.69	-2.9	-0.1	-2.5	-0.3
Electrical engineering			0.73	-3.9	1.1	0.5	0.8
			Annual averages[4]				
EEI[1]	GOR[6]	%	9.0	8.6	7.7	8.5	8.8
Electrical engineering			8.9	9.0	8.3	8.5	8.6

1) Electrical and electronic engineering; 2) Electrical and electronic components; 3) (Value added in 2010 prices) / employment; 4) (Nominal total labour costs) / (value added in 2010 prices); 5) for the period under consideration; 6) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The economic performance of EE1 compared to EEI reveals a slightly worse situation indicated by lower labour productivity, whereas labour costs per employee did not differ significantly. Over the period under investigation, economic performance decreased slightly, with an increase of unit labour costs (ULC) at an annual rate of 0.2 %. However, this worsening contrasts with the improvement for total EEI by -1.1 %. **The improved performance for EE2 and EE3 on price competitiveness was induced by technological progress which resulted in a strong increase of labour productivity and staff redundancy.**

Changes in the regional distribution of sub-sectors

As analysed in detail within the sub-sector chapters below, the regional structure of EE1 changed throughout the period under investigation. While northern economies and CEE economies gained importance, as measured by the number of workplaces, southern economies lost some ground. These losses have not been caused by the breakdown of demand during the global financial turmoil and the following banking and public debt crisis. The analysis of 1998 to 2008 revealed that most of the losses in employment took place during the pre-crisis years. With the exception of one small sub-sector "Batteries and accumulators", remarkable increases in the share of employment in northern economies and a loss in the south have been identified. **Table 2.5** reveals that there is not a specific sectoral pattern for these losses and gains. Extraordinarily strong gains for the northern economies in shares of employment of more than 50 % have been identified for the sub-sectors "Instruments for measuring etc." and "Fibre optic cables". The increase of the latter was accompanied by a slump in the United Kingdom employment levels. Nearly 50 % of the northern economies gains in the shares of EE1 employment happened in the sub-sector "Installation of industrial machinery", where industrial services, such as the set-up of plants and power stations, as well as the revamping of already existing facilities is subsumed. Two sub-sectors in which the northern economies lost some of their weight in employment were "Domestic appliances" and "Electrical and electronic equipment for cars". Their commonality is basic industrial production and low value added. Cost competition is pivotal for success in the market. During the period under investigation, relocation was carried out by large players in the market. CEE benefited much from these activities and its share in both of the sub-sectors' employment had increased from 10.4 % to 18.2 % and from 16.6 % to 28.4 %, respectively. Within the EU-27, CEE has been more attractive for basic industrial production than southern economies.

Table 2.5: Regional distribution and changes of employment for EE1 and sub-sectors (1998 to 2008)

Sector / sub-sectors	EU-27 Growth[4]	North[1]	South[2]	CEE[3]	North[1]	South[2]	CEE[3]
		Share of EE1 in 2008[5]			Changes in shares[6]		
Average of EE1	**0.0%**	**39.1%**	**17.5%**	**11.9%**	**gains**	**losses**	**gains**
Sub-sectors							
Electric motors, generators etc.	Above	=	Above	below	gains	losses	gains
Electricity distribution etc.	=	Above	Below	below	gains	=	gains
Instruments for measuring etc.	=	Above	Below	below	gains	losses	gains
Batteries and accumulators	Below	Below	=	=	=	=	gains
Fibre optic cables	Below	=	=	=	gains	=	gains
Electronic, electric wires and cables	=	Below	Above	above	=	=	gains
Electric lighting equipment	=	Below	=	above	gains	losses	=
Electric domestic appliances	Below	Below	Above	above	=	=	gains
Other Electrical equipment	=	=	Above	=	gains	=	gains
Electric, electronic equipment for cars	Above	Below	Below	above	losses	losses	gains
Installation of industrial machinery	Above	=	Above	below	gains	=	losses

1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia; 4) Annual average growth rates (**above**: at least 1.0 %-points higher / **below**: at least 1.0 % points lower than EE1 average); 5) **above**: at least 15 % higher / **below**: at least 15 % lower than the regions average for EE1; 6) **gains**: increase by at least 20 % / **losses**: decrease by at least 20 % of the regions share of the sub-sectors total within the EU27.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

Domestic demand for products from sector EE1 increased at 2.0 % p.a. over the period under investigation, which was more than the 1.8 % annual average increase in domestic demand for EEI products. The cyclicality of demand was quite similar for the sector and its benchmark. Domestic demand for EE1 increased at annual rates of 8.6 % from 1998 to 2000 and at 4.7 % from 2005 to 2008 (Table 2.6). The secular trend in rising demand was met to a large extent by domestic production. EU EE1 production increased at an annual average rate of 2.5 %. However, domestic sales increased only by 1.0 %, leaving room for foreign suppliers. Their portion of the domestic market, as measured by the import quota, increased from an average of 15.8 % during 1998 - 2000 to 24.7 % in 2012. This was well below the import quota of total EEI, which increased from 32.1 % during the early years of the period under investigation to 41.0 % in 2012.

The more than proportionate growth of EE1 production when compared to domestic sales led to a significant growth in exports at an average annual rate of 7.7 %, much higher than for EEI exports at 4.9 % p.a. This indicates that the international division of labour on the market for EE1 products had increased over the whole period stronger than for total EEI.

Table 2.6: Trade indicators "Electrical Engineering"

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EEI	bn. €	694.4	10.9	-0.9	4.7	-1.2
	EE1		341.8	9.0	0.3	5.2	-1.8
EU-27 exports	EEI	bn. €	226.0	17.2	3.0	1.9	3.7
	EE1		113.1	14.6	4.3	11.5	5.7
EU-27 imports	EEI	bn. €	284.6	19.3	0.3	2.7	2.7
	EE1		84.5	19.6	0.2	8.6	4.8
				Averages for the periods			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EEI	%	35.5	24.8	28.5	29.9	32.5
	EE1		30.5	16.2	18.6	22.6	27.3
Import quota[3)]	EEI	%	41.0	32.1	34.5	35.9	39.0
	EE1		24.7	15.8	16.7	18.7	22.4
Trade balances[4)]	EEI	%	-11.5	-17.8	-13.9	-13.7	-14.1
	EE1		14.5	1.6	6.7	11.9	13.1
RCA[5)]	EE1	Index	0.52	0.39	0.41	0.48	0.54

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

For **EE1**, the dependency from third countries has been increasing. During the early phase of the period under investigation, 16.2 % of production was exported. This share increased to 35.5 % in 2012, a quota that steadily increased in the past and can be expected to increase over the coming years. The most striking discrepancy of EE1 compared with EEI is a noteworthy trade surplus that shows a secular growth trend over the period under investigation and compensated for the negative trade balances of the other sectors.

Within EE1, the numerous **sub-sectors** are of different importance for the export performance of EE1. “Electrical distribution and control apparatus” (27.12) is the largest sub-sector by production at current prices. Hence, 27.12 was the most important driver of EE1 exports by its sheer size and its above average growth. As a result, the trade surplus widened significantly. The second important sub-sector by weight of EEI production is “Instruments and appliances for measuring, testing and navigation” (26.51). Its international integration through cross-border trade is much higher than for most other sub-sectors. In particular, the import quota that reached 45 % in 2012 indicates a high international division of labour. The third sector by size is “Electric motors, generators and transformers” (27.11), which also shows an above average international integration, although less pronounced than sub-sector 26.51. Together with the other sub-sectors, it contributed significantly to the expanding trade surplus of EE1. **These three sub-sectors account for around three quarters of the EEI’s exports. They form the core of the EEI and are part of, in a wider sense, an EU engineering cluster that commands a paramount competitive position in global markets.**

“Electrical equipment for engines and vehicles” (29.31) experienced the strongest growth, driven by its above average growing client industry. Its international integration is well below EEI’s average and is caused by Just-in-Time deliveries and the need for regional closeness of production sites. Nevertheless, there is a growing gap in the structural trade deficit. “Batteries and accumulators” (27.20) is another smaller sub-sector with a trade deficit caused, to a certain extent, by imports of power storages for consumer electronics, above all LiBs. It is noted that in absolute terms the trade deficit did not widen. Surprisingly, sub-sector 27.40, “Lighting equipment and electric lamps”, accounts for a trade deficit, despite the largest manufacturers and global players being located in the EU-27. To a large extent, the imports contain electronics dedicated to the control of lamps and in recent years, light-emitting diodes that are produced mainly in Asia. Production is highly specialised so that there is a strong demand for imports in Europe. Fibre optic cables (27.31) enjoyed high export rates in the early phase of the period under investigation, but the sub-sector suffered a strong decline over the years, not least because of the high weight of fibre optic cables, which result in high transportation costs relative to the price of the product. This is a handicap for long-distance transportation and prompts the establishment of new plants in regions with sufficient demand. For optic fibre cables – a new technology during the early years of the period under investigation – exports slowed over time. The set-up of new plants lead to regional distributed production capacities and cross-border deliveries were no longer required to the same extent as during the early phase of the technology.

2.1.1 Electrical motors, generators and transformers

Product programme

This sector comprises the following products according to NACE Revision 2, 27.11:

- Manufacture of electric motors (except internal combustion engine starting motors);
- Manufacture of distribution transformers, electric;
- Manufacture of arc-welding transformers;
- Manufacture of fluorescent ballasts (i.e. transformers);
- Manufacture of substation transformers for electric power distribution;
- Manufacture of transmission and distribution voltage regulators;
- Manufacture of power generators (except battery charging alternators for internal combustion engines);

- Manufacture of motor generator sets (except turbine generator set units);
- Rewinding of armatures on a factory basis.

This sector excludes:

- Manufacture of electronic component-type transformers and switches (NACE Rev. 2 26.11);
- Manufacture of electric welding and soldering equipment (NACE Rev. 2 27.90);
- Manufacture of solid state inverters, rectifiers and converters (NACE Rev. 2 27.90);
- Manufacture of turbine-generator sets (NACE Rev. 2 28.11);
- Manufacture of starting motors and generators for internal combustion engines (NACE Rev. 2 29.31).

Demand side

Global investment in **power generation** is strongly dependent on economic growth. The most promising markets are emerging economies, where new capacities have to be established to meet the permanently growing demand for electricity. In developed countries, demand for the construction of power generation plants has decreased after World War II when sufficient capacities had been installed. Since then, the demand for power generation equipment has lost importance and replacement has become the driver of demand. However, demand has been increasing in line with the growing concerns about climate change and political decisions taken to shift to renewables and increase energy efficiency requirements. Demand has shifted from large coal and oil-fired power plants towards gas power generation, combined heat and power stations and the substitution of fossil fuels with bio fuels that poses different requirements on burning processes. Moreover, new techniques have been developed for renewable power generation, in particular wind, solar, wave and geothermal electricity generation.

The market for power generation equipment has become more diversified, driven by the necessity to reduce anthropogenic climate change. Another crucial tendency of particular importance to developed countries is the investment in smaller, more decentralised power generation units, as there are combined heat and power generation units for detached houses, villas, etc. Regional and local power generation units are gaining in importance.[4] But taking into account more recent developments – the energy turnaround in the US, the so-called shale gas revolution, the UK initiative to fight the climate change with heavy investment in nuclear power stations – there are no clear trends in sight.

Nuclear power generation has contributed to the reduction of the global CO2 footprint, but its long-term prospects have worsened due to a decreasing level of acceptance from developed countries. Nuclear power generation will be abolished in some European countries, including Germany, Belgium and Switzerland. The UK, with its ambitious goals for the reduction of CO2 emissions, is heading in the opposite direction. In contrast, the emerging economies will stay on course, in particular Russia and China.

The shale gas revolution has provided access to new types fossil fuels. The US is leading the sector and within a couple of years has significantly reduced its former import dependency. Other countries are following suit; for instance Russia is prepared to heavily invest in this new technology. These markets will provide opportunities for EU manufacturers of gas power plants.

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[4] Jeremy Rifkin; Beyond Austerity A Sustainable Third Industrial Revolution Economic Growth Plan For the European Union (An Executive Summary of Jeremy Rifkin's Keynote Speech for the Mission Growth Summit: Europe at the Lead of the New Industrial Revolution, hosted by The European Commission, May 29th 2012). http://ec.europa.eu/enterprise/policies/innovation/files/mg-speech-rifkin_en.pdf

In the Middle East and North Africa (MENA) region, governments have become aware of the necessity to feed and employ their growing populations. They are about to develop processing industries for fossil resources and are expanding downstream activities. As a consequence, governments have become interested in energy efficient power generation and renewables to better exploit available resources. Wind power is particularly well-suited to the region, whereas solar power generation faces some challenges due to dust particles. (See: Chapter on MENA markets)

The demand for power generation in developed countries – in particular in the EU, which is leading in the efforts to reduce CO2 footprints – is driven by the refurbishment of existing plants and the replacement of outdated plants by new power generation technologies. The capital stock has to become more energy efficient and this will lead to an increase of the capital intensity of already available capacities. Moreover, new power generation technologies are by far more capital intensive than traditional large coal or gas fired plants per one gigawatt (GW) installed power. Additionally, capital costs are driven upward due to low capacity utilisation, in particular of wind and solar power generation[5]. Further factors, such as the uncontrollable supply of wind and solar power, require redundancies and storages, contributing to an additional rise of capital intensity. Power generation equipment manufacturers should benefit more than proportionately from the investment in a sustainable electricity supply by the construction of gas power plants, pumped storage power plants, and power-to-gas plants. However, much of this additional demand is strongly dependent on public co-funding. Complex and lengthy planning processes, as well as public resistance to decentralised power generation and investments in new high-voltage power lines, aggravate an energy turnaround.

Other products of this sub-sector, such as **transformers** that are applied in electricity grids, will also benefit from the need to distribute electricity over long distances, for instance to supply wind power to areas far from the sea.

An **electric motor** is a prime component of a machine or system. Frequently the motor comprises of a switch in combination with a switch overload contactor or a more sophisticated control and transmission system[6]. Industrial services, engineering and customised services have become important features; in particular, manufacturers in mature EU Member States have gained an ever-growing share of value added from this category. The most important indicator for the use of electric motors is the consumption of electricity by electric motorised applications. The OECD and IEA estimate that in terms of global electricity demand for all electric motors by sector, manufacturing is in the lead at 64 % in 2009, followed by Commercial (20 %), Residential (13 %), Transport (2 %) services, and Agriculture (1 %).[7]

The main client sector and important driver of new technological developments in the area of electric motors is expected to be the industry and its applications, such as machinery and moving of parts, driving chemical processes. Other applications are in transportation and logistics, moving goods and passengers on conveyors, escalators, etc. Servo-motors have gained importance during

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[5] Photovoltaic systems are among the products covered in this sub-sector. A detailed analysis of this market will be carried out in the chapter on semiconductors.

[6] For many applications gears, gear boxes etc. are designed for specific application and attached to electric motors. There is a strong linkage between electrical and mechanical engineering and numerous companies have emerged that combine both technologies in-house. See: H.-G. Vieweg et al.; Study on the Competitiveness of the EU Mechanical engineering, Munich 2011, pp. 68.

[7] OECD/IEA, Energy-efficiency policy opportunities for electric motor-driven systems, Energy Efficiency Series, International Energy Agency Working Paper. 2011, p. 37.

previous decades with growing automation of processes and efforts to ease the use for consumers, for instance, in automobiles. Electronic products are equipped with motors, such as hard discs, CD ROMs, etc. Demand for hard disc drives will be negatively affected by progress in data storage technologies.

Electric motors for electric mobility have not yet become significant in terms of quantity. According to the electric vehicle outlook of the IEA[8] about 40,000 plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (EV) were sold worldwide in 2011, the most in any year in history. According to the Electric Vehicles Initiative (EVI), the national EV and PHEV target sales announced by EVI member governments total about 6 million units by 2020, with assumed growth rates of 20 % per year. If achieved, this would almost reach 6 % of total vehicle sales by 2020, and result in 20 million units of EVs on the road in the same year.The EVI is an initiative launched by the Clean Energy Ministerial (CEM), a high-level global forum aiming to promote policies and programmes that advance clean energy technology. It brings together energy ministers and other high-level delegates from 23 of the world's leading economies to identify steps to promote the transition to a global clean energy economy. The first CEM was held in 2010 in Washington D.C. with three more yearly ministerial meetings in Abu Dhabi (UAE 2011), London (UK, 2012), and New Delhi (IN, 2013) since then.

Supply side

Generators fall into three categories: high-, medium- and low-voltage generators. Generators also have to be integrated into systems with a prime mover, a diesel engine, a steam turbine etc., and a control unit. Low-voltage generators are used as emergency and / or portable power units. There is some key expertise incorporated in the no-brake power supply equipment, which is necessary to switch from mains operation to emergency power. This market is highly regulated for safety reasons.

Medium-voltage generators are used in manufacturing companies and large office buildings to provide permanent or emergency power supply. Generators for aircraft and offshore installations must comply with specific technological requirements and safety provisions. High-voltage generators are used in small and medium-sized power plants. The production of generators with 100 megawatts or more requires extraordinary engineering knowledge and the ability to carry out turn-key projects.

An important area of application for power generators is wind turbines, which is also of particular importance with respect to European policies on energy and climate. Over the last decades, wind turbines have increased in size by a factor of 300 (from 25 kW to over 8,000 kW), while the cost of energy has significantly decreased with the growing size of turbines. Electrical generators are implemented primarily in horizontal-axis, for special applications in vertical-axis wind turbines. The wind energy industry has become an acknowledged part of the power generation industry.

The segment of **transformers** can be distinguished by the type of application. Small transformers (less than 1kVA) are used in electric and electronic appliances to transform electricity from the mains voltage to the voltage needed. Small transformers are also supplied as stand-alone aggregates, which in combination with rectifiers, are often used to charge batteries. Distribution and power transformers are used in the public infrastructure of energy distribution and in industrial production sites. Most of the larger electrical engineering firms have a stake in this business area.

[8] IEA, EV City Casebook – A Look at The Global Electric Vehicle Movement, International Energy Agency, p. 5.

Traditionally the players in the market for largest power plants are only a few companies. In the lead are Siemens (EU), GE (US) and ABB (CH-SE).The recently formed joint-venture of Mitsubishi and Hitachi, as well as Alstom (EU) are also important players. With Sinohydro (a partly state-owned company with a large stake in the global market) a Chinese player has accessed the market. In international bidding processes it has an edge over potential competitors due to preferential funding conditions. Chinese loans to recipient countries are supportive, paid back by the delivery of natural resources.

Alstom commands a strong position in the area of nuclear power stations. There is significant competition from Korean, Russian and US players. The Nuclear Power Corporation of India (NPCIL) has developed a new kind of nuclear reactor for the utilisation of Thorium, called Advance Heavy Water Reactor (AHWR) with 300 MW. The construction work of AHWR is slated to begin in the 12th Five Year Plan.[9] A US initiative driven by Bill Gates pursues another development towards small, automatically run nuclear power generation. However, this so-called Travelling Wave Reactor is inherently insecure, which is a major detriment.

The manufacturers of the largest power generation facilities are companies with turn-key abilities that – depending on their own production – subcontract to a large extent the delivery of core components to specialised suppliers. For the key components, such as large gas turbines and generators there are only few manufacturers globally, such as GE (US), Siemens (EU) and ABB (CH / EU).

For smaller power plants dedicated to regularly feeding the grid there are numerous players in the global market and a broad subcontracting industry for sophisticated and complex mechanical and electrical components. There are several suppliers from developed countries and a growing number of companies from emerging markets. The product programme for smaller power plants has been broadened with generators for different applications and decentralised smaller power plants for bio fuels, wind and wave power, and pumped storage power plants.

The market for non-stationary and back-up generators is characterised by serial production. Frequently generators are attached to internal combustion engines. There are numerous large players in the market, such as Mitsubishi (JP), Cummins (US) and MarelliGenerators (EU).

The production of **electric motors** for specific applications in plants – for example steel mills, paper machines etc. – is a challenging task. Moreover, electric motors based on specific technologies, such as servo units and linear induction motors, require key expertise. These products are mainly manufactured in the mature Member States. Direct-current (DC) motors have lost much of their former importance caused by progress in power electronics and have been substituted to a large extent by alternating current (AC) motors. Electric motors are further distinguished by different types of application, such as pumps, fans, compressors, rotating/stirring/mixing devices, and transport. Engine and machine are designed together to reach an optimal efficiency and manufactured as units.

Europe and Japan are the major centres of motor production in the OECD, with Japan producing more than 15 million electric motors per year.[10] Therefore, the fraction of motors sold with a variable-frequency drive (VFD) is increasing. The matching of motors with a VFD has the

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[9] NPCIL develops first nuclear reactor for thorium utilisation, 12 March 2011, http://www.dnaindia.com/india/1519117/report-npcil-develops-first-nuclear-reactor-for-thorium-utilisation

[10] OECD/IEA, Energy-efficiency policy opportunities for electric motor-driven systems, Energy Efficiency Series, International Energy Agency Working Paper. 2011, p. 27.

advantage of enabling greater efficiency when operating at partial loads. Japan is the global leader in production and use of inverters (VFDs and VSDs = variable-speed drive), and thus may use electromotive power more efficiently on average than other OECD nations. However, energy efficiency of new electro motors in the Japanese market is significantly lower than in the US and only slightly lower than in Europe. From a technological standpoint, this result is puzzling. However, the US has started earlier with tougher efficiency provisions than in Japan or the EU for electric motors to be sold in the domestic market.[11] Industry stakeholders stressed that these provisions were introduced in the US primarily to protect domestic manufacturers from technologically advanced foreign competitors.

The sub-sector has been consolidated over the past decades. The number of companies manufacturing electric motors, generators and transformers in the EU has declined. Powerful and competitive manufacturers have emerged, which operate in a wide range of electrical engineering activities. The most important players are the Swedish-Swiss ABB, which is active in the major electrical machinery segments, and the German Siemens. In the area of electric motors, companies such as the German ZF Friedrichshafen, Bosch Rexrodt, and the French Schneider Electric also play an important role.

Outsourcing is an important strategic option for the companies – particularly the manufacture of serial products for volume markets. Many companies procure castings, e.g. stators from subcontractors. Other parts, which have been outsourced, are rotors, shafts, and laminated yokes. In some companies the manufacturing penetration, in particular with electric motors, has become extremely low. In some high-tech and specialised products, the manufacturing penetration has remained high, e.g. brake motors with conic rotor, which are manufactured by the Germany based Demag, majority owned by the US Terex group since 2011. Other technologically important areas are linear motors, which are of major importance for factory automation and servo motors.[12]

Manufacturers of electric motors have frequently expanded their product range into the area of mechanical drives and gears, by acquiring or merging with firms from mechanical engineering. These complex drive units are optimally adjusted to each other for specific applications. They do not only meet clients' needs, but also contribute to a more efficient use of energy.[13]

Electric motors are key components for **locomotives and commuter trains** – a worldwide business with an enormous growth potential driven by urbanisation, industrialisation of emerging economies and long distance transportations. Large global players with a comprehensive system of supply are competing with each other, such as the European Siemens, Alstom and Bombardier. The latter is a Canadian company but has a large stake in EU-27 production. Japan has several manufacturers rolling stock, among them Hitachi, Kawasaki and Nippon Sharyo, with Hitachi already investing in a UK plant and expanding lobbying activities in EU capitals. The US supply side is quite fragmented with only few manufacturers of global relevance such as GE Transportation. Two large Chinese groups, Chinese North Railway (CNR) and Chinese South Railway (CSR), have emerged and greatly benefitted from massive domestic infrastructure investment. Slowdown of indigenous growth perspectives drives these companies to explore foreign markets.

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[11] OECD/IEA, Energy-efficiency policy opportunities for electric motor-driven systems, Energy Efficiency Series, International Energy Agency Working Paper. 2011, p. 27.

[12] For the manufacture of highly efficient electro motors with permanent magnets rare earth are needed. These minerals are materials of strategic importance, which are offered only be few companies. In recent years export restrictions imposed by China have highlighted the vulnerability of the EU industry.

[13] OECD/IEA, Energy-efficiency policy opportunities for electric motor-driven systems, Energy Efficiency Series, International Energy Agency Working Paper. 2011, p. 15.

The market for rolling stock is a good example – on the one hand – for downstream linkages of industries, here EE1 and the railway industry, and – on the other hand – for global competition and the necessity to tap non-EU markets. The vertical linkage defines a cluster where each player in the value chain contributes to competitiveness and needs to be taken into account in a successful industrial policy. The momentum in global competition requires EU companies to succeed in third countries because in the era of free trade there will no longer be a home turf advantage, not even in the market for rolling stock, and this poses some challenges on foreign companies.

Assessment of price performance

The economic development of the 27.11 sub-sector is close to the benchmark sector EE1. Electrical engineering experienced strong increases in nominal and real production during the upswing periods from 1998 to 2000 and 2005 to 2008, and lower growth during the aftermaths of the contraction periods during 2000 to 2005 and 2008 to 2012. Therefore, the growth performance of 27.11 was steadily above the entire EEI, at an annual average growth rate for nominal production of 5.1 % between 1998 and 2012. (**Table 2.7**) This overall picture is confirmed by the development of real value added, which increased at a rate of 5.2 % annually, whereas the benchmark sector only increased by 2.2 %.

Table 2.7: Key indicators "Manufacture of electric motors, generators etc."

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 – 05	2005 - 08	2008 - 12
Electrical engineering	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
C2711[1)]			51.4	14.3	3.1	11.1	-1.0
Electrical engineering	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
C2711[1)]			49.9	20.2	2.6	8.5	-2.0
Electrical engineering	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
C2711[1)]			17.7	15.8	1.1	9.4	2.4
Electrical engineering	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
C2711[1)]			261	3.5	-0.4	2.2	0.1
Electrical engineering	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
C2711[1)]			41.6	4.1	3.2	8.1	1.7
Electrical engineering	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
C2711[1)]			67.7	11.9	1.5	7.1	2.3
Electrical engineering	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
C2711[1)]			0.62	-7.0	1.7	0.9	-0.6
			Annual averages[4)]				
Electrical engineering	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
C2711[1)]			12.2	10.7	9.4	10.1	11.2

1) Manufacture of electric motors, generators and transformers; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Sub-sector 27.11 accounted for about 14 % of EE1's nominal production value in 2012 and thus represented a significant part of the entire sector. With 12 % of EE1's employment in 2012, the sub-sector also contributed significantly to employment in the entire benchmark sector. While EE1 only managed a moderate increase in jobs during 2005 and 2008 of 0.6 % p.a., which was more than compensated by a reduction of annually -1.2 % during 2008 and 2012 period, employment in the 27.11 sub-sector increased during the same period. Throughout the total period under investigation, the sub-sector 27.11 was able to expand employment by an annual average rate of 0.8 %, thanks to stronger growth of output, whereas for EE1 employment decreased slightly by 0.3 % p.a.

Price performance of the sub-sector measured by productivity, labour and unit labour costs provides a better picture for the developments in recent years compared to EE1. In particular, productivity gains in upswing phases 1998 - 2000 and 2005 - 2008 were extreme, while for the other phases under investigation they were close to the benchmark. Strong increases in labour costs compensated the efficiency gains. For all of the period under investigation ULC for the sub-sector and its benchmark evolved quite similarly. However, the 27.11's GOR, which is an indicator for profitability, started at a higher level than the benchmark and experienced a significantly better evolution in the long run compared to the benchmark.

Assessment of trade performance

In sub-sector 27.11, the dependency from third countries has been growing. During the early phase of the period under investigation around 29 % of production was exported. This share increased to 40.2 % for the most recent period of 2008 – 2012. The evolution of exports showed the same cyclicality as the EE1 sector. This also applies to the development of the imports. In terms of domestic demand, the sub-sector performed better than the benchmark. This demand was met by an increase in production from € 24.4 billion in 1998 to € 41.7 billion in 2012. The average annual growth rate of the sub-sector in production (5.1 %) was twice as high as its benchmark (2.47 %) in the period under investigation. However, the sub-sector lost some of its importance in the domestic market, as shown by the growth of the import quota. Nevertheless, the sub-sector 27.11 can be characterised as an internationally exposed sub-sector with an above average export quota of 44.6 % in 2012. (**Table 2.8**)

Compared to the benchmark, the sub-sector's **trade surplus has grown less dynamically, although it had nevertheless increased from around € 1.2 billion in 1998 to close to € 10 billion, roughly a third of EE1's total trade surplus**. The trade balances as a percentage of its trade volume reached around 27 % in 2012, whereas the benchmark reached only 14.5 %. The competitiveness of this sub-sector is reflected by the RCA, which experienced a very strong growth in the period under investigation. With a value of 0.25 it shows a very high comparative advantage or competitiveness that was gained by a less than proportionate growth of imports in comparison to domestic demand.

Table 2.8: Foreign trade indicators "Manufacture of electric motors, generators etc."

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	27.11		41.7	15.2	1.4	8.3	-1.5
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	27.11		22.9	13.2	3.9	20.0	3.3
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	27.11		13.3	16.6	-2.6	13.5	4.8
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	27.11		44.6	28.6	28.9	35.1	40.2
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	27.11		31.8	25.7	22.4	24.0	28.2
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	27.11		26.7	7.3	17.0	26.3	26.2
RCA[5)]	27.11	Index	0.25	0.11	0.20	0.26	0.29

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.1.2 Electrical distribution and control apparatus

Product programme

This sector comprises the following products according to NACE Revision 2, 27.12:

- Manufacture of power circuit breakers;
- Manufacture of surge suppressors (for distribution level voltage);
- Manufacture of control panels for electric power distribution;
- Manufacture of electrical relays;
- Manufacture of duct for electrical switchboard apparatus;
- Manufacture of electric fuses;
- Manufacture of power switching equipment;
- Manufacture of electric power switches (except pushbutton, snap, solenoid, tumbler);
- Manufacture of prime mover generator sets.

This sector excludes:

- Manufacture of environmental controls and industrial process control instruments (NACE Rev. 2 26.51);
- Manufacture of switches for electrical circuits, such as pushbutton and snap switches.

Demand side

Several areas will be taken as examples to show the factors that demand for products in the NACE 27.12 group depend on. In the case of power switching equipment for high-voltage electrical apparatus, which includes the individual stages of electricity production, transformation and transmission to consumers, demand mainly depends on the improvements in power distribution, which in turn depends on the growth of electricity consumption.

An important aspect that affects many of the products supplied by companies of this sub-sector concerns the infrastructure, and the integration of these products into comprehensive systems for the distribution of electricity. The investment in grids, their capacities and the control of power distribution is a crucial element by the implementation of policies dedicated to shift power generation from fossil fuels to renewables. In this context, advanced grid technologies, subsumed under the catchword ‘Smart Grid’, are discussed within this chapter.

According to the International Energy Agency (IEA), total IEA electricity consumption steadily increased over the last four decades, despite a short and moderate slowdown during the aftermath of the financial crisis.[14] Total electricity consumption in Europe more than doubled from 1340 to 3073 TWh[15] during the period from 1973 to 2010.[16] Thus, the industry sector decreased its share from 55 % to 37 %, while the residential and the commerce/public services sector increased their shares from 25 % and 15 % to 30 and 29 %, respectively.[17] Comparably for the same period, total electricity consumption in the world increased from 3724 to 9036 TWh, whereas the share of the industry sectors decreased from 49 % to 31 %. Again, it is the residential and the commerce/public services sector that substantially increased their share in electricity consumption with the latter showing the strongest increase from 20 % to 32 %. At the same time, the residential sector increased its share from 29 % to around 33 %.[18] It is remarkable that the industrial sector’s demand for electricity grew at a lower pace than that of private households, commerce, and public services. Global expansion of demand for electricity in both Europe (1973 to 2010: 1.8 %)[19] and the world (1973 to 2010: 1.7 %)[20] indicate that EU companies still encounter a level-playing field in domestic markets, as measured by electricity demand as an indicator for purchases of electrical products and electronics.

There are several factors that affect the demand for low-voltage electrical apparatus, such as the investment in power distribution, the manufacturing business cycle, and the development of construction volume. The focus of low-voltage electrical apparatus production is on switch-gears and control-gears, which are components for capital goods and automated systems. Other low-voltage installation equipment is in the area of building installations, where the demand mainly depends on the development of construction volume.

Demand for electricity distribution products – as is the case for products for electricity production and transformation – is determined in part by the public sector in countries where the electricity providers are partly in public ownership (e.g. provinces or municipalities). It is frequently these players that have to invest in public infrastructure, power distribution and lighting. These market segments are beneficial for companies with stakes in emerging economies. Strong investment needs and municipalities with sufficient funds offer opportunities for the acquisition of large projects and the sale of latest technology, whereas in the EU – even when taking into account public policies dedicated to the reduction of the CO2 footprint – the funding of projects is limited by financial resources.

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[14] IEA (2012), Figure 1, p. 215.
[15] TWh = Terawatt hour (1 TWh = 3.6 Petajoule)
[16] Europe includes EU IEA members: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.
[17] IEA (2012), Figure 5, p. IV.127.
[18] IEA (2012), Figure 5, p. IV.75.
[19] Electricity consumption per capita growth (measured in units of kWh/per capita), calculated as CAGR from Table 1, IV.128).
[20] Electricity consumption per capita growth (measured in units of kWh/per capita), calculated as CAGR from Table 1, IV.76).

Supply side

The majority of the products manufactured in this sector are produced in series and returns to scale are decisive for suppliers' success in many market segments. This is one explanation why large companies – such as the Swiss-Swedish group ABB, Siemens from Germany, the French Schneider Group and the US General Electric – are dominating players in the sector.

What characterises these global players is they do not only have stakes in markets as defined by NACE 27.12, but are also suppliers of generators, transformers, etc. which are subsumed under NACE 27.11 and are, to a certain degree, complementary to electrical distribution and control apparatus.[21] This is especially the case for equipment applied for switching, protecting and controlling electric circuits of high-voltage electrical apparatus. Moreover, many of the products in both sectors are delivered to the same clients, which are large utility companies.

In the area of low-voltage electrical equipment for switching, protecting and controlling electrical circuits, most clients are from the manufacturing industries or construction industry. In these market segments the supply side is more diverse. Important companies are the US Eaton Corporation, the German Siemens, and the French Schneider. Besides serial products, automated systems and customised solutions are of importance in the companies' product programmes.

The manufacturing process for the majority of the sector's products is marked by extensive industrial assemblage, though production in series prevails. In the area of volume production, the assembling process is highly automated. Insofar as manual work is required, i.e. in small-batch or even single-unit production, for instance, for large power circuit breakers, specific knowledge and qualified workers are necessary.

Assessment of price performance

In terms of nominal production and employment, the 27.12 sub-sector accounted for around 19 % and 17 % of EE1 in 2012, respectively. It is by far the largest sub-sector among all others within EE1, although it had lost some of its former weight over the period under observation.

The economic development of the 27.12 sub-sector followed a similar pattern to the broad benchmark sector EE1, which showed significant increases in nominal production as well as real value added during the periods of 1998 - 2000 and 2005 - 2008 and lower on average growth during 2000 - 2005 and 2008 - 2012. Throughout the period under consideration the sub-sector exhibits only moderate growth at annual average rates for nominal production and real value added of 1.3 % and 1.6 % respectively, whereas EE1 increased by 2.5 % and 2.2 % p.a. Similar to the benchmark, 27.12 showed a secular downward trend in the number of workplaces. Although it performed slightly better during 2008 to 2012 with growth of 0.2 % p.a., throughout the period under investigation it lost 0.5 % p.a., while the number of workplaces declined by only 0.3 % for EE1.

Regarding the price competitiveness of sub-sector 27.12, it becomes apparent that productivity increased at a slower pace with an annual rate of 2.1 %, than EE1's productivity at 2.5 %. Simultaneously, the sub-sector's labour cost increases were lower but the differences were not sufficient to prevent a loss in price competitiveness when compared with the benchmark sector. 27.12's ULC roughly stagnated for the period under investigation, for both EE1 and the 27.12 sub-sector, with respective growth figures 0.2 % and 0.1 %.

[21] Most of the large groups have stakes in other EE1 markets, in particular in power generation.

The sub-sector's profitability, indicated by the GOR, improved more than that of the EE1 over the period under investigation in spite of the less favourable development of ULC. In 2012, the GOR was slightly higher as compared to the benchmark sector.

It is important to note that the sub-sector shows a regional concentration within the EU. Most of the production sites are located in northern Member States. In 2012, more than 64 % of the sub-sector's employment was in Austria, Denmark, Finland, Germany, the Netherlands and Sweden. At the beginning of the period under investigation these countries' share of total sub-sector 27.12's employment was around 50 %. This regional concentration in the northern Member States is highest among all sub-sectors of EE1, and has been growing since the late 1990s. This particularity explains the remarkably higher wage and productivity levels for EE1.

Table 2.9: Key indicators "Manufacture of electricity distribution etc."

Sector	Indicator	2012		Annual average growth rate in % 1998 – 00	2000 - 05	2005 – 08	2008 – 12
Electrical engineering C2712[1)]	Production, in current prices	bn. €	370.4 70.1	8.3 2.9	1.1 0.4	5.9 3.9	-1.1 -0.1
Electrical engineering C2712[1)]	Production, in 2010 prices	bn. €	362.6 67.7	10.0 1.4	0.6 -0.5	4.9 2.8	-1.9 -1.5
Electrical engineering C2712[1)]	Value added, in 2010 prices	bn. €	130.7 28.0	10.2 7.4	-0.3 -3.2	2.6 2.5	1.0 4.2
Electrical engineering C2712[1)]	Employees	1,000	2210 381	2.4 3.2	-1.2 -2.1	0.6 -1.0	-1.2 0.2
Electrical engineering C2712[1)]	Labour costs per employee	1,000 €	43.4 56.4	3.5 1.9	2.1 1.8	2.5 2.0	3.0 2.7
Electrical engineering C2712[1)]	Productivity[2)]	1,000 €	59.2 73.5	7.7 4.1	0.9 -1.1	2.0 3.5	2.2 4.0
Electrical engineering C2712[1)]	Unit labour costs[3)]	€ / €	0.73 0.77	-3.9 -2.1	1.1 3.0	0.5 -1.5	0.8 -1.3
			Annual averages[4)]				
Electrical engineering C2712[1)]	GOR[5)]	%	8.9 9.2	9.0 5.1	8.3 3.4	8.5 4.2	8.6 8.1

1) Manufacture of electricity distribution and control apparatus; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

27.12 is the largest sub-sector of EE1 but it only increased by 1.3 % during the period under investigation due to muted growth of domestic demand and increased market penetration of non-EU producers. While domestic demand increased by 0.4 % p.a., imports increased at a strong rate of 6.6 %. At the beginning of the period under investigation foreign manufacturers' market penetration was one of the lowest of EE1's sub-sectors. This can be explained by the fact that the market was dominated by public demand or by demand of publicly-owned utilities. Historically, **there were high market access barriers for foreign companies. Since then markets have been liberalised and cross-border access was eased. Therefore, while the import quota of 11.4 % is low, third country competitors still gained significant market shares.** (**Table 2.10**)

In sub-sector 27.12 the dependency from third countries had been growing. Both the benchmark and the sub-sector showed an upward trend in terms of export quota, although for the sub-sector the increase was more pronounced. During the early phase of the period under investigation around 11 % of production was exported. This share increased to 14.3 % in 2000 – 2005 and further to 18.8 % in 2005 – 2008. In recent years more than one fifth (23.9 %) of production is delivered to third countries. The development of the exports is close to EE1. **The sub-sector's trade surplus nearly quadrupled over the period under investigation**. The trade balance, as a percentage of its trade volume, reached a remarkable 47.3 % and outperformed the benchmark (14.5 %).

Although import and export quotas of 27.12 have been rising steadily, they have remained below its benchmark. This sub-sector's international interdependencies are moderate. Private and public utilities are important clients for the sub-sector. These companies ask for specified products that comply with internal provisions. This hampers, to a certain extent, cross-border market access. The performance of this sub-sector is reflected by the RCA, which experienced a strong growth in the period under investigation. With a value of 0.74, it shows a very high comparative advantage.

Table 2.10: Foreign trade indicators "Manufacture of electricity distribution etc."

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 – 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	27.12		58.3	2.6	-0.6	2.7	-1.1
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	27.12		18.5	12.0	7.2	11.8	6.7
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	27.12		6.6	15.0	0.1	9.9	8.5
				Averages for the periods			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	27.12		26.4	10.7	14.3	18.8	23.9
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	27.12		11.4	5.4	6.2	7.4	9.7
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	27.12		47.3	35.4	43.6	48.4	49.0
RCA[5)]	27.12	Index	0.74	0.71	0.78	0.82	0.82

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.1.3 Instruments and appliances for measuring, testing and navigation

Product programme

This sector comprises of the following products according to NACE Revision 2, 26.51:

- Manufacture of aircraft engine instruments;
- Manufacture of automotive emissions testing equipment;
- Manufacture of meteorological instruments;
- Manufacture of physical properties testing and inspection equipment;
- Manufacture of polygraph machines;
- Manufacture of radiation detection and monitoring instruments;
- Manufacture of surveying instruments;
- Manufacture of thermometers liquid-in-glass and bimetal types (except medical);
- Manufacture of humidistats;

- Manufacture of hydronic limit controls;
- Manufacture of flame and burner control;
- Manufacture of spectrometers;
- Manufacture of pneumatic gauges;
- Manufacture of consumption meters (e.g., water, gas, electricity);
- Manufacture of flow meters and counting devices;
- Manufacture of tally counters;
- Manufacture of mine detectors, pulse (signal) generators; metal detectors;
- Manufacture of search, detection, navigation, aeronautical, and nautical equipment, including sonobuoys;
- Manufacture of radar equipment;
- Manufacture of GPS devices;
- Manufacture of environmental controls and automatic controls for appliances;
- Manufacture of measuring and recording equipment (e.g. flight recorders);
- Manufacture of motion detectors;
- Manufacture of radars;
- Manufacture of laboratory analytical instruments (e.g. blood analysis equipment);
- Manufacture of laboratory scales, balances, incubators, and miscellaneous laboratory apparatus for measuring and testing etc.

This sector excludes:

- Manufacture of telephone answering machines (NACE Rev. 2 26.30);
- Manufacture of irradiation equipment (NACE Rev. 2 26.60);
- Manufacture of optical positioning equipment (NACE Rev. 2 26.70);
- Manufacture of dictating machines (NACE Rev. 2 28.23);
- Manufacture of weighing devices (other than laboratory balances), levels, tapemeasures etc. (NACE Rev. 2 28.29);
- Manufacture of medical thermometers (NACE Rev. 2 32.50);
- Installation of industrial process control equipment (NACE Rev. 2 33.20);
- Manufacture of simple mechanical measuring tools (e.g. measuring tapes, callipers), see manufacturing class according to main material used.

Demand side

The 26.51 product programme comprises of a plethora of components in the field of measuring, testing, and navigation. The commonality between these products is the identification, measurement and analysis of physical, chemical or other technical variables and signal processing. While, historically, many of these components were part of standalone products with a display and some had to act according to changing values of an observed variable, today the components have become part of complex automated systems. Many of the former human-machine interfaces have been substituted by signal processing and transforming information into digits for automated activities. These products can be described as interfaces between material and data processing systems.

One of the common characteristics for most of these components is mixed-signal data processing. These products are, to a large and growing extent, based on the semiconductor technology. The CMOS transistor is the building block for logic devices and – in combination with storage components – represents the digital content of an Integrated Circuit (IC). Technological development of the products aggregated within this sub-sector reaches beyond the dimension of miniaturisation, coined as Moore's Law. It comprises of a second dimension; the diversification, driven by the processing of technical, physical and chemical variables. These additional functionalities might be merged on a microchip or a Printed Circuit Board (PCB), and result in small efficient components manufactured by companies within this sub-sector. In this second dimension, the combination of digital and non-digital technologies leads to hybrid technologies. They are labelled as More-Than-Moore (MTM).[22] Here once more, the linkages between EE1and EE3 have been intensified since the late 1980s and have become of crucial importance for EE1's ability to exploit all innovation opportunities and to contribute to technological progress in a broad range of downstream industries where Europe commands a strong position in international markets, such as transport equipment – among them airplanes, vessels and cars – machinery and equipment as well as plant engineering.

Supply side

Regarding the production side of NACE 26.51 goods, the technology of emissions testing equipment allows for testing the energy-efficiency of aircraft and automotive engines. As environmental regulations on more efficient usage of fossil fuels and the adoption of new energy sources are proceeding, technological developments need to keep pace with the new requirements of testing and measuring. Regulations will also have a significant impact on the production side. Consumptions meters are mainly manufactured to monitor fluid flows, such as water meters and gas meters. In addition to these applications, meters are also manufactured to monitor electricity consumption. With respect to the implementation of smart grids in particular, the technology and production development of meters will be highly complementary to high-tech grid components, power system automation, interfaces, and measurement devices. Large global players hold a strong position in these product segments.

GPS devices are usually included in handheld and automotive products. The biggest players in the field of GPS manufacturing are Garmin (US) and TomTom (NL), while there are other manufactures in the market such as Magellan (US) and Navigon GmbH (DE) – the latter has been acquired by Garmin.

Companies in the domain of laboratory instruments primarily engage in manufacturing of laboratory instruments and instrumentation systems for chemical and physical analysis of samples of different materials. Such analytic instruments are designed for monitoring and analysing samples of medical patients as well as for industrial process streams, whereas the need for increasingly efficient production processes impacts production development and technology. In this product segment there are numerous smaller enterprises specialising on specific market niches.

Assessment of price performance

In terms of nominal production the 26.51 sub-sector totalled € 61.5 billion in 2012 and accounted for 17 % of EE1 (**Table 2.7**). Its share in total EE1 employment was 15 %. Thus this sub-sector is second behind 27.12 with respect to its size.

The growth pattern of the sub-sector followed the cyclical development of EE1, with strong growth between 1998 – 2000 and 2005 – 2008. During the more recent period, 26.51 outperformed the benchmark showing a strong upward trend for nominal production of 2.3 %. For all of the years under investigation, real nominal production increased at an annual rate of 3.0 %, whereas total EE1 only increased at 2.5 %. In spite of the more favourable development of output, the employment record was negative. The number of workplaces decreased at 0.6 % per annum, nearly at the double-pace of the benchmark.

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[22] Wolfgang Arden, Michel Brillouet, Patrick Cogez, Bert Huizing Reinhard Mahnkopf, „More-than-Moore" – White Paper, pp. 7. http://www.itrs.net/papers.html

Sub-sector **26.51 has one of the highest wage costs among the EE1** sub-sectors. This is caused by an above average concentration of workplaces in the northern countries[23]. The regional concentration has grown throughout the period under investigation from 30 % of all of EU-27 employment in 1998 to around 50 % in 2012. This might have impacted the growth of labour costs that increased at 3.5 % p.a., significantly stronger than for total EE1. The growing cost burden has not been compensated by increased labour productivity at an annual rate of 2.6 %, compared with the benchmark sector's 2.2 %. ULC of sub-sector 26.51 increased throughout the period under consideration at a similar pace as for EE1. This relative stable economic performance – when compared with the benchmark – has been reached mainly because of more favourable growth between 2008 and 2012.

Table 2.11: Key indicators "Manufacture of instruments and appliances for measuring etc."

Sector	Indicator	2012		Annual average growth rate in % 1998 – 00	2000 - 05	2005 – 08	2008 - 12
Electrical engineering	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
C2651[1)]			61.5	9.2	0.8	3.9	2.3
Electrical engineering	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
C2651[1)]			60.5	8.2	-0.1	3.2	1.4
Electrical engineering	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
C2651[1)]			23.9	7.8	0.6	2.6	0.5
Electrical engineering	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
C2651[1)]			326	1.0	-1.0	-1.0	-0.4
Electrical engineering	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
C2651[1)]			55.1	4.7	2.8	3.2	3.8
Electrical engineering	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
C2651[1)]			73.4	6.7	1.7	3.6	1.0
Electrical engineering	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
C2651[1)]			0.75	-1.9	1.2	-0.4	2.9
			Annual averages[3)]				
Electrical engineering	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
C2651[1)]			10.1	10.6	11.2	12.2	10.5

1) Manufacture of instruments and appliances for measuring, testing and navigation; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

Sub-sector 26.51 enjoyed strong growth throughout the period under investigation. Only during 2000 to 2005 has some moderation has been observed. It enjoyed a strong recovery after the breakdown caused by the financial crisis. This growth was driven by non-EU markets. While the EU market only increased at an annual rate of 1.2 %, production had expanded at an annual rate of 3.1 %, above the 2.5 % of EE1. Sub-sector 26.51 is even more integrated in the global economy than its benchmark. The dependency from third countries has been growing. During the early phase of the period under investigation around 30 % of production was exported. During recent years even more than half of its output is delivered to third countries. Simultaneously, imports grew stronger than domestic demand as indicated by the import quota, which increased and ranges between 30 % and 45 %. Nevertheless, the sub-sector's trade surplus has grown stronger than for

[23] Austria, Denmark, Finland, Germany, Netherlands, Sweden.

EE1 as a whole. The trade balances as a percentage of its trade volume reached 26.5 % in 2012. This increase was even more pronounced than for its benchmark. (**Table 2.11**)

26.51 is one of those sub-sectors that are based upon technologies where the EU commands a leading role in international competition and is one of the drivers of innovation. The products are high-tech components for a wide variety of applications and are delivered into numerous downstream industries. A commonality of the majority of products lies in the combination of diverse technologies, in particular of analogous and digital signal processing, coined by the buzz word More-than-Moore. **The competitiveness of this sub-sector is underscored by the development of the RCA, which increased even stronger than the benchmark indicating that it had improved its position in international trade more than proportionately.**

Table 2.12: Trade indicators "Manufacture of instruments and appliances for measuring etc."

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 – 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	26.51		47.0	9.5	-1.4	3.7	-1.5
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	26.51		35.7	15.5	5.9	8.5	8.9
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	26.51		21.2	16.8	-0.4	9.7	2.5
				Averages for the periods			
				1998 - 00	2000 - 05	2005 – 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	26.51		58.0	29.3	35.8	44.2	52.4
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	26.51		45.0	28.6	30.9	37.9	41.3
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	26.51		25.5	1.6	10.9	12.9	21.9
RCA[5)]	26.51	Index	0.23	0.00	0.07	0.06	0.14

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.1.4 Accumulators and batteries

Product programme

This sector comprises the following products according to NACE Revision 2:

- Manufacture of primary cells and primary batteries (cells containing manganese dioxide, mercuric dioxide, silver oxide etc.);
- Manufacture of electric accumulators, including parts thereof: separators, containers, covers;
- Manufacture of lead acid batteries;
- Manufacture of NiCad batteries;
- Manufacture of NiMH batteries;
- Manufacture of lithium batteries;
- Manufacture of dry cell batteries;
- Manufacture of wet cell batteries.

Demand side

The battery and accumulator industry is characterised by a broad range of different electrochemical battery technologies, each with specific attributes. The market is dominated by the following three battery technologies: Lead-based batteries, Lithium-based batteries and Nickel-based batteries. Due to the large variety of possible applications, different technologies are developed in parallel as each battery type offers specific advantages and requirements.

To a large extent, the demand side of batteries and accumulators is strongly consumer driven and depends significantly on the market of consumer electronics. The widespread use of portable electronics, such as digital cameras, cell phones and laptop computers, has led to an enormous growth of the battery industry for more than the past two decades. It was driven by demand for battery powered electronic devices and a rapidly increasing production of electrical and electronic equipment. Batteries and accumulators have remained the mainstream source of power for applications ranging from portable electronic devices to electric vehicles.[24] The demand side for industrial applications comprises of various segments, including: backup energy storages, hand-held tools and medical devices, aerospace and defence, data collection, telecom and data communication.[25]

In 2009, primary batteries made up 24 % of the global market by value.[26] This market is dominated by alkaline batteries, as high energy density and longevity have made them the most popular primary battery with a share of 15 % of the total battery market, followed by carbon zinc and primary lithium batteries. The market for rechargeable batteries is dominated by Lithium-ion batteries, which make up about 37 % of the global market. Lithium-ion batteries (LiB) are leading in energy densities and are ubiquitous for mobile applications in consumer electronics. They have considerable potential for use in electric vehicles and have already achieved a significant penetration into hybrid and electric vehicle applications. LiBs state of technology is considered to provide much potential for further progress.

The lead-acid battery market is of similar size as Lithium-ion (32 % of the global battery market). Lead-acid batteries are generally characterised by longevity and cycle stability. They are widely applied due to their mature technology, availability and low costs. Above all, the application of lead-acid technology comprises of SLI batteries (starting, lighting and ignition) for vehicles, stationary batteries for power backup and deep-cycle batteries for wheeled mobility, such as scissor-lifts or wheelchairs.

Nickel-based batteries play a smaller role with an estimated share of only 5 % of the global market. Nickel metal hydride (NiMH) batteries have been commercially important in the area of consumer electronics and the industrial sector because of their eminent energy density, high power performance, design flexibility and environmentally compatibility. The main application of NiMH systems is considered to be for hybrid electric vehicles (HEVs). Nickel Cadmium (NiCd) batteries can be used for a wide range of applications in consumer goods and the industrial sector, especially under extreme environmental conditions. Due to the EU Directive 2006/66/EC, the use of highly poisonous heavy metal cadmium has been greatly restricted in the European Union to cases where suitable alternatives do not exist.

In recent years many advances have been made in battery technology. Continued improvement of specific electrochemical systems and the development of new battery chemistries have led to great

[24] Technologies such as fuel cells have not yet left the state of infancy.
[25] Frost & Sullivan (2013), European Lithium-ion Battery Market for Industrial Applications.
[26] http://batteryuniversity.com/learn/article/global_battery_markets.

progress. Research and development for secondary batteries is very much driven by the automotive industry. As a key technology of electro-mobility, the development and production of high capacity batteries is an issue of major strategic importance. Considering the different technologies, lithium-based batteries are regarded to offer the greatest potential. [27] Although, there are still strong R&D efforts to further improve technologies for batteries and accumulators, no breakthrough progress has been made to overcome the drawbacks of batteries for electromobility. As a result of overcapacities and poorly developing demand from the automotive industry, the manufacturer of large format LiB are facing great pricing pressure. Consolidation has already started.[28]

Furthermore, high capacity batteries in stationary energy storage solutions offer prospects for an immense market growth. They will be a fundamental part of the total storage solution of renewable energy in the years to come.[29] Renewable energy sources, such as solar and wind-generated power, produce electricity intermittently and require stationary energy storage systems, as they increase the availability and the value of those resources. Stationary electrical energy storage is widely regarded to change the way electricity is generated and used.[30] Applications for stationary storage batteries can be categorized in two groups: energy applications, like peak shaving or load levelling, and power applications, like frequency and voltage regulation. There are already many examples of large-scale stationary batteries in the field. The most widespread stationary battery used today is based on lead-based technology.[31]

Supply side

The battery industry is dominated by a few large global players. Leaders are Samsung SDI and LG Chem (both KR), Sanyo Panasonic and Sony (JP), Johnson Controls and Duracell (US) and BYD (CN). Of major importance for sub-sector 27.20 are serial manufacturing and a high volume output. Overcapacities, homogenous products and the pursuit of market share strategies have induced a tough price competition among manufacturers of batteries and accumulators. For the last three decades, mergers and acquisitions have been high on the agenda dedicated to increase market shares.

Asia commands a strong position in the consumer electronic industry to the benefit of battery manufacturers that have expanded their share in the global battery market. Japanese companies have historically been leaders in the world's LiB production. The most important Japanese manufacturers of LiBs are Sony and Sanyo Panasonic. Sony was the company which first commercialised LiBs about 20 years ago. Sanyo, which was acquired by Panasonic in 2011, produces NiMH batteries and LiBs for hybrid and plug-in-hybrid vehicles and supplies them to Honda, Ford, and SUZUKI. The merger gives the group a market share in nickel hydride batteries of around 80 %.[32]

In the last decade Japanese companies, which controlled 94 % of the global secondary battery market in 2000, have gradually lost their leading position.[33] In 2008, Japan still accounted for more than half of the global LiB market, while Korea already had gained a market share of 21 %.[34] Korea

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[27] Fraunhofer Institut (2012).
[28] Roland Berger. 2012. Global Vehicle LiB Market Study Update.
[29] Fraunhofer Institut (2012). Technologie-Roadmap Energiespeicher für die Elektromobilität 2030.
[30] The Electrochemical Society. Interface. Battery for Large-Scale Stationary Electrical Energy Storage. 2010.
[31] Batteries used for stationary use and grid storage.
http://batteryuniversity.com/learn/article/batteries_for_stationary_grid_storage
[32] http://www.marketwatch.com/story/panasonic-reportedly-to-reduce-stake-in-toyota-hybrid-battery-jv-2009-10-28
[33] http://www.koreaittimes.com/story/21199/korean-secondary-battery-leaping-10-years-overtaking-japan
[34] Korea IT Times. 2011 8th September. Korea tops global lithium-ion battery market in 2nd quarter.
http://www.koreaittimes.com/story/16803/korea-tops-global-lithium-ion-battery-market-2nd-quarter

quickly overtook Japan as the largest rechargeable batteries supplier, attaining about 40 % of the global LiB market in 2011. In 2010 Samsung SDI became the global leader of small sized LiBs. In 2012 the company shipped 1.07 billion cells, an amount that equals a global market share of 26 %.[35]

While Panasonic was able to hold its No. 2 position with an 18.7 % market share, the third largest manufacturer LG Chem (17.5 %, KR) is expected to surpass Panasonic in the next years.[36] LG Chem from Korea is one of the largest chemical companies in the world and supplies electric car batteries to General Motors. The company quickly became one of the largest suppliers of LiB for advanced vehicles. China, the most populous and rapidly growing country, has become an important manufacturer, consumer and supplier of LiBs. **About 50 % of battery cells for consumer products are produced in China, as companies, in particular Japanese, have shifted their production to China.**[37]

Duracell is a strong global player from the USA, as well as Johnson Controls (JC). JC is the leading global manufacturers of automotive batteries and supplier of SLI-batteries in the European market. The company expanded its market share by the acquisition of several strong brands over the years, including the automotive battery businesses of Hoppecke (2001, DE), Varta (2002, DE), Delphi (2005, US) and A123 (2012, US). JC commands a share of one third of the global automotive battery market. In 2006 JC and Saft (FR), which is a provider of advanced energy storage solutions with LiB expertise, founded a joint venture to develop and produce lithium-ion automotive batteries.

Assessment of competitiveness

Due to the immense public efforts for the development of electric vehicles and measures for the dissemination of this technology, the European automotive industry needs to make much progress in the development of the key-technology of storage batteries to keep up with international competition. Worldwide, only a few countries have the basis and the potential to build a lead market for batteries applied for electro mobility. **Measured by different key figures, like the shares of patent applications, scientific publications and market shares of production of LiB, Japan, South Korea, the USA and within Europe, Germany and France, provide the best framework conditions**.[38]

Japan commands the leading position in the global automotive LiB market.[39] According to a forecast by Roland Berger, the global automotive LiB market is expected to grow to about € 7.5 billion ($ 9.8 billion) by 2015. [40] About 70 % of the market will be dominated by five players: AESC (20 %; JP), followed by LG Chem (15 %, KR), Panasonic Sanyo (13 % JP), A123[41] (11 %; USA) and SB LiMotive (9 %; DE / KR). AESC (Automotive Energy Supply Corporation) is a joint venture between Renault-Nissan Motors and NEC Energy Devices.[42] SB LiMotive was a joint venture between Bosch, a globally leading supplier to the automotive industry, and Samsung SDI, the leading manufacturer of small sized LiBs, set up in 2008. It was dedicated to the development and manufacture of high-performance energy storage cells in Germany and to set-up manufacturing

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[35] Korea IT Times. 14.3.2013. Primary source: Japan´s secondary battery research institute.

[36] Korea IT Times, 14th March 2013. Samsung SDI has Ranked First in Secondary Battery Market for Three Straight Years. http://www.koreaittimes.com/story/27242/samsung-sdi-has-ranked-first-secondary-battery-market-three-straight-years

[37] Bericht der AG-2 Batterietechnologie für den Zwischenbericht der Nationalen Plattform Elektromobilität. 2010.

[38] Fraunhofer Institut (2012).

[39] Nationale Plattform Elektromobilität. 2012. Fortschrittsbericht der Nationalen Plattform Elektromobilität (Dritter Bericht).

[40] Roland Berger, Global Vehicle LiB, Market Study Update; Detroit/Munich, April 2012. ttp://www.rolandberger.at/media/pdf/Roland_Berger_Studie_Li-Ion_Batteries_20120417.pdf

[41] Acquired by Johnson Controls in 2012.

[42] Ifo Schnelldienst (11/2010). Batteriespitzentechnologie für automobile Anwendungen und ihr Wertschöpfungspotenzial für Europa. Ferdinand Dudenhöffer, CAR-Center Automotive Research.

facilities in Europe. In 2012, the JV was dissolved because both partners wanted to have more leeway in the development of this business area. An important component of the Bosch strategy is to establish manufacturing facilities in Europe and to set up a European specialist network to stay on the leading edge in this technology that is not only promising for electromobility but also for stationary power storages.[43] Bosch took over the subsidiary SB Limotive Germany and wants to further exploit and expand the commonly developed LiB technology. At the same time, the subsidiary Cobasys, which is important for the US market and was acquired by SB LiMotive in 2009, will be integrated into Bosch.

Even though the battery technology for electromobility has made progress over the last decade, there is more needed for a breakthrough in the market. Therefore, strategic alliances are forged with companies along the supply chain to develop efficient and competitive energy storage technologies. Several car manufacturers co-operate with companies of the battery industry, such as Tesla and Panasonic, both founded the joint venture Primearth EV Energy (Panasonic EV Energy) in 1996, Daimler and Evonik founded LiTec in 2006, and Nissan and NEC founded AESC in 2007.

There are several European chemical companies operating in the production of innovative materials and the production of cathode active material for new lithium-ion battery applications, including BASF, Evonik and Merck. Merck and Evonik are specialised in research and manufacturing of electrolytes for Lithium-ion cells, Evonik has also acquired high levels of expertise regarding the separator and the anode technologies and manufacturing techniques. **Evonik is the only European company that covers the whole supply chain of battery manufacturing** (except mining of raw materials).[44] As noted above, in 2006 Evonik and Daimler (DE) founded the joint venture Li-Tec to manufacture high performance batteries for serial production.[45] By the end of 2011, Germany´s Süd-Chemie and Korean LG Chem signed a memorandum of understanding to establish a joint venture for high-volume production of innovative cathode material used in lithium-ion batteries.[46]

While the primary battery market as well as the small-sized secondary battery market are both strongly dominated by Asian suppliers, Europe provides good framework conditions to gain relevant market shares in the dynamically growing segment of high performance energy storage systems as it has a traditionally strong background in the automotive industry as well as in the chemical industry. Chemical companies play a key role in the development of the battery industry. Advances in chemicals are critical to improving the safety, power and energy density of batteries and accumulators.[47]

European R&D activities have become more focused on Lithium based technologies to catch up the Asian lead. Looking at various technologies, LiBs are considered to offer the best prospects for now. However, some researchers are sceptical about claims that the energy density of LiBs can be increased greatly in the next years. In its current state, the only battery technology with an energy density that comes close to petrol is the lithium air cell. In Europe, much research is done to develop batteries of the more promising next (IV.) generation, such as lithium air or lithium sulphur.[48] Also, flow batteries, like Redox-Flow batteries, are becoming more important, and are

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[43] Green Car Congress. Bosch and Samsung SDI disbanding the SB LiMotive Li-ion joint venture. http://www.greencarcongress.com/2012/09/bosch-20120905.html

[44] Produktion Nr. 40, 2012. Elektromobilität: Wer bricht die asiatische Markt Macht? http://www.produktion.de/clean-tech/energiespeicherung/elektromobilitat-wer-bricht-die-asiatische-batterie-macht/

[45] Manager magazin. Fertigung von Hochenergiebatterien. Deutschlands dorniger Weg aus der Akku-Misere. 18.08.2011 http://www.manager-magazin.de/unternehmen/autoindustrie/0,2828,780812-4,00.html

[46] Korea IT Times. 22.05.2013. Korean Secondary Battery Leaping 10 Years, overtaking Japan.

[47] AT Kearney (2012). European Chemistry Industry 2013.

[48] Fraunhofer 2012. Technologie-Roadmap2030….

already used as stationary energy storage. There are several research institutes – for instance Fraunhofer ISE or ZSW (both DE) – and networks between science and companies to promote R&D and build up a strong and innovative battery industry in Europe. Technological leadership is of significant importance for the global competitiveness of the European battery industry.[49]

Assessment of price performance

In terms of nominal production, sub-sector 27.20 came up to € 7.2 billion in 2012. It is by far the smallest of EE1 and contributes only around 2 % (Fehler! Verweisquelle konnte nicht gefunden werden.). As measured by real value added and employment, its share of EE1 is even smaller, at around 1.5 %. The growth pattern of the sub-sector followed the cyclical development of EE1, going up between 1998 – 2002 and 2005 – 2008. The strong growth in nominal terms during the second timespan was caused by price increases for raw materials. This effect was at least partly passed on to sales prices. This cost driven development was the only period when the sub-sector's growth exceeded its benchmark.

The sub-sector's performance was muted. Production stagnated during the period of 2000 to 2005. The recovery after the slump in 2009 caused by the financial crisis was moderate and the 2008 peak was not reached until 2012. The average growth rate throughout the period under consideration between 1998 and 2012 was only 2.1 % p.a., well below the trend of EE1 with an annual rate of 2.5 %.

When measured in constant prices, sub-sector 27.20 did not grow at all. In 2012, real production was at the same level as 1998, while value added even declined, caused by a reduction of manufacturing depth – as measured by the quota of value added and gross output – from 30 % at the beginning of the assessment period down to around 20 %.

This poor development had been accompanied by a significant loss of employment. Around one third of workplaces – which corresponds to 15,000 of the 45,000 work places in 1998 – were slashed. Labour productivity did not improve much over the period under investigation. It only grew at an annual rate of 0.3 %, not sufficient to compensate for wage increases. Although wages increased at 2.0 % p.a., below the EE1's evolution, the ULC worsened significantly.

In line of the difficult business environment, profitability – as measured by the GOR – was below the EE1's average and has been declining since the financial crisis. This might have been caused by the muted recovery during the aftermath of the financial crisis.

[49] Ifo SD (2010).

Table 2.13: Key indicators "Manufacture of batteries and accumulators"

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electrical engineering	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
C2720[1)]			7.2	2.7	0.0	9.7	-1.1
Electrical engineering	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
C2720[1)]			6.9	3.7	-0.5	0.4	-1.1
Electrical engineering	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
C2720[1)]			1.7	3.6	-2.9	-7.8	-0.1
Electrical engineering	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
C2720[1)]			31	9.0	-6.4	-5.4	-1.0
Electrical engineering	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
C2720[1)]			41.7	-1.9	2.1	5.1	1.6
Electrical engineering	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
C2720[1)]			55.4	-5.0	3.8	-2.5	0.8
Electrical engineering	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
C2720[1)]			0.75	3.3	-1.6	7.9	0.7
			Annual averages[4)]				
Electrical engineering	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
C2720[1)]			5.8	7.3	7.5	6.6	5.7

1) Manufacture of batteries and accumulators; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

The most significant feature of this sub-sector is the trade deficit, **the only sub-sector of EE1 with a permanent deficit**: The imports of € 3.5 billion exceeded exports of € 2.2 billion in 2012. The outcome is a trade deficit of € 1.3 billion. The underlying explanation lays in imports of batteries and accumulators for consumer electronics, in particular LiBs. The growth pattern of the sub-sector followed the cyclicality of EE1 in terms of exports and imports, going up between 1998 – 2000 and 2005 – 2008. Although exports and imports had increased over the period under investigation, growth was less dynamic than for the benchmark. Imports increased at an annual rate of 4.0 %, well above domestic demand. Foreign suppliers gained market shares indicated by an import quota that increased from around 35 % during the early years of the period to more than 40 % during the latter years. (Table 2.14) Domestic sales of EU-27 manufacturers expanded by only 1.4 % p.a.

Poor domestic sales were compensated – to a certain extent – by strongly growing foreign demand. Exports expanded at an annual rate of 6.5 %. The sub-sector's exposure to the international division of labour had grown over the period under investigation as indicated by the export and the import quotas.

The trade deficit turned out to be stable at around € 1 billion. The international trade performance of 27.20 is reflected by the RCA: As expected, the index is steadily between -0.75 and -0.84.

Table 2.14: Trade indicators "Manufacture of batteries and accumulators"

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	27.2		8.5	6.1	-1.5	9.7	-1.4
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	27.2		2.2	15.0	-0.2	9.7	8.5
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	27.2		3.5	18.5	-4.0	9.7	3.5
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	27.2		31.1	19.1	22.2	22.0	27.6
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	27.2		41.5	34.4	34.7	34.4	38.6
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	27.2		-22.3	-37.9	-30.0	-30.2	-24.4
RCA[5)]	27.2	Index	-0.75	-0.83	-0.76	-0.84	-0.79

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.1.5 Insulated wires and cables

Product programme

This sector comprises of the following products according to NACE Revision 2:

- Manufacture of fibre optic cable for data transmission or live transmission of images (NACE Rev. 2 27.31);
- Manufacture of insulated wire and cable, made of steel, copper, aluminium (NACE Rev. 2 27.32).

This sector excludes:

- Manufacture of glass fibres or strand (NACE Rev. 2 23.14);
- Manufacture of optical cable sets or assemblies with connectors or other attachments, see depending on application (e.g. NACE Rev. 2 26.11);
- Manufacture (drawing) of wire (NACE Rev. 2 24.34, 24.41, 24.42, 24.43, 24.44, 24.45);
- Manufacture of computer cables, printer cables, USB cables and similar cable sets or assemblies (NACE Rev. 2 26.11);
- Manufacture of electrical cord sets with insulated wire and connectors (NACE Rev. 2 27.90);
- Manufacture of cable sets, wiring harnesses and similar cable sets or assemblies for automotive applications (NACE Rev. 2 29.31).

Demand side

In a publication by the Global Industry Analyst, Inc. (GIA), San Jose, CA, USA, it is confirmed that the global recession harmed the insulated wire and cable market in 2008 and 2009. The global cable market accounted an average growth of 5.3% during the period of 2003-2007. In 2008, it accounted a growth of just 1.2%. In 2009, the global market fell sharply by 7.7%.[50] The slowdown in the construction sector, especially in developed markets such as North America and Europe, and the drop in the worldwide automotive industry, hit the cable revenues considerably. In addition, the low demand for wire and cable products in other end-use sectors such as telecommunications and electronic equipment deterred market growth.

Nowadays the worldwide value of the cable market is estimated to amount € 100 billion (750 billion DKK) - each year. Among the market leaders are global players such as Nexans with an estimated market share of 8 %, Prysmian with approximately 6 % and General Cable with about 5 %. The most important high-voltage and submarine cable producers are: NKT Cables (DK), Nexans (FR), Prysmian (IT), ABB (SE), General Cable (USA) and LS (KR), accompanied by numerous regional competitors in Asia and Middle East.[51]

Another interesting point is the fact that large US and European cablemakers (General Cable, CommScope, Encore, Nexans, Prysmian and Draka) outperformed those from North East Asia (Sumitomo Electric, Furukawa, Hitachi Cable, Fujikura, Taihan and Pacific Electric) between 2007 and 2009. Their operating margins were markedly higher. CRU points out that the higher profitability in Western Europe and North America than in North East Asia can be attributed to manufacturers in Western Europe and North America focusing on specific market segments, whereas those in North-East Asia try to compete in almost all segments. There has been little industry consolidation, and thus, most of the manufacturers have a wide product range. This provides a big opportunity for Western European and North American companies to succeed in developing countries.[52]

According to the annual report of the Danish cable producer NKT, both the international and European industry are highly fragmented, which is reflected by the fact that no enterprise holds more than 10 % of the market share.[53]

In 2005 the more important economies contributed to global production: EU-27 (30.0 %), USA (14.5 %), Japan (12.0 %) and China (43.5 %). The consumption shares did not differ greatly: EU-27 (29.4 %), USA (16.8 %), Japan (12.3 %) and China (41.5 %).[54]

In the last decade, China has continued to grow whereas there was a big slump in the developed world concerning the metallic cable consumption volume. Furthermore, China accounted for over a third of global metallic cable output in 2009 and outperformed the two other large producing nations, US and Japan.[55]

Another important country, India, has edged higher in 2009: The Indian metallic cable market increased by 2.7 % and could become the fastest growing major market. Experts claim that India could become China's most important competitor and could even overtake China in a few years.

[50] Cru Analysis: Global Cable Market Review, (2010), http://arabcab.org/Arabcab_Presentation_CRU.pdf.

[51] Energiesektor belebt Kabelmarkt, (2012), in: Produktion – Technik und Wirtschaft für die deutsche Industrie, Nr. 12, http://www.nexans.de/Germany/2012/produktio_%20Maerz2012.pdf.

[52] Cru Analysis: Global Cable Market Review, (2010), http://arabcab.org/Arabcab_Presentation_CRU.pdf.

[53] Energiesektor belebt Kabelmarkt, (2012), in: Produktion – Technik und Wirtschaft für die deutsche Industrie, Nr. 12, http://www.nexans.de/Germany/2012/produktio_%20Maerz2012.pdf.

[54] http://ec.europa.eu/enterprise/sectors/electrical/files/electrareport_annex1_en.pdf.

[55] Cru Analysis: Global Cable Market Review, (2010), http://arabcab.org/Arabcab_Presentation_CRU.pdf.

In contrast, Russia had to face a collapse in its metallic cable production by 34.3 % in 2009 down to 254,000 ton conductors.[56]

The production in North America continued to fall in 2009 as well: Metallic cable by 22.4 % and fibre optic cable by 16.5 %.

In 2012, European (EU and other European countries) demand for cables declined due to crisis stricken countries, such as Spain, UK and Greece. Germany accounted for a growth rate in wire and cable production of 6.8 % in 2012, whereas Italy (-9.8 %) and Spain (-18.0 %) noted negative rates. The breakdown of Greece's output by -57.4 % was dramatic. On average, the EU-27 experienced a moderate decrease of -0.9 % (quantity in tons).[57]

The importance of Asia within the **global metallic cable industry** grew during the last crisis.[58] Asia-Pacific is today not only the largest but also the fastest growing regional market for insulated wire and cable worldwide.[59] In contrast, the western world is not expected to regain previous peaks in the total metallic cable production. Since the cable industry is growing in developing countries, these manufacturers will look to become more international players as their home markets mature. This will increase the competitive pressure, especially for those European manufacturers who are concentrated on specific product sectors.

In order to form a powerful communication network, **optical fibre cables** are indispensable. As optical fibres provide a high bandwidth the demand is continuously rising, especially driven by innovations like cloud computing and Internet Protocol Television (IP-TV).[60] Consequently, the fibre optic cable market is growing steadily. In the second half of 2011, it accounted a growth rate of more than 20 %.[61] Quite often, copper cables are used, particularly in Germany. But copper cables do not satisfy the rising demand for high transmission rates. They will almost certainly be replaced with optical fibres. However, this development will not be an easy transition. The main problem with the dissemination of optical fibre cable networks is that the investment costs are remarkably high. It is taken for granted that several operators are required in order to establish this complex infrastructure. Thus, the cooperation between local / regional actors will become more and more important.[62] In spite of the recession, the fibre optic cable market continued to grow in 2009. After the market collapse in 2002, it exhibited a strong growth, especially after 2005.

Furthermore, increased raw material price volatility is forecast for both the global metallic cable industry and the optical fibre cables, and therefore cable companies should be aware of how they could tackle this problem in advance.

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[56] Cru Analysis: Global Cable Market Review, (2010), http://arabcab.org/Arabcab_Presentation_CRU.pdf.
[57] Integer Research: European Cable 2012 General Assembly: Is there room for growth in Europe, (2012), https://www.integer-research.com/wp-content/uploads/downloads/2012/06/Europacable-Integer-presentation-June-2012.pdf.
[58] Cru Analysis: Global Cable Market Review, (2010), http://arabcab.org/Arabcab_Presentation_CRU.pdf.
[59] Overview, Volume 13, Issue 14 (2010), http://www.wiretech.com/pdfs/OVERVIEW%2013.14.pdf.
[60] Zentralverband Elektroindustrie – Jahresbericht 2011, S.26f, http://www.zvei.org/Verband/Publikationen/Seiten/Jahresbericht-2011-des-Fachverbands-Kabel-und-isolierte-Draehte.aspx.
[61] Integer Research: European Cable 2012 General Assembly: Is there room for growth in Europe, (2012), https://www.integer-research.com/wp-content/uploads/downloads/2012/06/Europacable-Integer-presentation-June-2012.pdf.
[62] Zentralverband Elektroindustrie – Jahresbericht 2011, S.26f, http://www.zvei.org/Verband/Publikationen/Seiten/Jahresbericht-2011-des-Fachverbands-Kabel-und-isolierte-Draehte.aspx.

Globalisation amongst customers is also increasing. This is expected to result in a more coordinated procurement by large international companies, which will be looking to take advantage of their purchasing power.

Experts assert that the metallic cable market in Europe and North America will still not regain pre-crisis levels even by 2013. The fibre optic cable market is forecast to remain relatively stable in 2013.[63]

To conclude, the growth and forecast assumptions can be summed up in the following way: The cable demand in Europe is expected to continue to shrink in Greece, Ireland, Spain and the UK. Germany will keep exceeding all expectations. The East European (non-EU countries) countries have been recovering and are likely to grow throughout 2013.[64]

Nevertheless, GIA claims that the isolated wire and cable market will face economic demand in the medium- to long-term. In the 21st century, modernising communication systems, extending networks and integrating renewable energy (wind solar and water power) to the power grid are becoming more and more important as drivers for positive economic conditions for cable producers. Information processing and communications, two of the largest markets, are also expected to drive growth. Applications such as base stations transmission units and antenna towers are expected to drive demand for wire and cable.[65]

In the medium- and long-term, emerging economies are expected to continue be the region with highest growth potential. Although a steady rise will take place, replacement and upgrading will be predominant.

According to a publication of GIA in 2010, the global market for insulated wire and cable was predicted to exceed € 88 billion by 2015. Current data shows that this forecast has already been overrun. The resurgence of the global construction activities and the robust expansion of the energy sector are two of the factors which impact the market in a major way. Further, the rise of smart grid technology in developed economies and increased investments in high-speed rail networks are poised to drive market growth in the next few years.[66]

Assessment of price performance

The two sections, 27.31 (fibre optic cables) and 27.32 (Electronic and electric wires and cables) of sub-sector “Insulated wire and cable”, do not have strong economic weight within EE1: In terms of nominal production and employment, 27.31 accounted for only 0.8 % and 0.5 %, respectively, whereas the respective shares of the 27.32 section were at 6.3 % and 4.5 % in 2012. (**Table 2.15**, **Table 2.16**)

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[63] Cru Analysis: Global Cable Market Review, (2010), http://arabcab.org/Arabcab_Presentation_CRU.pdf.

[64] Integer Research: European Cable 2012 General Assembly: Is there room for growth in Europe, (2012), https://www.integer-research.com/wp-content/uploads/downloads/2012/06/Europacable-Integer-presentation-June-2012.pdf.

[65] Overview, Volume 13, Issue 14 (2010), http://www.wiretech.com/pdfs/OVERVIEW%2013.14.pdf.

[66] Overview, Volume 13, Issue 14, (2010), http://www.wiretech.com/pdfs/OVERVIEW%2013.14.pdf.

Table 2.15: Key indicators "Manufacture of fibre optic cables"

Sector	Indicator	2012		Annual average growth rate in % 1998 – 00	2000 – 05	2005 - 08	2008 - 12
Electrical engineering C2731[1)]	Production, in current prices	bn. €	370.4 3.0	8.3 7.1	1.1 -1.8	5.9 5.2	-1.1 5.4
Electrical engineering C2731[1)]	Production, in 2010 prices	bn. €	362.6 3.1	10.0 7.1	0.6 -0.9	4.9 8.2	-1.9 5.6
Electrical engineering C2731[1)]	Value added, in 2010 prices	bn. €	130.7 0.7	10.2 8.9	-0.3 -2.0	2.6 13.9	1.0 2.1
Electrical engineering EE11	Employees	1,000	2210 10	2.4 2.2	-1.2 -4.1	0.6 0.7	-1.2 0.3
Electrical engineering C2731[1)]	Labour costs per employee	1,000 €	43.4 48.9	3.5 5.5	2.1 2.4	2.5 13.3	3.0 -0.3
Electrical engineering C2731[1)]	Productivity[2)]	1,000 €	59.2 73.8	7.7 6.6	0.9 2.1	2.0 13.1	2.2 1.8
Electrical engineering C2731[1)]	Unit labour costs[3)]	€ / €	0.73 0.66	-3.9 -1.0	1.1 0.3	0.5 0.1	0.8 -2.1
			Annual averages[4)]				
Electrical engineering C2731[1)]	GOR[5)]	%	8.9 7.5	9.0 9.1	8.3 7.6	8.5 8.0	8.6 7.3
1) Manufacture of fibre optic cables; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).							

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Both sections have shown a similar growth pattern to the broad EE1 (benchmark) with strong increases in production, especially during the periods of 1998 - 2000 and 2005 - 2008, but also a strong decline in the number of employees, particularly during the periods of 2000 - 2005 and 2008 - 2012. Both sections performed poorly in job development. However, in terms of nominal production they exhibit a more dynamic evolution than the benchmark. The annual average growth rate of 12.2 % of 27.32 in nominal production during 2005 – 2008 is remarkably high, driven not only by volume but by copper price increases caused by the scarcity of raw materials as a consequence of soaring global demand. In contrast, the fibre optic cable sector exhibited a price decline at the same time, a comparably new but maturing market. Growing supply and scale effects have allowed for price reductions.

Labour productivity of 27.31 is above the benchmark. Likewise, labour costs per employee are higher, which is explained by the concentration of production capacities in northern EU countries. Labour productivity of section 27.31 increased faster than its benchmark. The ULC of 27.31 fell by -0.6 % p.a. throughout the period under investigation and exhibited a much better development than the benchmark, as did the section "Electronic and electric wires and cables". In the recent past, the GOR remained constant, but slightly below the level of EE1.

Table 2.16: Key indicators "Manufacture of other electronic and electric wires and cables"

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 – 05	2005 - 08	2008 - 12
Electrical engineering C2732[1)]	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
			23.5	5.7	0.5	12.2	-2.5
Electrical engineering C2732[1)]	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
			21.9	11.5	-0.9	4.4	-4.4
Electrical engineering C2732[1)]	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
			4.6	8.2	-5.2	-0.4	-2.0
Electrical engineering C2732[1)]	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
			100	-0.5	-4.0	6.0	-3.7
Electrical engineering C2732[1)]	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
			34.5	1.9	1.4	-0.9	4.6
Electrical engineering C2732[1)]	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
			45.7	8.7	-1.2	-6.1	1.8
Electrical engineering C2732[1)]	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
			0.76	-6.3	2.6	5.5	2.7
			Annual averages[4)]				
Electrical engineering C2732[1)]	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
			5.6	7.6	5.8	6.1	5.6

1) Manufacture of other electronic and electric wires and cables; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The economic situation of 27.32 is quite different. Labour costs and productivity are below its benchmark and the performance was worse. With the exception of the period from 1998 to 2000, ULC grew and the GOR remained well below the benchmark.

The United Kingdom, once one of the biggest optic fibre producers, had lost importance. Within 15 years, its share declined from 40.7 % in 1998 to 18.1 % in 2012, whereas other countries like Germany and Italy expanded their capacities. In general, it can be stated that northern Member States and CEE increased their production shares of "Electronic and electric wires and cables" and "Optic fibre cables", while others lost. (**Table 2.17**)

Table 2.17: Regional distribution of employment for wires and cables

Year	Northern economies[1)]	Southern economies[2)]	CEE economies[3)]	Other Member States
	Electrical engineering			
2012	41.2%	16.9%	13.9%	28.1%
2010	39.3%	17.5%	13.7%	29.4%
1998	31.9%	19.9%	11.2%	37.0%
	Manufacture of other Electronic and electric wires and cables			
2012	29.4%	19.1%	15.0%	36.4%
2010	28.3%	20.3%	15.1%	36.3%
1998	26.5%	22.3%	13.6%	37.5%
1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia.				

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

In section "Fibre optic cable" the dependency from third countries has been falling. During the early phase of the period under investigation around 40 % of production was exported. This share dropped to 22.2 % for the most recent period, 2008 - 2012. In terms of domestic demand the section performed better than the benchmark. It increased by 3.8 % in the period under investigation and outperformed the benchmark (2.0 %). This rising demand was met by an increase of production from € 2.0 billion in 1998 to € 3.0 billion in 2012. The growth rate of the section in production (3.0 %) exceeded the growth rate of the benchmark (2.5 %) in the period under investigation. Import lost importance, as shown by the remarkable decline of the import quota: It accounts for 20.9 %, while in the early phase (1998 – 2000), it had peaked with a share of 36.4 %. An important reason for the decline of the imports (and also exports) is the high weight of fibre optic cables, which results in high transportation costs compared to the product price. Additionally, as the domestic demand has been increasing (except for the period 2000 - 2005), the firms had limited motivation to tap foreign markets. Consequently, this section's internal interdependencies had declined. It is small (with € 3.0 billion production in 2012, it has only 13% of the size of the second section 27.32) with a promising future, as its products are indispensable for the expansion and upgrading of the EU-27 information and communication infrastructure. (**Table 2.18**)

Table 2.18: Trade indicators "Manufacture of other electronic and electric wires and cables"

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	27.31		3.0	17.1	-4.1	5.3	6.7
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	27.31		0.7	21.6	-16.1	13.6	0.4
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	27.31		0.6	56.5	-23.7	17.3	5.5
				Averages for the periods			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	27.31		22.2	39.9	32.1	22.0	26.4
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	27.31		20.9	36.4	25.5	18.0	22.5
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	27.31		3.9	7.4	16.0	12.6	10.6
RCA[5)]	27.31	Index	-0.21	0.19	0.20	0.07	-0.03

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Furthermore, the section's trade surplus fell from € 0.24 billion to € 0.05 billion over the period under investigation. The trade balance as a percentage of its trade volume reached 3.9 % and was far behind the trade balance of the benchmark (14.5 %). The comparative performance of this section is reflected by the RCA: With a value of -0.21 (2012) it is well below EE1's average.

In contrast to 27.31, the dependency of the section "Electronic and electric wires and cables" from third countries has been growing. During the early phase of the period under investigation around 13 % of production was exported. This share increased to 24.9 % for the most recent period of 2008 – 2012. The evolution of exports showed the same cyclicality as the EE1 sector. This also applies to the development of the imports. The import quota had also grown throughout the period, but less strongly than the export quota, which is reflected by the increase of the trade surplus (from € 0.01 billion in 1998 to € 0.49 billion in 2012). Compared to the benchmark, this section's internal interdependencies have remained moderate. (Table 2.19)

Table 2.19: Trade indicators “Manufacture of fibre optic cables”

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	27.32		23.0	6.4	0.2	11.2	-2.3
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	27.32		5.9	13.4	3.4	20.2	3.2
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	27.32		5.4	18.8	1.5	14.6	4.8
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	27.32		24.9	13.5	15.7	17.7	22.2
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	27.32		23.3	13.9	16.1	16.5	20.7
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	27.32		4.4	-1.5	-1.5	4.2	4.4
RCA[5)]	27.32	Index	-0.20	-0.06	-0.15	-0.18	-0.16

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

In terms of domestic demand, the section saw a better development than the benchmark. This demand was met by an increase of production from € 12.9 billion in 1998 to € 23.5 billion. The annual average growth rate of the section was higher (4.39 %) than the benchmark (3.60 %). The trade balances as a percentage of its trade volume reached only 4.4 % - the benchmark’s was three times higher (14.5 %).

The international trade performance of 27.32 is reflected by the RCA: The index is steadily negative and ranges between -6 and -20 and had worsened in more recent years.

The evolution of both of the sections of the “Fibre and cable” sub-sector’s foreign trade has led to a convergence of trade patterns.

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2.1.6 Lighting equipment and electric lamps

Product programme

This sector comprises of the following products according to NACE Revision 2:

- Manufacture of discharge, incandescent, fluorescent, ultra-violet, infra-red etc. lamps, fixtures and bulbs;
- Manufacture of ceiling lighting fixtures;
- Manufacture of chandeliers;
- Manufacture of table lamps (i.e. lighting fixture);
- Manufacture of Christmas tree lighting sets;
- Manufacture of electric fireplace logs;
- Manufacture of flashlights;
- Manufacture of electric insect lamps;
- Manufacture of lanterns (e.g. carbide, electric, gas, gasoline, kerosene);
- Manufacture of spotlights;
- Manufacture of street lighting fixtures (except traffic signals);

- Manufacture of lighting equipment for transportation equipment (e.g. for motor vehicles, aircraft, boats);
- Manufacture of non-electrical lighting equipment.

This sector excludes:
- Manufacture of glassware and glass parts for lighting fixtures (NACE Rev. 2 23.19);
- Manufacture of current-carrying wiring devices for lighting fixtures (NACE Rev. 2 27.33);
- Manufacture of ceiling fans or bath fans with integrated lighting fixtures (NACE Rev. 2 27.51);
- Manufacture of electrical signalling equipment such as traffic lights and pedestrian signalling equipment (NACE Rev. 2 27.90);
- Manufacture of electrical signs (NACE Rev. 2 27.90).

Since the early 20th century, electric lighting has started penetrating all areas of life. For a long time technological progress was moderate with a predominant supply of incandescent filament lamps. However, technological progress has accelerated and more recent innovations have caused dramatic changes not only in the sector's product programme but also in the supply side's structure and organisation of value chains.

The most important light sources technologies are:
- Incandescent filament lamps that have been the predominant light source since electric lighting has started penetrating all areas of life. They are based on tungsten that – heated by electric current – emits electromagnetic radiation.
- Halogen lamps are also based on filament, but the glass envelope does not only contain an inert gas as halogen is added. This allows higher temperatures, a reduction of the size and a higher light yield.
- Gas discharge lamps are widely applied in the form of Linear Fluorescent Lamps (LFL). A heated electrode emits electrons that create an electricity conducting plasma, predominantly based on mercury vapour. Mobile electrons collide with atoms and photons are emitted. Many of the gases applied in LFLs emit ultraviolet light and a fluorescence coating is necessary to produce visible light. These gas discharge lamps have a much longer lifespan than filament lamps and a significantly higher light yield. The light of these fluorescent lamps is "cold" and predominantly applied in working environments and usually not accepted as a lighting source in living areas.
- High Intensity Discharge lamps (HID) emit radiation directly as visible light. These lamps contain gases under high pressure. The gas composition can be changed to get light of different wavelengths, allowing them to meet the requirements of a wide range of different applications.
- Solid-State Lighting (SSL) comprises of Light-Emitting Diodes (LED), Organic Light-Emitting Diodes (OLED) and Polymer Light Emitting Diodes (PLED). These light sources are based on semiconductor materials. The LED technology has evolved over past decades. OLED and PLED are more recent innovations and are still in their infancy. Since the mid-1960s, numerous metal organic materials have been identified that are suited for electromagnetic radiation in different wavelengths in the visible range. However, the production of LEDs has been a sophisticated, costly process and, to a certain extent, product characteristics have hampered a widespread application in the past. Their dissemination started during the early-1990s in ICT products. In the area of backlighting of laptop-displays, television (TV) monitors and mobile phones etc., LEDs are used predominantly.

Further on, the sector's product programme comprises of lighting fittings, luminaires ballasts and other related accessories. In line with the dissemination of the more advanced lighting sources, their possibilities to better adapt lighting for specific applications and growing concerns with climate change and energy efficiency, the control of lighting has gained much importance. In particular, the market for lighting systems is expanding stronger than other market segments. In this area, European manufacturers and engineering companies have a leading position in the global market.

Demand side

Demand for lighting products originates from a broad range of applications: construction by its branches dwellings, office buildings, civil engineering and is dependent on investment activity, equipment of living areas, shops, gastronomy, advertisement, outdoor lighting, infrastructure investment and replacement. These applications are subsumed under the term "General lighting". Moreover, there are numerous market niches; for instance, airport runway lighting. Of noteworthy importance by size are specific applications in the automotive industry and backlighting of monitors, TV screens etc.

In the light sources market segment, demand is dominated by replacement needs (around 80 %), which is independent of the business cycle, even though the growth of disposable incomes as well as new technological developments, fashion trends and energy-saving methods have also influenced the replacement rate.

In particular, the SSL technology incorporates an enormous potential for energy saving and can contribute much to the reduction of CO2 emissions. Lighting applications are found in all areas of life. The enterprise sector, public authorities and private households can take measures to support climate objectives. In many areas, the share of lighting in total electricity consumption reaches 50 % and more; for instance in office buildings and municipalities. Moreover, three quarters of lighting equipment in Europe is older than a quarter of a century.[67] A replacement by LED and OLED incorporates potential of energy savings of around 50 %. If SSL technology is combined with intelligent light management systems, which regulate light output according to ambient lighting conditions or people's presence and activities, another 20 % can be saved. Thus, advanced SSL could cut present-day electricity consumption by about 70 %.[68]

Currently Asia is leading the investment in SSL technology, in particular in public lighting. Strongly growing municipalities are major drivers. The EU is lagging behind as progress in urbanisation is slow and the financial situation of most of the municipalities is strained. Moreover, investment expenditures are significantly higher than for conventional lighting and pose a barrier for fast dissemination of the new technology. This is all the more unfortunate as Total Costs of Ownership (TCO), which comprises of all costs over the whole lifecycle, are lower than for conventional lighting.[69] Therefore, SSL technology could contribute to a long-term reduction of public authorities' power consumption payments.

The market penetration of LED technology is low in most segments. The only exception is backlighting where its share has already caught half of the market and will reach around 100 % at the end of the decade. Due to technical progress, process and product innovations, costs for LED are expected to decline. A high decrease in LED prices is forecasted: a 66 % reduction by 2015

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[67] GREEN PAPER (COM(2011) 889 final), Lighting the Future - Accelerating the deployment of innovative lighting technologies, Brussels 15.12.2011, p. 6.

[68] Second Strategic Research Agenda of the European Technology Platform PHOTONICS21, Lighting the way ahead, 2010, p. 30. cordis.europa.eu/fp7/ict/photonics/docs/reports/ph21-sra-2_en.pdf

[69] In contrast to many other alternatives for the reduction of CO2 emissions SSL technologies are economically advantageous. See: McKinsey Company, Lighting the way: Perspectives on the global lighting market, Munich, Vienna, July 2011, p. 16.

and 80 % by 2020, compared to 2011 prices.[70] Strong competition among global players to gain large market shares will stimulate price reductions and lead to low margins. Manufacturers with large shares in the global market are on the leading edge of competition in volume markets.

Dissemination of LEDs in the area of "general lighting" has not made much progress yet, due to high costs. Currently its share of the global market is around 10 %, but it is forecasted to reach 64 % in 2020.[71] Shrinking prices and product characteristics of LEDs are driving demand. While in Asia heavy investment in new capacities are predominant, for the EU replacement will be of major importance.

McKinsey's forecast for the global lighting market sees an annual average growth of 6 % (2010 – 2016) and 3 % (2016 – 2020). In general, lighting growth rates are expected to be higher at 7 % and 4 % respectively.[72] Urbanisation is an important driver for the demand for lighting equipment and lamps. Manufacturers in high growth Asian economies enjoy strongly growing demand, whereas in the EU the situation is different and – without public policies – a demand pull cannot be expected. The EU market will be trailing behind emerging economies. Due to the slow replacement of old lighting technology it will take a long time until the advantages of LED for energy savings will be fully exploited. **The ad hoc Advisory Group for Energy Efficiency has submitted several forecasts for the dissemination of LED. It will last until 2050 if – ceteris paribus – based on current dissemination rates the penetration of LED continues.**

An assertive scenario will not come to a different result at the end of the forecasting period. However, the pace of dissemination will accelerate – incited by joint efforts of public authorities and industry to demonstrate and promote on a large scale what can be achieved with intelligent control systems and SSL lighting. This will lead to significant energy savings throughout the dissemination period. However, no rebound effects have been taken into account, caused by growing lighting applications as a consequence of lower costs for operation.[73] Additional effects are expected by new applications that emerge with LED. They go beyond energy efficiency and exploit the possibilities provided by the new technology to automatically adjust the brightness and the colour of the light according to human needs in the working, private and leisure environment. The increasing awareness of health can raise power-based demand, whereas public leeway for investment will remain limited in the future.[74]

Supply side

In the area of light sources, large global players dominate the supply side. Global leaders are GE (US), Toshiba (JP), Samsung (KR), Philips (NL) and Osram (DE) with its US brand Sylvana. Most light sources are commodities. The products are standardised and the manufacturers' supply is interchangeable. Production is capital intensive and economies-of-scale are crucial elements in competition.

With LED, a new technology has emerged since the mid-1990s. It contributes to a change in the branch's structure and value chains. This technology will experience an accelerated penetration in the market. The future competitiveness of EU lighting equipment and lamps branch will be strongly

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[70] U.S. Department of Energy, Solid-State Lighting Research and Development: Manufacturing Roadmap, August 2012, p. 17 http://www1.eere.energy.gov/buildings/ssl/techroadmaps.html[71] McKinsey Company, Lighting the way: Perspectives on the global lighting market, Munich, Vienna, July 2011, p. 21.

[71] McKinsey Company, Lighting the way: Perspectives on the global lighting market, Munich, Vienna, July 2011, p. 21.

[72] McKinsey Company, Lighting the way: Perspectives on the global lighting market, Munich, Vienna, July 2011, p. 11.

[73] Second Strategic Research Agenda of the European Technology Platform PHOTONICS21, Lighting the way ahead, 2010, pp. 32. cordis.europa.eu/fp7/ict/photonics/docs/reports/ph21-sra-2_en.pdf

[74] ATKearney, ZVEI; Human Centric Lighting – Going beyond Energy Efficiency, Juli 2013 http://www.lightingeurope.org/uploads/files/Market_Study-Human_Centric_Lighting._Final_July_2013.pdf

dependent on the presence and performance of major EU players in global markets. Both of the largest EU light source manufacturers are among the largest in the LED market; Osram Opto and Philips Lumileds are in third and sixth place by turnover, respectively.[75] By the number of firms among the ten largest players, South Korea and Japan are in the lead with 3 firms each. (**Table 2.20**)

Table 2.20: Leading players in the global LED market 2011[76]

Company	Headquarter
Nichia	Japan
Samsung LED	South Korea
Osram Opto	European Union
LG Innotek	South Korea
Seoul Semiconductors	South Korea
Philips Lumileds	European Union
Cree	United States
Sharp	Japan
Toyoda Gosei (TG)	Japan
Everlight	Taiwan

Source: optics.org; Ifo Institute.

The market for lighting fittings is dominated by only few large international groups and numerous suppliers are also active in this sector. The most important European enterprises are Philips (NL) with an integrated business area comprising of lighting sources, fittings, luminaires and controls, Zumtobel Group (AT) one of the large global players in fittings with its affiliations Thorn (UK) and Tridonic (AT), specialising in lighting systems, light management and LED. These activities are to a large extent based on Philips expertise. Trilux (DE) is one of the larger family-owned companies in this market with a strong focus on specific applications. Most of the companies in this market segment are smaller firms, although usually much larger than SMEs as defined by the EU.

In the market of luminaires, there are some manufacturers with large batch production, such as for instance luminaires for LFLs, whereas others are specialising on customisation or even designer lamps dedicated for applications in living areas. There are numerous SMEs that command a strong position in the market by their design abilities.

Compared to other industries, the intra-industrial division of labour in the lighting equipment and lamps branch is less complex. The manufacture of light sources consists of a limited number of stages in the production process. Traditional light sources consist of voluminous glass light bulbs, metal (filament, contacts and electrodes), gas and only a few types contain integrated electronics. Moreover, chemicals are needed; hazardous and even noxious substances that pose threats for employees and the environment. High-quality requirements, reliability and longevity of products ask for reliable and well-monitored manufacturing processes for light sources. The production of light sources is capital intensive and highly-automated. Process supervision and quality assurance are crucial elements.

[75] In spite of the presence of the big European players in the market for LED they are challenged because the majority of their activities have remained in other light source technologies that to a large extent will be substituted in coming years. These problems are reflected in the spin-off of Osram by Siemens that took a couple of years and a complete separation has not yet been reached after the IPO in 2013.

[76] Matthew Peach, LED market grew 10% to $12.5 billion in 2011, 17 February 2012, http://optics.org/news/3/2/24a

Beyond light sources, complementary components, such luminaires, ballasts, controls and fittings, are necessary for illumination. The interfaces to light source manufacturers' products are well-defined by mechanical, electrical, electronic, thermal and photometric specifications. In most cases – due to standardised specifications – companies can carry out R&D as well as the design of their products independently from each other. Traditionally there is no specific need for a close innovation linkage between manufacturers of ballasts, controls and fittings on the one side and manufacturers of light sources on the other side.

This lose innovation linkage is about to change with the dissemination of LEDs as products of the lighting equipment and electric lamp branch. This development is due to the fact that standardisation has not yet made much progress and for optimisation needs it has transpired that an adjustment of LED modules to specific application requirements requires a co-operation of light source manufacturers and manufacturers of controls, fittings and luminaires. This will have an impact on the vertical integration of the branch.

Standardisation is understood as an important tool to support dissemination of SSL technology and the EU has taken initiatives to stimulate activities. However, the technology is at an early stage and evolves quickly and leeway is necessary to allow for technological progress and innovation. Moreover, SSL provides – in contrast to conventional lighting technologies – more flexibility to design products specified for different applications. As a consequence, R&D as well as product development processes will become more integrated along the value chain. It is expected that manufacturers in the area of controls, fittings and luminaires gain more freedom for design and become more important as drivers of product innovation. These players might pursue strategies to intensify co-operation upstream with manufacturers of light sources to get a lead in markets for specific applications. Other players will expand their areas of activities downstream to develop lighting systems, for instance dedicated to control for automatic energy efficiency under different environmental conditions. Power supply and light management are crucial for the longevity of LEDs. To become certified by manufacturers of LEDs will be important for companies active in the areas of fittings and luminaires to benefit from this emerging technology.

The sub-sector has previously faced problems with the procurement of rare earths, caused by Chinese policies. Today, however, this is no longer an urgent issue. Most of the LED-chips are procured from Asia. These chips are valued as commodities manufactured by numerous large players in several countries. With regard to large batch production in Asia and the importance of scale-effects and synergies with the production of semiconductors, the dependency on Asian deliveries will not change in the future. But this is not perceived as a strategic disadvantage as long as there is no concentration in the market.

The downstream linkages of the European lighting equipment and lamps industry are affected by the structure of the EU manufacturing. The strengths of this industry lie in metal industries, engineering and transport equipment, whereas in consumer electronics and PCs the EU is trailing behind Asia, which has become – due to this demand pull from downstream companies – strong in backlighting. However, the EU automotive industry is a driver of LED applications and has contributed much to the EU lead in this area of application. Specific applications in the area of life science and the ageing society have become important areas where EU manufacturers enjoy good market conditions. These applications are not of importance yet by market size, but technological progress and potential demand provide bright perspectives.

Assessment of price performance

In terms of nominal production the 27.40 sub-sector amounted € 20.7 billion in 2012 and accounted for 5.6 % of EE1 (**Table 2.21**). It is one of the smaller sub-sectors and – as measured by real value added and employment – had lost some of its former importance over the period under investigation. This was caused by a breakdown during the financial crisis in 2009 when value added and employment slumped by 24 % and 13 %, respectively. The following recovery was not sufficient to regain former levels.

Growth pattern of the sub-sector followed – grosso modo – the cyclical development of EE1, with strong growth between 1998 – 2002 and 2005 – 2008. Sub-sector 27.40 outperformed the benchmark between 1998 and 2005, while during the years thereafter it was the other way round. For the duration of the period under investigation, real value added increased at an annual rate of 1.7 %, whereas total EE1 increased by 2.2 %. The number of workplaces shrunk at 0.8 % per annum, at a stronger pace than the benchmark. **In particular, for the more recent period of 2008 to 2012, the employment record was worse than for EE1. This development is understood as a result of a consolidation process.**

Sub-sector 27.40 has one of the lowest wage costs at 85 % of the EE1 average. This is caused by an under average share of workplaces in northern countries. However, the regional concentration grew throughout the period under investigation from around 25 % of EU-27 employment in 1998 to 33 % in 2012. For the EE1, the share of northern countries[77] of total employment was 41 %. This regional shift was linked with an above average growth of labour costs per employee at 3.5 % p.a. for the period under investigation, compared to the benchmark with an annual increase of 2.6 %.

The growing cost burden has been more than compensated by the growth of labour productivity from 1998 to 2005, which was mainly caused by an above average growth compared to EE1. During the years after, sub-sector 27.40's business environment was less stimulating and put pressure on its economic performance. From 2008 to 2012, the ULC worsened at an annual rate of 4.7 %. Likewise, the former above average GOR fell for the period of 2008 to 2012 back to the level of its benchmark. The reversal of the performance relative to the benchmark was – to a certain extent - caused by a deteriorating economic situation in the southern Member States; in particular the breakdown of construction activities.

[77] Austria, Denmark, Finland, Germany, Netherlands, Sweden.

Table 2.21: Key indicators "Lighting equipment and electric lamps"

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electrical engineering	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
C2740[1)]			20.7	10.9	1.3	3.1	-3.9
Electrical engineering	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
C2740[1)]			20.0	17.0	0.5	1.9	-5.6
Electrical engineering	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
C2740[1)]			8.1	13.2	2.1	0.7	-3.3
Electrical engineering	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
C2740[1)]			165	1.8	-0.7	-0.1	-2.8
Electrical engineering	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
C2740[1)]			36.7	3.5	2.5	4.3	4.2
Electrical engineering	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
C2740[1)]			48.9	11.2	2.7	0.8	-0.4
Electrical engineering	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
C2740[1)]			0.75	-7.0	-0.3	3.4	4.7
			Annual averages[4)]				
Electrical engineering	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
C2740[1)]			8.5	11.6	11.8	12.5	8.9

1) Manufacture of lighting equipment; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

In the sub-sector "lighting equipment and electric lamps", the dependency from third countries has been growing. The evolution of the exports showed the same cyclicality as EE1. During the early phase of the period under investigation around 15.2 % of production was exported. This number increased to 16.1 % in 2000 – 2005 and further to 18.7 % in the period of 2005 – 2008. During recent years, one quarter (25.0 %) of its output is delivered to third countries. With the exception of the early period from 1998 to 2000, imports increased at higher rates than exports. On average for the total period under investigation, they increased at an annual average rate of 8.45 %, while the benchmark only reached 5.89 %. The trade surplus of the sub-sector of around € 0.2 billion at the end of the 1990s reversed into a deficit of € -0.8 billion in 2012. The EU-27 has become a net importer of lighting products. These products are both imports from the large European players in the market as well as being deliveries from non-EU competitors.

The domestic demand has increased continuously, except during the financial crisis. Throughout the period under investigation, imports grew stronger than domestic demand. It is important to note that even during the period from 2008 to 2012, when domestic demand fell by an annual average rate of 3.7 %, imports increased annually at 6.3 %. Foreign products strongly gained shares in the EU-27 market. During the early years of the period under investigation, the import penetration was around 14.4 % only, while in 2012 the import quota was more than double as high with 33.1 %. (**Table 2.22**)

Table 2.22: Trade indicators "Lighting equipment and electric lamps"

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	27.4		21.5	11.3	1.7	3.7	-3.7
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	27.4		6.3	13.1	3.3	8.2	7.1
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	27.4		7.1	16.3	6.0	10.4	6.3
				Averages for the periods			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	27.4		30.4	15.2	16.1	18.7	25.0
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	27.4		33.1	14.4	16.6	21.0	28.6
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	27.4		-6.3	3.1	-1.9	-7.1	-9.1
RCA[5)]	27.4	Index	-0.42	0.03	-0.13	-0.33	-0.44

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The trade performance of sub-sector 27.40 over the period under investigation was poor. The trade surplus had reversed into a remarkable deficit of -6.3 % as measured by its trade volume. This is also reflected by an RCA of -0.42 in 2012, indicating that the sub-sector performed worse than its benchmark.

2.1.7 Electric domestic appliances

Product programme

This sector comprises of the following products according to NACE Revision 2, 27.51:

- Manufacture of domestic electric appliances (such as refrigerators; freezers; dishwashers; washing and drying machines; vacuum cleaners; floor polishers; waste disposers; grinders, blenders, juice squeezers; tin openers; electric shavers, electric toothbrushes, and other electric personal care device; knife sharpeners; ventilating or recycling hoods);
- Manufacture of domestic electrothermic appliances (such as electric water heaters; electric blankets; electric dryers, combs, brushes, curlers; electric smoothing irons; space heaters and household-type fans, portable; electric ovens; microwave ovens; cookers, hotplates; toasters; coffee or tea makers; fry pans, roasters, grills, hoods; electric heating resistors etc.).

This sector excludes:

- Manufacture of commercial and industrial refrigerators and freezers, room air-conditioners, attic fans, permanent, mount space heaters, and commercial ventilation and exhaust fans, commercial-type cooking equipment; commercial-type laundry, dry-cleaning, and pressing equipment; commercial, industrial, and institutional vacuum cleaners, see NACE Rev. 2 division 28;
- Manufacture of household-type sewing machines (NACE Rev. 2 28.94);

- Installation of central vacuum cleaning systems (NACE Rev. 2 43.29).

Demand side

The demand for domestic appliances is strongly consumer driven and thus significantly dependent on consumer sentiment, as far as business cycles are concerned. Most market segments are saturated and secular demand is dependent on replacement. The demographic situation in the EU-27 is close to stagnation and dampens long-term perspectives for market growth. The financial crisis hit the demand for domestic appliances. In southern crisis-stricken Member States, the situation has not yet improved and the contraction of housing construction has prevented any recovery. With regard to market saturation in most of the Member States, the industry is faced with the necessity of product differentiation and strategies to maintain niches of competitive advantage. The latter can be achieved via the introduction of new products that are in line with changing consumer preferences. Important dimensions of product development alongside changing consumer preferences are in energy efficiency, functionality and product design.

Supply side

Most domestic appliances are standardised products manufactured in large quantities. However, consumer preferences and habits affect the demand and companies have to adapt their products to regional specifics. **Large domestic appliances are bulky and – with regard to the product price – transport costs matter. For smaller domestic appliances the situation is slightly different and they are traded over long distances.** There is a noteworthy production for large appliances within the EU-27. Competition from non-EU locations is less of importance with the exception of Turkey. For smaller appliances, competition from Asia is tough and non-EU products command noteworthy market shares; for instance, micro-waves.

The supply side consists of global players from developed economies, such as the US Whirlpool and Hoover, Electrolux (SE), BSH (DE) and Arcelik (TR). Other strong European players as Philips (NL), Fagor (ES), Indesit (IT), Liebherr (DE), Miele (DE) and Groupe SEB (FR) command significant market shares. The latter is specialising in small appliances. Since the turn of the millennium, Asian manufacturers have gained importance, among them LG (KR), Samsung (KR) and Haier (CN). They have already tapped the EU-27 market and are eager to expand their shares in a market that provides attractive price levels compared to other important markets.

Important players in the 27.51 market are the Turkish-based Arcelik Group and the Slovenian Gorenje Group. Arcelik mainly produces consumer electronics and consumer durables. Domestic appliances are sold and distributed by the company brand Beko. In recent years Beko has become one of the largest suppliers of domestic appliances in Western Europe with an outstanding strong position in CEE. Beko managed to reinforce its position in Eastern European markets with Europe being Arcelik's main export market.[78] The Gorenje Group, which is one of the leading companies in the 27.51 market, had an export share of more than 90 % of sales revenue in 2010, whereby most of the exports were sold to European markets.[79] Household appliances are sold under such brand names as Gorenje, Atag, Asko, Pelgrim, etc. Besides household appliances, Gorenje also provides a broad selection of home products, such as for kitchen and bathroom furnishings.

Regarding the value chain of the manufacturing of goods in sub-sector 27.51, the production process is characterised by internationalisation. This means that the production of smaller appliances is largely located in low cost countries, whereas the manufacture of products with a higher added value is less exposed to relocation. In case of Gorenje, this means that low-priced

[78] Arcelik, Annual Report 2011.
[79] Gorenje, Annual Report 2010, p. 17.

components are manufactured in Serbia, while high value-added parts are still located in Slovenia. In addition to sourcing alternative components from low-cost countries, other approaches to lower production costs are largely reflected by lowering the cost of materials.

Since the supply side in mature markets heavily depends on the introduction of new products, technological readiness is an important issue for opening up new markets and to get an edge in competition. In times of growing interest in energy-efficient products, firms could benefit from investments in R&D and the transformation of new technologies into marketable products. Energy efficiency is a feature for product differentiation, but has not turned out to be a stimulus for additional demand. There are only few new products in the market and saturation will be reached within a foreseeable future. Stepwise innovation is predominant and, as a consequence, growth prospects are limited.

Assessment of price performance

In terms of nominal production, sub-sector 27.51 amounted € 32.2 billion in 2012 and accounted for 8.3 % of EE1 (**Table 2.23**). From this perspective, the sub-sector is of medium size and when measured by real value added and employment, the sub-sector had lost some of its former importance over the period under investigation. This downward trend is already observed for the years 1998 to 2008. The breakdown during the financial crisis in 2009 hit the sub-sector's value added and employment, which declined by 7.5 % and 10.3 %, respectively. The following recovery was less strong for the sub-sector than for the benchmark sector and it lost further ground.

Over the entire period under investigation, real value added of the sub-sector decreased at -0.8 %, whereas for total EE1 it increased annually at 2.2 %. The sub-sector's employment declined at a rate of 1.6 % per annum. This was the strongest decrease that a sub-sector of EE1 had suffered. Most dramatic was the situation throughout the period of 2008 to 2012. The number of employees declined by around 18,000 within four years, which equals 8 % of the total workplaces in 2008. In spite of this consolidation, the GOR did not improve. In 2012, it was 4.4 % of total gross output, much lower than on average for the period under consideration.

Table 2.23: Key indicators “Manufacture of domestic appliances”

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electrical engineering	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
C2751[1)]			32.2	3.9	0.0	4.9	-4.4
Electrical engineering	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
C2751[1)]			32.0	9.7	-0.1	4.8	-4.8
Electrical engineering	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
C2751[1)]			9.4	5.7	-1.9	-0.7	-2.6
Electrical engineering	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
C2751[1)]			206	-2.4	-2.5	1.3	-2.1
Electrical engineering	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
C2751[1)]			37.8	4.9	2.4	0.6	2.0
Electrical engineering	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
C2751[1)]			45.6	8.3	0.6	-1.9	-0.5
Electrical engineering	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
C2751[1)]			0.83	-3.2	1.8	2.6	2.5
			Annual averages[4)]				
Electrical engineering	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
C2751[1)]			4.4	10.5	9.0	6.7	5.8

1) Manufacture of domestic appliances; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The labour costs of sub-sector 27.51 are 13 % below the EE1 average. This is explained by a disproportionately low share of workplaces in northern countries. Throughout the period under investigation there was a major change in the regional structure. The loss of workplaces was disproportionately high for northern as well as for southern Member States, while Central European Economies (CEE) enjoyed a growing employment, in particular Poland. (**Table 2.24**)

Table 2.24: Regional distribution of employment for sub-sector “Domestic appliances”

Year	Northern economies[1)]	Southern economies[2)]	CEE economies[3)]	Other Member States
	Electrical engineering			
2012	41.2%	16.9%	13.9%	28.1%
2010	39.3%	17.5%	13.7%	29.4%
1998	31.9%	19.9%	11.2%	37.0%
	Manufacture of electric domestic appliances			
2012	29.4%	26.1%	18.0%	26.6%
2010	28.4%	27.2%	18.2%	26.2%
1998	30.8%	29.7%	10.6%	28.9%

1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The shift in employment allowed companies to exploit the advantages of lower labour costs that only increased at an annual rate of 2.3 % for the years under investigation, whereas for EE1 the average rate was 2.6 %. However, the increase of labour productivity was much lower than for EE1. This might be explained to a certain extent by the stagnation of output throughout the period under consideration. In particular, the years of 2008 to 2012 put much pressure on the sub-sector. The years after the slump in 2009 are characterised by only a muted recovery and even in 2012 the output level was still far below the 2008 peak. The economic performance was poor, the ULC slightly increased over the period under investigation and the GOR did not improve during the years of the recovery up to 2012; quite the opposite in fact, as the GOR had declined.

Assessment of trade performance

In sub-sector 27.51 the dependency from third countries had been growing over time. During the early phase of the period under investigation 14.4 % of production was exported. Just before the financial crisis (2005 - 2008) the dependency on foreign demand had peaked with a share of 27.3 % of total output. Hit by the global financial crisis, the export quota declined to 21 % on average for the period 2008 – 2012, but has recovered in the most recent years. In contrast, the import quota has increased steadily to 31.7 % in 2012, well above its benchmark (24.7 %). The imports increaed at an average annual rate of 5.2 %, although domestic demand decreased at 2.9 % p.a. between 2008 and 2012. **Products from third countries had gained a share of roughly one third of the EU-27 market for domestic appliances.** The trade surplus at the beginning of the period under investigation had reversed into a significant deficit that – as measured as a percentage of trade volume – was -20.2 % in 2012. At the end of the 1990s, the RCA had indicated a comparative advantage for sub-sector 27.51 relative to EE1. However, in 2012 the sub-sector's position has reversed and its situation is worse than for EE1. (**Table 2.25)**

Table 2.25: Trade indicators "Domestic appliances"

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	27.51		36.1	4.2	1.0	6.2	-2.9
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	27.51		7.6	11.5	6.7	1.2	0.7
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	27.51		11.4	16.8	13.3	7.5	5.2
				Averages for the periods			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	27.51		23.5	14.4	18.7	27.3	21.0
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	27.51		31.7	11.1	17.9	27.2	28.8
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	27.51		-20.2	14.5	2.7	0.3	-20.8
RCA[5)]	27.51	Index	-0.70	0.26	-0.01	-0.19	-0.65

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.1.8 Electrical equipment for engines and vehicles

Product programme

This sector comprises of the following products according to NACE Revision 2, 29.31:

- Manufacture of motor vehicle electrical equipment, such as generators, alternators, spark plugs, ignition wiring harnesses, power window and door systems, assembly of purchased gauges into instrument panels, voltage regulators, etc.

This sector excludes:

- Manufacture of batteries for vehicles (NACE Rev. 2 27.20);

- Manufacture of lighting equipment for motor vehicles (NACE Rev. 2 27.40);
- Manufacture of pumps for motor vehicles and engines (NACE Rev. 2 28.13).

However, most advanced products – such anti-blocking systems (ABS), traction control systems (ASR), electronic controls for internal combustion engines etc. – are not contained in NACE 29.31. These products must be taken into account when developments in the market of electrical equipment for engines and vehicles are analysed. All of these products together form one market with the same participants on the supply and demand side. Between numerous market segments there are linkages and very often complementary relationships. Moreover, there are tendencies to integrate electrical and electronic components to common data processing equipment. Therefore, it was decided to discuss the market of all electrical and electronic equipment for vehicles and the more recently developed products. However, the data base has been bound to NACE 29.31.

Demand side

The latest forecast for the worldwide automotive supplier market expects an expansion of 20 % between 2010 and 2015 to € 620 billion. This equals and annual average growth rate of 3.8 % and is well above perspectives for other sub-sectors of EE1.

The market size was € 515 billion in 2010. Since 1985, it has been increasing steadily and is estimated to grow to € 620 billion by 2015.[80]

At the time of the financial crisis, global production in the automobile industry slumped by roughly half its former volume. Consequently, the automotive suppliers were also hit, in particular in the developed world.[81] In China and other emerging economies, the automobile industry did not suffer that much and regained former production levels quite quickly and, likewise, their suppliers were better off. The average worldwide EBIT margin for the industry increased from 1.6 % in 2009 to 6.2 % in 2010. The European enterprises exhibited an average EBIT margin of 6.9 % and outperformed their North American (4.3 %) and Japanese (5.6 %) competitors. Europe was only overtaken by China and Korea, which partially reached binary EBIT margins.

The most profitable sectors in the automotive supplier market are the chassis producers with an EBIT- margin of 8 %, followed by bodywork and drivetrain. The most unprofitable sectors are interior and electronics/ infotainment with an EBIT margin of nearly 5 %.

Also of significance is the fact that the gap between profitable and less profitable automotive suppliers was widened by the crisis. Automotive suppliers who strive for a higher EBIT need to concentrate more on product innovation in the future as a unique feature for a better negotiating position.[82]

NACE 29.31 comprises of electrical components based on mature technologies, most of which have been indispensable for vehicles. Although the pace of innovation is moderate, the growth potential is proportionate to the automotive industry, but not higher as for other, more advanced technologies not documented under NACE 29.31. Price competition is tough and relocation of production to low-cost countries is an important topic.

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[80] http://www.statista.com/statistics/162994/size-of-the-automotive-supplier-market-worldwide-since-1985/, 2013.
[81] http://www.auto-rlp.de/fileadmin/user_upload/PDF-Dateien/Auswertung_Fragebogen_v_02.01.2012.pdf, 2011.
[82] http://www.presseportal.de/pm/32053/2110758/globale-automobilzulieferer-studie-von-roland-berger-und-lazard-die-profitabilitaet-der-globalen, 2011.

The long-term trend for electrical equipment for engines and vehicles is driven by mechanical systems being increasingly supplemented or replaced by electrical and electronic components. This concerns, among others, the development of more sophisticated, fuel-efficient engines to meet clients' preferences for lower fuel bills or high performance cars. Systems for the electronic control of the complete combustion process to reduce fuel consumption and harmful emissions (hydrocarbons, NOx, CO) have become common. EU policies on car emissions and ever stricter provisions have stimulated this development and compliance with regulations is obligatory.

Anti-blocking systems (ABS) has disseminated up to 100 %, frequently in combination with traction control (ASR). Both systems are also being installed in commercial vehicles. Electronic components are also used in many other areas such as gearbox control units where sensors determine transmission and engine speed as well as engine load, or in airbag and seat-belt systems. The increasing demand for car safety had spurred growth in past decades, but with a dissemination of 100 % the development has become moderate.

More recent progress concerns automated driving and is linked to the buzzword 'drive by wire'. This includes electronically controlled steering, adaptive chassis, and systems dedicated to support the driver and increase safety on the road, such as lane change and lane departure warning, night vision, pedestrian recognition etc. Currently, these technologies are predominantly applied in premium cars. Their dissemination to more expensive cars will stimulate a more than proportionate growth.

The evolutionary process towards electro-mobility goes via light-hybrid and plug-in-hybrid cars that try to combine the advantages of internal combustion engines and electro drives. These cars require ever more technology parts and components in vehicles, compared to cars that are run by an internal combustion engine only. Their growing dissemination will stimulate the demand for electric and electronic parts and lead to an above average growth of suppliers to the automotive industry.

This general trend could be reversed with a widespread dissemination of electro-mobility. The number of parts will be significantly reduced, and small electric cars could become low price commodities if the current detriments, for instance in battery technology, are overcome. This will affect the entirety of the value chain. Traditional industrial clusters will lose some of their current importance and impact the global distribution of production.[83]

Supply side

In total, there exists an immense competitive pressure on the sector "Electrical equipment for engines and vehicles". Bargaining power of the large OEMs puts permanent pressure on subcontractors that are by no means small companies. They employ several thousands of people and have to exploit all opportunities for cost reductions. Beyond automation, process innovation and reorganisation the relocation of production to low-cost countries is of crucial importance to survive in cut-throat competition.

Among the most important global players are numerous European enterprises. Bosch is definitely leading by size and technological competence, having been the biggest automotive supplier worldwide in 2005 and 2006. Other important suppliers are Delphi, Johnson Controls, Lear, TRW Automotive from USA, Faurecia, Valeo from France, Denso and Aisin Seiki from Japan and Magna from Canada.[84]

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[83] For the perspectives of electromobility see: Chapter 2.1.4.
[84] http://automobilwoche.de/article/99999999/REPOSITORY/112300001, 2013.

In the manufacturing of electrical equipment for engines and vehicles, consolidation has increased strongly. The largest EU-27 producers of NACE 29.31 goods in the EU are the German Bosch, the French Valeo, the Italian Magneti Marelli, and the British Lucas Varity, a merger of Lucas and Varity in 1996. During the past decade, the supply side of the sector underwent a major structural change. Many of the small and medium-sized firms of the sector have been taken over by the big players in the sector. The US Tenneco made some acquisitions in Europe. The biggest Japanese supplier of car components to the automotive industry, Denso – a member of the Toyota Group – owns some production sites in Europe.

Electrical equipment for engines and vehicles are made in series which ensures considerable economies of scale by producing in large quantities and selling internationally. To remain at the cutting edge, manufacturers must invest large sums in R&D. This is another factor that favours consolidation since only the larger firms can fund these R&D expenditures. Enterprises seek to strengthen their core competencies, i.e. they seek to strengthen their position in those markets and technologies where they have a leading position.

Assessment of price performance

In terms of nominal production the 29.31 sub-sector realised € 22.8 billion in 2012 and accounted for 6.2 % of EE1. Its share in EE1 employment reached 9.1 % (**Table 2.26**). It is one of the smaller sub-sectors of EE1, although it grew relatively strong over the period under investigation. The driver of this development has been the automotive industry, one of the fastest growing among all manufacturing industries. In spite of the upward trend for output – nominal production increased at an annual rate of 2.6 % over the period under consideration – the sub-sector reduced employment, although at a lower rate than EE1.

Table 2.26: Key indicators "Electrical and electronic equipment for motor vehicles"

Sector	Indicator	2012		Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electrical engineering	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
C2931[1)]			22.8	15.5	1.6	4.4	-3.5
Electrical engineering	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
C2931[1)]			22.5	15.0	1.6	4.1	-4.0
Electrical engineering	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
C2931[1)]			6.0	8.1	2.0	3.1	-3.0
Electrical engineering	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
C2931[1)]			200	4.8	0.9	-0.1	-3.9
Electrical engineering	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
C2931[1)]			22.4	3.6	2.1	2.6	2.9
Electrical engineering	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
C2931[1)]			29.8	3.1	1.0	3.2	1.0
Electrical engineering	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
C2931[1)]			0.75	0.5	1.0	-0.5	1.9
			Annual averages[4)]				
Electrical engineering	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
C2931[1)]			6.0	7.9	6.9	7.1	6.2

1) Manufacture of electrical and electronic equipment for motor vehicles; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Value chains in the automotive industry are well organised and permanent improvements are required by the large clients. This had an impact on the development of sub-sector 29.31.

Specialisation and outsourcing are applied to fulfil the clients' cost targets. As a consequence, manufacturing depth was reduced from around 28 % in 1998 down to less than 23 %. Productivity growth was at an average rate of 1.8 % throughout the period under consideration.

Sub-sector 29.31's labour costs per employee are about half of the EE1's average. This is the sector with the most extreme regional structure of employment and changes therein throughout the period under investigation. Northern economies lost some of their former importance – however, most affected were the southern Member States with a reduction of 8.3 percentage points of total EU-27 workplaces in sub-sector 29.31. Simultaneously, CEE increased their share of employment by 12.3 percentage points. These losses of workplaces were driven by strong competition among locations within the EU (**Table 2.27**). The increase of labour productivity with an annual average rate of only 1.8 % is below the rate of 2.5 % for EE1.

Table 2.27: Regional distribution of employment "Electrical and electronic equipment for motor vehicles"

Year	Northern economies[1)]	Southern economies[2)]	CEE economies[3)]	Other Member States
	Electrical engineering			
2012	41.2%	16.9%	13.9%	28.1%
2010	39.3%	17.5%	13.7%	29.4%
1998	31.9%	19.9%	11.2%	37.0%
	Manufacture of Electrical and Electronic equipment for motor vehicles			
2012	13.0%	11.5%	29.1%	46.3%
2010	12.9%	11.9%	28.4%	46.7%
1998	14.5%	20.0%	16.8%	48.8%

1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

As a consequence of these changes in key economic indicators, the ULC worsened at an annual rate of 0.9 %. However, this development did not lead to an above average profitability. For most of the period it remained below the average level of EE1, and even became worse during the period of 2008 to 2012. Bargaining power of big clients and the mainly conventional product programme of the sub-sector – as documented in official statistics – limits the opportunities for an increase of profitability and employees' income.

Assessment of trade performance

The most noteworthy feature of this sub-sector is the growth rate of the imports. During the period under investigation they grew by almost 10 % p.a. and exceeded the benchmark (5.9 %) by far. This result is directly connected with the growth of domestic demand at an annual rate of 3.2 %, which is above the growth of its benchmark at around 2 %. The sub-sector's import quota increased steadily from around 9 % during the early years of the period under consideration to 23.1 % in 2012. The export quota increased from a 7% range between 1998 and 2008 to 12 % for the last period. In recent years the growing import penetration has reached the level of EE1. This indicates that the EU-27 automotive industry has become more reliant on third country deliveries. The export quota did not change much by 2008. In more recent years, it has nearly doubled and reached 14.5 % in 2012. However, imports – larger by volume and also soaring – caused a further deterioration of the trade balance. Consequently, the trade balance as a percentage of the trade volume worsened over the period under investigation. In 2012 it was -29.2 %. (**Table 2.28**)

A permanent loss of competitiveness of this sub-sector – compared to EE1 - is reflected by the RCA, which experienced a very strong decline in the period under investigation and fell to -0.89 in 2012. The relocation of production to low-wage Member States and other measures to increase efficiency and reduce costs have not been sufficiently successful in strengthening the sub-sectors' performance in international markets and attracting EU-27 clients to procure within the Single Market and not from competitors of third countries.

Table 2.28: Trade indicators "Electrical and electronic equipment for motor vehicles"

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE1	bn. €	341.8	9.0	0.3	5.2	-1.8
	29,31		25.4	16.0	1.8	5.4	-2.4
EU-27 exports	EE1	bn. €	113.1	14.6	4.3	11.5	5.7
	29,31		3.2	9.5	4.4	6.9	11.4
EU-27 imports	EE1	bn. €	84.5	19.6	0.2	8.6	4.8
	29,31		5.9	16.1	4.8	14.3	10.5
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE1	%	30.5	16.2	18.6	22.6	27.3
	29,31		14.2	7.0	7.2	7.7	12.0
Import quota[3)]	EE1	%	24.7	15.8	16.7	18.7	22.4
	29,31		23.1	9.6	10.7	12.8	20.5
Trade balances[4)]	EE1	%	14.5	1.6	6.7	11.9	13.1
	29,31		-29.2	-17.5	-21.2	-27.4	-30.9
RCA[5)]	29,31	Index	-0.89	-0.39	-0.54	-0.70	-0.90

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.1.9 Installation of industrial machinery and equipment

Product programme

This sector mainly comprises the specialised installation of machinery including: NACE Rev 2 33.20

- Installation of industrial machinery in industrial plant;
- Assembling of industrial process control equipment;
- Installation of other industrial equipment, e.g. communications equipment, mainframe and similar computers, and irradiation and electromedical equipment etc.;
- Dismantling large-scale machinery and equipment;
- Activities of millwrights;
- Machine rigging;
- Installation of bowling alley equipment.

This sector excludes:

- Installation of elevators, escalators, automated doors, vacuum cleaning systems etc. (NACE Rev. 2 43.29);
- Installation of doors, staircases, shop fittings, furniture etc. (NACE Rev. 2, 43.32);
- Installation (setting-up) of personal computers (NACE Rev. 2 62.09).

This sub-sector is quite different from all the other sectors mentioned under EE1 that are dedicated to the production of physical goods, be it intermediary goods, machinery and equipment or other durable consumer goods. This sub-sector's focus is on industrial services, the installation of power stations, steelworks, petrochemical plants, plants for the manufacture of chemicals, food and beverage processing, as well as plants for the manufacture of transport equipment, semiconductors etc.

The activities – subsumed within this sub-sector – have gained much importance over the past decades. They have become more challenging, driven by the growing integration of the numerous steps of production processes (a primarily horizontal integration) along the flow of material and – more or less vertical integration – necessary for monitoring, process and quality control with further linkages to warehousing and product development and design.

Growing automation and complexity of advanced production systems have contributed to the above average growth of the sub-sector.

Industrial automation

Industrial automation aims at operating and monitoring mechanised industrial processes by using control systems and software. Generally, there exist two main types of industrial automation: factory automation and process automation. While factory automation mainly refers to the manufacturing sector where a certain finished product is constructed out of various different components, process automation is applied in industrial sites where a flow or mixing of liquids needs to be monitored and controlled. Industries that typically include process automation technologies are, among others, the oil and gas industry, the chemicals industry as well as the pharmaceuticals industry. In contrast, end markets for factory automation components are constituted by the automotive industry, the machinery and mechanical engineering sector as well as electronics manufacturers. Yet, a clear distinction is not always possible as industries such as food and beverage, pulp and paper or metals use hybrid automation technologies (batch automation).[85]

Product programme

Different products from the overall product programme that is supplied by the automation industry can be assigned to the three main levels of automation: the supervisor level, the control level and the field level (automation instrumentation).[86]

- The **supervisor level** of industrial automation involves technologies such as Industrial PC's (IPC) and Panel PC's as well as Human Machine Interfaces (HMI). While an industrial PC is a PC-based computing platform for industrial applications, Panel PC's constitute a subgroup that can be distinguished from IPC's by an additional feature. This additional feature is a display which is incorporated into the enclosure of the PC. HMI's are products like text displays and graphic panels that may include a keypad or touchpad. Together, these components generate a user interface which simplifies the supervision and administration of automation equipment.[86]

- The **control level** includes products such as Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), Computer Numerical Controls (CNC) and again, HMI's. A DCS is a control system that consists of multiple controller elements that are distributed throughout the system. In contrast to PLC's which are digital computers that are typically employed in factory automation processes where machinery, robots and

[85] Mitchell, Julian et al. (2012). Global Industrial Automation. Credit Suisse, Global Equity Research, https://doc.research-and analytics.csfb.com/docView?language=ENG&source=emfromsendlink&format=PDF&document_id=994715241&extdocid=994715241_1_eng_pdf&serialid=hDabUewpvOqQcRiLxK7rxIQJZZ8TPLDrYHs47S97OOI%3d

[86] Infineon (2012). Industrial Automation - Efficient & Robust Semiconductor Solutions. Infineon Technologies AG. http://www.infineon.com/dgdl/Industrial_Automation_2013.pdf?folderId=db3a30431689f4420116a096e1db033e&fileId=db3a30433cabdd35013cb48285386c94

assembly lines need to be controlled, DCS's are applied in process applications. At the top of the control level sits the Supervisory Control and Data Acquisition (SCADA) system that monitors a network of PLC's, CNC's and DCS's. The SCADA will never instruct field level equipment (such as motors or drives) directly but rather the controller units (PLC, DCS) only.[85]

- Components that belong to the **field level** are robots, drives, valves and feedback instruments such as machine vision cameras, sensors as well as switches and relays. Robots are computer-controlled machines that mainly find application in the manufacturing of finished goods. Drives are motor control solutions that are used in the generation of mechanical motion. In contrast, valves regulate and control the flow of a liquid and therefore belong to the product range of process automation equipment. While robots and drives do have an active role in the automation process, feedback instruments gather information only. This information is processed by PLC and DCS systems. The processing of the information may lead to an adjustment of robotic activity or more generally, to an adjustment of flow and motion. Machine Vision Cameras consist of image sensors, cameras and processors and are typically applied in factory applications. A sensor is a device that converts a physical property such as temperature, speed or pressure into data. Finally, relays and switches are devices that are responding to an electric current and serve to control circuits.[85]

Besides the typical automation products, there exists mechanical and power supply equipment that is closely related to industrial automation but not belonging to the group of automation products, generally. The close relation arises from the fact that such equipment is used in combination with, or controlled by, automation products. Products that belong to the group of closely related mechanical equipment are actuators, bearings, compressors, mechanical gear and seals. Power equipment includes alternators, batteries, electric motors and switchgear as well as transformers.[85]

Today, enterprise level systems that allow a certain company to let its business objectives govern the plant level control systems (described above) are quite important in industrial automation, too. Yet, as these systems are software / IT systems, many of the established players in the automation industry do not currently produce such systems by themselves. Nevertheless, they typically have a stake in the market as system integrators. Relevant products in this area are Enterprise Resource Planning (ERP), Product Lifecycle Management (PLM) and Manufacturing Execution System (MES). PLM and ERP are both software systems. While the first collects and combines production information, it is the latter that integrates management information as well as finance, sales, service and manufacturing data. In contrast, MES is an IT system that manages manufacturing operations within a factory by combining information from the PLM and ERP.

The integration of R&D and product development into automated production systems has gained importance since the late 1980s. Customisation and acceleration of product innovation in line with reduced time to market intervals have stimulated demand not only for Computer Aided Design (CAD), but for automated interfaces to the production of prototypes and pilot series. This has led to the development of specific software tools, machinery and equipment. One of the newly developed machinery has been 3D-printing, which was first on the market during the mid-1990s. 3D printing is an additive process where layers of material are laid down successively. These printers are applied for model making, moulds etc. They are currently for limited applications only (production volumes are constraint, product sizes are constrained by the size of the printer, only some specific materials can be used). However, this is expected to change in future and 3D-printing will penetrate numerous applications beyond prototyping. With growing standardisation and – in the future – mass production, the manufacture of 3D-printers will be located in Asia.[87]

Demand side

Generally, demand for automation equipment is strongly related to the overall economic climate. Bad economic conditions are intertwined with shrinking profits and a growing cautiousness on prospects, which typically results in a slump in investments on the part of manufacturing industries. This in turn affects sales of the automation industry. While factory automation has proven very cyclical in the past, the overall economic fluctuations impacted the market for process automation equipment slightly less.[87]

Within Europe, the main clients of automation equipment are the automotive industry, the aerospace and defence industry as well as the machine builders. While these industries constitute the demand side for discrete automation products, industries that use process automation equipment are: pharmaceuticals, chemical and food & beverage industries.

According to Credit Suisse Global Equity Research, the global industrial automation market amounted to € 118 billion ($ 152 billion) in 2012, with the discrete automation market totalling € 55 billion ($ 72 billion) and the process automation market depicting a volume of € 63 billion ($ 83 billion). IMS research predicts positive future growth and estimates that the global market for automation equipment will reach € 154 billion ($ 200 billion) by 2015.[87] The most important markets in 2012 were the Asia Pacific (APAC) region and the Americas that together represented 65 % of the world market for automation equipment. With a market volume of € 50 billion ($ 65 billion), Asia itself accounted for about 40 % of the global automation market.[88]

While a resurging machinery production increases confidence in good growth perspectives for the automation market in the USA – machinery production accounts for nearly 50 % of the total demand for products from the automation industry – the APAC region is also very likely to show great demand for various industrial automation control solutions in future. This is due to the fact that many process and hybrid manufacturing companies in Western Europe and North America have recently set up manufacturing plants in the APAC region. Consequently, researchers expect regional growth rates to range between 7 % and 9 % in the coming years, compared to about 6 % in the Americas and 3 % in Europe.[87] Frost & Sullivan also see the BRICS and other emerging countries as growth drivers for demand in the automation market.[89] They expect growth to be the strongest in the Middle East, Southeast Asia and Eastern Europe. Additionally, they also note that opportunities will arise in more developed countries as well, mainly because of infrastructure modernisation.[89]

It is widely expected that China will experience much lower overall industrial and economic growth in future than in the last decade. Although this implies a poor outlook for many industries, it is unlikely to be true for the automation industry because demographic policies, an increasing educational level and massive integration of rural labour in the Chinese manufacturing sector during the past years have led to a rise in wage inflation. Automation equipment suppliers are very likely to profit from this trend as it will urge the domestic manufacturing industry to increase investments in automation in order to produce cost-competitively. Besides, researchers from Credit Suisse remark

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[87] Mitchell, Julian et al. (2012). Global Industrial Automation. Credit Suisse, Global Equity Research. https://doc.research-and analytics.csfb.com/docView?language=ENG&source=emfromsendlink&format=PDF&document_id=994715241&extdocid=994715241_1_eng_pdf&serialid=hDabUewpvOqQcRiLxK7rxIQJZZ8TPLDrYHs47S97OOI%3d

[88] Sultan, Sarah (2012). Global Industrial Automation Market to surpass $ 200 billion by 2015. IMS Research, Press release. http://imsresearch.com/press-release/Global_Industrial_Automation_Market_to_Grow_95_Percent_to_1598_Billion_in_2012_Passing_200_Billion_in_2015_According_to_IMS_Research&cat_id=106&from=

[89] Drives & Controls (2012). Global automation market is growing twice as fast as industrial production. Drives & Controls. http://www.drives.co.uk/fullstory.asp?id=3597

that robot penetration, which is a good proxy for the overall penetration of automation in the end product manufacturing sector, is very low in China. Thus, Chinese demand growth for automation equipment is expected to be strong in future to meet the challenges of rising wages in urban areas.[87]

By looking at end market growth drivers for the automation industry, three industries that together make up more than 50 % of global demand for automation equipment turn out to be of major importance. First, the automotive industry is likely to undertake higher automation investments in this cycle, compared with prior cycles. The explanations behind this are improved balance sheets and an increased product-centric competition among automobile manufacturers in developed markets. Moreover, producers from emerging markets aim at gaining higher market shares, globally. This promises rising capital expenditures. Second, it is the petrochemical industry that will drive future growth. Asian countries, in particular, will make remarkable efforts to develop domestic refinery and chemical processing capacity. Additionally, low gas prices in the US and the shale gas revolution will drive investments in petrochemical plants, too. Finally, the food and beverage industry is expected to push demand for automation equipment.[87]

Supply side

Currently, the most important suppliers of automation equipment are located in Europe, the USA and Japan. In contrast to many other industries, leading suppliers that are based in these countries do not have to face significant Chinese competition as there are only few companies available which are focused on their domestic market. The same is true for Korea which, besides Doosan (KR), does not host major players in the automation market yet.[90]

Among the equipment suppliers, one can observe a recent tendency towards the offering of additional services to customers. These additional services are designed to help clients to easily integrate automation control solutions with software-based plant management systems. Yet, as mentioned earlier, traditional automation equipment suppliers typically aim at having a stake in the market as integrators rather than producers.[91] Credit Suisse further predicts that in the future we will experience increasing vertical and horizontal convergence in the automation sector. This implies that equipment vendors will offer a broader range of products in both markets, for discrete automation as well as the one for process automation. In the past, equipment manufacturers tended to focus on one or few markets only. This convergence is very likely to go along with mergers and acquisitions. Recently, UK-based Softstart UK has, for example, formed a strategic partnership with Delta Electronics, a Taiwanese supplier of drives, PLC’s and HMI’s.[92]

The most important suppliers of automation equipment worldwide are Siemens (DE), ABB (CN) and Honeywell International (USA). Additionally, there are other major players – namely Emerson Electric (US), General Electric (US), Rockwell Automation (US), Schneider Electric (FR), Yokogawa Electric (JP) Mitsubishi Electric (JP) and Omron (JP) – that supply a wide range of automation products and hold remarkable shares in the global market.[91] Looking more specifically at certain products, it turns out that Siemens is the largest player in the PLC market, with a market share of approximately 50 %. In addition, the German company is currently the number one supplier of HMI’s in China. Swiss-based ABB is also very strong with a focus on process automation. It is the most important manufacturer of DCS worldwide. Beside these companies that typically are full-hand

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[90] Drives & Controls (2012). Global automation market is growing twice as fast as industrial production. Drives & Controls. http://www.drives.co.uk/fullstory.asp?id=3597

[91] Research and Markets (2013). The Global Industrial Automation Control Market to Reach US$47.57 Billion By 2015. Research and Markets, Press Release, http://www.researchandmarkets.com/research/j374pv/global_industrial

[92] Drives & Controls (2013). Taiwanese partnership brings automation portfolio to the UK. Drives & Controls, http://www.drives.co.uk/fullstory.asp?id=3797

suppliers, there can be found some more specialised companies. In the robotics market, for example, other important manufacturers are Yaskawa (JP) and Fanuc (JP). Amtel (US) and Sensata (US) are instead actively competing in the sensors market.[93]

According to Wholers Associates, the market for additive manufacturing amounted to about € 1.15 billion ($ 1.5 billion) in 2012. They expect significant growth in the coming years, leading to a market size of € 3.8 ($ 5) billion by 2020. The most important players in the market are 3D systems (US) and Stratasys (USA) followed by vendors such as EOS (DE), Cybaman Technologies (UK), EnvisionTEC (DE) and 3shape (DK).[93] This market segment is closely linked to product development and prototyping.

Assessment of price performance

This sub-sector attracts attention due to the fact that, concerning the average growth rate over the period under investigation, it outperforms the benchmark in all fields. In terms of nominal production the 33.20 sub-sector realised a considerable € 52.2 billion in 2012 and accounted for 14.1 % of EE1 (**Table 2.29**). Its share of employment reached 15.3 %. It is one of the bigger sub-sectors of EE1 and the sub-sector grew much stronger than the benchmark over the period under investigation. In line with the upward trend for output – nominal production increased at an annual rate of 3.4 % over the period under consideration – the sub-sector expanded employment at a higher rate than EE1.

Productivity growth was at an average rate of 4.4 % throughout the period under consideration. Hence, the sub-sector 33.20 belongs to the sub-sectors with the highest productivity gains.

The labour costs of sub-sector 33.20 are slightly higher on average than those of the EE1. The southern Member States and CEE lost some of their former importance as measured by the number of workplaces. In terms of share of employment, the northern Member States gained 15 percentage points, while the southern economies and CEE lost 2.4 and 3.6 percentage points, respectively (**Table 2.30**). Labour costs increased at an annual rate of 1.9 % for the years under investigation, somewhat lower than the growth rate of 2.6 % of the benchmark.

The unit labour costs declined at an average annual rate of 2.3 % between 1998 and 2012. This was roughly in line with the benchmark (-2.4 %).

[93] Mitchell, Julian et al. (2012). Global Industrial Automation. Credit Suisse, Global Equity Research.https://doc.research-and-analytics.csfb.com/docView?language=ENG&source=emfromsendlink&format=PDF&document_id=994715241&extdocid=994715241_1_eng_pdf&serialid=hDabUewpvOqQcRiLxK7rxIQJZZ8TPLDrYHs47S97OOI%3d

Table 2.29: Key indicators "Installation of industrial machinery and equipment"

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electrical engineering	Production, in current prices	bn. €	370.4	8.3	1.1	5.9	-1.1
C3320[1)]			52.2	10.6	1.5	6.1	0.4
Electrical engineering	Production, in 2010 prices	bn. €	362.6	10.0	0.6	4.9	-1.9
C3320[1)]			53.3	10.7	3.2	9.9	1.6
Electrical engineering	Value added, in 2010 prices	bn. €	130.7	10.2	-0.3	2.6	1.0
C3320[1)]			19.7	15.3	5.2	2.2	3.3
Electrical engineering	Employees	1,000	2210	2.4	-1.2	0.6	-1.2
C3320[1)]			337	4.3	-0.4	2.9	-0.4
Electrical engineering	Labour costs per employee	1,000 €	43.4	3.5	2.1	2.5	3.0
C3320[1)]			44.6	4.5	1.5	-0.5	2.7
Electrical engineering	Productivity[2)]	1,000 €	59.2	7.7	0.9	2.0	2.2
C3320[1)]			58.5	10.5	5.6	-0.6	3.7
Electrical engineering	Unit labour costs[3)]	€ / €	0.73	-3.9	1.1	0.5	0.8
C3320[1)]			0.76	-5.4	-3.9	0.2	-0.9
			Annual averages[4)]				
Electrical engineering	GOR[5)]	%	8.9	9.0	8.3	8.5	8.6
C3320[1)]			7.6	6.7	7.8	8.8	7.3

1) Installation of industrial machinery and equipment; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Table 2.30: Regional distribution of employment "Installation of industrial machinery and equipment"

Year	Northern economies[1)]	Southern economies[2)]	CEE economies[3)]	Other Member States
	Electronic engineering			
2012	41.4%	16.8%	17.2%	24.5%
2008	41.5%	17.3%	16.6%	24.6%
1998	47.5%	16.4%	11.8%	24.4%
	Installation of industrial machinery and equipment			
2012	38.2%	21.5%	10.3%	30.1%
2008	35.6%	21.8%	9.6%	33.1%
1998	23.8%	23.9%	13.9%	38.4%

1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.2 The electronic engineering industry

Overview

According to a forecast by DECISION, the world's electronic equipment production and market[94] are to grow at 4.7 % annually over the period 2010 - 2015. Valued at € 1,270 billion 2010, the fortunes of the electronics industry are completely intertwined with the global economy and are expected to reach € 1,600 billion by 2015 (at constant exchange rates 2010, see **Table 2.31**).

94 In DECISION's methodology, World total market value is equal to world production value as stock variation costs are not taken into account. Market and production are expressed in value, in euro at current price with constant exchange rate 2010. Production is calculated at manufacturers' price, i.e. out of factory. Production by region refers to factory location. Therefore, production value for Europe is defined by the factory output of European based factories (and not by the origin of the manufacturer).

Traditional 3C markets (Consumer, Communication, Computing), better known under the ICT acronym, represents the largest market segments of electronic equipment worldwide with 65 % of the global electronic market in 2010 (€ 753 billion, see **Table 2.31**). These end application sectors remain essentially driven, on the one hand, by mass-market demand and corresponding devices such as smartphones, PCs or TVs produced in hundreds of million or even billion units every year and, on the other hand, by the related infrastructure equipment necessary to cope with strongly growing data traffic over the internet. These markets are now fully engaged into the digital convergence era with profound consequences on suppliers' strategies and organisations.

The technological progress in electronics has led to innovative cross-over products that do not only provide value added to consumers but intensify competition. The paramount example is tablets cannibalising the PC market, but also TVs with internet access and smart phones with a wide range of features. This development goes beyond product markets, for instance telecom service providers are challenged by internet telephone service providers.

This development has an impact on business models and companies are adjusting their strategies by far-reaching decisions, most visible in the market for consumer electronics, internet and software. A pioneer in cross-over activities, offering hardware and services, has been Apple, with the iTunes Store successfully launched in 2003. Only recently large behemoths of the service sector have invested manufacturing companies. In 2011, Google acquired the Motorola Mobility. Google not only purchased an important stock of patents of strategic importance, but got access to the creation of innovative IT-products. This access provides an edge in competition with other internet service providers to attract users. The integration of specific features in new products, in particular Google-centric User Interfaces (UI), serves an intensification and extension of the relationship with users of their own services. In 2012, Microsoft, the global leader of PC operating systems, entered the hardware market with a tablet computer. In 2011, Microsoft and Nokia started a close co-operation that – after years of losses in the global market for smart phones attributed to poor product innovation – led to the successful launch of Lumia running the Microsoft operating system. Struggling Nokia decided only recently to focus on its network business area and finally sold its mobile phone business to Microsoft.

These developments lead to structural changes in EE2's supply side that will further increase competitive pressure beyond the trend in sales markets to create more and more cross-over products, cannibalising the more traditional products, such as the at least partial substitution of PCs by tablets. The investment of large service companies such as Google and Microsoft, with their enormous financial resources in equipment manufacturers, will change the whole sector. In the short-run these M&A will cause losses of workplaces in particular in target companies. What will happen in the long-run is not yet clear.

These corporate strategies are quite new and their success is not given. One of the most critical points is the fact that service companies investing downstream become competitors to their clients. OEMs, dependent on upstream software, have to be sure that they are treated fairly compared to their competitors with upstream affiliation. With regard to upstream market environment, the options for retaliation seem to be limited for manufacturers. Moreover, this can become an issue for anti-trust authorities. Currently it is too early to assess future trends.

Table 2.31: Global ICT equipment market from 2010 to 2015 in value (million euros)

In Million euros	2010	2011	2012(f)	2013(f)	2014(f)	2015(f)	2010-15 (*)
COMPUTER	**291 821**	**301 855**	**319 449**	**339 357**	**354 052**	**369 834**	***4.9%***
PCs	158 495	163 175	178 054	191 560	204 017	217 686	*6.6%*
Peripherals	98 776	102 980	105 145	109 247	110 345	111 268	*2.4%*
Mainframes, mid-range computing & dedicated terminals	34 550	35 700	36 250	38 550	39 690	40 880	*3.4%*
COMMUNICATION	**292 779**	**323 891**	**341 686**	**365 872**	**395 280**	**428 785**	***7.9%***
Mobile phones	148 300	168 812	179 926	191 867	209 072	229 454	*9.1%*
Terminals	16 324	16 699	17 200	17 575	17 668	17 750	*1.7%*
Telecom & network	128 155	138 380	144 560	156 430	168 540	181 581	*7.2%*
CONSUMER	**168 086**	**166 757**	**164 989**	**164 126**	**163 362**	**162 909**	***-0.6%***
TVs	80 202	80 942	82 224	80 535	80 172	79 953	*-0.1%*
Other (Set Top Box, DVD player, etc.	87 884	85 815	82 765	83 591	83 190	82 956	*-1.2%*
TOTAL ICT	**752 686**	**792 503**	**826 124**	**869 355**	**912 694**	**961 528**	***5.0%***
TOTAL NON-ICT[95]	**517 314**	**549 497**	**567 876**	**589 645**	**617 306**	**638 472**	***4.3%***
TOTAL Electronics	**1 270 000**	**1 342 000**	**1394 000**	**1 459 000**	**1530 000**	**1 600 000**	***4.7%***

(*) Compound average growth rate
Source: DECISION

Assessment of the economic performance of EE2

The EU-27 EE2's **gross output at current prices** reached € 201.1 billion in 2012. It represents 32 % of the aggregate EEI sector, which was down from the period of 1998 - 2003 when the ratio was around 40 %. This declining development was caused by two breakdowns followed by a moderate recovery only. The first one occurred as a result of the telecommunication crisis in 2001. The second one was caused in 2009 by the global financial crisis. The poor economic environment in Europe led to a muted increase after this slump. In 2012, the level of gross output was nearly 20 % below the 2008 peak. The evolution of the EE2's **production at current prices** was better off. In 2012 it missed its 2008 peak by "only" 7 %. Throughout the period under consideration – with the exception of 1998 to 2000 – EE2's nominal growth was below EEI. This is reflected in employment which declined at an annual average rate of 1.6 % between 1998 and 2012, whereas for EEI the number of workplaces decreased at 0.7 % p.a. In absolute figures this represents a reduction of around 200,000 staff. (Table 2.31)

Due to technological progress, product prices fell between 1998 and 2012 at an annual rate of 4.4 % – EE2's development performs better at constant prices. Real value added increased at an

[95] Non ICT refers to electronic dedicated to the industry, to aerospace and defence, to automotive, etc.

annual rate of 2.9 %, a higher pace than for the EEI and labour productivity even grew much stronger at a rate of 4.5 %. In combination with a trend growth in labour costs per employee of 1.7 % annually – well below the EEI (2.3 %) – the efficiency of labour input ameliorated and ULC fell at an annual rate of 2.7 % in the period of 1998-2012, whereas for the EEI the rate of improvement was only 1.1 % in the same interval. Profitability, as measured by GOR, was lower during the early years of the investigation for EE2 compared to its benchmark, but has since improved.

A detailed analysis of EE2 companies' balance sheets discloses that the financial performance of EU EE2 firms in international comparison had worsened when the financial crisis begun. The negative trend had continued up to the latest available figures. For preceding years the EU firms' performance was quite good, comparable with non-EU players (Chapter 4.5.3).

Table 2.32: Key indicators for the EU electronic engineering sector (EE2)

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
EEI[1]	Production, in current prices	bn. €	635.8	9.5	-0.2	4.6	-1.2
Electronic engineering			201.1	10.5	-1.9	1.5	-1.7
EEI[1]	Production, in 2010 prices	bn. €	651.1	9.7	0.8	7.2	-0.1
Electronic engineering			211.7	9.1	1.1	8.1	1.7
EEI[1]	Value added, in 2010 prices	bn. €	212.4	8.9	0.1	5.3	1.2
Electronic engineering			60.6	5.3	0.9	7.4	0.9
EEI[1]	Employees	1,000	3389	2.2	-1.7	0.5	-1.9
Electronic engineering			882	1.7	-2.4	0.1	-3.3
EEI[1]	Labour costs per employee	1,000 €	43.3	3.4	1.6	2.1	2.8
Electronic engineering			43.2	3.0	0.7	1.4	2.6
EEI[1]	Productivity[2]	1,000 €	62.7	6.5	1.7	4.8	3.2
Electronic engineering			68.8	3.5	3.5	7.3	4.4
EEI[1]	Unit labour costs[3]	€ / €	0.69	-2.9	-0.1	-2.5	-0.3
Electronic engineering			0.63	-0.5	-2.7	-5.6	-1.7
			Annual averages[4]				
EEI[1]	GOR[6]	%	9.0	8.6	7.7	8.5	8.8
Electronic engineering			9.6	7.9	7.2	8.6	9.6

1) Electrical and electronic engineering; 2) Electrical and electronic components; 3) (Value added in 2010 prices) / employment; 4) (Nominal total labour costs) / (value added in 2010 prices); 5) for the period under consideration; 6) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: Eurostat, Cambridge Econometrics

The moderate development in labour costs per employee is explained by a shift in the regional distribution of production. While during the early phase of the period under consideration nearly half the employment was in northern economies of the EU, this share reduced from nearly half to around 40 % in the recent past. Relocation of production has led to a creation of workplaces in CEE and the share of the sub-sectors of electronic engineering in total EEI employment increased to roughly 17 %. (**Table 2.32**)

Most of the EMS[96] have set up or acquired factories in CEE countries to cover Single Market needs, such as Flextronics and Foxconn in Czech Republic, Hungary, Poland and other Eastern countries. Among other firms are Jabil Circuits, Celestica, Sanmina, Zollner, etc. The Taiwanese ODMs[97] have also their CEE workplaces, most of them in the Czech Republic such as Asustek, BenQ, Inventec or Quanta.

[96] EMS: Electronic Manufacturing Services.

[97] ODMs: Original Design Manufacturers.

Table 2.33: Regional distribution of employment for "Electronic engineering"

Year	Northern economies[1)]	Southern economies[2)]	CEE economies[3)]	Other Member States
	Electrical and electronic engineering			
2012	40.7%	16.8%	14.8%	27.7%
2010	39.3%	17.4%	14.6%	28.7%
1998	36.6%	18.6%	11.2%	33.6%
	Electrical engineering (EE2)			
2012	41.4%	16.8%	17.2%	24.5%
2010	41.5%	17.3%	16.6%	24.6%
1998	47.5%	16.4%	11.8%	24.4%
	Electrical and electronic components (EE3)			
2012	33.7%	16.1%	16.6%	33.7%
2010	31.7%	16.3%	16.9%	35.1%
1998	33.5%	17.4%	9.7%	39.4%
1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia.				

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance of EE2

The domestic demand for products of EE2 increased at a modest 1.34 % p.a. over the whole period of investigation, well below demand for EEI products, at 1.8 %. This reflects the year-after-year price-per-unit decrease of popular mass-market items such as PCs, mobile phones, or TVs. Cyclicality and the impact of the two economic crises affected the electronics industry and the EE2 market during successive periods, comparable to EEI. With negative growth of its domestic demand over 2008 to 2012, the EE2 is challenged and EU-27 manufacturers become more dependent on foreign markets to survive.

The second specific evolution of the EE2 sector during the period of investigation is the low and further decreasing share of production on domestic demand. The import quota increased from 42.5 % during the first phase of the period to 58.3 % during the last one. Such levels describe a very globalised industry where mass-market items production has been massively transferred to low-cost countries, primarily to third countries, but also within the EU-27. Within the EU-27 above all CEE has benefitted. However, compared to competing economies in Asia, wages are high. With regard to wage differentials, CEE production locations need comparative advantages to stay competitive. Growing wage differentials between CEE and Asian economies would affect this fragile equilibrium negatively.

The export quota for EE2 had grown more rapidly than for its EEI benchmark, from 29.6 % (1998 – 2000) to 43.9 % (2008 – 2012) compared to 24.8 % increasing to 32.5 % for EEI. This increase is to a large extent caused by poor growth of EU-27 production while exports in some markets continued to grow.

Within EE2, the different sub-sectors are of different importance for the trade performance of the sector. "Manufacture of communication equipment" (26.30) is the largest sub-sector by production in current prices. This is due to the traditional fixed-line telephony which always has been dominated by European firms. In 2012, it is still one of the sub-sectors driving exports of EE2. The second sub-sector – or more adequately, group of sub-sectors – in importance within Electronic Engineering is the medical electronic industry represented by sub-sectors "Manufacture of irradiation, electromedical and electrotherapeutic equipment" (26.60) and "Manufacture of medical and dental instruments and supplies" (32.50). Almost equivalent in 2012 with sub-sector 26.30 in term of production, they together represent 39 % of the total exports of EE2, and exports from these two sub-sectors have grown by 10.0 % p.a. from 1998 to 2012, well above all other sub-sectors of

EE2. These sub-sectors are the only ones within EE2 to present largely positive trade balances. Third in importance within EE2 comes “Manufacture of computers and peripheral equipment” (26.20) which is characterised by the largest trade deficit. Reflecting the fragmentation and the specialisation of the world electronics industry, the ratios of export quota and import quota of 26.20 for 2012 are extremely high: 81.5 % and 93.1 %, respectively. Also presenting a significant trade deficit is the sub-sector “Manufacture of consumer electronics” (26.40). Having largely abandoned the production of TV sets and boxes, never involved in the manufacturing of DVD players or video game consoles, EU-27 is today mainly focused on audio systems. But sub-sector 26.40 represents only 13.7 % of the production of EE2 in 2012.

Table 2.34: Trade indicators for “Electronic Engineering”

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EEI	bn. €	694.4	10.9	-0.9	4.7	-1.2
	EE2		275.0	10.4	-1.3	2.9	-0.8
EU-27 exports	EEI	bn. €	226.0	17.2	3.0	1.9	3.7
	EE2		95.8	17.4	4.1	-1.2	3.0
EU-27 imports	EEI	bn. €	284.6	19.3	0.3	2.7	2.7
	EE2		169.7	14.3	3.0	2.4	2.5
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EEI	%	35.5	24.8	28.5	29.9	32.5
	EE2		47.6	29.6	36.2	39.3	43.9
Import quota[3)]	EEI	%	41.0	32.1	34.5	35.9	39.0
	EE2		61.7	42.5	48.5	54.2	58.3
Trade balances[4)]	EEI	%	-11.5	-17.8	-13.9	-13.7	-14.1
	EE2		-27.8	-27.6	-24.6	-29.4	-28.3
RCA[5)]	EE2	Index	-0.34	-0.21	-0.21	-0.30	-0.30

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.2.1 Computers and peripheral equipment

Overview

The computer industry consists of computers (PCs, servers, mainframes), peripherals (printers, monitors, keyboards, etc.), and a variety of other specific devices (smart card readers, projectors, etc.). Initially mainly made up of mainframes and used by corporate or governmental organisations, the computer industry turned to individual uses with the first PCs. Initially, it took time to see these personal computers installed everywhere, from offices to households. With a world production in 2012 of about € 320 billion (compared to € 302 billion in 2011, see **Table 2.31**), the computer and peripheral equipment industry represents 35 % of the whole ICT manufacturing equipment industry. During the past decade, the computer industry exhibited a fast growth rate in terms of the number of machines sold, which was balanced by a permanent retail and manufacturing price reduction. The sector was severely hit by the burst of the dot-com bubble in 2001 and the global economic recession in 2008. (**Table 2.33**)

Table 2.35: Production of computers and peripheral products, 2011 (€ billion)

	Europe[98]	North America	Japan	China	Other A/P	Rest of the world	**World**
Production	16.980	31.459	31.848	140.874	70.803	9.890	301.854
%	*5.6 %*	*10.4 %*	*10.6 %*	*46.7 %*	*23.5 %*	*3.3 %*	*100 %*

Source: DECISION

Europe still represents a major part of the world demand in 2011 with 27 %, which implies a slight but regular decrease compared to the nearly 31 % in 2005. In terms of manufacturing locations, after a move from Western Europe (and especially Ireland) to Eastern Europe, the assembly operations of computers and peripherals have been transferred to Asia. European production fell from 10% in 2005 to only 5.6 % of the global production in 2011 (**Table 2.35: Production of computers and peripheral products, 2011 (€ billion)**). These figures indicate that Europe is strongly dependent on imports to meet domestic demand, from 70 % in 2005 to nearly 80 % in 2011.

Product programme

Personal Computers

From its invention in the late 1970s, the Personal Computer (PC) industry has grown significantly to become an essential digital platform, providing productivity gains, comfort and entertainment across the board from enterprises to households.

Major product segments of the PC industry include:

- Desktop PCs;
- Notebook PCs (traditional laptops, netbooks and ultrabooks);
- Digital tablets.

During the 1980s PCs were among the first electronic equipment to be produced on a massive scale and PC production has long been the driver for the whole electronic industry. In 2011, out of 365 million PC units sold worldwide, 40 % were desktop and 60 % notebooks. Just like Apple did in 2007 with the smartphone market, reinventing the existing tablet concept into a new multi-application platform connected to the internet and providing access to a library of on-line content and services through its proprietary application store. The global tablet market is growing rapidly as shown in **Figure 2.1** with 120 million units sold in 2012. Tablets in fact have killed the netbook market in less than 3 years as in early 2013; both leaders, Acer and Asus have announced they would stop making such products. Tablets are also cannibalising desktop and laptop PC sales and are becoming a real alternative in both the consumer and enterprise PC applications.

Servers and mainframes

Ranging from low-end servers, which are not very different from a powerful personal computer, to high-end servers, up to powerful big mainframes called “supercomputers”, this segment represents around 10 million units sold worldwide per year. Big data processing and IT-Cloud computing are trends boosting this market.

Peripherals

The *printer/scanner* market has become a mature market challenged by uncertain perspectives, caused by more recent, dematerialised solutions offered by cloud computing that will limit potential growth in the coming years. The *monitor* market is mainly influenced by the declining desktop sales. It totalled 170 million units sold in 2011. The increase of built-in displays in notebooks, tablets, smartphones, and connected-TVs limits the growth prospects for monitors. The *storage equipment* market comprising of external Hard Disk Drives and Controller-Based Disk Storages will continue to

[98] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

grow rapidly with the development of data exchanges and communication devices. The most important driver in the market will be the substitution by solid-state drives. This semiconductor-based technology is characterised by permanent price decreases. It should entail a reorganisation of the value chain, which will benefit semiconductor manufacturers.

Dedicated terminals
The smart card readers market (under their various forms, including ATM and POS[99] devices) is expanding as the smart card industry is one of the most dynamic market segments. New applications are constantly stimulating its growth, both in traditional applications and in new ones, such as government or health systems. Smart cards provide an increased level of security, privacy and trust in all digital transactions and secured communications, which are rising exponentially due to the worldwide development of e-business, e-government, e-banking, and e-health solutions.

Demand side

From 140 million units in 2000, the PC world market reached 218 million units in 2005 and 365 million units in 2011 (See: **Figure 2.1)**. But in 2012, due to competition from the exploding tablet market, PC unit shipments decreased to 353 million units. In the meantime, tablet shipments increased from 71 million units in 2011 to 122 million units in 2012. Over the recent past, the major trend influencing the development of the PC market was the gradual overtaking sales of desktop PCs by notebook PCs in both unit and average selling prices. The latest major trend of the PC market was triggered in 2010 with the arrival of the Apple's tablet capturing 70 % of the market during the first year of iPad's commercialisation and 50 % in 2012 with Samsung and Amazon being its closest followers. The tablet growth momentum is forecasted to continue as tablets will carry on to cannibalise traditional PC sales, growing on average at 71 % per year to more than 280 million tablet sales in 2015, representing a similar volume of the entire notebook market. This is a remarkable achievement for a product category that barely existed in the beginning of 2010.

Over the period of 2010 to 2015, the global PC market should grow on average over 6.6 % reaching € 218 billion sales in 2015. This € 60 billion growth in value terms over 2010 will be equally shared among notebook PCs and tablets, the latter representing in 2015 a € 33 billion market. Tablet sales in value terms will be 50 % higher in 2015 than ultra-mobile PC sales, which will suffer due to competition from tablets.

Europe, with a market value of € 46 billion (29% global market share) in 2011, continues to represent a very large slice of world demand for PCs. While desktops are on the decline with sales of € 12 billion in 2011 (down by 8% over 2010), notebook sales were stable at € 31 billion. During 2010 to 2015, ultra-mobile PCs and tablets, with respectively 27 % and 52 % average growth rates, are the most dynamic product segments. Europe is expected to be a very significant market for tablet PCs, representing sales of € 10 billion in 2015 and approximately 30 % of the global demand for this product category, while only a few are manufactured in the Single Market.

Table 2.36: Tablet market (E-readers excluded): EU-27 market share 2010 and 2015

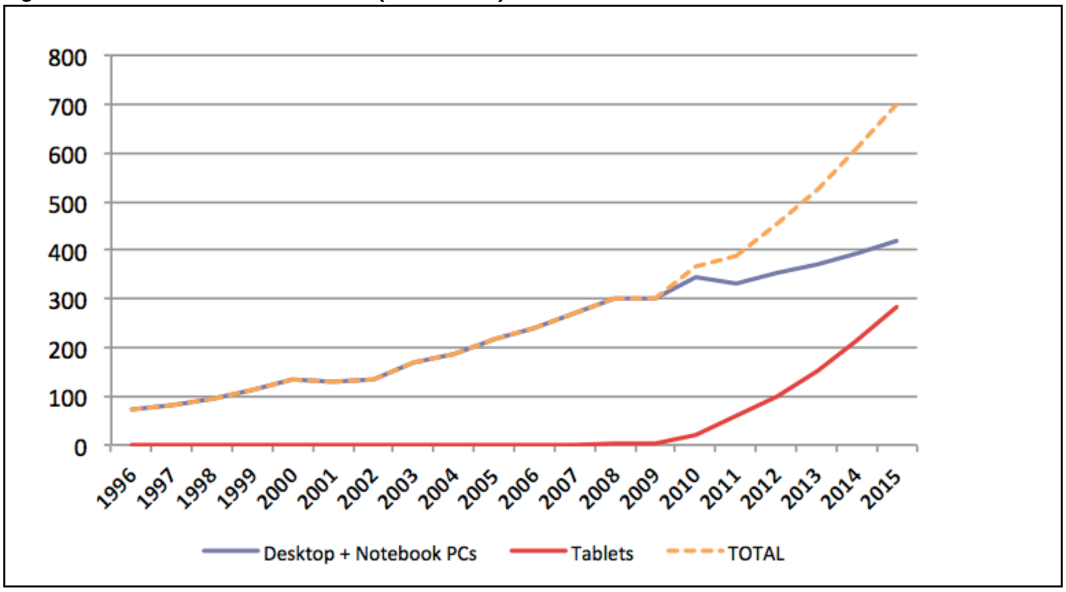
Tablet market (million units)	2011	2015
World	65	175
Europe	13	52
% Europe	*20.0 %*	*30.0 %*

DECISION

[99] ATM: Automatic teller machine POS: Point-of-Sale.

With an average growth rate of 3.6 % over 2010 - 2015, the total European PC market is expected to grow at a slower pace than the world market. Accordingly, Europe will lose market shares against other regions and, in particular, the Asia Pacific region where demand is more dynamic. From 29 % of the global PC demand in 2011, Europe's share of the world PC market will decline to 25 % by 2015.

Figure 2.1: PC Sales in Million Units (1996 - 2015)

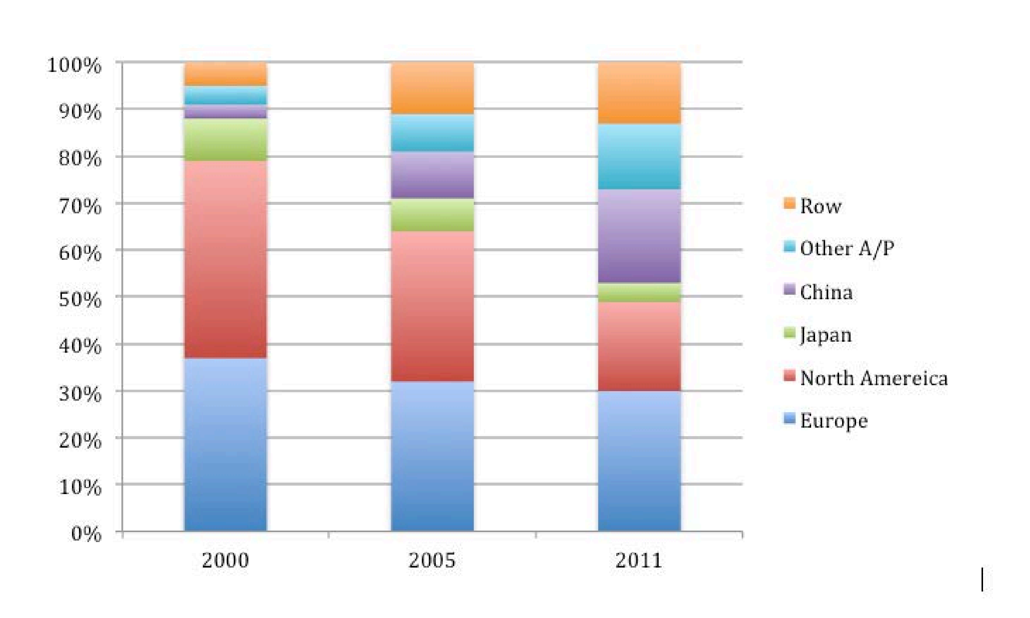


Source: Companies' reports; DECISION

In the course of the last decade, the PC market split between regions in the world has completely changed (See **Figure 2.2**). Since the early days of computers the largest market for PCs, the US, has been surpassed by China in 2011. In spite of the slowdown in 2012, the PC market continues to move from developed countries, namely the US and Western Europe, to the emerging economies in Asia, Latin America and other areas. Long-term growth drivers will continue and in spite of growing functionality prices will continue to decline. Inside Western Europe, the three main markets, Germany, UK and France, represent together nearly 60 % of the total EU market for PCs.

The mainframe and server market is still dominated by North America, Europe and Japan. The server market is changing: low-end servers are declining alongside desktop computers. Virtualisation, on the other hand, is creating growth in the high-end server segment.

Figure 2.2: PC sales breakdown by region in value (%)

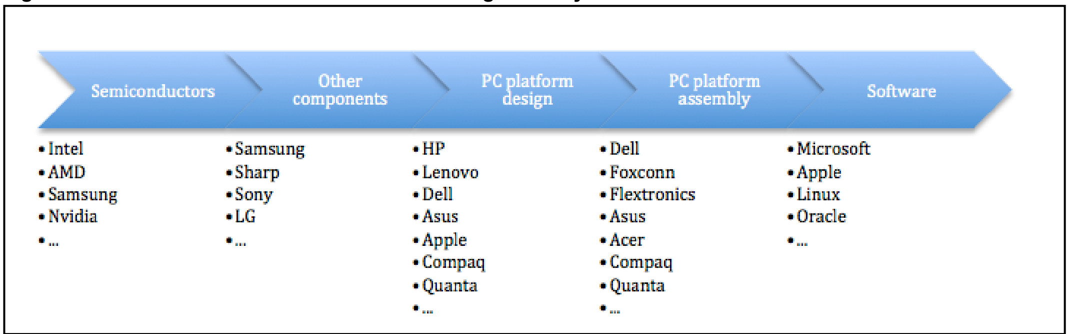


Source: DECISION

Supply side

The PC industry is characterised by its continuous price decreases that have not only been made possible through economies of scale but also through industrial specialisation and value chain restructuring. The value chain of the PC manufacturing industry is illustrated by **Figure 2.3** showing major players at the different steps. A first observation is that no European company is mentioned.

Figure 2.3: Value chain of the PC manufacturing industry



Source: DECISION

The driving factor of PC industry specialisation finds its origin in the PC's core architecture. Since the first computers were assembled by young students in their garage, the key building blocks of a PC remained almost unchanged: a microprocessor, different types of memories including Random Access Memories (semiconductor) and magnetic Hard Disks Drives, peripherals (external disks, monitor, keyboard, mouse, speakers, etc.) all connected through a motherboard. In addition, the software running the computer, its operating system, was from the very beginning one of its major elements. Within this value chain, the respective parts are not contributing equally to the operating margin finally obtained from the end-customer. During the period of 1990-2005, the monopoly of Intel for semiconductors and Microsoft with Windows as the universal PCs operating system has allowed these companies to generate the highest margin rates (See: Chapter 4.5 on the international comparison of companies' financial performance).

This stable and rather standardised architecture – organised around integrated products containing most of the added value (microprocessors, memories) – encouraged PC integrators to outsource manufacturing activities either to functional module specialists performing both the product development and manufacturing (motherboards, monitors, Hard Disk Drives, etc.) or to sub-contractors for electronic boards assembly.

The development of the PC industry in the 1980s consequently gave birth to a complete supply chain comprising not only of brand markets like modules suppliers (for instance, Seagate or Western Digital for Hard Disk Drive supply) and motherboards (main actors are Taiwanese companies such as Asus, Gigabyte and AsRock), but also of display modules, which have more recently become a key component for notebooks, tablets, hand-held devices such as mobile phones etc.[100].

Due to the fact that most of the manufacturing processes involved in the PC industry were labour intensive (with the notable exception of the semiconductor industry), the cost pressure led these suppliers to progressively locate most of their manufacturing activities in low cost regions, starting with Mexico and then Asia soon after. These investments eventually concentrated to form clusters in specific countries, much like what happened to the Hard Disk Drive suppliers in Thailand (which was hit by a massive flood, causing distortions in the global value chain).

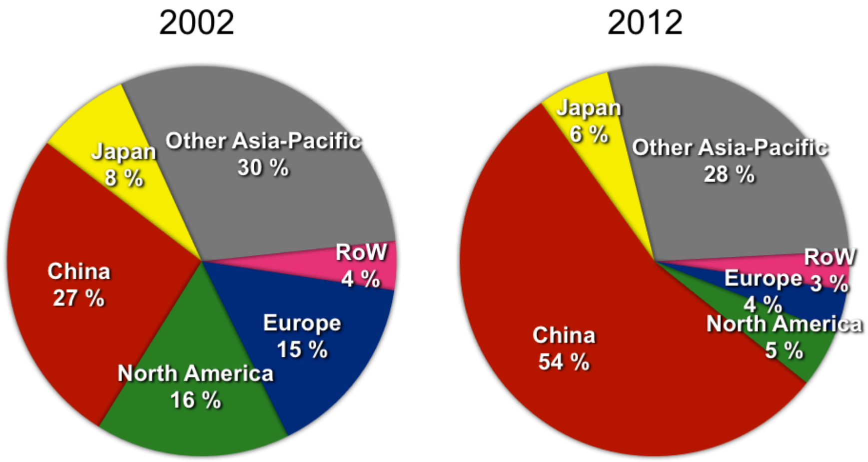
Contract Electronics Manufacturers (CEM) also evolved to provide additional services to their clients from the PC industry (including procurement, logistic, etc.), transforming their business model to become global Electronic Manufacturing Services companies (EMS).

The influence of semiconductor memories and processors on the costs, performance and global architecture of PCs made it possible for some EMS to even add design services to their offering, thereby transforming their business model to become Original Design Manufacturers (ODMs). These ODMs, almost exclusively located in Taiwan (Compal, Quanta, Wistron, Inventec, etc.), are capable of designing and manufacturing complete products (PCs) based on the global specifications given by clients who are simply branding and marketing the final product.

The ODM model developed very rapidly in the PC industry and specifically in the notebook segment, explaining the massive relocation of PC production to China during the last decade (See **Figure 2.4**).

[100] The market for small and medium-sized displays comes up to 200 million units per month. The main manufacturers are Taiwanese (ChiMei Innolux, Hannstar, AU Optronics, etc.), Korean (LG Display and Samsung), and to a lesser extent Japanese (Sharp, Japan Display, Panasonic).

Figure 2.4: PC production breakdown in value by region, 2002 and 2012



Source: DECISION

In the PC market, the top 5 ranking of major manufacturers has seen much movement and change over the past six years. Fujitsu-Siemens, previously ranked 5th in 2005, was ousted by Toshiba, specialised in notebook sales; however, this company also lost its position in 2011 – only a couple of years later – to Asus. Dell lost its leading position to HP due to declining business demand and its historic focus on desktop computers and has fallen to 3rd place after Chinese Lenovo (ex-IBM), which took second place in 2011.

Table 2.37: PC market shares by units 2005 and 2012 (without tablets)

Manufacturer	Country	World market share (%)	
		2005	2012
Hewlett-Packard	USA	14.5 %	16.0 %
Lenovo	China	6.9 %	14.8 %
Dell	USA	16.8 %	10.7 %
Acer	Taiwan	4.6 %	10.4 %
Asus	Taiwan	-	6.9 %
Fujitsu-Siemens	Japan/Germany	3.8 %	-
Others		53.3 %	41.3 %

Source: Gartner

This traditional ranking of PC suppliers has lost its significance as it does not take tablet sales into account. Within this larger market Apple is leading ahead of Hewlett-Packard both in units and revenue thanks to its outstanding position in the tablet segment. It is becoming more and more difficult for the market leaders of the data processing industry to generate profits out of PC sales since all major suppliers are now adopting a follower approach.

Table 2.38: PC + tablets market shares by units in 2012

Manufacturer	Country	World market share% 2012
Apple	USA	17.6 %
Hewlett-Packard	USA	12.0 %
Lenovo	China	11.3 %
Dell	USA	8.0 %
Acer	Taiwan	7.0 %
Others		44.1 %

Source: Gartner, IDC

The only exception is Apple, which manages to differentiate its products thanks to an in-house-design and therefore unique Operating Systems (OS) built to suit the specific choice of hardware architecture. Other PC manufacturers do not design their own OS and are dependent on Microsoft to bring innovation on the software side. With no possibilities of customisation for the OS and therefore little differentiation between their products, these computer manufacturers are obliged to enter in a fierce price competition. In such conditions, PC manufacturers are making little margins and the supply consolidation trend initiated in 2000 (HP-Compaq, Fujitsu-Siemens, Lenovo-IBM, Acer-Gateway, Packard-Bell) is expected to continue with future mergers and acquisitions. Historical leaders in the audio-video or telecommunication business are also eager to find a way to grab some of the benefits of digital convergence.

The server market used to be almost exclusively monopolised by the US: only few years ago, over 70 % of world sales were made by IBM, Hewlett-Packard and Dell. These companies' domination is slowly eroding and their common share is now at around 60 %. The sub-segment of supercomputers is a niche and specialists market. Among today's vendors of the fastest supercomputers are US companies Cray, IBM and SGI, but also the Chinese Dawning and Nudt, the Japanese NEC and Fujitsu, and the French Bull.

Technology, R&D policies

The heart of a PC (desktop or notebook) is its motherboard on which processors, memories, and other semiconductors are mounted. There is a brand market of motherboards for which the main actors are Taiwanese companies (e.g. Asus, Gigabyte and AsRock). The display module is also a key component for notebooks, tablets, hand-held devices as mobile phones, etc. The market for small and medium-sized displays (PCs, tablets and mobile phones) reaches 200 million units per month. The main manufacturers are Taiwanese (ChiMei, Innolux, Hannstar, AU Optronics, etc.), Korean (LG Display and Samsung) and to a lesser extent Japanese (Sharp, Japan Display, Panasonic).

R&D in the PC area is organised differently by Apple and its competitors. Apple has concentrated its R&D labs and offices at its headquarters in California. It defines its PC platforms internally and has equipped them initially with Motorola, then IBM and finally Intel processors. Currently Apple is investigating the possibility of using on PCs the ARM processors used on its iPhone and iPad devices. In addition, Apple configures its PC Operating System and friendly-user software packages in-house. This is one of its major success factors.

ARM, a European processor manufacturer, is using a technology based on RISC methods (Reduced Instruction Set Computing) that is using much less power than others. ARM is not a chip manufacturer like Intel or AMD, but negotiates licence deals to those who want to use its technology. The company provides a proven technology and its strategy has turned out to be very successful, especially for all mobile device applications. Here we see one of the strengths of the EU-27 in the area of advanced information and telecommunication technologies to drive the pace of development by expertise and remain indispensable to international manufacturing networks. Thus, such companies have the potential to overcome the detriment of the weak (compared to Asia) EU manufacturing cluster for large batch production of electronic products. These companies will also be able to keep up with the pace of global developments to the benefit of the EU semiconductor industry.

Competitors such as Hewlett-Packard and Dell have transferred their R&D works for PCs to their Taiwanese ODM subcontractors, which work in close relations with the semiconductor firms, in order to manage the time-to-market of each new generation of processor.

Due to the relocation of computer manufacturing from Europe[101] (and the US) to Asia, the remaining operations are limited to niche markets and customised items. But this is masking the fact that an important part of ICT manufacturing and R&D in Europe is made of "embedded" ICT. However, these are "computers" for specific applications, an area where Europe commands a leading position globally, based on European clusters. Of major importance for these strengths are the automotive, machinery and aeronautics industries. Dedicated parts of this study will present these activities, which are not currently covered by available statistics.

Assessment of economic performance

The production of the 26.20 sub-sector accounts for 14 % of EE2's nominal production in 2012, half the percentage reached in 2000. Throughout the period under consideration the sub-sector's production decreased by 4.1 % on average per year. In parallel, the European share of global production of computers etc. fell from 10.5 % in 2005 to below 6 % in 2011 (see: **Table 2.33**). It is important to note that the poor development became more pronounced in the recent past. The sub-sector did not only suffer a major slump in 2009 due to the global financial crisis. In contrast with EEI industry as a whole, the decline continued in 2010 (-20.5% for sub-sector 26.20 versus +10.1% for EEI).

The shrinking nominal production had a strong impact on employment. In 2012, the workforce of the 26.20 sub-sector totalled around 90,000, accounting for approximately 10 % of EE2. (**Table 2.39**) Over the period under investigation the sub-sector had shed nearly one third of the employees occupied around 2000. This development is interlinked with a strong growth in labour productivity at an annual average rate of 6.5 %, well above the benchmark EE2 with productivity gains of 4.5%. The sub-sector's improvement of productivity exceeded by far the growth of value added – as calculated in constant prices – which has caused the reduction of workplaces. 26.20 is one of EE2's sub-sectors that, in contrast to the general tendency, were able to reduce labour costs per employee. Together with a growth of productivity, this has led to a noteworthy improvement of ULC. But the reduction of ULC at an annual rate of 7.4 % did not contribute to an increase of profitability on a comparable level with its benchmark. Moreover, the improvement was primarily the result of consolidation driven by the closure of production sites with the lowest margins.

[101] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

Table 2.39: Key indicators "Manufacture of computers etc."

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electronic engineering	Production, in current prices	bn. €	201.1	10.5	-1.9	1.5	-1.7
C2620[1)]			27.9	4.8	-4.3	-2.4	-9.3
Electronic engineering	Production, in 2010 prices	bn. €	211.7	9.1	1.1	8.1	1.7
C2620[1)]			31.5	-3.8	2.2	17.1	-3.8
Electronic engineering	Value added, in 2010 prices	bn. €	60.6	5.3	0.9	7.4	0.9
C2620[1)]			6.1	-6.8	-1.1	18.7	-1.6
Electronic engineering	Employees	1,000	882	1.7	-2.4	0.1	-3.3
C2620[1)]			90	-0.9	-6.6	-0.8	-6.0
Electronic engineering	Labour costs per employee	1,000 €	43.2	3.0	0.7	1.4	2.6
C2620[1)]			38.1	2.3	-1.5	-3.6	-1.4
Electronic engineering	Productivity[2)]	1,000 €	68.8	3.5	3.5	7.3	4.4
C2620[1)]			67.5	-5.9	5.8	19.7	4.7
Electronic engineering	Unit labour costs[3)]	€ / €	0.63	-0.5	-2.7	-5.6	-1.7
C2620[1)]			0.57	8.7	-6.9	-19.4	-5.8
			Annual averages[4)]				
Electronic engineering	GOR[5)]	%	9.6	7.9	7.2	8.6	9.6
C2620[1)]			7.0	3.9	3.9	4.6	7.0

1) Manufacture of computers and peripheral equipment; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Regional changes in the locations for the production of computers and peripherals are indicated by the distribution of workplaces within the EU-27. In 1998, roughly one third of employment was in northern economies. This region lost some of its former importance, similar to the losses of southern economies. Most important were the changes for CEE. Roughly 9,000 workplaces were created up to 2012, not a large number, but the total CEE share of the sub-sector's employment came to 18% of the total. This more than compensated for the losses of employment in this country group "Other Member States", among them Ireland, which lost importance. This regional change contributed to the reduction of labour costs per employee during the period under investigation. (**Table 2.39**)

Table 2.40: Regional distribution of employment for "Computers and peripheral equipment"

Year	Northern economies[1)]	Southern economies[2)]	CEE economies[3)]	Other Member States
	Electronic engineering			
2012	41.4%	16.8%	17.2%	24.5%
2010	41.5%	17.3%	16.6%	24.6%
1998	47.5%	16.4%	11.8%	24.4%
	C2620 Manufacture of computers and peripheral equipment			
2012	30.0%	11.8%	17.3%	41.0%
2010	30.2%	12.4%	19.5%	38.0%
1998	31.5%	14.4%	5.5%	48.6%

1) Austria, Denmark, Finland, Germany, Netherlands (2010), Sweden; 2) Italy, Portugal, Spain; 3) Czech Republic (2010), Hungary, Poland, Slovakia.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

In 2012, the domestic demand of computer and peripheral equipment reached almost € 75 billion and represents 27 % of total EE2. For three out of four periods under investigation demand had declined. EU-27 market value in nominal terms had shrunk by € 13 billion, caused by falling prices. In real terms, the market volume had grown at an annual average rate of around 8 %.

Exports only marginally increased during the period under investigation, from € 20.3 billion in 1998 to € 22.7 billion in 2012, but in the meantime imports progressed at a faster pace from € 58 billion to € 69.7 billion. The trade deficit increased greatly and trade performance was worse than for the benchmark. This is reflected by the RCA ratio that was negative already during the early phase of the period under investigation and had fallen to -0.55 in 2012.

The computer and peripheral equipment sub-sector is an assembly industry and its competitiveness relies heavily on labour costs. Like Japan or the US, EU-27 has seen its production being transferred over to cheap labour countries like China. However, it is not only the mature developed economies that relocate production; Taiwan and Korea also exploit wage differentials in Asia. Their advantages are neighbouring low-wage countries and close economic relationships. For EU-27 companies, the situation is far more challenging with higher transport costs and the considerable logistic effort to organise long distance value chains.

Table 2.41: Trade indicators for "Computers and peripheral equipment"

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE2	bn. €	275.0	10.4	-1.3	2.9	-0.8
	26.2		74.9	6.1	-2.9	-1.7	-2.0
EU-27 exports	EE2	bn. €	95.8	17.4	4.1	-1.2	3.0
	26.2		22.7	14.3	0.5	-7.6	1.3
EU-27 imports	EE2	bn. €	169.7	14.3	3.0	2.4	2.5
	26.2		69.7	10.1	-0.5	-3.5	3.1
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE2	%	47.6	29.6	36.2	39.3	43.9
	26.2		81.5	43.4	52.3	55.6	70.3
Import quota[3)]	EE2	%	61.7	42.5	48.5	54.2	58.3
	26.2		93.1	68.0	73.9	77.9	87.8
Trade balances[4)]	EE2	%	-27.8	-27.6	-24.6	-29.4	-28.3
	26.2		-50.9	-47.0	-44.2	-47.7	-50.6
RCA[5)]	26.2	Index	-0.55	-0.46	-0.45	-0.42	-0.52

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.2.2 *Communication equipment*

Overview

The communication equipment industry (NACE Rev. 2, 26.30) includes two quite different market segments: infrastructures (fixed- and mobile communication networks for voice and data) and terminals for the access. With a world production in 2012 of € 342 billion at factory prices (compared to € 324 billion in 2011), the communication equipment industry represents 41 % of the whole ICT manufacturing equipment industry (**Table 2.31**).

Table 2.42: Production of communication products, world and regional, 2011 (€ billion)

	Europe[102]	North America	Japan	China	Other A/P	Rest of the world	**World**
Production	44.970	38.376	30.868	133.832	61.259	14.587	323.892
%	*13.9 %*	*11.8 %*	*9.5 %*	*41.3 %*	*18.9 %*	*4.5 %*	*100 %*

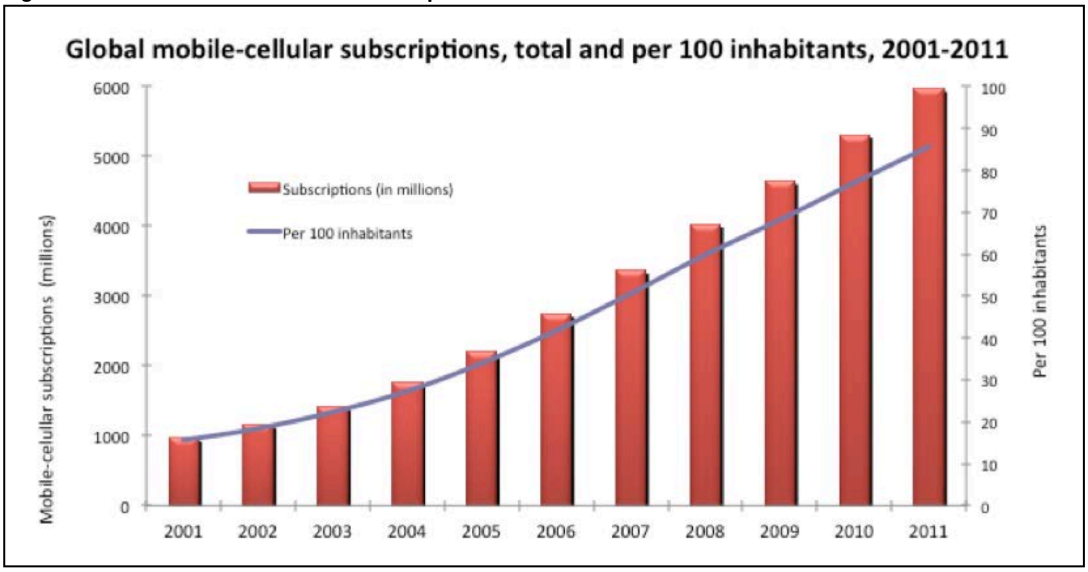
Source: DECISION

The last decade has seen a major and extremely fast evolution in the telecommunications world. Concentrated in the developed countries before 2000, mobile telephony has exploded around the world and 73 % of the mobile subscriber base – totalling 6 billion users at the end of 2011 – is now located in the developing countries. Today, 87 % of the world's population enjoys access to mobile communications (See **Figure 2.5**). Mobile communications offer tremendous advantages over fixed communications, particularly in terms of deployment costs in developing regions that do not benefit from existing communication infrastructure.

In 2011, Europe still represented almost the same percentage of the world demand of communication equipment as a decade ago, at 21 %. This market is quite different from emerging economies because much is spent, on the one hand, on maintaining its old fixed telecommunication networks, and, on the other hand, on investing in the latest generations of mobile networks. Moreover, consumers are buying high-end smartphones instead of feature phones and other low-price mobile phones as most consumers in emerging markets do. In contrast, Europe's contribution to world production decreased from 25 % in 2005 down to 14 % in 2011.

[102] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

Figure 2.5: Global mobile-cellular subscriptions evolution



Source: ITU World Telecommunications / ICT Indicators database

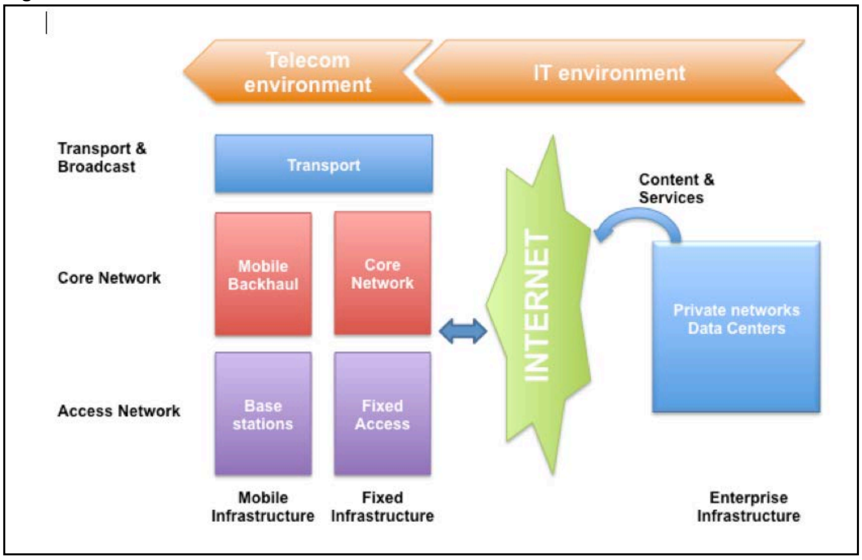
Product programme

Modern communication technology results from the convergence of two industries: voice communications offered by the century-old telecommunications industry, and digital data communications supplied by the younger data network industry. Two categories of products are necessary to realise a communication network: infrastructures and terminals.

Infrastructures:

- Communication infrastructures are made of networks. There are fixed networks and mobile networks, with both types comprising of three parts: transport, core network and access network. There are also private networks from the IT environment (Local Area Networks). All of these networks are now linked together as shown in **Figure 2.6**.
- From an end-user perspective, telecommunication networks either address telecom operators (Carriers) offering fixed and/or mobile telecom services to a large client base, or private companies that require a dedicated and customised telecom network infrastructure tuned to their specific activity (banking, transport operators, retail & logistics, etc.).

Figure 2.6: Network and Telecoms Infrastructure world



Source: DECISION

- Historically, these two segments of the telecom infrastructure industry were separated from each other as well by technology and players. Enterprise networks were essentially addressed by the Data Processing industry with market leaders like Cisco or Juniper, while Carriers deployed purely telecom-based technologies using voice switching with leading infrastructure suppliers such as Ericsson, Nokia-Siemens or Alcatel-Lucent.

Terminals

- Including fixed telephone sets, cordless telephones, and pagers, the communication terminals world is dominated by the mobile phone industry that passed the 500 million units manufactured a year in 2003, 1 billion in 2006 and passed 1.7 billion units in 2011.
- This industry has seen a revolution in 2007 when Apple launched its first iPhone. From then, the market has rapidly split between low-end mobile phones, high-end smartphones and, in the middle, so-called feature phones (smartphones with limited features).

Demand side

Infrastructures

Financed by operators' investments, the mobile network's yearly market is dependent on both the overall economic environment and the evolution of the technology (see **Figure 2.7**). During the 2001 – 2003 period, the mobile communication infrastructure market dropped by 25 %. The major reason for this drop was the dramatic reduction of the operators' investments in the USA and in Europe. At the time, the start of the third generation (3G) was been delayed as the related products and services were not ready. The real implementation of the 3G networks in Europe started in 2004. In 2010, 940 million users are acquiring 3G services.

The landscape of the mobile networks market is today deeply affected by the now four-year-old financial crisis, the aggressive competition between operators and the resulting evolution of their investment strategies. In addition, the emergence of Chinese network manufacturers has accelerated the restructuring of the industry. The increasing need for mobile broadband internet access is now leading to the emergence of 4G networks, enabling the development of advanced IP technology, mobile web applications, gaming applications, and mobile HD television. In 2017, 4G is expected to be 10 % of mobile connections and 45 % of mobile traffic[103].

In the fixed-networks market, the installed base of classic telephonic lines is decreasing year after year, as the development of broadband access is growing. By the end of 2011, according to ITU, 588 million of broadband accesses were installed, almost three times more than in 2005.

Table 2.43: Number of fixed telephone and fixed broadband subscriptions (million units)[104]

	2005		2011	
	Fixed-telephone subscriptions	Fixed (wired) - broadband subscriptions	Fixed-telephone subscriptions	Fixed (wired) - broadband subscriptions
World	1243	220	1204	588
Europe	273	66	258	154
% Europe	*22,0%*	*30,0%*	*21,4%*	*26,2%*

Source: ITU indicators

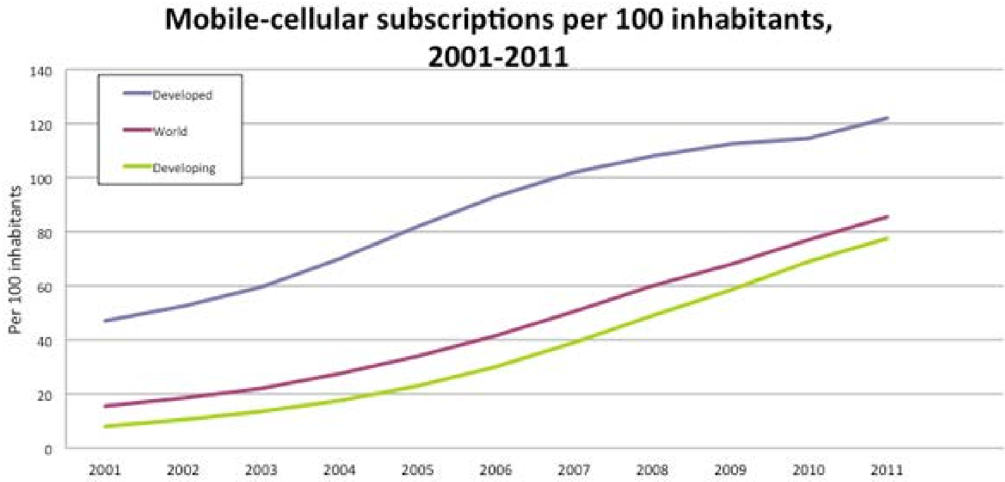
Terminals

[103] "Global Mobile Data Traffic Forecast Update, 2012-2017" Cisco Visual Networking Index

[104] Fixed-telephone subscriptions: equivalent to *active* telephone lines connected to the Public Switched Telephone Network
Fixed (wired) broadband subscriptions: high-speed access to the Internet like cable modem, DSL, or fibre-to-the-home

Initially the demand for mobile telephony subscription was concentrated in developed countries. The mobile market has been reaching saturation levels in mature economies. More recently, the main driver comes now from developing countries and especially from Asia. In 2010, India and China accounted for 300 million of total new mobile phone subscriptions.

Figure 2.7: Mobile-cellular subscription trend 2001 - 2011



Source: ITU World telecommunications / ICT Indicators database

Supply side

Considering the communication world as a whole, there are four categories of suppliers: on the one hand, infrastructures and terminals suppliers (hardware), and on the other hand, access suppliers (operators) and content suppliers. Analysing the industrial side, we consider only the hardware side, keeping in mind that both worlds are intimately linked.

Infrastructures

The telecommunications infrastructure market is highly concentrated and competitive. This concentration has increased over the past years following the consolidation of telecom services that took place after the liberalisation of national telecommunication markets. In 2011, the top 10 equipment suppliers represented over 80 % of the total telecom infrastructure market.

Compared to the end of the last decade, the most impressive change in the infrastructure suppliers' ranking is the fast decline of traditional market leaders in North America, such as Motorola and Nortel, and their replacement by new Asian entrants, primarily Huawei and ZTE. They benefit from large and strongly growing national markets as well as government support.[105] However, it must also be taken into account that they build their strengths on product programmes and their employees focused exclusively on latest generation products with little legacy technologies in their portfolio, contrary to their major competitors in mature economies.

In the *mobile networks segment*, according to research firm Dell'Oro, the main competitors in this market segment include Ericsson (#1), Huawei (#2), Nokia Siemens Networks (#3) and Alcatel-Lucent (#4). It should be noted that to complete the 3G covering and – in the near future – to implement the next 4G generation[106], operators have become keen to share their networks in efforts to reduce the costs of infrastructure.

[105] ""The European Commission, the EU's executive body, has been collecting evidence to prepare a possible case against Huawei and ZTE over state subsidies it says allows the companies to undercut European firms." Reuters April 16th 2013".

[106] 4G standards are defined by the ITU-Radio sector specification «International Mobile Telecommunications Advanced».

When deployment of 3G networks started in 2003, there were already plans to define what 4G will be. In fact, passing from one generation to the next is a succession of progressive improvements. There are several versions of 3G networks coexisting, and there will be several versions of 4G networks. In 2010 the first LTE (Long Term Evolution) networks were launched, which are close but not totally complying with 4G standards. The first real 4G network is named LTE Advanced and has been first deployed in Japan in 2012. Another family of networks, Wimax, offering today only 3G capabilities, is also in competition with LTE technology.

In the Carrier Networks sub-segment, market leaders are mainly based in Europe with Ericsson (#1), Nokia Siemens Networks (#2 after the acquisition of Motorola Wireless Networks in 2011) and Alcatel-Lucent (#3). This European leadership is only being challenged by the Chinese company Huawei.

However, it must be highlighted that this is one of the few market segments in the sector EE2 where EU-27 companies command a strong position in global markets. The supply is to a large extent characterised by complex products, system engineering and specification of products to client needs. This is a typical pattern for other industries too: frequently, European manufacturers are internationally competitive with product programmes that are characterised by these properties.

In the Enterprise and Private Networks sub-segment, major suppliers are predominantly US-based with the undisputed market leader being Cisco, and also Juniper Networks and Motorola Solutions.

Table 2.44: Ranking of Telecom Infrastructure Equipment Suppliers (sales in billion euros)

Manufacturer	Country	2005	2010	2011
Cisco Systems	USA	25	40	43
Ericsson Networks	Sweden	15	12	15
Nokia Siemens Networks	Finland	20	13	15
Huawei	China	5	14	13
Alcatel-Lucent	France	18	10	10
NEC	Japan	6	5	6
ZTE	China	3	5	5
Juniper Networks	USA	2	3	3

Source: Companies' reports

Mobile phones

The mobile phone market is also highly competitive. It has seen a fast evolution during the recent years due to the inability of some leaders to maintain their domination of the smartphone (Nokia and Motorola) and of aggressive Asian competitors (Samsung, Huawei, ZTE). The business model of Nokia has always been to keep most of its manufacturing in-house (Samsung has the same policy). Sony Ericsson and Motorola are subcontracting most of their production and Apple is subcontracting 100 %.

When looking at the value chain of the mobile phone manufacturing industry, most of the established players in the industry were at some point involved in the manufacture of everything from basic components to wireless networks on which the mobile phone runs. This is no longer the case, as the industry has not only split into components – design, assembly, software and networks – but also into a variety of components and software; more layers of manufacturing and assembly functions are provided by different companies. Fragmentation, as shown in **Figure 2.8,** has enabled economies of scale in the manufacture of the most standardised components, such as core processors (baseband and application), radio frequency transceivers and amplifiers, power management, memory, displays and batteries[107].

A few components today account for around 80 % of the manufacturing cost of a mobile phone, from low-end models to smartphones: display and touch-screen, core processors, memories, power management and batteries. In 2005, assembly and test operations accounted for 4 % of the Motorola Razr V3 mobile phone manufacturing cost. In 2012, the same operations still account for the same percentage in the making of the most popular smartphones. A mobile phone manufacturer can expect several advantages when subcontracting these assembly and test operations to a contract manufacturer: a cost reduction, a better logistic organisation and a better global margin (operating margins for the major EMS companies are low, between 2 % to 4 %). But there are also some disadvantages, such as the risk for the IP security, or the definitive inability to reintegrate the production in-house.

Regarding their respective R&D networks, all mobile phone manufacturers have several R&D centres located in Europe, the Americas and Asia. The only exception is Apple, whose R&D is concentrated in its Californian headquarter.

Table 2.45: Top mobile phone manufacturers [1)]

Manufacturer	Country	2000	2005	2011	2012
Samsung	Korea	21	104	331	406
Nokia	Finland	128	265	417	336
Apple	USA	-	-	93	136
ZTE	China	-	12	69	65
LG Electronics	Korea	-	55	88	56
Huawei	China	-	10	40	47
Motorola	USA	60	146	37	41
Sony Ericsson *	Japan	44	51	43	34
Other	USA	160	177	597	615
Total		**413**	**820**	**1715**	**1736**

Source: DECISION; IDC.
* Sony Mobile Communications from 2011
[1)] in million units including smartphones.

In 2000, Nokia had 31 % market share and Samsung 5 %. Apple, LG and Chinese makers were not in the market. In 2005, Nokia and Motorola were dominating the market with 32 % and 18 % market shares respectively. Korean giant Samsung was 3rd place with 13 %. The smartphone market was still in its infancy. The situation changed drastically when Apple released its first iPhone in 2007. The first Apple phone has set the standards with three breakthrough innovations that its competitors did not have:

- On the hardware side, a full-screen multi-touch interface;
- On the software side, an intuitive Operating System (OS), easily synchronisable with your computer;
- An eco-system of services centred on an application store, which allows users to download applications with an incentive policy for software developers. In 2007, one of the main drawbacks of existing smartphones was their interface that needed either a stylus or a physical keyboard. By equipping the iPhone with a large multi-touch touchscreen, Apple immediately outdated other devices and paved the way to a new standard. From this

[107] Study on internationalisation and fragmentation of value chains and security of supply: case study on Mobile Devices *Danish Technological Institute, FWC SCS Consortium, February 2012.*

period, the smartphone segment increased rapidly, accounting for 41% of all mobile phones sold in 2012. As a result, the global ranking has changed with Samsung first with 23 % market share, Nokia second with 19 % and Apple third with 8 %.

Its commercial success boosted the smartphone market and led to Apple rapidly dominating this segment until 2010. But in 2012, Korean giant Samsung overtook Apple and became the new leader in volume with 210 million smartphones sold by the Korean and 130 million by its US competitor. Samsung has reached this position thanks to a broader range of smartphones sold at lower prices. This achievement was made possible because Samsung is vertically integrated and is internally sourcing an important portion of its key components, therefore having a cost control, which its competitors did not have. Furthermore, Samsung has adopted the Android Operating System, the most popular open source platform, which reduced its OS R&D expenses compared to Apple and controls both software and hardware development of its phones. Nevertheless, in terms of revenue and profit, Apple's strategy is still the most successful one. Indeed, Apple has managed to maintain its brand image as a driver of the innovation in the smartphone segment, allowing the company to sell its products at higher prices and to make double the profit of its Korean competitor.

In 2012, Apple, which is only positioned in the high-end segment, could claim not only to be the leader in the smartphone market but also to be the worldwide leader in the whole mobile phone market. With € 68.2 billion of revenue, the US manufacturer outperformed both Samsung, which generated € 67.1 billion through its IT & mobile phone division and also the former number one, the European Nokia, whose revenues reached € 30.2 billion in 2012.

A newcomer has a bold ambition to challenge this domination: the Chinese Huawei, having released its first smartphones in 2009, is tapping the market at the bottom thanks to its affordable products designed for emerging countries and was ranked third place during the last quarter of 2012.

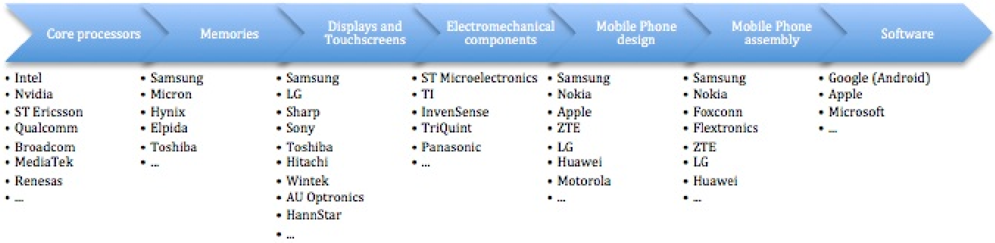
In the value chain of the smartphone industry, some elements are of key importance. One of them is the Operating System that manages the hardware and software functionalities of the smartphone. Surrounded since 2007 by the iOS of Apple and the Android OS of Google, Nokia made a strategic and risky move in April 2011 by giving up its native Symbian OS solutions and by adopting the new Windows Phone OS of Microsoft in replacement. Two years later, Nokia has sold its mobile business to Microsoft.

In 2011, 25 % of all mobile phones produced were manufactured by EMS[108] or ODM[109] companies, down from 31 % in 2005. The most active subcontractors are Foxconn (TW), Flextronics (SG), Compal (TW) and Arima Communications (TW). Two trends contributed to changing the manufacturing chain during recent years: first, Nokia, still one of the global world leaders, has progressively reintegrated in-house as part of its subcontracted volume of mobile phones. Secondly, the rapid growth of the smartphone segment has forced subcontractors to adapt their manufacturing lines for these high-end devices and few of them are ready today. However, a growing segment of the other mobile phones is today consisting of "feature phones", which are low-cost simplified smartphones (cheaper components, limited smartphone functionalities and low-cost manufacturing process). This type of devices is more and more manufactured by subcontractors in China and in other countries.

[108] EMS: Electronic Manufacturing Services = subcontractor manufacturing loaded electronic boards or more complicated electronic sub-systems or systems.
[109] ODM: Original Design Manufacturer = subcontractor offering design services. Today, many EMS looking for more added value are also providing ODM services.

The value chain of the mobile phone industry today (See **Figure 2.8**), demonstrated by the current tough competition between Samsung and Apple, starts with the most powerful chipset, which requires sophisticated and user-friendly software, and includes new type of components, such as MEMS, turning a smartphone into a real portable game console. But the most important value component is the library of applications offered much like Apple did through the App store, its dematerialised on-line store. Moreover, since the smartphone is, at the same time, a mobile phone, a video camera, a GPS, a console, etc. it cannibalises part of the consumer electronics market.

Figure 2.8: Value chain of the mobile phone manufacturing industry



Source: DECISION

Technology, R&D policies

For communication *infrastructures*, increasing downstream but also upstream data rates is the key technological objective. Successive mobile network generations coming to the current 3G and the emerging 4G lead to the “anywhere, anytime, anything” objective and one could include “instantaneous” as a fourth characteristic. Innovative technologies allow operators to optimise the use of their available frequencies spectrum. In the fixed networks, on the one hand, the Ethernet 10 Gb/s technology is succeeded by the 100 Gb/s and the next step will be the 400 Gb/s, which is starting to be tested by some operators. On the other hand, the fibre technology is continuously improving; for example with successive generations of optical modules.

The future development of smartphone capabilities will take three directions: video calling, computer in-the-pocket and identification device. In addition, the convergence between smartphones and computers or tablets initiated in human communication will extend to the “Internet of things” allowing billion of devices to become smart and communicating. What will be the critical technologies for this evolution? Most important will be:

- Materials: thanks to advances in nanotechnologies, *graphene* could enable new lighter and stronger boxes than stainless steel. Chinese, US and South Korean entities are the most active in graphene industrialisation. Graphene is also appointed an EU future emerging technology flagship. *Industrial sapphire* could become an alternative to glass in display modules.
- Display technology will use AMOLED[110] technology preferably to LCD[111] for high-end smartphones and could reach 50 % of total use by 2015. As mentioned earlier, the main display manufacturers are Taiwanese, Korean and Japanese. Neither US, nor European players are present on this market.
- ARM processors will continue dominating the smartphone other smart mobile devices market. This technology is European (ARM is a British company) and all semiconductor manufacturers are using it under licences.

[110] Active Matrix Organic Light Emitting Diode.
[111] Liquid Crystal Display.

- Sensors: future mobile devices will integrate new mobile sensor types, allowing smartphones to offer new sensitive functionalities.
- Batteries: among other research directions, lithium-sulphur technology could give much more capacity, power density and life time than lithium-ion is giving. Europe, USA and Asia are in the race.
- Operating systems will converge between smartphones, tablets and PCs. Synchronisation between all devices will become the rule.

The manufacture of communication equipment is the most R&D-intensive segment among the ICT European industry with 38 % (ICT BERD[112] / ICT value added) in 2009. It is also the sector with the highest share of R&D personnel (14.7 %).

In terms of communication equipment production value, North America (including Mexico) is 17 % lower than Europe in 2011. When analysing the ICT industry, it is usual to consider North America as a whole due to the importance of the Mexican "maquiladoras" established along the US boarder and run by US companies.

Table 2.46: R&D-investing Telecom Equipment companies: 2011 R&D expenditures

Manufacturer	Country	2011 (€ m)
Nokia	Finland	5612
Cisco Systems	USA	4171
Ericsson	Sweden	3612
Alcatel-Lucent	France	2472
Apple	USA	1722
Blackberry	Canada	1150
Motorola Mobility	USA	1076

Source: Companies' reports

Assessment of economic performance

The EU-27 production of the 26.30 sub-sector accounts for 36 % of EE2's nominal production in 2012, a very stable share over the entire period considered. And this production was flat in nominal values during the 10 past years, with the exception of some peaks in 2007 and 2008. (**Table 2.47**) Its weight of global production fell by roughly 60 %.[113] Within the EU-27, employment in 26.30 declined by one third between 2002 and 2012, even more strongly than its EE2 benchmark (-19 % over the same period). With a workforce of 214.000, the sub-sector accounts today for approximately 24 % of EE2, whereas in 1998 this share was still 28 %.

This massive reduction is the combined effect of the massive relocation of the production of handheld devices to – and of the emergence of new mobile network manufacturers in – China. In 2000, 36 % of mobile phone world production was made in Europe, and Huawei or ZTE were still in their infancy.

During the entire period under consideration, labour productivity of the sub-sector recorded an annual growth rate of 7.1 %, the best among all sub-sectors of the benchmark EE2 (4.5 % on average). However, despite a reduction of labour costs per employee, resulting in a reduction of ULC at an annual rate of 3.8 % per year, profits – as measured by the GOR – were always below

[112] BERD: Business Expenditures in R&D.

[113] Figures for the development of the global supply side, selected from DECISION's statistics: In 2002, the European production of communication equipment accounted for 33 % of the global production, and fell to 14 % in 2011. Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

the EE2 average after 2000. In this sub-sector the improvement of the price performance was driven by consolidation where the least profitable firms left the market.

Table 2.47: Key indicators for sub-sector "Manufacture of communication equipment"

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electronic engineering	Production, in current prices	bn. €	201.1	10.5	-1.9	1.5	-1.7
C2630[1)]			71.8	21.6	-4.8	1.5	-2.2
Electronic engineering	Production, in 2010 prices	bn. €	211.7	9.1	1.1	8.1	1.7
C2630[1)]			79.1	26.7	-2.1	10.1	4.6
Electronic engineering	Value added, in 2010 prices	bn. €	60.6	5.3	0.9	7.4	0.9
C2630[1)]			18.3	18.4	-2.9	12.5	0.2
Electronic engineering	Employees	1,000	882	1.7	-2.4	0.1	-3.3
C2630[1)]			214	4.3	-4.6	-1.5	-5.1
Electronic engineering	Labour costs per employee	1,000 €	43.2	3.0	0.7	1.4	2.6
C2630[1)]			62.1	5.5	2.2	1.3	4.1
Electronic engineering	Productivity[2)]	1,000 €	68.8	3.5	3.5	7.3	4.4
C2630[1)]			85.5	13.5	1.9	14.2	5.6
Electronic engineering	Unit labour costs[3)]	€ / €	0.63	-0.5	-2.7	-5.6	-1.7
C2630[1)]			0.73	-7.0	0.3	-11.3	-1.4
			Annual averages[4)]				
Electronic engineering	GOR[5)]	%	9.6	7.9	7.2	8.6	9.6
C2630[1)]			4.2	8.7	5.1	6.5	5.4

1) Manufacture of communication equipment; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

Domestic demand has followed the same cyclicality as its benchmark EE2, with a rapid growth between 1998 and 2000, followed by a drop of 3.2 % during 2000 - 2005. In fact, demand fell from its peak in 2000 – when the New Economy Bubble burst in 2003 – by 26 %. The following recovery until 2005 was not sufficient to outbalance the former losses. From 2005 to 2008, the growth was 7.9 % on average p.a., much higher than the 2.9 % reported for EE2. During the last phase from 2008 to 2012, domestic demand expanded at 0.6 % on average p.a., but its benchmark even declined. (**Table 2.48**)

The dependency of sub-sector 26.30 on third countries grew progressively over the period of investigation. From almost 30 % on average between 1998 and 2000, the share of exported products of production reached 38.9 % (2008 - 2012). The EU-27 communication equipment industry is mainly concentrated on fixed and mobile network infrastructures. Imports of the sub-sector mostly include communication terminals (mobile and smartphones), though recently more and more infrastructure equipment is actively sold in EU-27 by the Chinese manufacturers Huawei and ZTE. The import quota of 26.30 has more than doubled between the period of 1998 - 2000 and the most recent one of 2008-2012, from 24.4 % to 53.6 %, respectively. When considering the mobile phone market, the most important evolution throughout the period has been the emergence of the smartphone in 2007 and the inability of Nokia to keep its market leading position in this segment. As a result, the trade balance of the sub-sector had deteriorated over the period, from a trade surplus of 13.1 % during the first years (1998-2000) to a trade deficit of -29.0 % during the more recent years (2008-2012), reaching even -32.9 % in 2012.

Measuring the trade performance of the sub-sector, the RCA ratio has been positive until the period of 2005 to 2008 at a value of 0.28. For the latest period, the RCA turned touched the zero, indicating that its comparative advantages in relation to its benchmark disappeared. The sub-sector's very competitive position, originally based on the old fixed network "Telecommunications Age" at 0.84 on average between 1998 and 2000, has faded away. The competitive position in mobile networks is less pronounced and terminals are nearly 100 % imported from Asia. The RCA reached an all-time low in 2012 at -0.11.

Table 2.48: Trade indicators for "Manufacture of communication equipment"

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 – 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE2	bn. €	275.0	10.4	-1.3	2.9	-0.8
	26.3		99.5	23.9	-3.2	7.9	0.6
EU-27 exports	EE2	bn. €	95.8	17.4	4.1	-1.2	3.0
	26.3		28.3	20.4	3.5	-5.7	-0.4
EU-27 imports	EE2	bn. €	169.7	14.3	3.0	2.4	2.5
	26.3		56.0	29.4	9.1	9.0	4.3
				Averages for the periods 1998 – 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE2	%	47.6	29.6	36.2	39.3	43.9
	26.3		39.4	29.6	34.5	36.5	38.9
Import quota[3)]	EE2	%	61.7	42.5	48.5	54.2	58.3
	26.3		56.3	24.4	32.9	47.3	53.6
Trade balances[4)]	EE2	%	-27.8	-27.6	-24.6	-29.4	-28.3
	26.3		-32.9	13.1	3.7	-21.8	-29.0
RCA[5)]	26.3	Index	-0.11	0.84	0.62	0.28	0.01

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.2.3 Consumer electronics

Overview

Named in the past "brown products" in contrast with home appliances as "white products", the consumer electronics sub-sector group together with various electronic devices were intended for everyday use in entertainment (NACE 26.40). Initially limited to radio broadcasters and B&W TVs, the number of mass-market consumer products has increased progressively (colour TVs, HiFi, VCRs, etc.) and nowadays is subject to a constant flow of innovation and renewal.

Table 2.49: Production of consumer electronics products, world and regional 2011 (€ billion)

	Europe[114]	North America	Japan	China	Other A/P	Rest of the world	**World**
Production	10.799	9.335	30.594	65.903	44.106	6.021	166.757
%	*6.5 %*	*5.6 %*	*18.3 %*	*39.5 %*	*26.4 %*	*3.6 %*	*100 %*

Source: DECISION

[114] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

With a world production in 2012 close to € 165 billion (compared to € 167 billion in 2011), the consumer electronics industry represented 20 % of the whole ICT manufacturing equipment industry (**Table 2.31**). Despite the permanent flow of innovative consumer and mass-market products, companies' profitability has never been satisfying due to a constant downward pressure on prices together with increasing requirements on technology and quality. Some major players have progressively left these markets, the most recent example being the European Philips. Accelerated technological progress has turned out to be an advantage for newcomers prepared to enter affected markets when a technological revolution occurs. This was the case, for instance, when flat screens replaced CRTs in the TV business.

The specific nature of the mass-market segment is characterised by:

- High level of innovation that upgrades rapidly all devices functionalities, making product life very short. As a consequence, being first on the experience curve is of major importance for manufacturers;
- Low margins and constantly falling prices compared to dedicated-market professional products;
- Worldwide standardisation and globalisation of markets and production leading to intense worldwide competition.

A new era is now emerging with the convergence of these consumer electronic products and other mass-market electronic products developed in other segments of the ICT industry, such as smartphones, tablets or personal computers.

Products

TV sets, digital cameras and camcorders, digital picture frames, DVD players and recorders, set-top boxes, video game consoles and audio devices are the main devices making the consumer electronics sub-sector.

TV sets

Previously the only screen available in the home, the TV has seen its position unsettled by the arrival of other screens that could all be used for a variety of applications such as data display, viewing pictures and films, playing games or watching TV. In the middle of the 2000s, some claimed that the TV set had lost the game and would be replaced by large PC monitors, possibly one for each member of the family, except in social spaces where people would enjoy watching the same TV show together. This prediction never occurred but the number of video devices available today makes, once again, the place and the role of the TV set questionable for the future. By 2020, the TV industry will have gone through 3 major and consecutive market shifts, leading to a complete reshuffling of its industrial base and competitive landscape. Over two decades, the TV industry has and will go through:

Transition to flat screen displays

The transition from traditional Cathode Ray Tubes to flat panel displays, either based on LCD or plasma technologies, started in the early 2000s. This technological step has triggered the development of larger screen sizes and first led to increased average selling prices on a global basis. This transition is now almost complete and CRT TVs have become a technological dead-end. CRT TVs production represents already less than 10 % of the total TV market and will eventually end by 2015. What is regularly overlooked is that the transition to flat panel displays is not only a technological shift from one TV category to another, but is also predominantly a shift to another industrial model. Indeed, the flat panel industry is very similar to the semiconductor industry where huge capital expenditure in manufacturing assets enables price reduction through massive economies of scale. After a significant increase in the average TV selling price, which led to an impressive growth up to 2010 (double digit in volume and value terms from 2005 to 2010), the TV industry now has entered a deflationary period triggered by this new technological paradigm that is even further accentuated by over-capacities built by major industrial players eager to grab large shares of the pie during the booming years.

Global switch from analogue to digital broadcasting

The progressive introduction of full "digital broadcasting" terrestrial systems means that the TV broadcast signal is switching from analogue to digital in most regions of the world. The digital broadcast signal can be conveyed through Hertzian waves (terrestrial broadcast), cable, satellite and now broadband Internet Protocol (IP) connections, and requires either a specific decoder or a new TV set capable of receiving such signals. These new generation TV sets are commonly referred to as "digital TV" (DTV) or "high definition TV" (HDTV).

The digital switchover will naturally stimulate TV sales over the next period and increase the replacement rate of the installed base. It is set to happen all around the world with different timescales before the end of the 2010 - 2015 forecasting period.

The development of 'Connected TVs' to compete with PCs or other devices

The competition is open between TVs and other devices to become the household's digital hub. Major TV set manufacturers have already introduced such devices into their offer with different approaches and value propositions, from simple integrated Set-Top Boxes to dedicated TV portals and services making the TV set the central point of access to the internet. Whatever the forms taken by this last shift, connected TVs will most likely have an important impact on the TV market dynamic, profoundly modifying TV set manufacturers' business model by adding new content-based revenues to their traditional TV set sales. As an example, many TVs are today Skype-enabled making them a new home communication device. This trend may also modify the competitive landscape with the penetration of new entrants with large investment capabilities such as Apple or Google, willing to develop synergies with their existing ecosystems and already existing content offerings. These structural evolutions are deeply influencing TV viewer behaviour as well as the investment patterns of the major suppliers in this market, which represents approximately half of the value of the total consumer electronic equipment worldwide.

Other consumer electronic devices

As mentioned above, they form a variety of devices that were historically used to perform dedicated functions (taking pictures, recording videos, playing music, showing movies, running video games, etc.). This heterogeneous panel includes: Digital Still Cameras and Camcorders, Digital Picture Frames, DVD Players/Recorders, Game Consoles, Portable Media Players, Set-Top Boxes and Other Audio (hi-fi, radio, docking stations, etc.). All these devices together represented in 2011 a total production value of around € 80 billion at factory prices, only one quarter of the amount observed in 2005. Such a fall is due to fantastic technological evolution, which has made VCR systems obsolete and replaced by DVD and Blu-Ray, digital cameras and camcorders largely replaced by camera equipped mobile phones, portable media players and audio systems replaced by internet streaming, and now DVD players and recorders are also starting to decrease.

Depending on the type of devices, specialists and technology developers are mainly:

- Japanese for DVD systems (Sony and its Blu Ray having beaten Toshiba and its HD-DVD system in 2008) and for Digital Still Cameras and Camcorders (Canon, Sony, Nikon, Panasonic, etc.);
- European and US for Set Top Boxes (Pace from UK, Motorola and Cisco from USA, Technicolor from France);
- US only with a quasi-monopoly of Apple on the Portable Media Player market (90 % market share);

- Shared between European, US and Asian specialists for audio devices market.

Common characteristics of these market segments are manufacturing locations in Asia (mainly in China) from 70 % for STB and Audio devices to 90 % for DVD/Blu Ray readers, DSC and Camcorders or Portable Media Players. Hardware production is not of particular interest to new standards developers.

These standard developers play an important role in the creation of new and up-grading of existing markets. They are located at the interface between, on the one hand, hard- and software and products and services supplied to final clients, on the other hand. This is a big business dominated by large and financially strong companies that try to make their fortune through license fees. In these areas, US media and internet companies have become pacemakers of de facto standards that have to be applied and paid for by manufacturers. One of the few European examples is the standard “MP3” set by Thomson (FR) and Fraunhofer (DE).

Demand side

World TV set market

The global recession that had started in 2008 and the consecutive depressed consumption patterns in developed economies have had a profound impact on the TV market. The recovery since mid-2009 has been beneficial for TV sales in unit terms and 250 million TV sets were shipped in 2010 and 2011 each year, but only 235 million in 2012 resulting in a drop by 6 %. Despite the development of the connected TV market and associated services, global TV sales are expected to be less dynamic than they used to be during the past 5 years. From the recent 235 million units, it is expected that global TV sales production will reach close to 275 million units in 2016, growing on average by 4 % over the forecast period. Of course, the overall picture does not reflect the diversity of the growth patterns in the sub-segments as TV set production accounts for less than 8 % of the European market demand. (**Figure 2.9**)

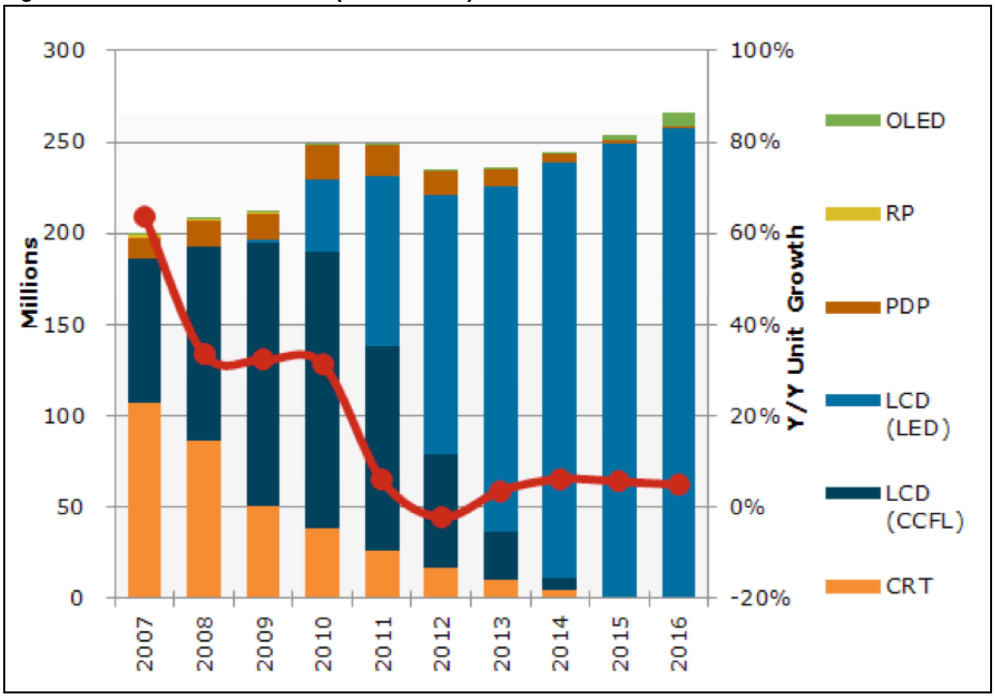
The battle between plasma and LCD technologies to seize the benefits of the development of flat TVs has come to an end to the entire benefit of the latter. In 2011, LCD TVs accounted for 83 % of all TV sets sold worldwide. In 2016, plasma TVs will only survive for large size displays used in specific niche applications such as advertising.

On the innovation front, OLED TVs will make a remarkable entry into the TV set market in 2013 or 2014 thanks to superior technical performances and design capabilities. Although volumes of OLED TVs will not be large enough to influence the overall TV market trend over the next coming years, these are expected to represent the biggest market driver for the TV set industry at the end of the decade.

With over 30 % of the global demand in 2012, Europe[115] continues to represent a large market for TV suppliers, in particular for flat panel TVs. This share is, however, expected to decline progressively as Asian consumption and production develops and captures market share against developed economies. EU-27 is largely dependent on imports as TV set production accounts for less than 8 % of the European market demand – an extremely low share that is expected to fall further on.

[115] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

Figure 2.9: World TV set market (million units)



Source: NPD DisplaySearch

Other consumer electronic devices

The *digital camera* market has exploded in the last five years, superseding the legacy film camera market. From 70 million units in 2005 and after a decline in 2009, the market recovered in 2010 and 130 million units were sold in 2011. Today, however, competition is fierce with mobile phones. Future growth of the market will result from permanent innovation such as transferring digital images via internet and cellular networks or incorporating GPS modules to record the location a photo is being taken. Digital photo sharing on social networks are also poised to positively benefit the market in the future. Sophisticated components, such as gyro function to stabilise shaky images, interchangeable lenses or improved data storage capacity, are also part of the permanent technological race between manufacturers. The world *camcorder* market represents 17 million units sold in 2011 (16 million in 2005) and the main technological evolution since 2005 has been the use of flash memory instead of tape. Today, the most successful development is coming from the recent miniaturised action-camcorders.

Although Europe does not play any role on the supply side, it represents 30 % of the world market. It is exactly the same in the US. Here again, a technological revolution – the digital camera replacing the argentic film technique – allowed new players to put former reference market makers such as Kodak (US) or AGFA (DE) into marginal roles. As for other consumer electronics, such as TV screen production, the former dominance of developed economies collapsed.

The *DVD industry* has reproduced almost exactly the same scenario that prevailed for competing standards for VCR (VHS vs. Betamax). 2008 marked the end of the long lasting format war between the HD DVD format backed by Toshiba and the Blu-ray format backed by Sony. Following Warner Bros' decision to release its films only on Blu-ray discs major retailers in North America and Europe start to drop HD DVDs from their inventory. Consequently, Toshiba withdrew its support for the HD DVD format leaving Blu-ray as the winner. In volume terms, the development of Blu-ray sales have helped maintain worldwide DVD player shipment levels at around 140 million units on a global scale in 2011 (129 million in 2005). Sony kept a strong competitive advantage on the Blu-ray disc market by licensing studios and other companies wanting to manufacture such specified media storages. However, DVD sales are down today, killed by new behaviours of movie viewers through internet and the recent generations of set-top boxes, integrating recording capabilities and VoD services. As a consequence, the perspectives for the DVD market players/recorders are also negative. A fall of 40 % is expected in the coming years. Marketing is leading the race, not technology.

As for other consumer devices, Europe has no supply side on this market but accounts for 33 % of the world market.

The *game console* market is highly cyclical, with a cycle starting every 3 or 4 years prompted by the arrival of new generation consoles that enable new gaming functionalities thanks to increased processing power. Time-to-market is thus a key success factor in this sector, which is always at the forefront of technological developments. The arrival of the seventh generation of game consoles in 2005 and 2006 led to a spectacular growth of the market in 2007 (+80 % in value). These game consoles brought competition to the market from Microsoft's Xbox 360, Sony's PlayStation 3 and Nintendo's Wii game console. The eighth generation started at the end of 2011 with Sony's PlayStation Vita, followed one year later by Nintendo Wii U. The future console of Microsoft, the Xbox 720 is expected to be released during summer 2013. The world video game console market reached 76 million units in 2011 versus 78 million in 2010 (28 million in 2005). The medium term horizon is rather pessimistic due to increased competition from other gaming platforms, such as smartphones or tablets. Today, over 100,000 games are available on the Apple Store.
Once more, Europe is not competing on the game console market segment. And also once again, Europe represents a large share (38 %) of the world market for manufacturers.

The *Portable Media Player* (PMP) market has experienced rapid swings in trends and technologies during the last decade. CDs or mini disks replaced magnetic tape readers and soon afterwards new market growth was stimulated by the European MP3 standard co-developed by Thomson and Fraunhofer, which remains an important source of royalties for both organisations. The portable media player market reached a peak at 240 million units in 2008 (126 million in 2005), then declined progressively down to 170 million in 2011 as many other platforms such as mobile phones, televisions, portable and tablet PCs, and radio sets are now able to read MP3 and other digital media formats. Even Apple, the undisputed market leader with over 70% market share (white box market excluded), has experienced decreasing sales from 2008 to 2011 for its flagship iPod product, concentrating its strategy on new higher value platform such as the iPhone or the iPad.

Europe again does not have any stake in the PMP competition, but is an important part of the world market.

A *set-top box* (STB) is an interface device between a television and an external signal source, which may be a satellite dish, a cable, a telephone line, a DSL connection or an ordinary VHF or UHF antenna. Set-top boxes range from simple Pay-TV decoders to sophisticated digital-to-analogue signal converters with hard-disk drives or complete home gateways. The following factors are the main STB market drivers:

- The shift from analogue to digital broadcasting;
- The development of broadband access and subsequent service offerings like VoD (Video on Demand), IP phones, IoTV (Internet on TV);
- Triple and Quadruple Play services combining fixed/mobile phone, broadband access and TV.

The STB market is linked to the development of broadband access technologies worldwide. Because each country / region pursues its own access strategy (satellite, cable, IP and hybrid technology) the market for this interface equipment is fragmented.

From around 100 million units shipped in 2005, the STB market reached 143 million in 2010 and 160 million in 2011. The market thus continues to offer bright perspectives, reflecting its position as one of the two gateways (alongside PCs) to IP-based multimedia services into households. Europe is a traditional player of the STB market but its position is expected to decline due to the impact of digital STB development and the consecutive commoditisation of products and pressure on prices.

Radio receivers and HiFi/Tuners make up the main part of the *other audio devices* segment. In the radio receivers market, the trend is the development of the Digital Audio Broadcasting (DAB) devices, which in Europe account for around 15 % of all radio receivers sold. Initiated by an EU research programme (Eureka 147), the DAB standard and its extensions (DAB+, T-DMB) is a good example of new technologies with which European firms – in the present case: Pure, UK – can keep leading market positions, at least on EU territory, provided they have been able to be among the very first ones to understand and develop the right products. And it does not matter if manufacturing their devices has to be subcontracted to low cost country partners.

Supply side

TV sets

As for the computing industry, with most of the value being generated at the core component level (microprocessor), the modern TV set industry is getting most of its added value from its core component, the flat panel, and more specifically the large LCD panels, where large sales volumes are required in order to provide return on the huge investments that are necessary.

By the end of 2009, all major suppliers of large-size LCD panels (Samsung, LG, AU Optronics, ChiMei Innolux and Sharp) announced new investment projects in order to set up latest generation manufacturing plants to address TV market demand. The competitive environment in the TV marketplace is changing dramatically, with some companies having direct access to the core technology (flat panel production) and others only assembling and marketing products.

The technological shift from CRT to flat panel TVs has thus dramatically changed the competitive landscape in the TV marketplace, where Japanese suppliers, once dominant, are now fighting for their survival in front of their Korean competitors and where European suppliers are now simply out of business.

Since the decline of traditional CRT technology in favour of flat panel TVs, Europe remains a marginal player in the TV industry. Lately, however, Asian flat TV manufacturers have set up state-of-the-art flat panel modules and assembly facilities in Eastern Europe (Poland, Czech Republic, Bulgaria, etc.) in order to serve their largest market, the EU-27. The situation is roughly the same in the USA. It is interesting to observe how difficult it is for Japanese manufacturers to compete today against their Korean competitors.

Table 2.50: Top LCD TV manufacturers (global shipments in million units)

Manufacturer	Country	2011	2012 (F)
Samsung	Korea	38	40
LG Electronics	Korea	25	27
Sony	Japan	20	15
Toshiba	Japan	15	12
Sharp	Japan	14	8
TPV Technology (including AOC/Philips)	China	13	13
Panasonic	Japan	13	10
TCL	China	11	12
Hisense	China	9	9
Skyworth	China	7	8
Other		40	50
Total		**205**	**204**

Source: DisplaySearch

Other consumer electronic devices

A Japanese sphere for long time, the digital camera market is still dominated by Canon, Sony, Panasonic, Nikon, JVC, Olympus, Fuji, etc. Samsung and Kodak are also in the field. In the DVD players market, leader manufacturers include Sony, Samsung, Toshiba and Panasonic. The game console domain is shared between Microsoft, Sony and Nintendo. Apple is the undisputed leader of the portable media player market with around 70 % market share worldwide. The set-top box market is still today led by US manufacturers: Cisco Systems, Arris (ex-Motorola unit), Echostar, and European ones: Pace (UK) and Technicolor (FR). All are under pricing pressure from new Chinese competitors (Changhong, Hisense, Haier, Co-Ship, Hasee).

Technology, R&D policies

The key technological value in the consumer electronics sub-sector comes from two major families of components: semiconductors and display modules. Both are dominated by the US, Japan, Taiwan and, progressively, China. However, European semiconductor companies try to keep a position on the global market in specialising on “More than Moore” developments (see the semiconductors chapter hereafter).

In the TV field OLED[116] high definition flat screens are emerging that will outperform LCD and plasma characteristics. Another evolution will come from the internet-connected TV and the online video services offered.

For most of the other consumer electronic products, innovations will come in the imaging field. This will also apply for mobile phones and tablets. Curved image sensors, back side illumination as well as reduced camera footprint are some of the most promising technological progresses.

Within EU-27, Business R&D funding for the manufacture of consumer electronics presents an R&D intensity ratio ICT BERD[117] / ICT value added of 12 % compared to an average of 30 % for all ICT Manufacturing segments. It is also having one among the lowest share of R&D personnel in total employment: 5 % compared to 10 % for all ICT Manufacturing segments.

[116] OLED: Organic Light Emitting Diode.
[117] BERD: Business Expenditures in R&D.

Although developed economies account for a minor part of the global manufacture of consumer electronic goods today, their ICT firms can obtain significant revenues from their licensing activities. The European Technicolor, for instance, has negotiated 650 licenses of its MP3 digital music file format and the company employs 220 people all around the world to manage its 1,100 licensing agreements of various video products and services. Another example in the computer services market is IBM which generates € 800 million per year through licensing activities. This will give companies an edge in the market and opportunities for funding R&D. However, taking into account the contribution of employment within the EU, the trade balance will remained limited. All consumer electronics market segments show large trade deficits. Employment effects of imports are limited and are focused above all at low-end qualifications in distribution, wholesale and retail.

Assessment of economic performance

The production of the EU-27 sub-sector 26.40 accounts for 14 % of EE2's nominal production in 2012, a slight but constant decrease since 1998. (**Table 2.51**) For Europe[118] as a whole the share of worldwide production for consumer electronics has never been important, declining from 8 % in 2005 to 6.5 % in 2011. Over the complete period under consideration, the employment of the sub-sector in EU-27 also decreased, from 131.000 down to 80.000. During this time, labour productivity increased by 5.2 % per year, above the benchmark EE2 (4.5%). But the ULC reduction and consolidation in the sub-sector at a rate of 4.3 % per year were insufficient to drive profitability – as measured by GOR – up to the EE2 level. Consumer electronic products are no longer a European specialty, neither in design, nor in manufacturing.

Table 2.51: Key indicators for sub-sector "Manufacture of consumer electronics"

Sector	Indicator	2012		Annual average growth rate in % 1998 – 00	2000 - 05	2005 - 08	2008 - 12
Electronic engineering C2640[1)]	Production, in current prices	bn. €	201.1 27.5	10.5 3.2	-1.9 0.2	1.5 -3.6	-1.7 -1.3
Electronic engineering C2640[1)]	Production, in 2010 prices	bn. €	211.7 28.6	9.1 8.8	1.1 1.7	8.1 -0.1	1.7 0.5
Electronic engineering C2640[1)]	Value added, in 2010 prices	bn. €	60.6 5.0	5.3 5.9	0.9 1.6	7.4 -2.3	0.9 2.4
Electronic engineering C2640[1)]	Employees	1,000	882 80	1.7 -0.4	-2.4 -4.5	0.1 -0.7	-3.3 -5.7
Electronic engineering C2640[1)]	Labour costs per employee	1,000 €	43.2 30.4	3.0 3.8	0.7 0.4	1.4 0.5	2.6 -0.3
Electronic engineering C2640[1)]	Productivity[2)]	1,000 €	68.8 62.7	3.5 6.3	3.5 6.4	7.3 -1.6	4.4 8.5
Electronic engineering C2640[1)]	Unit labour costs[3)]	€ / €	0.63 0.48	-0.5 -2.4	-2.7 -5.7	-5.6 2.1	-1.7 -8.1
			Annual averages[4)]				
Electronic engineering C2640[1)]	GOR[5)]	%	9.6 8.4	7.9 5.4	7.2 6.1	8.6 6.8	9.6 7.8

1) Manufacture of consumer electronics; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

With € 37.6 billion, the 26.40 sub-sector accounted for around 14 % of the total EE2 domestic demand in 2012. (Table 2.52) The consumer equipment sub-sector is characterised by fierce global competition which explains why less than a quarter (23.9 %) of European production was exported

[118] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

in 2012 and the import quota of 44.4 % indicates a prominent position of foreign manufactured products on the EU-27 market. As a consequence, the trade balance was negative. But it is to be noted that the trade performance of the sub-sector has substantially improved since 1998, almost tripling since 1998 to reach a peak of 23.9 % in 2012. However, this is only half the export ratio of its benchmark and a decline of production from € 30.1 billion to € 27.5 billion.

The trade deficit as a percentage of trade volume improved to set at -43.6 % in 2012 compared to -68.2% on average for the period from 1998 to 2000. This trend is explained by the exports which in value have increased threefold whereas the 2.5 times larger imports merely doubled. For the same reason the RCA ratio measuring the trade performance of the sub-sector remarkably improved over the period under investigation, but remained negative indicating a worse position in international competition than its benchmark.

Table 2.52: Trade indicators for "Manufacture of consumer electronics"

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 – 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE2	bn. €	275.0	10.4	-1.3	2.9	-0.8
	26.4		37.6	6.0	1.2	-2.8	-3.8
EU-27 exports	EE2	bn. €	95.8	17.4	4.1	-1.2	3.0
	26.4		6.6	19.8	3.3	23.2	-1.5
EU-27 imports	EE2	bn. €	169.7	14.3	3.0	2.4	2.5
	26.4		16.7	15.1	3.6	4.3	-6.6
				Averages for the periods			
				1998 - 00	2000 – 05	2005 - 08	2008 - 12
Export quota[2)]	EE2	%	47.6	29.6	36.2	39.3	43.9
	26.4		23.9	8.6	11.1	19.5	22.5
Import quota[3)]	EE2	%	61.7	42.5	48.5	54.2	58.3
	26.4		44.4	33.2	39.3	46.0	45.4
Trade balances[4)]	EE2	%	-27.8	-27.6	-24.6	-29.4	-28.3
	26.4		-43.6	-68.2	-67.6	-55.6	-48.3
RCA[5)]	26.4	Index	-0.36	-1.10	-1.13	-0.86	-0.49

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.2.4 Medical engineering

Overview

All around the world, health expenditures represent a growing percentage of GDP as shown in **Table 2.25**. Unaffected by the economic crisis in 2009, the medical engineering segment is experiencing continuous development. It represents a worldwide market of € 40 billion and is expected to continue growing in the coming years.

Table 2.53: Production of medical engineering products, world and regional 2011 (€ billion)

	Europe[119]	North America	Japan	China	Other A/P	Rest of the world	**World**
Production	9.050	15.797	3.878	7.180	2.313	578	38.796
%	*23.3 %*	*40.7 %*	*10.0 %*	*18.5 %*	*6.0 %*	*1.5 %*	*100 %*

Source: DECISION.

The medical engineering industry is changing very quickly and has to meet new demands, such as individual miniaturised diagnostic or healthcare solutions and many innovative devices such as pill cameras, contactless power charging or communicating pacemakers, etc. These new needs for low-cost mass-market products will contribute to reducing expenditures for hospitals and the attendant social security systems. In many cases, the new products have been developed by start-ups or recent spin-offs.

Table 2.54: Health expenditures as a percentage of GDP

Country	**2000**	**2010**
USA	13.4 %	17.9 %
Japan	7.7 %	9.5 %
European Union*	7.5 %	9.0 %
Brazil	7.2 %	9.0 %
China	4.6 %	5.1 %
India	4.6 %	4.1 %
Russia	5.4 %	5.1 %

Source: World Bank, OECD, EC

* *with a large discrepancy between Western and new Member States*

Products

Medical engineering equipment comprises the following segments:

- Medical imaging equipment;
- Cardiac Rhythm Management (CRM);
- Other diagnostic and therapy equipment.

Telemedicine is just a part of what is emerging under the name of *Telehealth or e-Health,* which is based on coordinated networks between all actors involved around the patient. New technologies, especially in communications equipment and computer equipment, are at the forefront of this evolution.

Medical imaging equipment

This segment is subdivided into different technologies:

- Conventional and Digital Radiography and Radiology (X-Ray);
- Scanners and Computed Tomography (CT);
- Magnetic Resonance Imaging (MRI);
- Ultrasound;
- Nuclear Medicine;
- Other technologies.

Globally, the medical imaging market reached € 16 billion worldwide in 2011. The Radiography segment is still today receiving the biggest part of this amount. The main trend in the medical imaging equipment market relates to the fast development of ultrasound imaging technology,

[119] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

especially through compact ultrasound systems. The segment is also pursuing its conversion from analogical to digital systems, enabling institutions to get rid of analogue's reliance on paper film. Another trend is the development of 3D medical imaging technology, especially in MRI and CT applications.

Cardiac Rhythm Management (CRM)

The cardiac implants segment is composed of pacemakers and defibrillators. Both are implantable or external. Globally, the world CRM equipment market reached € 10 billion in 2011. The pacemaker market is mature, but still developing in emerging countries. The defibrillator market is growing more rapidly. The most popular device today is the CRT-D (Cardiac Resynchronization Therapy Defibrillator), an advanced combined item which reduces heart failure and patient mortality. This type of device is rapidly grabbing market shares against the IDC (Implantable Cardioverter Defibrillator).

Other diagnostic and therapy equipment

A variety of medical devices used for diagnostic and/or therapy applications are also part of the medical engineering domain, such as anaesthetic/respiratory equipment, dental devices, functional screening equipment (ECG, EEG), patient monitoring equipment, surgery equipment (coelioscopy, endoscopy, medical lasers, etc.), functional substitutes (dialysis equipment, hearing aids, etc.) and other therapy equipment (lithography, incubators, etc.). Most of these devices are manufactured in relatively low volumes.

Demand side

Not surprisingly, the medical engineering equipment market is dominated by the developed countries. North America is dominating the world market with 47%, leaving Asia with 28% and Europe with 21%. Health expenditure is the sum of public and private (out-of-the-pocket) expenditure. The sharing out between both is very different from one country to another related to the social organisation and the wealth of each.

Table 2.55: Public and private health expenditures % in 2010

Country	Public	Private
USA	53 %	47 %
Japan	82 %	18 %
European Union	70 %	30 %
Brazil	47 %	53 %
China	54 %	46 %
India	29 %	71 %
Russia	62 %	38 %

Source: World Bank, OECD, EC

In the developed countries, the demand for home-care medical devices will grow strongly, firstly because populations are ageing and will require more assistance, and secondly because governments want to reduce health expenditures and specifically hospital costs. However, this market should also grow in the emerging countries where populations are large and health infrastructures are scarce. The most promising domain will include numerous devices for the telemedicine practice (tele-diagnostic, tele-assistance, tele-monitoring, etc.), including medical sensors and measuring instruments, transmission systems, etc. Medical devices designed for home use differ from devices designed for hospitals because they are not used by the same populations, for the same purpose and in the same way.

Health is an important part of public budgets. In 2010, public spending on healthcare accounted for 15 % of all government expenditure in the EU-27[120]. Public expenditure on healthcare and long-term care is expected to increase by one third by 2060. The European Commission has included health as an integral part of the Europe 2020 strategy. Its recommendations for reforming health systems intend to provide access to high quality healthcare and to ensure using public resources more efficiently. Its policy "Investing in health" covers three main elements:

- Investing in sustainable health systems: health systems in Europe are at the core of its high level of social protection and they are at the cornerstone of the European social market economy. The large share of healthcare costs in the EU raises the issue of cost-effectiveness and the financial sustainability of health systems. The problems caused by the economic crisis, coupled with more structural changes in demography and the types of diseases affecting populations in Europe, reinforce the necessity to reform and modernise those systems.
- Health as an investment in human capital: health can boost economic growth by enabling people to remain active longer and in better health. The health status of the population influences labour market participation and productivity.
- Investing to reduce inequalities in health contributes to social cohesion. Universal access to healthcare services can help reduce poverty and fight social exclusion.

A number of areas where structural reforms and efficiency gains could improve the sustainability of health systems have been identified.

Innovation in medical technology is considered one of the primary drivers of healthcare spending. E-health covers the range of tools that can be used to assist and enhance prevention, diagnosis, treatment, monitoring and management concerning health and lifestyle. Examples of successful e-health developments include health information management and networks, electronic health records, telemedicine services, wearable and portable monitoring systems and health portals[121].

Supply side

The *medical imaging* market is very concentrated: the first three players General Electric (USA), Siemens (Germany) and Philips (Netherlands) corner 70 % of the total market, while the fourth Toshiba (Japan) is mainly present on its domestic market. Other regional actors include Hitachi and Shimadzu in Japan, Carestream Health, Varian Medical Systems and Hologic in the USA, Mindray and Wandong in China. The *CRM* market is dominated by three US companies: Medtronic (50 % world market share), Saint Jude Medical and Boston Scientific. In 2011, the geographical distribution of the most important medical engineering equipment manufacturers was as follows: 41 % in North America, 23 % in Europe, 18 % in China and 10 % in Japan.

Technology, R&D policies

Different technological trends illustrate the current evolution in the medical engineering domain. In radiology techniques, for instance, the objective is to reduce the dose of rays required. In other imaging technologies, researchers try to develop mobile apparatus or to get more details at a greater speed. Another trend is to develop combined systems of diagnostic and therapy through image guided technique allowing for minimal invasive solution. The medical devices industry is among those industries investing the most in R&D. Cost-cutting and innovation are the drivers, contributing to all governments' need to reduce health expenditures. European companies spend on average 8 % of their annual sales for product R&D. In the US, CRM specialists invest between 10 % and 12 % of their revenues on R&D.

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[120] "Investing in health » Social Investment Package, European Commission SWD (2013) 43 final, February 2013.
[121] "Investing in health » Social Investment Package, European Commission SWD (2013) 43 final, February 2013.

Assessment of economic performance of sub-sector 26.60

Medical engineering is one of the EEI sub-sectors where the EU-27 competitiveness is outstanding by its supply. The EU-27 commands a 23 % share of the worldwide production (see **Table 2.53**). But it is a limited business with a production of EU-27 in sub-sector 26.60 accounting for 6 % of EE2's nominal output in 2012. Nominal production increased at an annual rate of 5.3 % over the whole period under consideration, most dynamic between 2005 and 2008, whereas EE2's output more or less stagnated. (**Table 2.56**) The employment of the sub-sector is limited with a workforce of 46,000, but the employment record was – in contrast to its benchmark – slightly positive.

The improvement of labour productivity was well below EE2 for most of the years under consideration. However, its development accelerated in recent years and came close to its benchmark at an average rate of 4.5 % for the period of 1998 to 2012. Unlike other sub-sectors of EE2, the labour cost per employee increased at a higher rate than its benchmark over the whole period and compensated for all of the labour productivity gains. As a consequence ULC stagnated. Profitability as measured by GOR declined in recent years, but it remained well above its benchmark. The medical sub-sector is still a domain of expertise and operational excellence in Europe, as indicated by average annual labour costs per capita of € 58,800, an amount that exceeds the EE2 average by 36 %. **However, with wages increasing stronger than labour productivity since 2005 this sub-sector gives some leeway for competitors, primarily from developed economies such as the US but also Japan, a country with traditionally low wage increases.**

Table 2.56: Key indicators for sub-sector "Manufacture of irradiation, electromedical and electrotherapeutic equipment"

Sector	Indicator	2012		Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Electronic engineering	Production, in current prices	bn. €	201.1	10.5	-1.9	1.5	-1.7
C2660[1)]			13.5	-0.8	7.2	4.4	5.2
Electronic engineering	Production, in 2010 prices	bn. €	211.7	9.1	1.1	8.1	1.7
C2660[1)]			13.3	-2.3	7.9	2.1	5.5
Electronic engineering	Value added, in 2010 prices	bn. €	60.6	5.3	0.9	7.4	0.9
C2660[1)]			4.3	-1.1	6.6	0.1	2.5
Electronic engineering	Employees	1,000	882	1.7	-2.4	0.1	-3.3
C2660[1)]			46	0.2	2.5	1.1	-1.9
Electronic engineering	Labour costs per employee	1,000 €	43.2	3.0	0.7	1.4	2.6
C2660[1)]			58.9	-1.7	1.8	4.1	5.7
Electronic engineering	Productivity[2)]	1,000 €	68.8	3.5	3.5	7.3	4.4
C2660[1)]			93.4	-1.3	4.0	-0.9	4.5
Electronic engineering	Unit labour costs[3)]	€ / €	0.63	-0.5	-2.7	-5.6	-1.7
C2660[1)]			0.63	-0.4	-2.1	5.1	1.1
			Annual averages[4)]				
Electronic engineering	GOR[5)]	%	9.6	7.9	7.2	8.6	9.6
C2660[1)]			11.9	14.7	15.7	15.5	13.1

1) Manufacture of irradiation, electromedical and electrotherapeutic equipment; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

The domestic demand for sub-sector 26.60 stood at € 7.7 billion in 2012, just 2.8 % of EE2. This is well below its share of EE2's production. (**Table 2.57**) However, it increased at a higher rate of 2.2 % on average p.a. between 1998 and 2012 than its benchmark (1.4 % p.a.). This better development was caused by strong growth between 2005 and 2008 with an average of 10.8 % p.a. and a significant recovery after the financial crisis. Healthcare needs are growing across the world, but the medical equipment markets differ from others by some specifics: numerous different stakeholders are involved (medicine professionals, hospital administration, public authorities, patients, etc.), pursuing different objectives. Moreover, public budgets are crucial for demand for equipment in this highly regulated market and they are currently tight in all developed economies. These framework conditions are limiting the growth perspectives of this sub-sector.

Table 2.57: Trade indicators for "Manufacture of irradiation, electromedical and eletrotherapeutic equipment"

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE2	bn. €	275.0	10.4	-1.3	2.9	-0.8
	26.6		7.7	-3.6	1.8	4.5	2.5
EU-27 exports	EE2	bn. €	95.8	17.4	4.1	-1.2	3.0
	26.6		12.1	15.8	11.5	5.1	5.5
EU-27 imports	EE2	bn. €	169.7	14.3	3.0	2.4	2.5
	26.6		6.4	15.6	5.8	5.7	2.6
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE2	%	47.6	29.6	36.2	39.3	43.9
	26.6		89.9	60.6	88.1	85.4	79.2
Import quota[3)]	EE2	%	61.7	42.5	48.5	54.2	58.3
	26.6		82.4	53.4	81.8	77.9	68.7
Trade balances[4)]	EE2	%	-27.8	-27.6	-24.6	-29.4	-28.3
	26.6		31.2	14.5	24.6	24.8	27.0
RCA[5)]	26.6	Index	1.22	0.86	0.97	1.08	1.13

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

In terms of production with 13.5 € billion in 2012 (6.7 % of EE2 sector), sub-sector 26.60 is extremely dependent on other countries as 90 % of the production is exported. In contrast, 82 % of the domestic demand was covered by imports in 2012, indicating a strong international division of labour. The trade balance of the sub-sector is largely positive and relatively stable at around 25 % of trade volume, which completely opposition to the benchmark EE2 for which the trade balance is also relatively stable, but negative around -25 %. This trade performance describes a high technology sub-sector for which EU-27 has several world leaders. Companies are well positioned not only in their domestic market but also in the other parts of the world.

Sub-sector 26.60 is best in trade performance of all sub-sectors of EE2. RCA had improved throughout the period under investigation. On average for the years from 1998 to 2000, it was 0.86 and increased to 1.22 in 2012.

2.3 The electronic component and semiconductor sector (EE3)

Overview

For the design and manufacture of any electronic equipment, it is necessary to combine different elements, complex electronic components and, at the core, semiconductors, the most sophisticated intermediary products that might be commodities or specified products for certain applications or due to a customer's provisions. In most cases, the packaging of these elements leads to an *electronic board*, similar to that shown in **Figure 2.10**. It might contain:

- Semiconductors: integrated circuits, microcontrollers, memories;
- Passive components: capacitors, resistors, magnetic components, filters;
- Interconnection components: printed circuits boards, connectors.

The performance of these complex components is above all dependent on the semiconductor's state of technology, the level of integration and the processing speed. These parts are of key importance for all manufacturing industries and are pivotal for quality, functionality and abilities of the final products. For the EU-27, with its globally competitive industries (in particular, machinery and transport equipment), the availability of latest semiconductor technologies is decisive for keeping the pace of technological progress and competitiveness in the respective product groups.

Figure 2.10: Typical electronic board packaging

Source: Toshiba laptop motherboard

Technological progress, growing complexity and capital intensity have driven the specialisation of SC companies. During the early 1970s, the predominantly Integrated Device Manufacturers (IDM) already started separating the more labour intensive back-end processes from capital intensive front-end processes. Underlying reasons were differentials in wage and qualification levels as well as market access. The process of specialisation was further accelerated by emerging Electronic Design Automation (EDA) tools during the early 1980s. IDAs outsourced design to specialised service providers. Some of these design houses evolved from contractors to companies with an independent product development, the first fabless companies. During the 1990s, the foundry business gained momentum. These contract manufacturers took orders from IDMs as well as from fabless SC developers. In recent years the so-called fab-lite model emerged, which means that IDMs started outsourcing larger parts of their production to foundries and concentrating in-house manufacturing on certain product segments only. This development is owed to the ever-growing capital intensity of fabs that exceed the financial resources of most individual companies.

The current situation of the SC industry is characterised by a complex value creation network. Different business models exist in parallel: in addition to the few IDMs, there are also highly specialised companies. Both approaches have their advantages and disadvantages. Long-term research projects and product development cycles up to the deployment of production benefit from stable relationships in IDMs. Specialised companies outweigh these disadvantages by long-term co-operation agreements. The latter might turn out as an opportunity in particular for the European SC industry and research units with their high-tech spots. By their global lead in distinct technologies they are attractive partners in joint global projects. Such an upside assessment for EU companies of the current situation is underscored by recently concluded co-operation agreements. For instance Intel, a global IDM, leading by output and state of technology in SC, has taken a stake in the Dutch ASML, a global leader in lithography process technology. Another example is provided by the joint project of spin-transfer torque magnetoresistive random access memory (STT-MRM) of GlobalFoundries, Qualcomm and the Belgian imec. imec is a research body leading on emerging high-density memory technologies. It has attracted Qualcomm, one of the largest fab-lite manufacturers, to join a common project with GlobalFoundry, a contract manufacturer with headquarters in the US and plants in the US, Asia and Germany. A critical criterion for the sustainability of such projects will be that beyond the technological success, economic benefits will be received by all partners.

Assessment of the economic performance of EE3

The EU-27 EE3's production reached € 64.3 billion in 2012. It accounts for one tenth of EEI sector. Around 80 % of the output comprises electronic components (sub-sector 26.11). The telecommunication crisis, which began in 2001, had its major effects on EE3 in 2002 and 2003. High inventories of components accumulated during the boom phase along the entire supply chain caused EU EE3 gross output to decline by 10 %. As for EE2, the financial crisis in 2009 followed by an unfavourable economic climate in Europe, pushed EE3 2012 gross output below 2006 levels, its worst year in the recent past with the exception of 2009. The evolution of EU EE3's production was slightly better. Employment in the sector declined at an annual rate of 1.3 % each year from 1998 to 2012, twice as fast as the total EEI. **Even worse, since the mid-1990s the reduction of workplaces accelerated. Between 1998 and 2012 the number of employees was reduced by 59,000 down to 298,000.**

In contrast to nominal output, value added at constant prices grew. This discrepancy is explained by technological progress incorporated in EE3's products which led to a higher value of use without a noteworthy increase of input factors. This is reflected in a remarkable increase in labour productivity. But revenues did not grow in line with technological progress and employment was reduced. However, this development was just sufficient to maintain the GOR on long-term levels. For 2012, a GOR of 7.8 was reported, well below the level of EEI (Table 2.58). **The slight improvement since the middle of the past decade – accompanied by massive lay-offs – is reflected in the firm level analysis, which also states that the sector is confronted with tight funding conditions** (Chapter 4.5.4).

Table 2.58: Key indicators for the EU electrical and electronic components sector (EE3)

Sector	Indicator	2012		Annual average growth rate in % 1998 – 00	2000 - 05	2005 - 08	2008 - 12
EEI[1]	Production, in current prices	bn. €	635.8	9.5	-0.2	4.6	-1.2
Intermediary products[2]			64.3	13.2	-1.0	7.5	-0.3
EEI[1]	Production, in 2010 prices	bn. €	651.1	9.7	0.8	7.2	-0.1
Intermediary products[2]			76.8	8.4	1.7	24.5	5.0
EEI[1]	Value added, in 2010 prices	bn. €	212.4	8.9	0.1	5.3	1.2
Intermediary products[2]			21.1	10.1	-0.2	21.8	2.9
EEI[1]	Employees	1,000	3389	2.2	-1.7	0.5	-1.9
Intermediary products[2]			298	2.7	-2.3	0.8	-3.5
EEI[1]	Labour costs per employee	1,000 €	43.3	3.4	1.6	2.1	2.8
Intermediary products[2]			43.2	4.2	2.1	2.3	2.2
EEI[1]	Productivity[3]	1,000 €	62.7	6.5	1.7	4.8	3.2
Intermediary products[2]			70.8	7.2	2.2	20.8	6.6
EEI[1]	Unit labour costs[4]	€ / €	0.69	-2.9	-0.1	-2.5	-0.3
Intermediary products[2]			0.61	-2.8	0.0	-15.3	-4.1
			Annual averages[5]				
EEI[1]	GOR[6]	%	9.0	8.6	7.7	8.5	8.8
Intermediary products[2]			7.4	9.4	7.0	7.6	7.9

1) Electrical and electronic engineering; 2) Electrical and electronic components; 3) (Value added in 2010 prices) / employment; 4) (Nominal total labour costs) / (value added in 2010 prices); 5) for the period under consideration; 6) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance of EE3

EE3 is characterised by its one-sided structure in terms of domestic demand between its two components: the manufacture of electronic components (26.11) and the manufacture of electronic boards (26.12), which accounted for 81.2 % and 18.8 % respectively in 2012. Therefore, the evolution of the EE3 sector is heavily driven by the trend of the first sub-sector.

In 2012, the EE3 domestic demand represented 11 % of total EEI demand compared to 10 % in 1998. Demand cycles for electronic components are remarkably more pronounced than for total EEI. (Table 2.59) Secular trend growth for EE3 products is slightly steeper than for total EEI, at annual average rates of 3.0 % and 1.8 %, respectively.

For EE3, the dependency from third countries decreased during the period under investigation. In 1998 exports came to 56.6 % of production. This share fell to 26.6% in 2012. **This trend is partly explained by the EU-27 electronic components manufacturers focusing on the demand of the EU EEI and other EU-27 client industries. The electronics components sector has become less dependent to demand from other regions of the world, such as Asia which has become the power house for the manufacture of computers and peripheral equipment, communication equipment and consumer electronics, with its large batch demand for electronic components.**

Over the period under investigation, the amount of exports dwindled from € 23 billion in 1998 to € 17.1 billion in 2012 after a first peak in 2000 and a second peak of € 35 billion in 2006. The year after exports tumbled by roughly one third. This negative development is to be blamed on the poor performance of the 26.11 sub-sector which was not offset by the increase of the exports of loaded electronic boards. EE3 imports showed a quite similar cyclical pattern, with growth only during the first years of the period under consideration.

In international trade with EE3 products the EU-27 has a structural deficit. As a percentage of the trade volume, the deficit was between 15 % and 20 % until to 2008. For the most recent period from 2008 to 2012 it was on average 38.9 % and indicates a worsened situation. Likewise, the RCA shows that EE3's international performance – which was worse than for the EEI, indicated by negative values already evident at the beginning of the period under investigation – had worsened markedly for the most recent period.

Table 2.59: Trade indicators for "Electronic components and electronic loaded boards (EE3)"

Indicator	Sector	Units	2012	Annual average growth rate in %			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EEI	bn. €	694.4	10.9	-0.9	4.7	-1.2
	EE3		77.6	22.1	-5.0	9.1	0.2
EU-27 exports	EEI	bn. €	226.0	17.2	3.0	1.9	3.7
	EE3		17.1	21.3	-1.6	-14.3	-3.5
EU-27 imports	EEI	bn. €	284.6	19.3	0.3	2.7	2.7
	EE3		30.4	32.8	-7.1	-6.1	-1.1
				Averages for the periods			
				1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EEI	%	35.5	24.8	28.5	29.9	32.5
	EE3		26.6	55.0	57.6	40.7	26.4
Import quota[3)]	EEI	%	41.0	32.1	34.5	35.9	39.0
	EE3		39.2	64.5	65.2	48.5	44.9
Trade balances[4)]	EEI	%	-11.5	-17.8	-13.9	-13.7	-14.1
	EE3		-28.0	-19.5	-15.9	-15.7	-38.9
RCA[5)]	EE3	Index	-0.35	-0.02	-0.05	0.03	-0.45

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

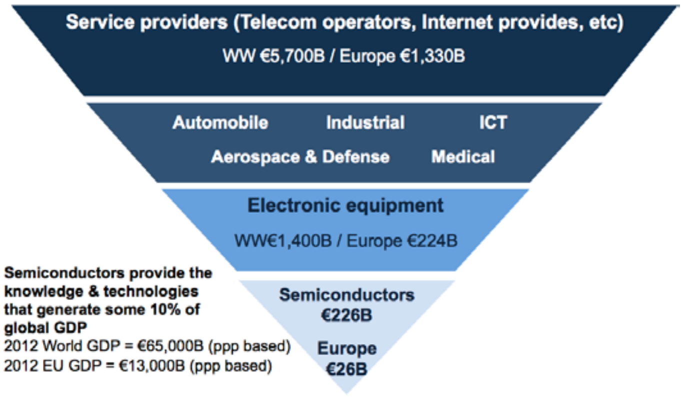
Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.3.1 *Electronic components (NACE 26.11): Semiconductors*

Semiconductors (SC) are a key enabling technology for the whole electronics value chain. In 2012, the semiconductor market represents € 226 billion (USD 290 bn) and provides inputs to markets worth € 1,400 billion for electronics systems and € 5,700 billion for services (as shown in **Figure 2.11**).

Since the invention of the transistor in the late 1940s, semiconductor content in electronic equipment has grown from 2 % in the 1960s to 20 % in the 2000s and is expected to reach 25 % by 2020. The contribution of semiconductor technology to the global product added value is increasing and the pervasive use of semiconductors across many economic sectors has been, and will continue to be, the main driver of SC market growth.

Figure 2.11: Economic leverage of the semiconductor sector



Source: DECISION/IMF/WSTS, 2013

Products

Semiconductor technology can be broken down into four major component families:

- **Integrated Circuits (IC)**: accounting for more than 80 % of the € 226 billion (USD 290 bn) world total SC production in 2012; IC is the largest family in value, € 185 billion (USD 237 bn). ICs (also called "chips") are used in almost all electronic equipment. Because of specific technical features and dedicated use, ICs are split as follows:
    - Analogue € 31 billion (USD 40 bn): Amplifier circuits, Interface circuits, Conversion circuits, Voltage regulators, Comparators, etc.
    - Micro € 47 billion (USD 60 bn):
        - Microprocessors (MPU) are designed for general purposes and are, for instance, largely used in the computer industry;
        - Microcontrollers (MCU) are, in contrast, specifically designed for embedded systems like automotive, medical devices, industrial machines, etc.
    - Logic € 63 billion (USD 81 bn): Application-Specific Integrated Circuits (ASIC), Application-Specific Standard Products (ASSP)
    - Memory € 44 billion (USD 56 bn): DRAM, SRAM, Flash memory (NOR and NAND), ROM and EPROM
- **Discrete** € 15 billion (USD 19 bn): Diodes, Power transistors (IGBT, etc), Rectifiers, Thyrisistors, etc.
- **Opto** € 20 billion (USD 26 bn): Displays, Lamps, Couplers, Laser pickups, Laser transmitters, Infrared devices, etc.
- **Sensors** € 6 billion (USD 8 bn)

Demand side

The evolution of demand patterns over time both stimulates investment and growth cycles for the SC industry.

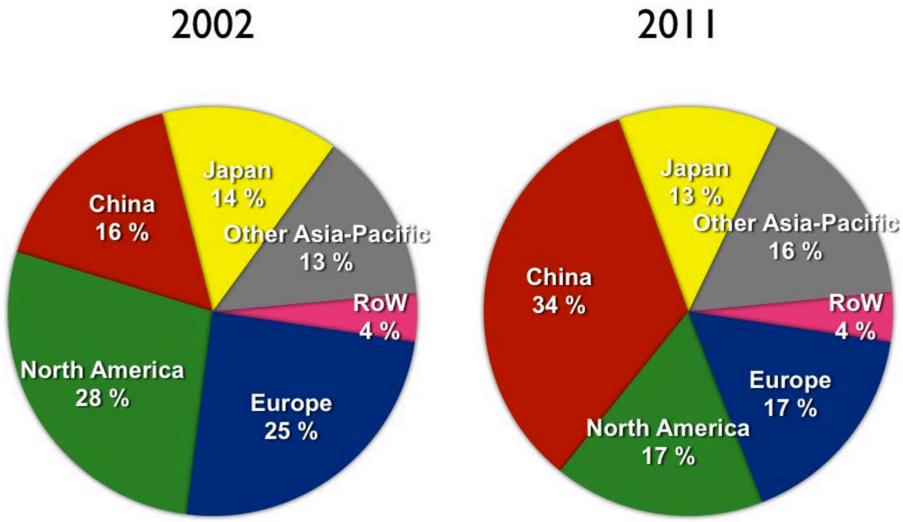
Originally, the need for semiconductors stemmed from military applications (radars, etc.) and with their large defence industry, the US dominated the semiconductor industry (SCI) both in terms of production and market. Driven by the combined effect of miniaturisation and the verification of the Moore's law[122], which entailed large economy of scales, SCI found new applications and started to be mass-produced, meeting the demand of consumer electronic goods like TVs in the 1970s, and

[122] Moore (co-founder of Intel) says that: "The number of transistors that can be placed inexpensively on an integrated circuit doubles approximately every two years". As the rhythm seems to slow down with physical and economic constraints, other ways are explored to continue fast integration of new functions.

also micro-computers in offices in the 1980s and computers for households and mobile phones in the 1990s. Over recent decades, these innovations in electronics allowed the emergence of new market leaders, which in turn had an impact on the structure of the SC sector.

From a demand side perspective, the semiconductor market is directly linked to the evolution of the electronic equipment regional production landscape. Over the past ten years, production of electronic equipment in Asia, and particularly in China, skyrocketed. Accounting for 34 % of the world electronics production in 2011, China has doubled its share since 2002 (See: **Figure 2.12**). In 2011, China and other Asia Pacific countries represented half of the electronic equipment production whereas North America, Europe[123] and Japan production shares dropped respectively to 17 %, 17 % and 13 %.

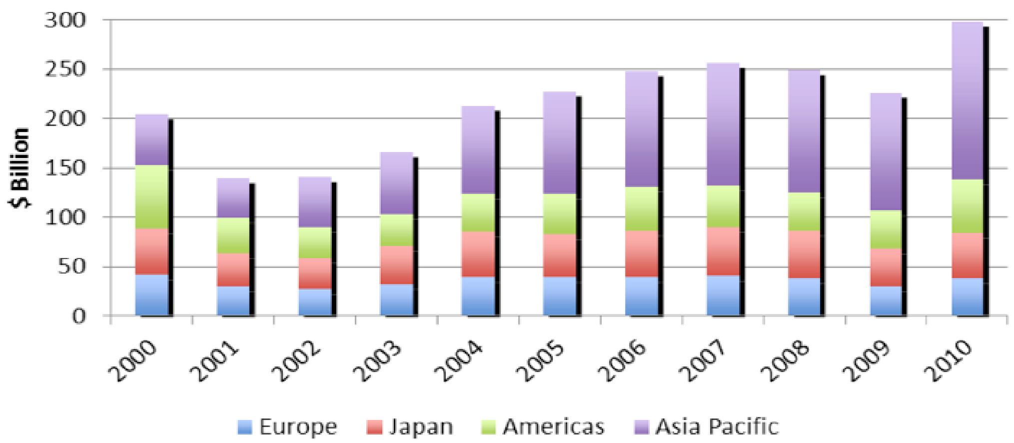
Figure 2.12: Electronics equipment breakdown by region 2002 and 2011



Source: DECISION

This rush of electronic equipment production to China was especially true for the mass-market electronic products (PCs, mobile phones, TVs, etc.), which absorb the largest SC volumes and value.

Figure 2.13: Semiconductor sales by region



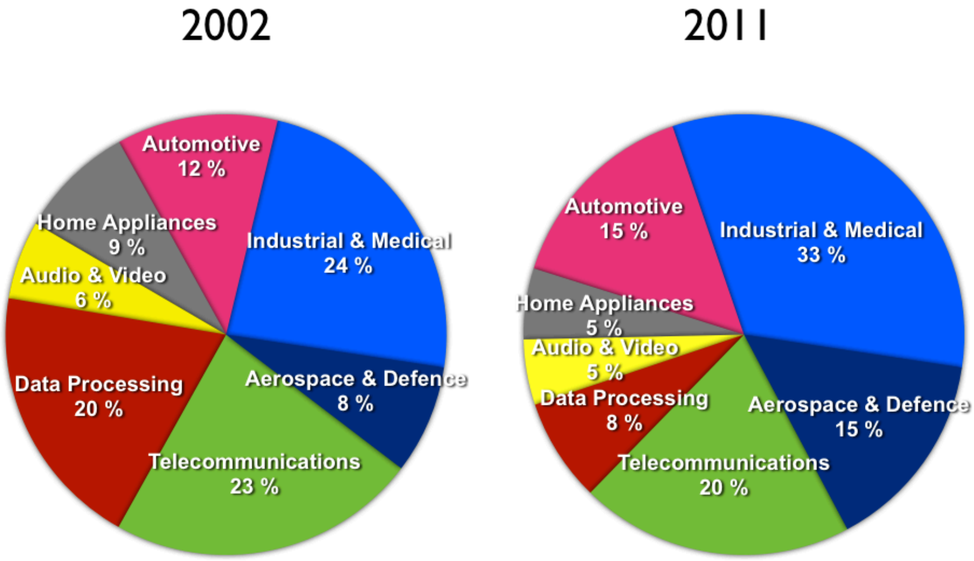
Source: WSTS (2011)

[123] Europe in DEC surveys includes: EU-27 + all other European countries (including Turkey), and excludes CIS countries.

As a consequence, and in spite of a growing SC market, the last decade has seen continuous deterioration of Europe's position in the global semiconductor market. The worldwide share of Europe as a consumer of semiconductors has been declining over the last 15 years: from a peak of 22 % in 1998 to 13 % in 2010 – and is still declining further. It is noticeable that all regions have lost shares to Asia-Pacific, which now represents more than half of worldwide sales, and that the US has lost even more shares than Europe (See **Figure 2.13)**.

This new electronic equipment production landscape has entailed a shift for the European electronic equipment sector towards new areas of specialisation. Nowadays, the three areas of strengths for the European electronic equipment are Industrial & Medical, Aerospace / Defence & Security and Automotive, whose share accounts for 31 %, 30 % and 29 % respectively of the world electronic equipment production.

Figure 2.14: Electronic equipment production breakdown in Europe by application 2002 and 2011 in value



Source: DECISION

Following the evolution of the production of electronic equipment in Europe, the SC market in Europe moved from a low mix / high volumes pattern towards a high mix / low volume pattern, which better corresponds to the demand of professional sectors as opposed to mass-market ICT and suits down-stream industries where Europe enjoys comparative advantages in global competition.

Supply side

The electronics industry fundamentally behaves as a 'technology-push' industry.
Electronic equipment manufacturers (OEMs) rely on semiconductor technology to differentiate their product functionalities. Having access to the latest semiconductor technologies allows the OEMs to optimise the performance of their products while keeping costs under control.

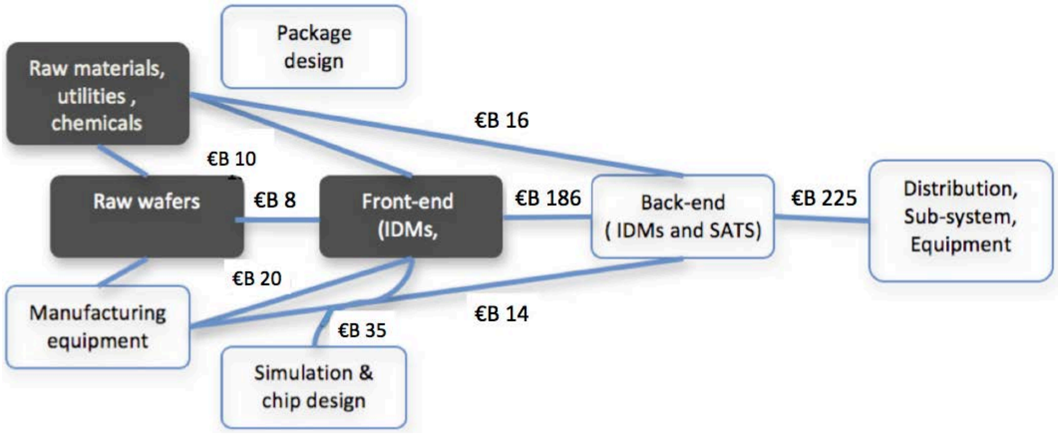
Driven by Moore's law, the semiconductor industry has thus become a highly capital intensive industry. Each technological leap has been linked with higher capital intensity. Capital costs remain at the forefront of the technological roadmap and have become prohibitive for the vast majority of players. Only few companies have remained in the market and investment in the next process technology with 450 mm wafers will lead to even lesser players in the market.

The annual turnover necessary to continue investing in state of the art design and manufacturing facilities is now over € 7.7 billion ($ 10 billion), which corresponds to the estimated cost of an advanced semiconductor manufacturing facility by the end of the current decade. Semiconductor technology and industry are now more than ever pushed by mass-markets generating sufficient volumes of activities to make some return out of such investment.

The growing complexity of nano-electronics technology and electronic products has pushed the semiconductor value chain to evolve from a linear chain to a networked model to become today a highly fragmented and internationalised supply chain following almost two decades of intense industrial consolidation and de-integration.

The following picture (**Figure 2.15**) provides a snapshot of the semiconductor supply chain. The numbers quoted give an idea of the sales between the various parts of the process. They are estimates for 2010 and can vary tremendously from one year to another.

Figure 2.15: Semiconductor supply chain



Sources: DECISION, SEMI, Gartner, WSTS, Electronic Design

The SC fabrication process is very complex but can roughly be broken down into three major steps:

1. ***Raw wafers production:*** a raw wafer is a thin slice of semiconductor material, such as a silicon crystal, that serves as the substrate for micro-electronic devices built in and over it. Wafers are formed of highly pure (99.9999% purity) single crystalline material. Its fabrication involves many complex steps and the use of several types of raw materials and chemicals.
2. ***Front-end processing:*** is the sequence of operations that lead, according to the design instructions from the wafer, to the small piece of silicon (die), which, once packaged, will become an integrated circuit. Most modern complex chips require over 300 processing steps including doping or ion implantation, etching, deposition of various materials and photolithographic patterning.
3. ***Back-end operations*** traditionally include assembly, the final step of semiconductor device fabrication, and testing of the resulting 'chip'. These operations have long been considered as the less glamorous part of the process and were offshored and outsourced earlier than other parts. However, they are regaining favour as an important part of "more than Moore[124]" developments (multiple dies in one package).

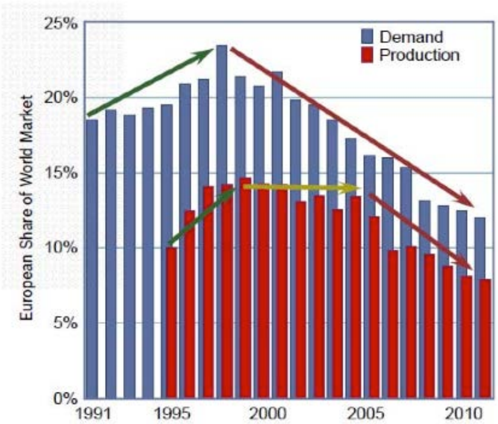
[124] The "More than Moore" approach typically allows for the non-digital functionalities (e.g. RF communication, power control, passive components, sensors, actuators) to migrate from the system board-level into a particular package-level (SiP) or chip-level (SoC) potential solution.

Among the previous categories, only the first (raw material and wafer production) remains to a significant proportion produced in Europe thanks to the position of German Siltronic AG as the 3rd silicon wafer manufacturer worldwide after Japanese SUMCO and US MEMC (which also has some production facilities in Italy). Siltronic has heavily invested close to its customer base in Asia (Singapore) and the US (Portland) not to lose its position as one of the leaders in the global market.

Back-end operations have been the first to leave Europe to the benefit of Asia due to lower contribution to the chip added value and a more labour intensive process compared to front-end processing. Today, back-end operations have almost disappeared in Europe with the notable exception of high value added packaging technologies.

Capital investment in front-end facilities, after a strong development during the 1990s, has progressively diminished and Europe represents today below 5 % of the total capital investment in front-end manufacturing facilities. This is illustrated in the following chart (**Figure 2.15**) showing the rapid decline of the share of European SC production since 2000.

Figure 2.16: European share of SC sales and production



Source: WSTS, ICInsights

Europe industrial leadership in manufacturing equipment for the semiconductor industry should, however, be mentioned more explicitly in the field of advanced lithography (the most sensitive and critical manufacturing step in advanced front-end semiconductor facility) where the European company ASML is now dominating the market to such extent that it has recently become the 1st semiconductor equipment supplier worldwide, ahead of competitors like US Applied Material (AMAT) and Japanese Tokyo Electron (TEL) with broader product portfolio.

A semiconductor manufacturer manages both **front-end** and **back-end** processing steps (which can be carried out in different places) and, at the turn of the century, there were three European semiconductor manufacturers in the world top ten (STMicroelectronics, Infineon and Philips). Today, however, there is only one European manufacturer.

Table 2.60: SC manufacturers ranking by revenue

Rank	2012			2005		1998	
	Company	Origin	Revenue (million $ USD)	Company	Origin	Company	Origin
1	Intel		49,114	Intel		Intel	
2	Samsung		32,251	Samsung		NEC	
3	TSMC*		17,167	Texas Instr.		Motorola	
4	Qualcomm**		13,177	Toshiba		Toshiba	
5	Texas Instr.		12,147	STMicro		Texas Instr.	
6	Toshiba		11,217	Infineon		Hitachi	
7	Renesas		9,314	Renesas		Samsung	
8	Hynix		9,057	NEC		Philips	
9	STMicro		8,364	Philips		STMicro	
10	Micron		8,002	Freescale		Fujitsu	

*Foundry, ** Fabless

Remark: Qualcomm is a fabless supplier. A large part of its sales comes from TSMC. There is no information available on the volume and the double count in this table.

Sources: Gartner, iSuppli, IC insights, Companies reports

Historically, **back-end** processing operations (semiconductor assembly and testing) were the first to be offshored and this move started very early in the globalisation process (Fairchild was the first to move its assembly to Hong-Kong in 1961). Reasons were costs as well as labour quality and quantity because US companies were under competitive pressure from Japanese competitors and this was the easiest part of the process to offshore. Labour intensive back-end operations are today almost entirely located in South East Asia with only high value added and new processes development remaining in Europe.

Front-end chips production offshoring by US SC manufacturers started later in the 1970s and for different reasons. At this time, trade barriers especially in Europe (where semiconductor production had started in large firms namely Philips, SGS, Siemens and Thomson) made American exports to Europe (and Japan) uneconomic. During this period US corporations built many semiconductor plants in Europe.

Hence, it was in the early 1980s when the fabrication segment separated from the design segment and fabless firms emerged. This was the real start of fragmentation of the semiconductor value chain. The main reason was the high cost of entry into the semiconductor industry, while the catalysts were the development of Electronic Design Automation (EDA) tools (1981) and of pure-play foundry fabs (the companies MOSIS and TSMC were created respectively in 1981 and 1987).

With the arrival of EDA companies, IDMs (Integrated Device Manufacturers) were able to outsource not only the Computer-Aided-Design (CAD) tools they were developing themselves, but also some of their designs to a new breed of companies, the "design houses". In turn, because the demand from IDMs was not steady, design houses started developing products of their own (thus creating the first fabless companies) and looking for companies to produce them. The first foundries were laboratories or small companies only able to produce prototypes and small volumes.

In the 1990s, the company TSMC played a central role in the evolution of the semiconductor value chain as a pioneer in the foundry business. It remains the leader of pure-play foundries today with almost 50 % market share (its compatriot UMC is at the 2nd rank worldwide with almost 15 % of the market) and is also an established member of the top five manufacturers. Its presence and leadership have been one of the main reasons for the development of the semiconductor industry in Taiwan as well as of the dominance of Taiwan in a number of IT equipment manufacturing sectors. Taiwanese integrated circuits (IC) design firms use as much as 85 % of local foundry services for their own products. This shows that spatial proximity matters for the IC design industry and clusters are pivotal for competitiveness. In 2011, SC foundry business accounted for around 10 % of the whole SC production. The US with GlobalFoundry (3rd world leader) and IBM (7th) but also South Korea with Samsung (4th) and China with SMIC (5th) are the leading countries of the foundry activity; Europe is lagging behind with only one small actor, the German X-Fab (14th).

In the 1990s, the emergence of the so-called "system-on-chip" methodology led to the disintegration of the design part of the value chain into EDA and Intellectual Property (IP)[125] providers and design houses. The fragmentation of design undermined the prevailing wisdom that off-shoring production of semiconductors was not a relevant business issue given that design, as the high value-adding part, remained in the country of origin.

Accompanying the long-term trend in fragmentation of the semiconductor value chain, this decade has seen the emergence of the "fab-light" model due to the increasing cost of building state-of-the-art fabs, which today are only affordable by a handful of IDMs (Intel, Samsung, Toshiba, Renesas, etc.) and foundries (TSMC, UMC, Global Foundries, etc.). This new model makes the value chain more complex. "Fab-light" refers to the move by a large number of companies from the "fab" model of a full IDM manufacturer towards an intermediate model where they act as an IDM for only part of their sales and as "fabless" for the rest (i.e. by outsourcing production to a foundry).

Europe fell significantly behind in semiconductor manufacturing during the last decade as European suppliers followed this fab-light strategy based upon the assumption that in-house production was both too expensive and unnecessary with no strategic or commercial benefit.

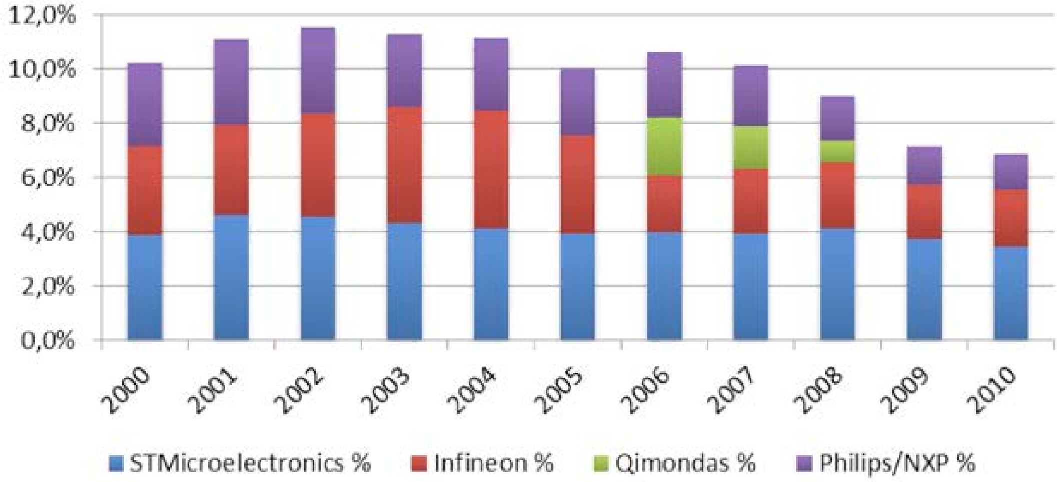
During the 1990s, Europe saw growth in new fabs but since then the flow has reversed as no major investment in advanced front-end fabs has been done in Europe over the last decade. In other words, old fabs closed with few new ones opening to replace them. The largest fabs currently operating in Europe are those of Intel (IE), GlobalFoundries (DE), STMicroelectronics (FR) which

[125] In electronic design a semiconductor intellectual property core, IP core, or IP block is a reusable unit of logic, cell, or chip layout design that is the intellectual property of one party. IP cores may be licensed to another party or can be owned and used by a single party alone.

are being upgraded to handle the latest 300mm technologies thereby assuring some high-volume advanced IC manufacturers remain in Europe until these will also become obsolete.

Therefore, the decline of the EU-share of worldwide SC production value has been significant: from close to 14 % in 1998 to less than 10 % in 2011. The EU now ranks 6th behind Japan, Taiwan, South Korea, the US and China. Global investment conditions, 'manufacturing culture' and now the advanced manufacturing ecosystem convergence (cluster effect) are pointed out by industrial investors as more attractive in the US or Asia.

Figure 2.17: "Top 3" European SC manufacturers' worldwide market share



Source: iSuppli

Note: in 2006, the SC operations of Philips were sold to a consortium of private equity firms through an LBO to form a new entity named NXP Semiconductors. The same year, the memory activities of Infineon were spun off to form a new separate legal entity named Qimonda.

Technology, R&D Policy

There is not only fierce global competition in the semiconductor industry but also between nations and regions to attract investment in this key-enabling technology. Governments have adopted aggressive strategies to support the development of their national suppliers and encourage foreign direct investment in the sector, thus securing their innovation capability at the product, system and service levels.

Initially, subsidies were made as direct grants but over the last two decades many governments have implemented more advanced tools in order not to get in conflict with WTO rules:

- Fiscal incentives, for example tax, salaries, R&D tax credits, depreciation and infrastructure development;
- Land acquisition, improvement of infrastructure (roads, ICT networks, power supply);
- Equipment funding, including capital grants for buildings and manufacturing equipment;
- Energy cost subsidies;
- Employee training programmes;
- R&D funding.

Like other funding instruments, R&D is a part of the competitiveness equation. In Europe the impact of R&D funding has been particularly important for the semiconductor industry, starting with the JESSI[126] pre-competitive programme in 1989 and its successors (MEDEA, CATRENE). Such

[126] Eureka cooperative R&D program dedicated to SC industry.

programmes enabled Europe not only to close the technology gap with competing regions, but also to demonstrate its ability and leadership in both advanced system applications and technology clustering. Europe now holds three world-class Research and Technological Organisations covering all aspects of the SC supply chain (imec in Belgium, Leti in France and Fraunhofer institutes in Germany) and co-operation within the European semiconductor supply chain on pre-competitive R&D projects remains a huge European asset in the global competition.

In the document "Vision, Mission and Strategy: R&D in European Micro-and Nanoelectronics"[127] issued by representative R&D organisations of the European SC industry (CATRENE, AENEAS), a SWOT analysis of the current state of European SC supply chain was provided. Among the major strengths of Europe in the global competition were the following items:

- Excellent R&D capabilities/capacities in industry, institutes and academia;
- Global leadership in More-than-Moore technologies and applications;
- Leading position in several semiconductor market segments and applications – e.g. automotive, industry, security and communications;
- Highly skilled employees with outstanding professional experience.

However, the same document also provided a list of European weaknesses, among which:

- Deterioration of the already unfair level playing field and persistence of the unfavourable European framework conditions;
- Loss of major parts of technology and production expertise and as a consequence, risk of degradation in leading-edge R&D;
- Brain drain to other regions.

Despite Europe's undisputable wealth of R&D experience, it is failing in capitalising on this as again reiterated in the February 2011 KET Report[128]. While in the 1990s European companies leveraged this R&D to attain strong positions in the global supply of semiconductors and equipment, since the turn of the decade, with relatively few exceptions, there has been a dearth of European companies willing to commercialise this research fully at the most advanced steps of the technological ladder also concentrating most of the investment in the supply chain. Among the main reasons are:

- The European regulatory framework has changed with additional constraints on public funding to large SC projects, making Europe a less attractive area to invest in state of art manufacturing facilities;
- The specialisation of the European electronic equipment industry towards professional market segments appeared less demanding in terms of technological integration for the SC industry and its collateral impact for the semiconductor industry, i.e. the displacement of the major SC market to the East;
- The policy of European SC suppliers to both (a) move out of advanced manufacturing to a fabless business model and its intermediate 'fab-lite' stage and (b) exit commodity mass markets in favour of niche and speciality areas.

In such a context there is consequently a major concern today that R&D could also leave Europe in order to keep access to state-of-art manufacturing infrastructure. One long term strategy for Europe in order to prevent such a dislocation of its SC supply chain can be to incite companies to abandon their current fab-lite strategy and to keep advanced manufacturing capacities in Europe.

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[127] http://www.eureka.org.tr/eureka_content_files//545/Kumeler/Catrene/VMS_Final_Feb2011_1.pdf.

[128] http://www.google.fr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&ved=0CDEQFjAB&url=http%3A%2F%2Fec.europa.eu%2Fenterprise%2Fsectors%2Fict%2Ffiles%2Fkets%2Fhlg_report_final_en.pdf&ei=zUBUUZvjLLDH7Aby94CoCw&usg=AFQjCNE37L4aoMfO6QQWLTq3y5WOOsBWEw&bvm=bv.44442042,bs.1,d.d2k.

In the early days of semiconductors IDMs were able to handle the entire value chain, sometimes even extending their business into manufacturing equipment and materials at one end and electronic products and services at the other end. Although that model has changed over the years and many successful "fabless" (fabrication-less) companies (semiconductor companies relying totally on third-party foundries)[129] have emerged. Competing perimeters in the SC industry are moving and business models are changing, and it is possible that new forms of industrial integration develop in the future due to increased process complexity and industrial consolidation. Intel, the world leader and last fully-fledged IDM, is developing a foundry activity (like its direct competitor Samsung) while TSMC, the dominant player of the foundry market, is building design capacities leveraging its technological and industrial leadership.

This evolution currently takes place while the global SC industry is preparing for its next step to 450 mm manufacturing which will double the area of the SC wafer used in front-end manufacturing activities, providing a 30 % production cost advantage over current (300mm) most advanced plants and further increasing the investment cost to access state-of-art semiconductor technologies.

Indeed, the investment volume of the transition from the current technology (300mm) to the 450 mm technology is estimated between € 20 billion and € 30 billion from 2012 until the early adopters open their first 450 mm volume fab (as early as 2018). The largest share of the investment will be for equipment and material development as well as qualification (between € 12 bn and € 15 bn). This funding amount for transition has to be added to existing investment in 300 mm technology development and thus translate into a significant increase in funding requirement. In the short-term, only three SC manufacturers can adopt this latest 450 mm technology: Intel (US), Samsung (KR) and TSMC (TW).

It is most likely that advanced SC production will remain in the hands of foundries and the remaining full-fab IDMs that are developing foundry services in parallel. However "co-operative" foundries (supported by several companies) are a possible development that should be investigated. For Europe, this could take the form of an industrial cooperation between major European SC suppliers.

A study published last year states that this next-generation technology could turn into a genuine opportunity for Europe, building on its strengths (R&D, equipment & material, cooperative development) and an increased level of coordination, to regain the position it once held in SC manufacturing by securing a complete SC supply chain and making sure that the most advanced SC technologies continue to be manufactured on European soil[130].

However, the loss of client industries with a demand for mass-manufactured SCs and the strong demand for professional intermediary products – manufactured in smaller batches – and the growing product diversification in the European market for SCs and related electronic products will pose a high barrier for an economically sustainable run 450 mm Fab. The latter depends on large batch production to raise necessary scale effects to be internationally competitive with similar fabs close to client industries, above all in Asia (for a discussion of pros and cons of different alternatives see: Chapter 4.7).

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[129] A semiconductor foundry is a company, which operates semiconductor fabrication plants producing integrated circuits (ICs) for other companies - for manufacturing.

[130] "Benefits and Measures to Set Up 450mm Semiconductor Prototyping and to Keep Semiconductor Manufacturing in Europe » study for the EC (2012, DECISION).

Electronic sub-sectors outside Electronic Engineering

The semiconductor industry is mostly analysed through technological and/or geographic criteria. But it is also useful to consider in which end-user markets its application take place and where European players are best positioned.

Table 2.61: Worldwide semiconductors market split by end-user segment (%)

Market segments	2006	2011
Data processing	39.0%	37.3%
Communications	28,1%	24.0%
Consumer electronics	17.3%	20.3%
Automotive	7.1%	7.7%
Industrial	10.5%	10.9%

Source: PwC

One can see that due to the continuous pervasion of the electronic technology across all industries, the share of semiconductors used outside the Electronic Engineering sub-sectors is progressively growing, reaching today almost 20 % of the total.

Assessment of economic performance

Semiconductors and other electronic components (sub-sector 26.11) are the main part of Intermediary products (EE3), accounting for 79 % of EU-27 EE3 nominal production in 2012. Employment declined by 62,000 employees between 1998 and 2012 with a remaining staff of 214,000, which equals a decline of 22 %. (**Table 2.62**) As mentioned above, the European share of the global production of SC reduced from 14 % in 1998 to less than 10 % in 2011. Even worse, EU-27 exports of semiconductors plunged from about one tenth of global trade at the beginning of the period under consideration to less than one twentieth during the more recent years. **A bright spot – compared to other sub-sectors – was the development of labour productivity at an annual average rate of 9.8 % over the whole period. However, when compared with the other competing economies, this pace of improvement was in the usual range.** The US and Taiwan showed a somewhat stronger growth, while Japan was a bit below and South Korea with a soaring growth of labour productivity outpaced all competitors, when EE3 is taken as the next best proxy (See: **Table 4.8**). As expected, the performance of ULC and GOR over the whole period are close to EE3.

Table 2.62: Key indicators for sub-sector "Manufacture of electronic components"

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Intermediary products[1] C2611[2]	Production, in current prices	bn. €	64.3 50.8	13.2 10.0	-1.0 0.6	7.5 8.7	-0.3 -1.3
Intermediary products[1] C2611[2]	Production, in 2010 prices	bn. €	76.8 62.4	8.4 1.8	1.7 4.6	24.5 29.9	5.0 4.6
Intermediary products[1] C2611[2]	Value added, in 2010 prices	bn. €	21.1 17.1	10.1 5.2	-0.2 1.7	21.8 28.2	2.9 3.1
Intermediary products[1] C2611[2]	Employees	1,000	298 214	2.7 2.1	-2.3 -2.3	0.8 0.2	-3.5 -4.5
Intermediary products[1] C2611[2]	Labour costs per employee	1,000 €	43.2 44.9	4.2 3.4	2.1 2.6	2.3 3.4	2.2 2.4
Intermediary products[1] C2611[2]	Productivity[3]	1,000 €	70.8 79.7	7.2 3.1	2.2 4.0	20.8 27.9	6.6 7.9
Intermediary products[1] C2611[2]	Unit labour costs[4]	€ / €	0.61 0.56	-2.8 0.3	0.0 -1.4	-15.3 -19.2	-4.1 -5.1
			Annual averages[5]				
Intermediary products[1] C2611[2]	GOR[5]	%	7.4 8.1	9.4 8.8	7.0 6.6	7.6 7.5	7.9 8.4

1) Manufacture of Electronic components; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

The domestic demand of electronic components increased on average at a yearly rate of 3.0 % from 1998 to 2012, somewhat below EE3. This trend hides the high cyclicality of this sub-sector (Table 2.63). Likewise the ups and downs of demand have affected imports. During the early years of the period under investigation, between 1998 and 2000, the import quota was extremely high, on average at 76.5 %. **Foreign deliveries have lost much of their former importance as shown by an import quota that fell to 43.1 % in 2012. This decline is explained by the loss of downstream production capacities in areas like consumer electronics, computers and communication equipment.**

Over the whole period under investigation, the sub-sector's exports ups and downs were similar to demand. One peak in exports was at the New Economy boom in 2000 at € 32.1 billion and another in 2006 at € 32.7 billion. During the years after exports tumbled. In 2009 – during the financial crisis – they bottomed out at € 12.9 billion and never regained former heights. In 2012 they stood at € 15.6 billion. On average over the whole period the EU exports of sub-sector 26.11 declined at an annual average rate of 2.4 %. Simultaneously, imports shrunk at an annual rate of 0.7 %.

The decrease is explained not only by a loss of some competitiveness, but is chiefly the result of the specialisation during the last decade of the European electronic equipment industry towards professional electronics markets, i.e. electronics for automotive or for aerospace and defence, whose production units are still well implanted on the European territory. **This trend drove the European electronic components industry, and even more the semiconductor manufacturers, to specialise and adjust its product portfolio for these electronic equipment markets that have remained in Europe, while large batch electronics manufacturing locations were relocated to Asia.** EU-27 manufacturers of large batch semiconductors did not follow their downstream industry by exports, but by production in Asia. This explains the slowdown of the sub-sector's exports, while simultaneously production went up by 52 % from € 33.4 billion in 1998 to € 50.8 billion in 2012.

With regard to the assessment of the sub-sector's international trade performance one has to remember that the sub-sector has a weight of four fifths of the benchmark.

Table 2.63: Trade indicators for "Manufacture of electronic components"

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE3	bn. €	77.6	22.1	-5.0	9.1	0.2
	26.11		61.9	20.9	-4.4	10.3	-0.7
EU-27 exports	EE3	bn. €	17.1	21.3	-1.6	-14.3	-3.5
	26.11		15.6	20.9	-1.8	-14.6	-3.9
EU-27 imports	EE3	bn. €	30.4	32.8	-7.1	-6.1	-1.1
	26.11		26.7	32.3	-7.2	-6.9	-1.6
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE3	%	26.6	55.0	57.6	40.7	26.4
	26.11		30.7	69.2	70.2	46.9	30.2
Import quota[3)]	EE3	%	39.2	64.5	65.2	48.5	44.9
	26.11		43.1	76.5	76.1	54.0	49.4
Trade balances[4)]	EE3	%	-28.0	-19.5	-15.9	-15.7	-38.9
	26.11		-26.2	-18.5	-14.8	-14.1	-38.5
RCA[5)]	26.11	Index	0.04	0.02	0.02	0.03	0.02

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.3.2 Manufacture of loaded electronic boards (NACE 26.12)

Overview

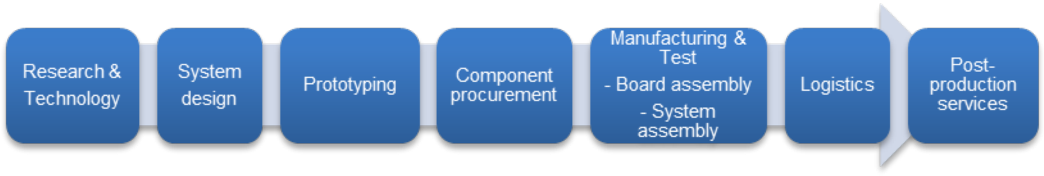
This is the sub-sector that is more than others characterised by subcontracting business. There are a significant number of extremely large players. But even these companies pursue the typical subcontracting business model based on low-cost production and access to an abundant, cheap labour force. They are dependent on a few large OEMs with strong bargaining power built on their access to final clients, their design and innovation autonomy and the size of contracts offered. Their business model was driven by an above average growth caused by strong demand in the final goods markets and an increasing share of workload outsourced by OEM. However, profitability has remained poor in the mass-market business.[131]

Most of the electronic device or equipment manufacturers have – starting from the early 70's – outsourced partly or all their industrial operations to specialised subcontractors named Electronic Manufacturing Services (EMS) or Original Design Manufacturers (ODM). These changes in the value chain are on par with the development in the value chain for PCs (see: Chapter 2.2.1). EMS companies have progressively extended their range of services, while ODM companies – initially focused on the computer market – have accessed new segments such as mobile phones and

[131] EETimes (7/19/2012); EMS at the crossroads, http://www.eetimes.com/author.asp?section_id=36&doc_id=1266127&page_number=1.

smartphones as well as consumer electronics as LCD TVs or game consoles. The world n°1 electronic subcontractor, the Taiwanese Foxconn, is a perfect example of an EMS being also an ODM firm. As shown in Figure 2.18, manufacturing of loaded electronic boards is just a part of a complex value chain.

Figure 2.18: Range of services offered by the EMS/ODM industry



Source: DECISION

In the electronics industry, the trend for outsourcing was truly boosted when the PC industry appeared in 1981, then extended to the mobile telephony industry from 1995, and is developing today in all the other segments, but at various levels. Globally, both the world EMS and ODM industry realised € 270 billion sales in 2011, a 3 % increase over 2010. From 2005 to 2011, the annual average growth rate was over 10 %, more than twice the annual growth rate of the world production of electronic equipment.

It is not surprising that 75 % of the EMS/ODM business is made in Asia where the production of these categories of goods is concentrated. As already described for semiconductors, Asia is focusing on mass-production closely related market segments, such as consumer electronics, communication terminals, computers and tablets, whereas European manufacturers are focusing on specific applications for market segment, such as aerospace, automotive, medical equipment and industrial applications. The European EMS/ODM business reached € 38 billion in 2011, representing 14 % of the world output. A noteworthy part of this business is made through Eastern European manufacturing sites.

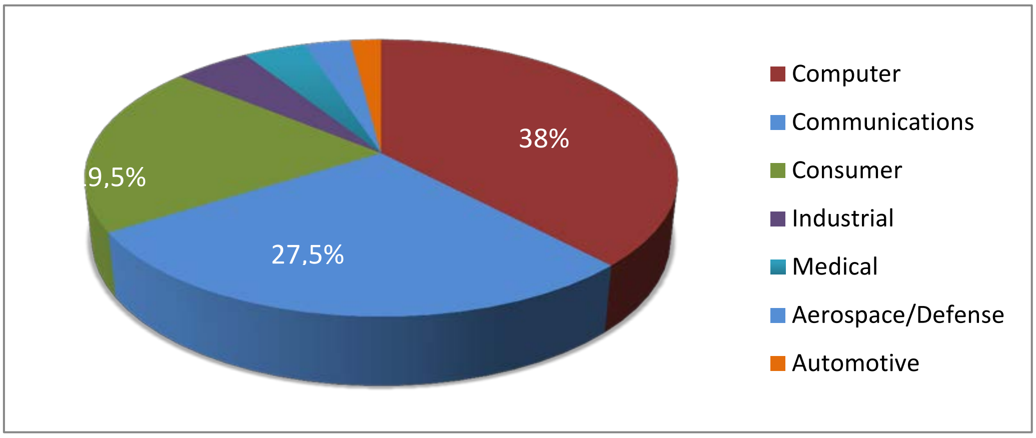
The Asian EMS supply side will experience major changes in coming years. Their clients, the large OEMs, are expected to integrate backwards. Nowadays, they can exploit the scale effects, which in the past was only possible for specialised subcontractors. Some of the subcontractors who already have been able to become ODM try to access the final demand market themselves. The business model “mass-market EMS” becomes more and more fragile.

Most European EMS left mass-markets long ago. They focus on comparative advantages, as there are short lead times and client specific know-how. Therefore, they outbalance their disadvantages in factor costs compared to Asian suppliers. They command a better position in negotiations with clients. However, costs play an important role and changes in the Asian EMS supply sight might affect European EMS only indirectly. In fact, Asian subcontractors have already invested in production sites in CEE countries to get a better access to the European market with its specific needs.

Demand side

Computer and telecommunication industries together still account for more than half of the EMS/ODM business as shown in Figure 2.19. Consumer electronics account for almost 20 %. Market consultants expect strong growth in all market segments. In the lead will be medical equipment with nearly a doubling of the market value between 2010 and 2015, followed by computers and consumer electronics at around 80 %. Noteworthy growth is expected for the automotive, industrial and aviation electronics market segments, although they will be trailing behind the others with "only" an increase of around one half.[132]

Figure 2.19: EMS/ODM world market by segment (2010)



Source: New Venture Research

Supply side

The EMS/ODM industry is highly concentrated with 20 players catching 80 % of the worldwide market as shown in Table 2.64. During the six years from 2005 to 2011, ODM companies increased at an average annual rate of 13.5 %, whereas EMS only increased by 8.3 %. This explains why most EMS have added design capabilities into their service offering, moving their business model closer to ODM with higher growth rates. For the coming years, the global EMS/ODM market is expected to expand at lower pace of 6 % p.a.

The European EMS industry includes few important actors[133]. The n°1, Zollner Elektronik (DE) is ranked n°21 in the worldwide list. The top 10 European EMS had in 2011 revenues between 275 and € 1,000 million each. Unlike the world leaders of their industry, such as Foxconn or Flextronics, they are focused on the low volume/high product mix market segment and, with the exception of AsteelFlash (FR), are only regional players.

Above all, the sub-sector manufactures intermediary products. To a large extent these are products dedicated for assemblage in consumer electronics and telecommunication terminals, a business area in which Europe has lost most of its former importance. Traditionally, Europe has been strong in professional electronics, products designed for specific applications that require proximity to clients and services. Usually these professional products are manufactured in smaller numbers and dedicated for assemblage in client industries where Europe is internationally highly competitive, such as transport equipment, machinery, defence and automation. The share of professional electronics manufactured in low-wage countries was below one tenth of global output in this market segment in 2000. In the meantime, their share of global output in this market segment has multiplied. Global competition drives European EMS companies to make better use of their comparative advantages, as there are flexible supply, short reaction times, product differentiation, consultancy and services. The

[132] New Venture Research (07/15/2012); The Worldwide Electronic Manufacturing Service Market – 2011 Edition, http://www.newventureresearch.com/electronics-assembly/the-worldwide-electronic-manufacturing-services-market-2011-edition/.

[133] Many European EMS companies have added ODM-type services to their business activities to consult their clients, such as design. However, they do not have such close relations with chip and computer manufacturing industries as their Taiwanese counterparts that are ODMs in the true sense of the word.

development of wireless communication and big data transfer and treatment in all downstream industries offer also opportunities to regional EMS. This is true for the supply of professional products in the value chain to OEMs as well as for increasing client companies' organisational efficiency by the application of advanced ICT tools.

Table 2.64: Top 20 EMS / ODM companies (sales in € million)

Manufacturers	Country	EMS / ODM	2005	2010	2011
Foxconn (Hon Hai)	Taiwan	EMS	21 950	58 435	66 785
Quanta Computer	Taiwan	ODM	9 767	26 894	27 246
Flextronics (+ Solectron)	USA	EMS	20 910	18 980	19 690
Compal Electronics	Taiwan	ODM	5 354	21 209	17 018
Wistron	Taiwan	ODM	3 756	13 070	14 400
Jabil Circuit	USA	EMS	6 500	10 860	12 020
Inventec	Taiwan	ODM	3 940	9 018	9 330
Pegatron	Taiwan	ODM	-	7 120	9 126
Asustek	Taiwan	ODM	8 836	7 800	7 096
TPV Technology	Chine	ODM	3 750	6 640	5 765
Celestica	Canada	EMS	6 810	4 930	5 170
Sanmina-SCI	USA	EMS	9 120	4 470	4 330
Cal-Comp/Kinpo Electronics	Thailand	EMS	1 460	2 980	3 205
LIte-On Technology	Taiwan	ODM	4 085	2 492	2 351
BenQ	Taiwan	ODM	4 075	2 138	2 084
Microstar International	Taiwan	ODM	1 387	2 141	1 915
Benchmark Electronics	USA	EMS	1 810	1 810	1 650
Plexus	USA	EMS	1 855	1 620	1 575
SIIX	Japan	EMS	820	1 430	1 510
Venture	Singapore	EMS	1 610	1 570	1 390
Top 20 leaders of 2011			**117 795**	**205 607**	**213 656**

Source: Circuit Assembly, Companies reports

Assessment of economic performance

Loaded electronic boards (sub-sector 26.12) is the smaller part of intermediary products (EE3), accounting for 21 % of EU-27 EE3 nominal production in 2012. Employment increased by 3,000 persons between 1998 and 2012 to 83,000. (Table 2.65) But from the peak of employment in 2001 the number of workplaces saw a reduction of 10 %. This decline was caused by a transfer of production to Asia of most of the ICT mass-market product manufacturing between 2001 and 2007.

In contrast to semiconductors (NACE 2611), the economic performance of EU firms of this sub-sector has worsened throughout the period under consideration. This is understood as an indication for strong international competition and an on-going need for consolidation and concentration on product areas in line with regional comparative advantages available in Europe.

Table 2.65: Key indicators for sub-sector “Manufacture of loaded electronic boards”

Sector	Indicator	2012		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Intermediary products[1]	Production, in current prices	bn. €	64.3	13.2	-1.0	7.5	-0.3
C2612[2]			13.5	23.8	-6.1	2.2	4.0
Intermediary products[1]	Production, in 2010 prices	bn. €	76.8	8.4	1.7	24.5	5.0
C2612[2]			14.4	23.5	-4.0	7.2	7.0
Intermediary products[1]	Value added, in 2010 prices	bn. €	21.1	10.1	-0.2	21.8	2.9
C2612[2]			4.0	20.1	-3.8	4.2	2.1
Intermediary products[1]	Employees	1,000	298	2.7	-2.3	0.8	-3.5
C2612[2]			83	4.7	-2.5	2.8	-0.4
Intermediary products[1]	Labour costs per employee	1,000 €	43.2	4.2	2.1	2.3	2.2
C2612[2]			38.9	6.8	0.8	-1.2	2.1
Intermediary products[1]	Productivity[3]	1,000 €	70.8	7.2	2.2	20.8	6.6
C2612[2]			47.7	14.7	-1.3	1.4	2.5
Intermediary products[1]	Unit labour costs[4]	€ / €	0.61	-2.8	0.0	-15.3	-4.1
C2612[2]			0.82	-7.0	2.1	-2.5	-0.5
			Annual averages[5]				
Intermediary products[1]	GOR[5]	%	7.4	9.4	7.0	7.6	7.9
C2612[2]			4.0	11.0	8.3	8.2	5.9

1) Manufacture of loaded electronic boards; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices); 4) for the period under consideration; 5) Gross-operating rate (Value added - total labour costs) / (gross output) (all in nominal terms).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Assessment of trade performance

The domestic demand of loaded electronic boards grew on average at a yearly rate of 2.9 % from 1998 to 2012, below EE3 at 3.0 % but higher than EE2 at only 1.8 %. This trend, even irregular with ups and downs, reflects the necessity for OEMs to reduce their manufacturing costs using advantages offered by outsourcing to EMS: economies of scale (optimisation of the industrial facilities), component procurement, negotiation power and logistics. And, more and more, design capabilities as well as product life cycle management.

Over the whole period of consideration, EU exports as a share of production was remarkably low. It did not exceed the 20 % threshold. In recent years it has fallen to around 11 %. This is explained by the fact that loaded electronic boards manufacturing for customers requires regional proximity. The European manufacturers focus on products for special applications. Imports had peaked in 2002 at 28 % of the domestic demand, but for most of the years the import quota hovers around 24 % and shows no clear trend. US or Asian EMS / ODM have opportunities to serve the EU-27 market with loaded electronic boards from low cost non-European facilities. Their supply comprises serial products manufactured in large batches and is to a lesser degree linked to the proximity of clients. For client specific solutions, most of the non-EU players have erected production facilities in CEE Member States to serve this market segment too.

In international trade, 26.12 shows a trade deficit that is more pronounced than for its benchmark EE3. It became even worse since 2005. This indicates – in spite of the development mentioned above – a strong dependency on foreign deliveries for EU companies of the EEI and other concerned industries, such as mechanical engineering and transport equipment.

Table 2.66: Trade indicators for "Manufacture of loaded electronic boards"

Indicator	Sector	Units	2012	Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Domestic demand[1)]	EE3	bn. €	77.6	22.1	-5.0	9.1	0.2
	26.12		15.7	26.7	-6.9	4.0	4.2
EU-27 exports	EE3	bn. €	17.1	21.3	-1.6	-14.3	-3.5
	26.12		1.5	27.5	2.1	-10.1	0.3
EU-27 imports	EE3	bn. €	30.4	32.8	-7.1	-6.1	-1.1
	26.12		3.7	40.0	-5.2	2.1	3.1
				Averages for the periods 1998 - 00	2000 - 05	2005 - 08	2008 - 12
Export quota[2)]	EE3	%	26.6	55.0	57.6	40.7	26.4
	26.12		11.0	11.5	15.0	14.9	11.1
Import quota[3)]	EE3	%	39.2	64.5	65.2	48.5	44.9
	26.12		23.8	20.9	25.1	25.4	24.0
Trade balances[4)]	EE3	%	-28.0	-19.5	-15.9	-15.7	-38.9
	26.12		-43.0	-34.0	-31.1	-32.1	-43.2
RCA[5)]	26.12	Index	-0.34	-0.31	-0.32	-0.32	-0.16

1) Production plus imports minus exports; 2) Share of production; 3) Share of domestic demand; 4) Quota of trade balance (exports minus imports) and trade volume (exports plus imports); 5) Revealed comparative advantage: $\ln(X_{ij}/M_{ij})/(X_{tj}/M_{tj})$ where X is exports, M imports, i is the sub-sector, j is the country, t refers to the related sector. Values over 0 refer to high (domestic) competitiveness (0=neutral, >0=advantage; <0=disadvantage).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

2.4 Smart grids an example for a cross-sectoral technology

Smart grids

An interesting example of growing together of different technologies, which offers enormous growth potential for a variety of industries, is the field of smart grids. According to the European technology platform "Smart Grids", a smart grid is an "electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver [and store] sustainable, economic and secure electricity". This definition depicts smart grids as comprising of the whole energy generation and distribution and consumption process. It lays open that data is produced which may be to the disposal of utilities, network operators and end-users. Further, the idea of smart grids includes the possibility to communicate and use the data for grid control as well as automated organisation of in-home energy consumption. Industrial, commercial and residential end-users are not only consumers but may be electricity producers at the same time. Altogether, this implies a very important function of smart grids; the bi-directional flow of electricity and exchange of data. The latter, as well as the integration of renewable generation technologies into the grid, create special needs that require new products from various technological areas.

Product programme

The smart grid value chain roughly follows the flow of electricity. Starting with generation, electricity is transmitted via transmission lines and finally reaches industrial, commercial and residential end users that may also be electricity producers, through the distribution grid. In between generation and transmission as well as transmission and distribution, electricity is stepped up and down, respectively. This is needed for both an efficient and secure delivery of electricity. Besides, electricity storage is an integral part of the development of smart grids. However, until now, most of the activities concerning smart grids focused on the distribution side of the chain, which is the part that stretches from the substation to the customers rather than from the big plant generators to the substations.[134]

There exist eight major smart grid technological areas that may stretch over one or multiple stages of electricity power delivery. In each technological area, different hardware components are deployed, promoting certain functions which are described as follows[135]:

- **Transmission enhancement applications** involve technologies such as superconductors or FACTS (Flexible AC Transmission System) devices that shall serve to maximise power transfer and make transmission networks more controllable. Additionally, these technologies will be deployed in order to cope with changing loads that originate from the integration of variable generation technologies such as wind and solar into the electricity grid. The development of High Voltage Direct Current (HVDC) is also gaining importance recently because transmission of electricity can be effectuated more efficiently in such systems.
- **Distribution grid management** refers to the installation of transformers, wire and cable sensors as well as automation technologies (automated re-closers, switches and capacitors) in order to allow for the control of distributed power generation and ensure that installed equipment performs optimally, e.g. by locating faults instantly and reconfiguring feeders automatically.
- **Wide area monitoring and control** aims at gathering data that can serve as a basis for decisions for system operators and improve the electricity reliability and use of renewables. Although monitoring and control are typically restricted to the generation and transmission part of the value chain, it may extend over large geographic areas. Hardware that is being deployed are phasor measurement units (PMU) and other sensor equipment.
- **Advanced Metering Infrastructure (AMI)** is the principle technology that makes the smart grid's bidirectional flow of electricity and data possible by combining smart meters with communications and data exchange. Besides smart meters and in-home displays, an AMI consists of infrastructure components such as servers and relays in order to realise the transmission of data from the meters to the utilities. Advanced Metering infrastructure is deployed in distribution substations and across the distribution lines that connect industrial, commercial and residential electricity consumers and producers to the grid.
- **Customer Side Systems** include building automation systems that integrate network sensors, monitors and data from major electric and electronic devices as well as information that is provided by utilities. In addition, new technologies include energy dashboards, routers and smart appliances enabling "Demand Response". Demand Response gives consumers the possibility to react to, for example, price signals by reducing / increasing actual demand for electricity.

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[134] c.p. Lowe M., Fan H. and Gary Gereffi (2011). Smart Grid: Core Firms in the Research Triangle Region, NC. May 24, 2011 Center on Globalization, Governance & Competitiveness, Duke University.

[135] The herein presented description of technological areas and their functions follows Lowe M., Fan H. and Gary Gereffi (2011). Smart Grid: Core Firms in the Research Triangle Region, NC. May 24, 2011 Center on Globalization, Governance & Competitiveness, Duke University that in turn base on the definitions of: IEA (International Energy Agency) (2011). Technology Roadmap – Smart grids. Paris, NETL (National Energy Technology Laboratory) (2010). Understanding the Benefits of Smart Grids. Pittsburgh and NIST (National Institute of Standards and Technology) (2010). NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, Office of the National co-ordinator for Smart Grid Interoperability.

- **Electric vehicle charging infrastructure**. Similarly to AMI, electric vehicle charging infrastructure is not relevant throughout the whole value chain, but in the distribution grid only. The idea is to use electric vehicles as a means to store electricity and balance grid loads. The vehicles' batteries shall be charged during low demand periods and discharged during peak demand. Batteries and converters are the main products that will be deployed in charging infrastructure.
- **Information and communications technology** will find application throughout the entire power delivery-value chain. ICT will allow for real time and bi-directional communication, which in turn enables power system operators to manage electricity efficiently. There exist seven technologies that can be used for communication and may be distinguished by the mode of transmission. While ZigBee, WiMAX, GSM/GPRS/ UMTS/LTE and Radio Frequency (RF) Mesh Network represent wireless transmission technologies, DSL, Fiber Communications and Power Line Communications (PLC) need cables to transmit data and information.[136] The technologies differ with respect to their application space, processing speed, maximum data rates, availability, deployment costs and security issues.[137]
- **Renewable and distributed generation** integration requires the installation of products such as inverters because direct current (DC) producing solar arrays and wind farms need to be connected to the grid that was built to deal with alternating current (AC). Besides, power conditioning equipment for bulk power and grid support is needed and communication and control hardware for generation and enabling storage technology.

Demand side

According to Bloomberg New Energy Finance, the global smart grid market amounted to € 10.7 billion in 2012. With investments in smart grids, worth € 3.3 billion, the US represented the largest market, followed by China who bought smart grid equipment – particularly smart meters – for a total value of € 2.5 billion. The European market grew slightly since 2011, from € 850 million to about € 1.1 billion. However, mandated rollouts of smart grid technologies are in the pipeline, e.g. in the UK (realisation until 2020), Spain (2018) and France (2016). Therefore, market growth is likely to gain momentum after 2014. More important – by size and growth rates – than Europe, will be Asia throughout the years from 2013 until 2018, having invested € 4.3 billion in the preceding year. Energy initiatives in Japan, India and Korea, as well as Chinese government targets, demanding for the deployment of 300 million smart meters during these years, will serve as growth impulses.[138] Among these countries, China will be of outstanding importance. Its smart grid market is expected to total EUR 15 billion by 2015. The rollout of an Ultra-High-Voltage transmission system will account for about 60 % of the market, followed by the deployment of metering infrastructure that is expected to make 10 % of total Chinese smart grids market.[139]

An investigation of market potentials separated by the business segments Consumer Applications, Advanced Metering Infrastructure/ Smart Meters and Grid Applications reveals that market sizes are quite different. A market forecast for 2014, executed by McKinsey, predicts the global market size for Advanced Metering Infrastructure (AMI) and smart meters to be between € 5.4 billion and € 10 billion. This is the most developed segment of the smart grid value chain. In the past, most smart meters and AMI were deployed in the USA. This is because Europe's deregulated energy market

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[136] Rossi, Michele. Communication Technologies and Architectures for Smart Grids. Lecture, University of Padova. URL: http://www.cttc.es/resources/doc/120423-mrossi-sg-cttc-april-2012-36150.pdf.

[137] Rossi, Michele. Communication Technologies and Architectures for Smart Grids. Lecture, University of Padova. URL: http://www.cttc.es/resources/doc/120423-mrossi-sg-cttc-april-2012-36150.pdf.

[138] c.p. EcoSeed (2013). Global smart grid market hit $13.9 billion in 2012. URL: http://www.ecoseed.org/low-carbon/smart-grid/16041-global-smart-grid-market-hit-13-9-billion-in-2012.

[139] Xu, David, Wang, Michael, Wu, Claudia and Chan, Kevin (2010). Evolution of the smart grid in China. McKinsey & Company.

and strong fragmentation across the value chain distorted incentives of any single player to invest in the sector. Regulators should have provided incentives for society and industry, but often, such efforts were delayed due to a lack of standards. In the Netherlands, for example, smart grid efforts were suspended in 2008 in order to wait for the adoption of Europe-wide standards. A first step towards the development of Europe-wide standards was the mandate for standardisation of smart grids[140] that has been issued by the European Commission in February 2011. It resulted in the proposal of a first set of standards that were made available at the end of 2012 by the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunications Standards Institute (ETSI), the three European Standards Organisations (ESO)[141]. Consequently, overall smart meter deployment and development of AMI is likely to play a major role not only in China but also in Europe[142].

Therefore, one should be aware of the fact that deployment efforts and market size may vary importantly across Europe. First, there are the early adopters such as Italy, Norway, Sweden Finland and Denmark that have already reached relatively high penetration rates of AMI. Among these, Italy has the greatest number of smart meters deployed. Through the initiative “Progetto Telegestore” (2002), about 30 million smart meters have been installed, resulting in the fact that nowadays, nearly 100 % of Italian households are equipped with a smart meter. Penetration rates in Norway, Sweden, Finland and Denmark are also high and have risen above 50 %. A second group consists of countries where deployment efforts have been rare in the past but where future installation of AMI is mandated by governments and local authorities. As mentioned before, one can find the UK, Spain and France among these countries. Third, Germany and the Netherlands are countries where thousands of meters have been installed in the past but in the absence of clearly defined government targets. Finally, budget constraints have led to the fact that the former Eastern Bloc states form the group of European countries that are inactive with respect to the deployment of smart meters.[143]

The global market volume for consumer applications is highly uncertain because it depends on adoption rates of home, commercial and industrial energy management systems that are difficult to predict. This is why the forecasted market size ranges from € 2.3 ($ 3) billion to € 7.7 ($ 10) billion. In addition, there may be great market volume differences with respect to the types of devices that are used. Market growth in this segment is expected to concentrate in USA and Europe.[144] Finally, the market size for grid applications is expected to be between € 3.8 billion and € 6.2 billion. Generally, the deployment of grid applications will lag behind the installation of smart metering infrastructure by three to five years.[145]

Key market drivers that emerge from the energy supply side, mainly utilities and network operators, are the ageing European infrastructure and an increasingly volatile (peak) energy demand. Additionally, the need for the integration of renewable energy integration such as wind and solar power will push demand for smart grid equipment, too. Policy targets with respect to decarbonisation and energy efficiency such as EU 20-20-20 targets or international treaties like the

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[140] European Telecommunications Standards Institute (ETSI) (2013). European Standards Organizations present the latest results of their work to develop standards for Smart Grids. ETSI URL: http://www.etsi.org/news-events/news/646-2013-01-smart-grid-results.

[141] European Commission (2011). Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment. European Commission. European Commission.

[142] c.p. Booth, Adrian, Demirdoven, Nuri and Humayun Tai (2010). The smart grid opportunity for solutions providers. McKinsey & Company.

[143] Giglioli, Enrico, Panzacchi, Cosma and Leonardo Senni (2010). How Europe is approaching the smart grid. McKinsey & Company.

[144] Xu, David, Wang, Michael, Wu, Claudia and Chan, Kevin (2010). Evolution of the smart grid in China. McKinsey & Company.

[145] Xu, David, Wang, Michael, Wu, Claudia and Chan, Kevin (2010). Evolution of the smart grid in China. McKinsey & Company.

Kyoto Protocol are important drivers for continued investments in smart grids. Suppliers might also need to deploy smart grid equipment in order to ensure their ability to compete in the market with respect to services and prices.

The possibility to save energy and money through the deployment of consumer applications such as demand response and AMI may push demand for smart grid equipment as well.[146]

The actual demand will further depend on technology availability and how active regulators and governments are in developing standards that evolve consequently with the rapid technological development in the sector. The end-users' willingness to use the new technology that typically depends on their awareness of their own electricity consumption and price changes over time will also affect the market for smart grid equipment.[147]

Supply side

Although Chinese suppliers are steadily closing the gap to their global competitors, the most important global suppliers of smart grid equipment are currently located in Europe and the USA. Greentech Media, a research and news provider for the green-tech market, ranked the ten most important vendors across the smart grid value chain in the following order: ABB (CN), Cisco (US), IBM (US), Itron (US), Siemens (D), S&C Electric (US), Schneider Electric (FR), Opower (US), Silver Spring Networks (US) and Tendril (AU). For the ranking supplied, Greentech Media evaluated the companies' relative strengths by comparing their market presence, integrated strategy, customer portfolio, recent financial developments and, most importantly, their core technology offerings.[148]

Large groups such as ABB or Siemens – full-hand suppliers with nearly all product categories in their portfolios, including transmission and distribution grid management equipment, EV charging infrastructure, renewable and distributed generation integration and wide-area monitoring systems – are included in the list as well as more specialised companies. Greentech Media also put some more specialised companies in the list of 150 smart grid vendors, which it had investigated in depth. Among the latter we can find Landis & Gyr (CN/JP), a Toshiba Company formed in 2011 that is one of the leading developers of end-to-end advanced metering solutions with the largest fraction of deployed smart meters worldwide[149]. Currently, this company is also smart meter market leader in Brazil. Another example is SEL (CN), which focuses primarily on control and protection equipment in substations and distribution lines. It is the global leader in the production of digital relaying technologies that partly derives its success from focusing research and development investments on their client's needs, with whom they typically maintain well established relationships[150].

While China relied on foreign companies such as Siemens, Toshiba or Mitsubishi (JP) in order to develop its electricity transmission and distribution system during the 1990s, these days it has

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[146] Alain Glatigny (2012). Drivers towards smart grid deployment. Lecture, Schneider Electric, Nice. URL: http://www.iea-isgan.org/b/workpre/523 and Shinkawa, Tatsuya (2012). Smart Grid and beyond. Lecture, New Energy and Industrial Technology Organization (NEDO), Nice. URL: http://www.iea-isgan.org/b/workpre/523.

[147] European Telecommunications Standards Institute (ETSI) (2013). European Standards Organizations present the latest results of their work to develop standards for Smart Grids. ETSI URL: http://www.etsi.org/news-events/news/646-2013-01-smart-grid-results.

[148] Leeds, David J. (2013). The Networked Grid 150: The End-to-End Smart Grid Vendor Ecosystem Profiles and Rankings. Summary. GTM Research. URL: http://www.greentechmedia.com/research/report/the-networked-grid-150-report-and-rankings-2013.

[149] PR Newswire (2013). Toshiba and Landis & Gyr take another step toward the smart community. Wallstreet-online. URL: http://www.wallstreet-online.de/nachricht/5092744-toshiba-and-landis-gyr-take-another-step-toward-the-Smartcommunity.

[150] Leeds, David J. (2013). Who Are the Top Ten Vendors in Smart Grid? - GTM Research profiles the leading 150 smart grid vendors in its latest market report. Greentech Media. URL: http://www.greentechmedia.com/articles/read/who-are-the-top-ten-vendors-in-smart-grid/N9.

become difficult for foreign firms to enter the Chinese smart grid market which is dominated by key domestic players such as Guodian Nanjing Automation Co Ltd or the Nari Group, a unit wholly owned by State Grid (one out of two state owned grid companies in China). As the Chinese market promises enormous selling opportunities in coming years, European and North American smart grid equipment manufacturers are currently seeking to get a stake in it through venturing with Chinese firms. Smart meter maker Echelon (US), for example, announced a joint venture with China's Holley Metering; Analog Devices (US) is working with Nari Group; and Italy-based Accent is working with Chinese PLC technologies maker Topscomm. Yet, Chinese suppliers that, until now, rarely showed up in foreign markets are also emerging as contenders in international markets. Chinese telecommunications equipment giant Huawei announced a co-operation with Landis+Gyr as well as work on the United Kingdom's plan to roll out 47 million smart meters by 2020.[151]

[151] St. John, Jeff (2013); The China-US-UK Smart Grid Connection, Greentech Media.
URL: http://www.greentechmedia.com/articles/read/the-china-u.s.-u.k.-smart-grid-connection and
Ed. (2013); In China, local smart grid equipment suppliers trump foreign names, The Indian Express.
URL: http://www.indianexpress.com/story-print/1030433/.

3 Major important competing economies in the market for electrical and electronic engineering products

This chapter gives a detailed look into the structure and performance of the EEI and its three sectors for the competing economies under consideration. The qualitative description and evaluation is supplemented by a quantitative assessment of changes in competitiveness. In a first step for each of the economies, a comparative assessment of EEI relative to its benchmark – the national total manufacturing sector – is carried out. In a second step, the evolution of the competing economies EEI is evaluated against the evolution of the EU EEI.

3.1 The United States

The EEI is one of the largest US industries with a production value of € 385.2 billion (conversion rate 1.3 $ = 1 €) in 2012 and commanded a share of 10.4 % of total manufacturing (**Table 3.1**). At the turn of the millennium its share was remarkably higher, around 18 %. This might be exaggerated by the New Economy Bubble, because the EEI's share of total manufacturing slumped immediately after. But from 2002 onwards – the share steadily fell to 13 %. In 2012 the EU-27's production stood at € 634.4billion, around 64 % more than its US counterpart. However, the EU's EEI makes up a similar share of total manufacturing as it does in the US. The US EEI's share of total manufacturing shrunk between 1998 and 2011, while EU EEI's relative size changed little.

Table 3.1: Key figures for the EU and US EEI

Sector	Indicator	2012[1)]		Annual average growth rates in %				
				1998 - 00	2000 - 05	2005 - 08	2008 – 12	08 - 2012
		Electrical and electronic engineering (EEI)						
US	Production, in current prices	bn. €	385.2	7.4	-4.1	2.0	-2.6	-0.8
EU-27			634.4	9.3	-0.3	5.9	0.1	2.4
US	Employees	1,000	1488	-5.3	-5.4	-0.4	-4.7	-4.1
EU-27			3377	2.2	-1.7	0.5	-2.0	-0.8
		Electrical engineering (EE1)						
US	Production, in current prices	bn. €	212.7	2.7	-1.4	4.6	-2.7	0.1
EU-27			370.4	7.8	1.1	8.2	1.3	3.6
US	Employees	1,000	854	-5.1	-4.8	-1.1	-4.3	-3.9
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
		Electronic engineering (EE2)						
US	Production, in current prices	bn. €	87.6	11.4	-6.7	-1.2	-4.1	-2.4
EU-27			201.1	10.5	-2.0	1.7	-1.7	0.6
US	Employees	1,000	364	-5.3	-5.5	0.8	-4.2	-3.8
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
		Electrical and Electronic components (EE3)						
US	Production, in current prices	bn. €	84.9	12.1	-6.2	-0.7	-0.8	-1.1
EU-27			62.9	12.6	-0.6	9.1	-0.8	3.2
US	Employees	1,000	271	-6.0	-6.9	0.4	-6.3	-5.1
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6
1) Conversion rate 1.3 $ = 1 €.								

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

For decades, the US has been the power house for information and communication technologies. The headquarters of most prominent ICT companies are located in the US. Although ICT and, in particular, the semiconductor industry are perceived as strategic sectors and benefit from public policies – similar to the EU – the core electronic industries EE2 and EE3 have been losing ground compared with total US EEI. In nominal terms EE1 remained constant whereas both of the other sectors' production declined at annual rates of 2.4 % and 1.1 %, respectively. In 2012, EE1 commanded 55 % of EEI production (EU EE1'share of EU EEI was 58 %), a gain of 8-percentage points since the turn of the millennium. They are largely mirrored in the losses of EE2 that fell to 23 % (EU EE2's share of EU EEI was 31 %). EE3, the sector that comprises of the most important product group, semiconductors, fell by 2 percentage points down to 22 %. Compared to the EU, this sector – pivotal for innovation in downstream industries – is more than twice as large relative to EEI overall: in 2012 EE3 comprised just 10% of EU EEI.

Over the period under investigation, the US EEI's evolution of output was not only well below total manufacturing, it did not even meet the EU EEI's growth rates. However, within the US EEI the evolution of the three sectors showed a pattern similar to the EU EEI: US EE1 increased, although more moderately than EU EE1; US EE2 declined significantly at 2.4%; while EE3 dropped at an annual rate of 1.1 %. This poor growth – compared with the EU-27 – negatively impacted employment: the EE1 and EE3 sectors shed, respectively, 3.9 % and 3.9 % p.a. of their workforce between 1998 and 2012. Much of the reduction took place during the aftermath of the New Economy Bubble, but large-scale lay-offs also occurred during the global financial crisis and lost workplaces have not been replaced during the years since.

Comparative price performance of US EEI

The focus of the comparative analysis is on the EEI's performance relative to total manufacturing (TM). In contrast to production in nominal terms, the US EEI's value added at constant prices grew at a moderate pace. The same, moderate, growth was also present in the benchmark TM. It is of note that – although EEI's employment declined between 2008 and 2012 – the value added continued to grow at least moderately and contributed to a strong increase of labour productivity. Throughout the period it had grown by 4.5 % p.a. and reached € 177,800. This value exceeds productivity for total manufacturing by 4 %, while labour costs per employee are 19 % higher. EEI's wage growth was stronger than for total manufacturing, but below EEI's productivity growth. This led to a slight decline of ULC that was roughly in line with the development of the benchmark. It can be concluded that the growth in price competitiveness of US EEI lagged overall development in US manufacturing. (**Table 3.2**)

The comparative analysis for the EU EEI shows a quite different development relative to total manufacturing. The value added at constant prices increased at an annual rate of 3.8 % for the period under consideration, preventing significant losses in employment. Wage increases were much lower than its benchmark, at 2.6 % compared to 3.1 % for total manufacturing. EEI's productivity gains exceeded labour costs by far and contributed much to a noteworthy improvement of ULC that declined at an annual rate of 1.9 %, while ULC for the benchmark grew. The comparative development of the EU EEI shows a noteworthy improvement of price competitiveness in relation to its EU benchmark.

Table 3.2: Comparative economic performance of the EU and US EEI

Sector	Indicator	2012[1]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 – 2012
				United States				
TM[2]	Value added, in 2010 prices	bn. €	1859	2.1	2.2	-4.2	0.1	0.2
EEI[3]			265	7.9	-3.0	0.5	0.3	0.2
TM[2]	Employees	1,000	10826	-4.1	-3.8	-1.1	-4.0	-3.3
EEI[3]			1491	-5.3	-5.4	-0.4	-4.6	-4.1
TM[2]	Labour costs per employee	1,000 €	58.1	3.2	2.9	3.0	3.3	3.1
EEI[3]			69.3	3.5	4.5	3.3	3.7	3.9
TM[2]	Productivity[2]	1,000 €	171.7	6.5	6.2	-3.2	4.3	3.6
EEI[3]			177.8	14.0	2.5	0.9	5.2	4.5
TM[2]	Unit labour costs[3]	€ / €	0.34	-3.0	-3.1	6.3	-1.0	-0.5
EEI[3]			0.39	-9.2	1.9	2.4	-1.4	-0.6
				European Union (27)				
TM[2]	Value added, in 2010 prices	bn. €	1610	1.7	-0.3	-2.3	-1.2	-0.6
EEI[3]			211	9.5	0.4	7.5	3.8	3.8
TM[2]	Employees	1.000	29985	-0.3	-1.4	-1.6	-3.1	-1.6
EEI[3]			3377	2.2	-1.7	0.5	-2.7	-0.8
TM[2]	Labour costs per employee	1,000 €	38.8	2.9	2.5	5.5	3.2	3.1
EEI[3]			43.4	3.4	1.6	3.2	3.9	2.6
TM[2]	Productivity[4]	1,000 €	53.7	2.0	1.1	-0.6	2.0	0.9
EEI[3]			62.4	7.2	2.1	7.0	6.7	4.6
TM[2]	Unit labour costs[5]	€ / €	0.72	0.9	1.4	6.5	0.9	2.2
EEI[3]			0.70	-3.6	-0.5	-3.7	-2.3	-1.9

1) Conversion rate 1.3 $ = 1 €; 2) Total manufacturing; 3) Electrical and electronic engineering; 4) (Value added in 2010 prices) / employment; 5) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

US EEI's price performance compared to the EU

The most striking phenomenon regarding the comparison of the EU and the US is the difference in labour productivity. For total manufacturing the US labour productivity is 3.2 times higher and for EEI it is 2.9 times higher. This discrepancy is not reflected in wage levels. The US labour costs per employee are only higher by factors 1.5 and 1.6, respectively.[152] As a consequence, ULCs are much lower and indicate a relative competitive disadvantage for the EU 27.

The following analysis takes 1998 as status quo and assesses the changes in price competitiveness over the period under consideration. Wage increases for the EU EEI were well below that of its US counterpart, but also lower than for total manufacturing of the EU. Simultaneously, the EEI's labour productivity grew much more and led to a significant improvement of the EU EEI's ULC. In absolute figures the EU remains far behind the US EEI's ULC.[153] Further insight will be provided by the foreign trade analysis in the chapter on trade performance.

[152] The much higher US labour productivity is a well-known phenomenon and has incited the European Commission to take measures to follow up the US lead. This fact cannot be explained by the more heterogeneous EU that comprises high-wage and low-wage economies. Even for member states like Sweden and Germany labour productivity is lagging behind the US although wage levels are of similar magnitude. However, this disadvantage has not turned out as a problem in international competition. See for instance studies on the competitiveness of the EU aerospace industry and of the EU mechanical engineering.

[153] Under the premise that the EU EEI's overall competitiveness was not disastrous in 1998 and other hidden factors have been of importance to outbalance the disadvantageous ULC level then it can be concluded that ceteris paribus the EU EEI's competitiveness has improved against the US in spite of the large gap.

Sectoral price performance

The value added at constant prices for the US **EE1** had declined at an annual rate of 1.9 %. The reduction was pronounced after the break down of the New Economy Bubble but continued throughout the rest of the period under investigation. In 2012, EEI's value added stood at € 126.4 billion, equal to roughly 98 % of the value for its EU counterpart. The value creation was carried out with a workforce of only 39 % of the EU. Labour productivity was 2.5 times higher than for the EU, while the wage level was only 1.6 times higher. This mirrors the US EEI compared to the EU EEI overall, only the discrepancy in labour productivity is less pronounced. The evolution throughout the period under investigation was characterised by higher growth of labour productivity for the EU EE1, while simultaneously wage increases were below the US trend. As a result, EU price competitiveness has improved, although the most recent US ULC remains only two thirds of the EU level. (**Table 3.3**)

For **EE2** the US - EU comparison yields similar results with respect to the size of the sector and the relationships between the key economic figures, labour productivity and wages. Even more than for EE1, the EU price performance has improved, but the discrepancy between US and EU ULC is of the same magnitude.

However, for **EE3** the situation is quite different. Labour productivity of the US sector exceeds the EU counterpart by a factor of 3.9, although differences of wage levels are similar to both of the other sectors. For the period under consideration value added at constant prices increased an average rate of 5.2 %, while simultaneously the workforce shrunk by 5.1 % p.a. Labour productivity increased at a higher pace than for the EU, indicating an increasing disparity. Taking into account wage increases for the EU and the US, the ULCs declined. The improvement was only a bit more pronounced for the EU, indicating no relevant change. This is a less advantageous picture than for EE1 and EE2.

Table 3.3: Sectoral performance of the EU and US EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical engineering (EE1)				
US	Value added, in 2010 prices	bn. €	126.4	3.0	-4.1	-1.4	-2.0	-1.9
EU-27			129.2	10.6	-0.2	2.7	1.1	2.2
US	Employees	1,000	859	-5.1	-4.8	-1.1	-4.2	-3.9
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
US	Labour costs per employee	1,000 €	70.5	2.9	3.6	3.6	3.7	3.5
EU-27			43.4	3.5	2.1	2.1	3.3	2.6
US	Productivity[2)]	1,000 €	147.1	8.5	0.7	-0.3	2.3	2.0
EU-27			58.5	8.0	1.0	2.1	2.3	2.6
US	Unit labour costs[3)]	€ / €	0.48	-5.2	2.9	3.9	1.3	1.5
EU-27			0.74	-4.2	1.2	0.0	1.0	0.1
				Electronic engineering (EE2)				
US	Value added, in 2010 prices	bn. €	60.3	15.3	-2.5	1.9	-2.6	0.8
EU-27			60.6	6.3	1.9	9.6	-1.6	3.1
US	Employees	1,000	361	-5.3	-5.5	0.8	-4.4	-3.8
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
US	Labour costs per employee	1,000 €	67.7	4.5	5.9	3.7	3.4	4.5
EU-27			43.2	3.1	0.6	0.5	1.8	1.3
US	Productivity[2)]	1,000 €	166.8	21.8	3.2	1.1	1.9	4.8
EU-27			68.8	4.5	4.4	9.5	1.7	4.7
US	Unit labour costs[3)]	€ / €	0.41	-14.2	2.6	2.5	1.5	-0.3
EU-27			0.63	-1.0	-3.7	-8.0	0.0	-3.2
				Electrical and electronic components (EE3)				
US	Value added, in 2010 prices	bn. €	78.5	17.3	-0.5	3.7	7.7	5.2
EU-27			21.1	12.5	1.0	20.6	3.3	7.2
US	Employees	1,000	271	-6.0	-6.9	0.4	-6.3	-5.1
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6
US	Labour costs per employee	1,000 €	67.6	4.4	5.3	2.3	4.1	4.2
EU-27			44.6	4.1	2.2	2.0	4.5	3.1
US	Productivity[2)]	1,000 €	290.0	24.9	6.9	3.3	15.0	10.8
EU-27			73.6	9.6	3.4	19.6	8.0	8.9
US	Unit labour costs[3)]	€ / €	0.23	-16.4	-1.5	-1.0	-9.4	-6.0
EU-27			0.61	-5.1	-1.0	-14.9	-3.0	-5.3

1) Conversion rate 1.3 $ = 1 €; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Industry overview

Electrical engineering industry

The US EEI is of major global importance and has many well-known firms, including Apple, Cisco Systems, IBM, Hewlett-Packard (HP), Dell, Emerson Radio and Zenith. Emerson Radio and Zenith focus on TV, DVD Audio and Video equipment. Apple, Dell and HP develop and build laptop and desktop computers, operating systems, connected devices and consumer electronics. Cisco and IBM concentrate on infrastructure – however, Cisco's special focus lies on networking technology, while IBM also works in consulting. This list shows the clear focus on electronics and the wide range ICT products and services of the US EEI.

Despite the US' focus on EE2 there are companies successfully operating in the **electrical engineering** sector EE1. General Electric (GE), one of the largest corporations in the world, is an industrial conglomerate with a broad range of business areas. The company is highly active in the EE2 sector; among their products and services are power plants, aircraft engines, electric motors, consumer electronics, electricity distribution, lighting and wind turbines.

With companies like Exide, one of the world's largest producers of batteries and accumulators, the US EE1 sector is also leading in the field of lead acid batteries. The company supplies transportation markets as well as industry with energy storage devices. The outlook for this market is bright given that there will be a rise of electric vehicles and renewable energy generation. Even more important by size in the energy storage business is Johnson Controls, a company that is a global player with a large stake in the EU market.

US firms were also among the pioneers in the area of nuclear power plants. The company Westinghouse Electric Company, today owned by the Toshiba group, is a major supplier of nuclear products and services, design of nuclear plants, control of plant activities, maintenance and instrumentation. In particular, emerging economies with their growing need for electricity are driving demand. A new type of reactor has been developed, the so-called Travelling Wave Reactor (see: Chapter 2.1.1).

Electronic engineering industry

Starting in the 1990s, the **electronics industry** EE2 has been moving manufacturing jobs abroad to countries where labour costs and taxes are lower. Firms have become more and more global and perceive themselves as less American – for instance IBM held its investor conference for the first time outside the US in 2006. However, in recent years this trend seems to have slowed down. As wages rise in traditional low-wage countries, such as China, and higher fuel prices increase shipping costs, some firms prefer to keep production within the US or even move manufacturing back into the country. The Shale Gas Revolution adds to the strengthening of US manufacturing. Against the global trend, energy costs in the US have been coming down. Another reason for this trend might be unsolved problems with intellectual property regulations and enforcement, which put companies in constant worry that their technology might be copied. One has to take into account that this more recent movement emerged after a phase of massive off-shoring, referred to as "hollowing out" and cannot be badged as re-industrialisation, but as a stabilisation of current levels.

US companies in the area for communication equipment – once undisputed technological leaders in the global market – are coming under growing pressure from Chinese firms and face strong competition, even in the domestic market.

Components, semiconductors

The US semiconductor industry is dominated by a few major players. Intel, the world's leading semiconductor producer with more than 15 % world market share in 2012 is based in the US as well as Qualcomm (4.3 %), Texas Instruments (4.0 %), Broadcom (2.6 %) and others[154]. While Intel develops and produces PC microprocessors and other microchips for computers and smart phones, many of the other chip producers, such as Qualcomm, Texas Instruments, focus on the research, development and marketing side and have outsourced production to fabs.

When semiconductor production started in the US in the 1960's firms were highly vertically integrated, taking care of the whole production process from research to manufacturing. Also, the whole production process used to be located in the US. However, recent developments show that vertical integration is declining as corporations increasingly rely on collaboration and outsourcing in order to keep profits high. Chip production is highly innovative and firms are constantly improving their products by making chips smaller and faster. But constant improvements in chip production also demand more and more advanced manufacturing equipment, meaning that equipment has to

[154] Such as Micron Technology, AMD, NVIDIA, Freescale, Marvell Technology Group. http://www.isuppli.com/Semiconductor-Value-Chain/News/Pages/Qualcomm-Rides-Wireless-Wave-to-Take-Third-Place-in-Global-Semiconductor-Market-in-2012.aspx

be renewed much faster than in other industries. As this poses a high cost factor for companies, many firms have outsourced their manufacturing to so-called foundry companies or started industry wide collaborations in order to be able to cover the massive production costs.

Foundry firms run plants and take over the manufacturing production while the so-called fabless companies concentrate on design, marketing, and sales. Since foundry firms take orders from more than one fabless company and thus produce very large amounts, they are able modernise equipment more frequently. Intel remained the only US semiconductor company large enough to maintain its own production plants. Moreover, Intel is by far the dominating leader in the market for PC processors, a market with high access barriers created by a combination of scale effects and know-how.[155] It keeps several of those plants within the US and recently also invested in a new US based plant[156] but also partly moved production abroad, with manufacturing facilities in Ireland, Israel and China.

The reason for Intel to run plants outside the US is not so much lower labour costs since the production of semiconductors requires large capital investments and power. It is much more due to incentives offered by governments, such as low taxes on income or specific lump sum support or tax breaks. With the exception of Intel, all other firms decided to outsource manufacturing since their produced volume is too small to operate one production facility at full capacity. Since capital costs for the manufacturing part of the semiconductor production process are extremely high, machines have to run almost nonstop in order to be profitable. Since smaller corporations do not produce enough to take advantage of economies of scale, this is taken over by foundries. The two largest foundries are based in Taiwan[157], but the 9th largest foundry firm worldwide is the American company IBM. Pure research, employing high levels of human capital but facing low capital costs, is still largely conducted in the US.

Strategies to restructure cross-border value chains in the area of semiconductors, taking into account advantages of specialised foundries, have had an impact on the global dominance of the US in international trade. Aspects of IPR might have limited relocation, but the number of workplaces has been halved over the whole period under consideration, revealing the magnitude of the combined effect of relocation and labour saving technological progress.

3.2 Japan

The EEI is possibly the largest manufacturing industry in Japan with a production value of € 447 billion (conversion rate 130 YEN = 1 €) in 2012, which is 24 % of total manufacturing (**Table 3.4**). At the turn of the millennium this share was higher. In 2012, the EU-27 production stood at € 634.4 billion, around 42 % higher than the Japanese. However, as measured as a share of total manufacturing the EU EEI is only about half the Japanese EEI. The EEI shares in total manufacturing for the EU stayed roughly the same, at around 11 %, whereas for Japan it declined from 29 % (1999) to 22 % (2012).

In Japan, EE1 is larger than EE2 and EE3 combined. In nominal terms EE1's production decreased slightly at 0.6 % over the whole period under consideration, whereas both of the other sectors' production declined at annual rates of 5.5 % and 4.6 %, respectively.

[155] In recent years the mobile market has turned out to be more promising and products, such as smart phones and tablets have been cannibalising the PC-market. This development has put some pressure on Intel, because its processors have not been sufficiently energy efficient. In 2013 Intel has put a new processor on the market and has won a large contract from Samsung, indicating that this detriment has been overcome.

[156] http://www.reuters.com/article/2012/05/01/us-semiconductors-manufacturing-idUSBRE8400N920120501

[157] TSMC and UMC, according to 2011 sales.

In 2012, EE1 commanded 58 % of EEI production (similar to the EU equivalent), an increase of around 13 percentage points in weight of EEI over the period under consideration. They are to a large extent mirrored by losses of EE2 over the same period and in 2012 only contributed 18 % to EEI's production (EU EE2's share of EU EEI was 31 %). EE2 is the worst performing sector of EEI with an annual average reduction of production by 5.5 % over the period under consideration. The sector is largely characterised by consumer electronics. Therefore, the loss is most remarkable, because the Japanese consumer electronics industry was the most innovative and had dominated the global market for two decades. But during the 1990s, it lost its lead to Korea and much of the remaining production has been relocated, primarily to China. EE3, the sector that comprises of the most important product group, semiconductors, also declined over the period at an annual average rate of 4.2 %. In spite of this decrease, the Japanese EE3 is 1.6 fold as large as the EU EEI. Moreover, the Japanese EE3's weight of the Japanese EEI is around one quarter as measured by production, even a bit higher than for the US. For both of these economies EE3, the sector that is pivotal for innovation in downstream industries, is much more of importance for EEI, whereas the EU EE3's share is only around one tenth. Moreover, Japan has focused on leading edge technology in semiconductors and pursues strategies to serve specialised products, instead of commodities. This contrasts to Taiwan, with its low marginal costs foundries, and South Korea, with its focus on mass-manufactured DRAMs. The Japanese strategy has led to a unique position in the market, where only few, sometimes only one, Japanese suppliers are globally available.

Table 3.4: Key figures for the EU and Japanese EEI

Sector	Indicator	2012[1)]		Annual average growth rates in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 – 2012
				Electrical and electronic engineering (EEI)				
Japan	Production, in current prices	bn. €	447.0	0.9	-1.6	-0.3	-7.4	-2.7
EU-27			634.4	9.8	-1.6	3.9	-2.2	1.0
Japan	Employees	1,000	1879	-3.8	-2.5	-1.0	-2.4	-2.4
EU-27			3377	2.2	-1.7	0.5	-2.0	-0.8
				Electrical engineering (EE1)				
Japan	Production, in current prices	bn. €	263.5	0.2	1.7	3.2	-6.5	-0.6
EU-27			370.4	8.2	1.0	5.5	-0.6	2.5
Japan	Employees	1,000	1189	-3.0	0.0	0.7	-1.1	-0.6
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
				Electronic engineering (EE2)				
Japan	Production, in current prices	bn. €	81.3	1.2	-6.2	-7.1	-6.7	-5.5
EU-27			201.1	11.0	-4.7	1.2	-5.3	-1.5
Japan	Employees	1,000	271	-3.7	-5.8	-5.2	-3.0	-4.6
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
				Electrical and Electronic components (EE3)				
Japan	Production, in current prices	bn. €	102.3	1.8	-3.0	-2.1	-10.2	-4.2
EU-27			62.9	12.7	-1.1	5.4	-0.2	2.4
Japan	Employees	1,000	419	-5.2	-5.1	-2.3	-5.4	-4.6
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6
1) Conversion rate 130 YEN = 1 €.								

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Over the period from 1998 to 2012, EEI in Japan declined, whereas it increased in Europe. While the overall decline in Japan is mostly due to EE2 and EE3, the increase in Europe is due to the performance of EE1.

Comparative price performance of the Japanese EEI

Table 3.5 compares the performance of the Japanese EEI to total manufacturing (TM) overall. First we note that although TM shrunk at -2.2% annually in nominal terms between 1998 and 2012, EEI grew in real terms with an average 0.8 % over the same period. In the EU as well, EEI outpaced total manufacturing in terms of real value added.

Table 3.5: Comparative economic performance of the EU and Japan's EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 – 2012
				Japan				
TM[2)]	Value added, in 2010 prices	bn. €	651	0.0	-1.2	-4.1	-3.1	-2.2
EEI[3)]			157	5.4	2.8	-0.1	-3.2	0.8
TM[2)]	Employees	1,000	7547	-3.4	-2.3	0.8	-2.5	-1.9
EEI[3)]			1879	-3.8	-2.5	-1.0	-2.4	-2.4
TM[2)]	Labour costs per employee	1,000 €	34.5	-0.1	-0.7	0.6	-0.3	-0.2
EEI[3)]			38.2	-0.2	-0.5	1.2	-1.1	-0.2
TM[2)]	Productivity[2)]	1,000 €	86.3	3.5	1.2	-4.9	-0.6	-0.4
EEI[3)]			83.8	9.5	5.5	1.0	-0.8	3.3
TM[2)]	Unit labour costs[3)]	€ / €	0.40	-3.5	-1.9	5.8	0.3	0.1
EEI[3)]			0.46	-8.9	-5.7	0.3	-0.3	-3.4
				European Union (27)				
TM[2)]	Value added, in 2010 prices	bn. €	1610	1.7	-0.3	-2.3	-1.2	-0.6
EEI[3)]			211	9.5	0.4	5.9	0.6	2.8
TM[2)]	Employees	1,000	29985	-0.3	-1.4	-1.6	-3.1	-1.6
EEI[3)]			3377	2.2	-1.7	0.5	-2.7	-0.8
TM[2)]	Labour costs per employee	1,000 €	38.8	2.9	2.5	5.5	3.2	3.1
EEI[3)]			43.4	3.4	1.6	1.6	3.9	2.2
TM[2)]	Productivity[4)]	1,000 €	53.7	2.0	1.1	-0.6	2.0	0.9
EEI[3)]			62.4	7.2	2.1	5.4	3.4	3.6
TM[2)]	Unit labour costs[5)]	€ / €	0.72	0.9	1.4	6.5	0.9	2.2
EEI[3)]			0.70	-3.6	-0.5	-3.2	0.5	-1.3

1) Conversion rate 130 YEN = 1 €; 2) Total manufacturing; 3) Electrical and electronic engineering; 4) (Value added in 2010 prices) / employment; 5) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Although value added increased, the number of employees in EEI fell by an average 2.4 % per annum, leading to a strong decline in unit labour costs and an increase in labour productivity for the period. This increase in productivity is much stronger for the EEI than for manufacturing overall. The increase in productivity is much lower in the global boom years, 2005 to 2008. Whereas in Japan almost 25 % of manufacturing employment is in EEI, in EU-27 it is only about 11 %. Also the average rate in employment growth for EEI in Europe was -0.8 % compared to -2.4 % for Japan. But thanks to a higher growth in value added, productivity growth in EU-27 (4.6 %) was actually slightly stronger than in Japan (3.3 %). However, unit labour costs fell at annual average rates for all of the period under investigation of 3.4 % in Japan and 1.9 % p.a. in EU-27 overall. Compared with domestic TM, the Japanese and the EU EEI price competitiveness have performed better. However, compared to the Japanese EEI, the EU EEI has lost price competitiveness. This is mostly due to long term differences in wage trends: Japan's have fallen while Europe's continue to increase.

Japanese EEI's price performance compared to the EU

Just as for the US, the difference in labour productivities compared to the EU-27 is striking. For total manufacturing the Japanese labour productivity is a factor 1.6 higher and for EEI it is 1.3. This discrepancy is not reflected in wage levels, which are even lower in Japan, and cause significantly higher ULC for the EU. They exceed the Japanese levels by 56 % and 65 %, respectively.[158]

The evolution of price performance over the whole period indicates an improvement for Japan. Although the EU experienced a higher growth of labour productivity, wages grew stronger than for Japan, and the EU-27's price position has worsened.

Sectoral price performance

Table 3.6 has the same variables as above but the comparison is for Japan and the EU-27 by sub-sector rather than between EEI and total manufacturing. While the EU-27 EE1, in terms of value added, is about 139 % of the Japanese EE1, the numbers for EE2 and EE3 are only 220 % and 57 %, respectively. The comparably small Japanese EE2 is explained by two facts. Firstly, Japan's former strengths in consumer electronics has been fading and much of the remaining production has been relocated to low wage countries, namely to China. Secondly, the sub-sector electrical medical equipment is of minor importance, whereas for the EU-27 this sub-sector is of outstanding importance. Although Japan has lost much of its importance in the global semiconductor market by leaving the price sensitive market for commodities, it has maintained its position as an important supplier of high-tech products in the area of specific applications. EE3 has remained comparably large. As compared to value added, the EU-27 labour input is much higher. The EU-27 employment percentages relative to Japan for the EE1, EE2 and EE3 are 185 %, 325 % and 68 %, respectively, and highlight differences in labour productivity: Japanese EE1 labour productivity is 33 % higher than the EU's; for EE2 and EE3 the relations are 47 % and 20 %. The sectoral labour productivity differences between the EU and Japan are less pronounced than between the EU and US. In particular, the outstanding US lead in labour productivity for EE3 is not found in Japan.

Of the three sub-sectors, value added growth in Japan is strongest for EE3. The same is true for the EU-27. All three sectors in both Japan and the EU-27 have reduced employment leading to substantial improvements in labour productivity. Again the component's sub-sector (EE3) shows the strongest growth in labour productivity in both regions. In all three sectors, growth in labour cost per employee is much higher in the EU-27. That is, although growth in value added is higher in EU-27, the increase in labour costs is also much higher. Thus, relative price competitiveness in terms of labour productivity for all three sub-sectors has improved for Japan relative to the EU-27.

[158] The differences in labour productivity are not that large as compared with the US, however, Japanese labour cost are lower and the EU disadvantage in price competitiveness as measured by ULC is of similar magnitude as for the US.

Table 3.6: Sectoral performance of the EU and Japan's EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical engineering (EE1)				
Japan	Value added, in 2010 prices	bn. €	92.8	3.0	2.1	0.9	-3.2	0.4
EU-27			129.2	10.6	-0.2	2.7	1.1	2.2
Japan	Employees	1,000	1189	-3.0	0.0	0.7	-1.1	-0.6
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
Japan	Labour costs per employee	1,000 €	36.5	-0.2	-0.1	1.5	-2.3	-0.4
EU-27			43.4	3.5	2.1	2.1	3.3	2.6
Japan	Productivity[2)]	1,000 €	78.1	6.1	2.1	0.3	-2.1	1.1
EU-27			58.5	8.0	1.0	2.1	2.3	2.6
Japan	Unit labour costs[3)]	€ / €	0.47	-6.0	-2.2	1.2	-0.2	-1.5
EU-27			0.74	-4.2	1.2	0.0	1.0	0.1
				Electronic engineering (EE2)				
Japan	Value added, in 2010 prices	bn. €	27.5	10.1	0.5	-4.7	-2.3	-0.2
EU-27			60.6	6.3	1.9	9.6	-1.6	3.1
Japan	Employees	1,000	271	-3.7	-5.8	-5.2	-3.0	-4.6
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
Japan	Labour costs per employee	1,000 €	41.3	2.9	-0.4	0.2	0.5	0.4
EU-27			43.2	3.1	0.6	0.5	1.8	1.3
Japan	Productivity[2)]	1,000 €	101.5	14.3	6.7	0.5	0.7	4.6
EU-27			68.8	4.5	4.4	9.5	1.7	4.7
Japan	Unit labour costs[3)]	€ / €	0.41	-10.0	-6.6	-0.4	-0.2	-4.0
EU-27			0.63	-1.0	-3.7	-8.0	0.0	-3.2
				Electrical and electronic components (EE3)				
Japan	Value added, in 2010 prices	bn. €	37.1	8.3	7.4	1.1	-3.7	2.9
EU-27			21.1	12.5	1.0	20.6	3.3	7.2
Japan	Employees	1,000	419	-5.2	-5.1	-2.3	-5.4	-4.6
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6
Japan	Labour costs per employee	1,000 €	41.1	-2.2	-1.0	1.4	1.1	0.0
EU-27			44.6	4.1	2.2	2.0	4.5	3.1
Japan	Productivity[2)]	1,000 €	88.6	14.2	13.2	3.5	1.8	7.9
EU-27			73.6	9.6	3.4	19.6	8.0	8.9
Japan	Unit labour costs[3)]	€ / €	0.46	-14.3	-12.6	-2.0	-0.6	-7.3
EU-27			0.61	-5.1	-1.0	-14.9	-3.0	-5.3

1) Conversion rate 130 YEN = 1 €; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Industry overview

Electrical engineering

The Japanese electric and electronics industry is dominated by large corporations engaging in many fields of production. Toshiba, for instance, is a large conglomerate producing products and services in information technology as well as communications equipment and systems, electronic components and materials, power systems, household appliances, medical equipment, office equipment, lighting and logistics.

Among the important players in Japan's EE1 are companies supplying equipment for power generation such as pumps, motors and generators. Firms engaged in this sector are SANSO, Fuji Electric and Mitsubishi Electric, the latter as sub-company of the large Mitsubishi conglomerate.

Another relevant branch is the automotive components industry. DENSO and Hitachi, for example, are important suppliers for the automotive industry worldwide. DENSO, a member of the Toyota group, produces small motors and engine-related components, climate control systems, powertrain control systems and other electric and electronic systems for vehicles. Hitachi offers a large range of products, including white goods such as washing machines, LCD displays, wires and cables and automotive systems such as drive control systems or electric powertrain systems. When the tsunami disrupted the Japanese economy in 2011, automotive companies worldwide, including those in Germany, felt a disruption to the supply of electrical and electronic parts.

The Japanese firm Daikin Industries is the world's largest manufacturer of air conditioning systems after its takeover of the US American company Goodman Global Inc. Daikin has invented the variable refrigerant flow technology, which significantly increases energy efficiency of heating and cooling units. The company still aims to enlarge its market and customer base. After the American market – which tapped into through the acquisition of Goodman Global – the focus is now on gaining a larger share in the European market.

Electronic engineering

Japanese manufacturing is well known for its important role in consumer electronics. The long list of firms includes: Canon, Casio, Citizen, Fujifilm, Fujitsu, Hitachi, JVC Kenwood, Mitsubishi Electric, NEC, Nikon, Nintendo, Olympus, Panasonic, Pioneer, Ricoh, Seiko Group, Sharp, Sony, TDK and Toshiba.

After World War II, the Japanese electronics industry grew rapidly and became one of the world's most important and innovative ones. Among the most influential Japanese inventions are Sony's Walkman, the VHS recorder by JVC and LCD screens. Also, Toshiba was first to sell mass produced laptops. By the 1980s, the industry accounted for the major share of Japan's exports investment and activity abroad. During the 1990s, the Japanese electronics industry lost its lead in innovativeness. It was overtaken by Korean companies. Besides a slowdown in the pace of technological progress in Japan, the overvalued national currency put much pressure on the industry. Since 2000, revenues of many major companies in the field of electrical engineering and electronics have declined rapidly, forcing firms to restructure. The Japanese market share in this sector reduced significantly because price differentials play a key role in mass-manufactured consumer electronics.

The new monetary policy of the Japanese central bank could stimulate competitiveness of Japanese manufacturers in an era of a no longer overvalued Yen.

Components, semiconductors

Japanese semiconductor manufacturers can be found among the top producers worldwide[159]. In 2012, Toshiba semiconductors ranked fifth with a market share of 3.6 % (decline from rank 4 in 2011), directly followed by the Japanese firm Renesas Electronics (rank 5 in 2011). The drop in market share can be explained by the emergence of Qualcomm (US), which quickly increased its share over the past years. Sony ranked 11th with a market share of 2.0 % (improved from rank 13 in 2011), while rank 18 and 19 were also occupied by Japanese companies (Elpida Memory with 1.1 % and Rohm Semiconductor with 1.0 %). Interestingly, two of these companies do not focus only on semiconductor production but have a large range of active fields in the electronics industry. Toshiba and Sony are large conglomerates generating all kinds of products and services in addition to semiconductors[160]. Renesas Electronics mainly focuses on semiconductors and is leading in the production of semiconductors for mobile phones and automotive applications. Moreover, it is the largest producer of microcontrollers worldwide and the second largest producer of application

[159] According to 2012 revenue; http://www.isuppli.com/Semiconductor-Value-Chain/News/Pages/Qualcomm-Rides-Wireless-Wave-to-Take-Third-Place-in-Global-Semiconductor-Market-in-2012.aspx

[160] See above.

processors. Also Rohm concentrates on semiconductors while Elpida Memory mainly sells dynamic random-access memory (DRAM) products.

The Japanese semiconductor industry developed in the 1970s and quickly gained a large market share. In 1990, Japan surpassed the US and held more than half of the world's semiconductor market. But since 2000, this share has been decreasing and fallen below 20 %. Reasons for the decline of the industry are the growing competition of other Asian countries such as Korea and Taiwan[161]. The Korean DRAM product line has put Japanese producers under pressure. Yunogami[162] argues that the Japanese culture of always pursuing and producing the most advanced and technically feasible maximum turned into a disadvantage in DRAM production. Since Korea has been able to offer DRAMs of lower but sufficient quality at significantly lower prices, Korean manufacturers could take over market shares from Japanese producers. Moreover, Japanese firms failed to compete with or adjust to the Taiwanese foundry system which means that large foundry firms have taken over the manufacturing part of semiconductor production and through economies of scale are able to lower costs. However, DRAMs and other standardised semiconductors are commodities and sold via pricing. Here the Japanese manufacturers suffered from the long-term overvalued YEN.

The technological strength of the Japanese semiconductor industry is explained to a large extent by its equipment industry which is among the leading global suppliers of process and production technology, dominated by US, Japanese and a few European players.

3.3 South Korea

Table 3.7 reveals that South Korea's EEI is potent with a 2012 production value of € 214 billion, over 33.8 % of the production of the entire EU-27, and growing rapidly: 10.3 % during the period from 2008 to 2012, compared to a decrease of -2.2 % for the EU-27 in the same period. The separation in growth rates is accelerating. In the 14 years between 1998 and 2012, the South Korean EEI has grown in production value at 9.4 % per annum, while the EU-27 has added a more modest 1.0 % annually. Interestingly, EEI employment in both regions has fallen in the same period -0.5 % annually in South Korea compared to -0.8 % in the EU-27.

EEI production value was relatively evenly distributed in South Korea with 25 %, 34 % and 41 % in Electrical Engineering, Electronic Engineering and Components respectively during 2012. The EU-27 by comparison, produced 59 %, 31 %, and 10 % in those same sectors. The EU-27 produces relatively more electrical engineering value, while Korea's EEI emphasises EE3 even more than the US and Japan. Employment fractions are comparable to the production value distributions in the two regions.

[161] India Semiconductor Association: "India-Japan Collaboration in the Semiconductor Space" (June 2007).
Development Bank of Japan: Research Report 34: "Prospects and Challenges Surrounding Japan's Electrical Equipment Industry" (November 2002).

[162] Takashi Yunogami, Institute for Technology, Enterprise and Competitiveness, Doshisha University: "International Technological Competitiveness of the Japanese Semiconductor Industry" (2005).

Table 3.7: Key figures for the South Korean and EU EEI

Sector	Indicator		2012[1)]	Annual average growth rates in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical and electronic engineering (EEI)				
S.-Korea	Production, in current prices	bn. €	214.0	13.4	7.7	8.6	10.3	9.4
EU-27			634.4	9.8	-1.6	3.9	-2.2	1.0
S.-Korea	Employees	1,000	577	7.6	-6.2	-1.7	3.9	-0.5
EU-27			3377	2.2	-1.7	0.5	-2.0	-0.8
				Electrical engineering (EE1)				
S.-Korea	Production, in current prices	bn. €	52.7	10.0	6.5	12.5	9.3	9.1
EU-27			370.4	8.2	1.0	5.5	-0.6	2.5
S.-Korea	Employees	1,000	189	7.7	-1.2	1.8	4.0	2.1
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
				Electronic engineering (EE2)				
S.-Korea	Production, in current prices	bn. €	74.5	17.1	2.9	7.4	6.1	6.7
EU-27			201.1	11.0	-4.7	1.2	-5.3	-1.5
S.-Korea	Employees	1,000	169	9.0	1.2	-1.3	0.2	1.4
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
				Electrical and Electronic components (EE3)				
S.-Korea	Production, in current prices	bn. €	86.8	9.2	17.3	7.5	15.4	13.4
EU-27			62.9	12.7	-1.1	5.4	-0.2	2.4
S.-Korea	Employees	1,000	220	6.9	-13.0	-5.1	7.2	-3.1
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6

1) Conversion rate 1,500 WON = 1 €.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Comparative price performance of South Korean EEI

Table 3.8 compares EEI in South Korea and the EU-27 to their total manufacturing (TM) performance. Although South Korea's manufacturing complex has experienced strong growth since 1998, 6.3 % per annum in nominal terms, its EEI growth has been remarkable: 19 % annually over the same period, for value added at constant prices. At the beginning of that period, EEI's labour costs were actually lower but have since caught up at approximately € 25,400 per employee in EEI and TM.

The Korean EEI performed quite well compared to the national TM. Labour productivity soared at an annual rate of 19.6 % over the whole period and exceeded, by far, the increase of labour costs that grew simultaneously at 7.4 % p.a. As a result, ULC declined strongly at a double digit rate and gave the Korean EEI an enormous edge over its national TM.

South Korea has a 3-times advantage over the EU-27 in ULC in TM, but the advantage increases to 4-times in EEI. However, it appears that the increase in this latter advantage may be slowing as ULC fell in both regions, by -4.0 % for Korea and -2.3 % for the EU-27 in the most recent sampled years from 2008 to 2012.

Korean EEI's price performance compared to the EU

Korea's unit labour cost advantage over the EU-27 is not only a function of lower wages — which are only 59 % of EU rates – but also of higher labour productivity. For TM and EEI, Korea leads by a factor of around 2. It is significant, though, that labour costs in South Korea have risen in other areas of manufacturing faster than in EEI, when one considers the per employee productivity gains that have been made in EEI. In Korea, TM wages have roughly kept pace with productivity gains

(4.8 % vs 4.8 %), but EEI productivity has risen much faster than wages (19.6 % vs. 7.4 %) in Korea. The pattern in the EU is puzzling: TM wages have increased faster than EEI wages (3.1 % vs. 2.6 %), while relative growth in productivity has been in precisely the opposite direction (0.9 % vs. 4.6 %). For the Korean EEI, as well as for the EU EEI, price competitiveness improved over the period under consideration, but far more in Korea.

Table 3.8: Comparative economic performance of the EU and South Korean's EEI

Sector	Indicator	2012[1)]		Annual average growth rate in %				
				1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				South Korea				
TM[2)]	Value added, in 2010 prices	bn. €	338	14.5	5.5	3.7	5.3	6.3
EEI[3)]			86	19.2	26.4	15.1	12.9	19.0
TM[2)]	Employees	1,000	2763	4.7	-0.3	0.2	3.0	1.4
EEI[3)]			577	7.6	-6.2	-1.7	3.9	-0.5
TM[2)]	Labour costs per employee	1,000 €	25.4	-4.2	9.7	5.0	3.3	4.8
EEI[3)]			25.4	-10.0	18.4	6.7	4.3	7.4
TM[2)]	Productivity[2)]	1,000 €	122.2	9.3	5.8	3.6	2.3	4.8
EEI[3)]			149.7	10.8	34.8	17.2	8.7	19.6
TM[2)]	Unit labour costs[3)]	€ / €	0.21	-12.4	3.7	1.4	1.0	0.0
EEI[3)]			0.17	-18.8	-12.1	-8.9	-4.0	-10.2
				European Union (27)				
TM[2)]	Value added, in 2010 prices	bn. €	1610	1.7	-0.3	-2.3	-1.2	-0.6
EEI[3)]			211	9.5	0.4	7.5	3.8	3.8
TM[2)]	Employees	1,000	29985	-0.3	-1.4	-1.6	-3.1	-1.6
EEI[3)]			3377	2.2	-1.7	0.5	-2.7	-0.8
TM[2)]	Labour costs per employee	1,000 €	38.8	2.9	2.5	5.5	3.2	3.1
EEI[3)]			43.4	3.4	1.6	3.2	3.9	2.6
TM[2)]	Productivity[4)]	1,000 €	53.7	2.0	1.1	-0.6	2.0	0.9
EEI[3)]			62.4	7.2	2.1	7.0	6.7	4.6
TM[2)]	Unit labour costs[5)]	€ / €	0.72	0.9	1.4	6.5	0.9	2.2
EEI[3)]			0.70	-3.6	-0.5	-3.7	-2.3	-1.9

1) Conversion rate 1,500 WON = 1 €; 2) Total manufacturing; 3) Electrical and electronic engineering; 4) (Value added in 2010 prices) / employment; 5) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Sectoral price performance

Table 3.9 compares the performance of South Korea's EEI to that of the EU-27 by sector. While South Korea has a large EEI advantage over the EU in terms of productivity and labour costs when measured from 1998 to 2012 across all sectors, the detailed picture is more nuanced. For example, although Korean unit labour costs are about a quarter to a third of European labour costs across the EEI, the EU has made relative gains in Electrical Engineering, especially in more recent years.

In EE3, the EU-27 has made modest relative gains in ULC in the most recent years. In interpreting figures for this sub-sector, which includes semi-conductors, its extreme volatility (observable in the highly variable growth rates) and capital intensive nature (observable in the high value added per employee) should be kept in mind.

Although Korea is still reducing ULC more quickly in EE2 than EU-27, the growth of this advantage has been markedly slow in the last years. This trend in unit labour costs has been mostly due to the fact that Korean wages have increased more compared to European ones.

Table 3.9: Sectoral performance of the EU and South Korean EEI

Sector	Indicator	2012[1)]		Annual average growth rate in %				
				1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical engineering (EE1)				
S.-Korea	Value added, in 2010 prices	bn. €	16.3	14.8	3.8	4.8	7.3	6.5
EU-27			129.2	10.6	-0.2	2.7	1.1	2.2
S.-Korea	Employees	1,000	189	7.7	-1.2	1.8	4.0	2.1
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
S.-Korea	Labour costs per employee	1,000 €	24.0	-7.4	9.2	6.4	4.4	4.7
EU-27			43.4	3.5	2.1	2.1	3.3	2.6
S.-Korea	Productivity[2)]	1,000 €	86.3	6.6	5.0	2.9	3.2	4.3
EU-27			58.5	8.0	1.0	2.1	2.3	2.6
S.-Korea	Unit labour costs[3)]	€ / €	0.28	-13.2	4.0	3.4	1.2	0.4
EU-27			0.74	-4.2	1.2	0.0	1.0	0.1
				Electronic engineering (EE2)				
S.-Korea	Value added, in 2010 prices	bn. €	30.9	14.2	25.7	24.8	6.2	18.0
EU-27			60.6	6.3	1.9	9.6	-1.6	3.1
S.-Korea	Employees	1,000	169	9.0	1.2	-1.3	0.2	1.4
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
S.-Korea	Labour costs per employee	1,000 €	26.6	-11.5	8.2	6.5	4.0	3.6
EU-27			43.2	3.1	0.6	0.5	1.8	1.3
S.-Korea	Productivity[2)]	1,000 €	182.8	4.8	24.2	26.5	6.0	16.3
EU-27			68.8	4.5	4.4	9.5	1.7	4.7
S.-Korea	Unit labour costs[3)]	€ / €	0.15	-15.5	-12.9	-15.8	-1.8	-10.9
EU-27			0.63	-1.0	-3.7	-8.0	0.0	-3.2
				Electrical and electronic components (EE3)				
S.-Korea	Value added, in 2010 prices	bn. €	39.2	25.1	30.3	7.3	23.1	22.3
EU-27			21.1	12.5	1.0	20.6	3.3	7.2
S.-Korea	Employees	1,000	220	6.9	-13.0	-5.1	7.2	-3.1
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6
S.-Korea	Labour costs per employee	1,000 €	25.7	-11.6	33.4	7.2	4.7	12.0
EU-27			44.6	4.1	2.2	2.0	4.5	3.1
S.-Korea	Productivity[2)]	1,000 €	178.7	17.0	49.9	13.1	14.8	26.2
EU-27			73.6	9.6	3.4	19.6	8.0	8.9
S.-Korea	Unit labour costs[3)]	€ / €	0.14	-24.4	-11.0	-5.2	-8.8	-11.3
EU-27			0.61	-5.1	-1.0	-14.9	-3.0	-5.3

1) Conversion rate 1,500 WON = 1 €; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Industry overview

Electrical engineering industry

More than for its EE1 sector, South Korea is well known for its companies active in the market of consumer electronics and semiconductors. Yet, the South Korean company LS Cable & System ranks among the world's largest cable manufacturers and produces both power and telecommunications cables and systems. The company also takes care of installation, especially regarding submarine cabling projects. Its cable products for power transmission include extra-high voltage cables, medium and low voltage cable and over-head and submarine transmission lines**. LS Cable & System has been the first Korean company to export high-voltage direct current (HVDC) cables to Europe**[163]. In 2008, the Korean firm took over Superior Essex, the largest cable maker in North America, and in 2009 it acquired the Chinese cable producer HongQi Electricity, thus manifesting its international position as an important global player in the cable and wire industry.

Electronic engineering industry

South Korean companies play a major role in the global market of consumer electronics as well as in the semiconductor sector. Electronics and semiconductors account for roughly 30 % of total South Korean exports.[164]

In the 1950s, Korea started industrialising using the Chaebol model. The government picked a few firms and supported them through infrastructure and subsidised credit to become large conglomerates expanding in various branches. The electronics industry, Korea's main driver of industrialisation, heavily used this model and still reflects the Chaebol structure featuring a few but giant corporations involved in different sectors.[165] The two largest electronics companies are Samsung and LG which are both engaged in the production of TVs, mobile phones and PCs. Samsung is the world market leader in the production of LCD TVs with a share of 18 % in 2010 and also ranked first in the market for smart phones (29 % market share) in 2012[166]. In the total market for mobile phones Samsung is second to Nokia, with a share of 17 %. In 2010 the company accounted for 8 % of South Korea's GDP. LG comes second after Samsung in the mobile phone market with a 7 % share and ranks 5th in the LCD TV market. Thus, both companies combined made up one fourth of the world supply of LCD TVs and mobile phones in 2010.[167]

In the beginning of its industrial development, Korea used its labour cost advantage and acted mainly as export base or centre for outsourced manufacturing for American and Japanese companies. However, in order to produce in South Korea, foreign companies were required to build joint ventures with local companies which enabled an exchange of technology and knowledge. South Korean firms could build up R&D and technology and became able to produce high-end technology themselves. Government support helped companies such as Samsung to further grow and to reach a size which made production profitable due to economies of scale. Samsung is on the leading edge of technology and competes heavily with the US Apple. Patent litigation has become a permanent feature of competition for technological leaders in mass markets.

Components, semiconductors

In the semiconductor sector Korea ranks 3rd in terms of worldwide sales, behind the US and Japan. The world's second largest semiconductor producer is the Korean corporation Samsung with a world market share of 10.1 % in 2012. SK Hynix, another South Korean company, ranks 7th (market share: 2.8 %)[168]. These companies managed to advance from mainly manufacturing other companies' products, offering low cost labour and efficient production, to building their own brands

[163] Korea IT Times: 2013; http://www.koreaittimes.com/story/27789/ls-cable-system-exported-hvdc-europe.
[164] ED Research; Jewon Lee: Korean Electronic Industry.
[165] The Economist: The chaebol conundrum. March 31 2010; http://www.economist.com/node/15816756
[166] http://www.forbes.com/sites/chuckjones/2013/01/25/samsung-increasing-its-smartphone-market-share-vs-apple-and-the-rest-of-the-pack/.
[167] Thomas White Global Investing: South Korea and Taiwan Electronics: A race to the top. March 2011.
[168] According to 2012 revenue; http://www.isuppli.com/Semiconductor-Value-Chain/News/Pages/Qualcomm-Rides-Wireless-Wave-to-Take-Third-Place-in-Global-Semiconductor-Market-in-2012.aspx.

and becoming leaders in technology innovation. In 1992, South Korea developed the first 64 mega DRAM semiconductor chip; in 2005, the country introduced the first 16 Gb NAND flash memory chip[169].

The South Korean semiconductor industry is specialised, focusing on DRAM and NAND flash memory chips. Samsung is a market leader in both fields, producing more than one third of all DRAM and NAND flash worldwide. SK Hynix ranks second in the DRAM and third in the NAND global markets. Broad governmental support and high R&D spending facilitate technological advancement. Samsung currently enjoys a large technological advantage over its competitors as it was the first to mass produce an advanced form of DRAM[170].

However, specialisation on DRAM and NAND technology also means that the Korean semiconductor industry is little diversified in a commodity low-margin market. Only a small share of the non-memory semiconductor market is supplied by South Korea[171]. The fact that in 2011 system semiconductor exports surpassed memory semiconductors for the first time is largely due to increased foundry production and the expansion of the packaging industries within Korea's borders[172].

The Electronics and Telecommunications Research Institute (ETRI) is the largest publicly funded research institute in Korea. ETRI worked on 547 projects in 2011 with an annual budget of € 365 million (KRW 547,618 million). In 2011 ETRI applied for 3574 patents. The focus is on various areas of electronics, software and technology and also for the semiconductor sector.[173]

Samsung and Hynix, the two largest semiconductor producers in South Korea, have built a R&D partnership and collaborate with universities and their research institutes in order to develop Next-Generation Memories[174]. The joint research centre's budget is funded by both of the companies and the government at equal shares.

In the 1960s, the government founded the Ministry of Science and Technology to manage all government research activities as well as the Korea Institute of Science and Technology which functions as an industrial research laboratory. Moreover, in 1971, the Korea Advanced Institute of Science was founded as a scientific university focusing on research. Many other universities were encouraged to develop programmes in science and technology.

South Korea has ambitious goals for its economic and technological performance. In 2007, the country was the tenth-largest power in science and technology; in 2025 its aim is to be number seven. The main strategy to reach this advancement is investment in research and development in close co-operation with industry. Thus, the government supports research projects set-up and funded by private businesses, for instance through a generous R&D tax credit system. It is widely acknowledged by the government, businesses and society that only research and further technological development will ensure further growth and welfare. In fact, Korean R&D

[169] Business Times: Korean Semiconductor Industry. September 2005, Vol. 15, No. 4.

[170] Namely the 20nm-class DDR3; http://www.koreaittimes.com/story/20060/microsoft-and-samsung-collaborate-create-efficient-cloud-implementation.

[171] Business Times: Korean Semiconductor Industry. September 2005, Vol. 15, No. 4.

[172] For instance, also Samsung acts as foundry company. Dongbu is another Chaebol acting as semiconductor foundry.

[173] ETRI: http://www.etri.re.kr/eng/.

[174] Namely spin transfer torque-magnetic random access memory (STT-MRAM); http://news.mk.co.kr/english/newsRead.php?sc=30800006&cm=English%20News_&year=2013&no=299570&selFlag=&relatedcode=&wonNo=&sID=308.

expenditures have been growing by about 9.5 % annually and, as percentage of sales, are higher than those of Europe and Japan[175].

3.4 Taiwan

The EEI is possibly the largest Taiwanese manufacturing industry with a production value of € 125 billion (conversion rate 40 TW$ = 1 €) in 2012, which is about 33 % of total manufacturing. In Taiwan, EE3 is by far the largest sub-sector at more than twice the size of EE1 and EE2 combined. As a share of EEI production, EE3 has around 70 %. This concentration is not found in any of the other competing economies under investigation. In nominal terms, the Taiwanese EEI has grown much faster than in EU-27 with an average annual growth rate of 5.6 % over the whole period, while the EU only grew by 1.1 % p.a. EE3, the largest sector, has also seen the highest average growth rate with 8.4 %. Unlike the EU-27, Taiwan has hardly seen any dip in its EEI growth rate after the crisis in 2008, just like Korea. This is in line with the fact that emerging economies have not been much affected by the global financial crisis (Fehler! Verweisquelle konnte nicht gefunden werden.).

Unlike in the EU-27 and other competing economies, Taiwan increased employment in the EEI by 3.0 % annually over the whole period (-0.8 % in EU-27). The increase in employment is driven primarily by EE3, but also by EE2. In particular, Taiwan's strong employment growth is unique among the competing economies.

[175] Tax and Global Guide to R&D Tax Incentives 2011/2012
Thomas White Global Investing: South Korea and Taiwan Electronics: A race to the top. March 2011

Table 3.10: Key figures for the Taiwanese and EU EEI

Sector	Indicator	2012[1)]		Annual average growth rates in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical and electronic engineering (EEI)				
Taiwan	Production, in current prices	bn. €	125.0	16.1	3.1	5.6	3.8	5.6
EU-27			650.6	9.8	-1.6	3.9	-1.5	1.1
Taiwan	Employees	1,000	896	7.4	3.3	2.9	0.5	3.0
EU-27			3381	2.2	-1.7	0.5	-2.0	-0.8
				Electrical engineering (EE1)				
Taiwan	Production, in current prices	bn. €	10.9	-1.6	0.5	4.7	1.1	1.3
EU-27			377.8	8.2	1.0	5.5	-0.1	2.7
Taiwan	Employees	1,000	126	1.1	-3.7	-0.5	1.7	-0.8
EU-27			2203	2.4	-1.2	0.6	-1.2	-0.3
				Electronic engineering (EE2)				
Taiwan	Production, in current prices	bn. €	27.2	9.7	-4.6	-3.6	10.9	1.8
EU-27			205.5	11.0	-4.7	1.2	-4.8	-1.4
Taiwan	Employees	1,000	208	5.7	2.1	0.6	-0.2	1.6
EU-27			886	1.7	-2.4	0.1	-3.2	-1.5
				Electrical and Electronic components (EE3)				
Taiwan	Production, in current prices	bn. €	86.9	25.7	7.1	8.4	2.3	8.4
EU-27			67.3	12.7	-1.1	5.4	1.5	2.9
Taiwan	Employees	1,000	561	11.2	6.1	4.6	0.6	4.9
EU-27			292	2.7	-2.3	0.8	-3.9	-1.4

1) Conversion rate 40 TW$ = 1 €.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Comparative price performance of Taiwanese EEI

Table 3.11 compares the performance of the Taiwanese EEI to total manufacturing (TM). In terms of real value added, EEI makes up nearly half of TM. In terms of employment, it is around one third (again in EU-27 the importance of the EEI in manufacturing is much lower). EEI's labour productivity grew at a much higher pace over the whole period (8.4 % p.a.) than for TM (1.7 %). It is 38 % higher than for domestic TM on average while wages are only 12 % higher. This gives the Taiwanese EEI a significant edge in price competitiveness. This comparative advantage has grown over the whole period, and in 2012 ULC are 19 % below TM's average.

Taiwanese EEI's price performance as compared to the EU

The average annual growth figures of value added at constant prices for the period 1998 to 2012 show that the Taiwanese EEI is rapidly gaining in importance with a growth rate of 11.6 % compared to 2.4 % for TM. Simultaneously in the EU, EEI also added value relative to TM, but this was less pronounced. However, EU-27 employment had decreased in both TM and EEI, whereas it actually increased in Taiwan for our sample period. The net effect is that in Taiwan EEI labour productivity growth is far higher than in TM as well as in EU EEI. Productivity growth rates in Taiwan are trending down; mainly because value added growth is trending down. For the EU EEI the improvement of labour productivity has continued at a steady yet much lower pace. (**Table 3.11**)

Taiwan can build on extremely low labour costs. They are around 40 % of the EU-27 average for TM as well as for EEI. They are even lower than in some of the EU Member States. This provides an edge in price competitiveness for Taiwanese companies despite low labour productivity which only reaches levels of 60 % and 70 % of the EU for TM and EEI, respectively.[176] ULCs are well below the EU with 56 % and 66 %, respectively. Throughout the period under investigation, the Taiwanese ULC for EEI improved at an annual rate of 5.1 %, whereas for the EU-27 the rate was only 1.9 %. Taiwanese development outpaced the EU EEI's over the entire period, although the EU EEIs made some progress. The EU TM's price competitiveness also worsened.

Table 3.11: Comparative economic performance of the EU and Taiwanese EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Taiwan				
TM[2)]	Value added, in 2010 prices	bn. €	90	7.9	3.4	-4.0	3.5	2.4
EEI[3)]			42	23.7	13.9	10.3	4.4	11.6
TM[2)]	Employees	1,000	2652	1.4	0.2	1.1	0.8	0.7
EEI[3)]			901	7.4	3.3	2.9	0.7	3.0
TM[2)]	Labour costs per employee	1,000 €	16.1	2.1	2.4	2.4	0.7	1.9
EEI[3)]			18.1	0.9	4.6	3.9	0.8	2.8
TM[2)]	Productivity[2)]	1,000 €	33.8	6.3	3.2	-5.1	2.6	1.7
EEI[3)]			46.6	15.2	10.3	7.2	3.7	8.4
TM[2)]	Unit labour costs[3)]	€ / €	0.48	-3.9	-0.8	7.9	-1.8	0.2
EEI[3)]			0.39	-12.4	-5.2	-3.1	-2.8	-5.1
				European Union (27)				
TM[2)]	Value added, in 2010 prices	bn. €	1610	1.7	-0.3	-2.3	-1.2	-0.6
EEI[3)]			211	9.5	0.4	7.5	3.8	3.8
TM[2)]	Employees	1,000	29985	-0.3	-1.4	-1.6	-3.1	-1.6
EEI[3)]			3377	2.2	-1.7	0.5	-2.7	-0.8
TM[2)]	Labour costs per employee	1,000 €	38.8	2.9	2.5	5.5	3.2	3.1
EEI[3)]			43.4	3.4	1.6	3.2	3.9	2.6
TM[2)]	Productivity[4)]	1,000 €	53.7	2.0	1.1	-0.6	2.0	0.9
EEI[3)]			62.4	7.2	2.1	7.0	6.7	4.6
TM[2)]	Unit labour costs[5)]	€ / €	0.72	0.9	1.4	6.5	0.9	2.2
EEI[3)]			0.70	-3.6	-0.5	-3.7	-2.3	-1.9

1) Conversion rate 40 TW$ = 1 €; 2) Total manufacturing; 3) Electrical and electronic engineering; 4) (Value added in 2010 prices) / employment; 5) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Sectoral price performance

Table 3.12 has the same variables as above but the comparison is for Taiwan and the EU-27 by sub-sector and not between EEI and total manufacturing. Whereas the EU-27 EE1 is about 45 times larger than the Taiwanese EE1 in terms of value added; EE2 is about 5 times larger and EE3 is actually slightly smaller. These numbers underline the massive importance of EE3 for Taiwan as global powerhouse for the manufacture of semiconductors. EE1 is only of minor importance for the Taiwanese economy and had lost of importance as indicated by a reduction of workplaces, while EE2 and EE3 had increased employment. From an economic standpoint, EE1 is underperforming: slowly improving low labour productivity (roughly one third of EU-27) leaves Taiwan's EE1 ULC 13 % below the EU average.

[176] This contrasts to the findings for the US, Japan and Korea. All of these three economies show much higher labour productivity than the EU-27.

Table 3.12: Sectoral performance of the Taiwanese and EU EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical engineering (EE1)				
Taiwan	Value added, in 2010 prices	bn. €	3.0	-2.5	1.1	-1.8	2.6	0.4
EU-27			132.2	10.6	-0.2	2.7	1.7	2.4
Taiwan	Employees	1,000	126	1.1	-3.7	-0.5	1.7	-0.8
EU-27			2203	2.4	-1.2	0.6	-1.2	-0.3
Taiwan	Labour costs per employee	1,000 €	14.2	0.3	3.4	2.9	-0.1	1.8
EU-27			42.4	3.5	2.1	2.1	2.7	2.5
Taiwan	Productivity[2)]	1,000 €	23.7	-3.6	5.0	-1.2	0.8	1.2
EU-27			60.0	8.0	1.0	2.1	3.0	2.7
Taiwan	Unit labour costs[3)]	€ / €	0.60	4.1	-1.5	4.2	-0.9	0.6
EU-27			0.71	-4.2	1.2	0.0	0.0	-0.2
				Electronic engineering (EE2)				
Taiwan	Value added, in 2010 prices	bn. €	12.8	18.0	9.9	13.9	12.1	12.5
EU-27			60.6	6.3	1.9	9.6	-1.6	3.1
Taiwan	Employees	1,000	208	5.7	2.1	0.6	-0.2	1.6
EU-27			886	1.7	-2.4	0.1	-3.2	-1.5
Taiwan	Labour costs per employee	1,000 €	18.7	-5.1	3.9	4.0	0.4	1.6
EU-27			41.9	3.1	0.6	0.5	1.0	1.0
Taiwan	Productivity[2)]	1,000 €	61.5	11.6	7.6	13.2	12.3	10.7
EU-27			68.5	4.5	4.4	9.5	1.6	4.7
Taiwan	Unit labour costs[3)]	€ / €	0.30	-15.0	-3.5	-8.1	-10.6	-8.2
EU-27			0.61	-1.0	-3.7	-8.0	-0.8	-3.5
				Electrical and electronic components (EE3)				
Taiwan	Value added, in 2010 prices	bn. €	25.9	42.4	20.1	11.5	1.4	15.4
EU-27			22.0	12.5	1.0	20.6	4.4	7.5
Taiwan	Employees	1,000	561	11.2	6.1	4.6	0.6	4.9
EU-27			292	2.7	-2.3	0.8	-3.9	-1.4
Taiwan	Labour costs per employee	1,000 €	17.9	5.2	5.0	3.9	-0.2	3.3
EU-27			42.4	4.1	2.2	2.0	3.2	2.7
Taiwan	Productivity[2)]	1,000 €	46.1	28.1	13.1	6.6	0.9	10.0
EU-27			75.2	9.6	3.4	19.6	8.6	9.1
Taiwan	Unit labour costs[3)]	€ / €	0.39	-17.8	-7.2	-2.6	-1.1	-6.1
EU-27			0.56	-5.1	-1.0	-14.9	-5.1	-5.9

1) Conversion rate 40 TW$ = 1 €; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

For EE2, Taiwan is only 11 % behind the EU EE2 in terms of labour productivity. Productivity grew at a faster pace, suggesting convergence in the near future. Taiwanese labour costs grew at a similar rate as for the EU-27. This led to a significant improvement of ULC during period under consideration. Taiwan's EE2 can build on strongly improved price competitiveness. For EE3 the situation is quite different. The EU labour productivity is 61 % higher, but EU labour costs exceed the Taiwanese by 237 %. This gives the Taiwanese EE3, once more, an edge in ULC – at two thirds of the EU EE3 costs. Over the whole period, labour productivity increased at a similar pace while Taiwanese wages grew stronger. This led to a slight improvement of EU EE3's price competitiveness.

Industry overview

Electrical and electronic engineering industry[177]

Taiwan's economy is specialised in the Information and Communications Technology sector, specifically the development and production of computers and related equipment and electronic components such as semiconductors. The main export goods of the ICT industry are intermediate products, as opposed to end products. Generally, Taiwanese firms are involved in the production of many foreign companies' products, a trend which has been enforced by the rise of Taiwanese foundry companies in the semiconductor sector.

The industry is marked by vertical disintegration and thus, unlike the Japanese or Korean system of giant conglomerates dominating the market, there are many highly specialised small and medium sized firms and few large companies. These enterprises often focus on only one step in the value chains of electronics products but usually are located in industry clusters, for example in business or science parks.

Two larger and important companies are Acer and HTC. Acer is the world's second largest producer of personal computers, smaller than HP but larger than Dell. In addition to computer-related product, the company also produces LCD TVs. Despite current economic problems, HTC is still the 4th largest maker of smart phones.

Taiwan is well positioned in the optoelectronics sector. AU Optronics is a leading Thin Film Transistor (TFT) LCD manufacturer supplying major electronics companies such as Samsung, Apple and Dell. Epistar Corp., **Taiwan's largest producer of light emitting diodes (LEDs) is world's leader in the market for red and yellow LEDs and owns more than 1000 patents**. Edison Opto Corporation specialises in the research, development and production of high power LEDs, such as building and outdoor lighting, and is leading in its field. In general, there are roughly 40 Taiwanese companies supplying on the upstream of the LED production process (chips), around 90 companies producing modules and light engines and roughly 600 supplying lighting fixtures and system solutions (downstream).

The Taiwanese company TECO Electric and Machinery engages in the production of electrical and mechanical equipment, mainly focusing on medium voltage motors. With a market share of 8 % it ranks 3rd in the global market for medium voltage motors and also ranks 5th in the worldwide low-voltage motor market[178].

Certain energy related fields are well represented in the Taiwanese economy, in particular photovoltaic (PV) cell production. Taiwan has a complete PV industry supply chain and ranks 2nd in the production of PV cells; in 2011 the industry experienced a 12 % growth[179].

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[177] Shin-HorngChen, Pei-Chang Wen, Meng-Chun Liu: Trends in the ICT Industry and ICT R&D in Taiwan. Chung-Hua Institution for Economic Research, Taiwan; 2011.

Chen et al.: Excellent Government on a far-east silicon island. Taiwan Central University Working paper 2009.

Chou and Kirkby: Taiwan's Electronics sector: Restructuring of form and Space. Competition & Change 2: 331-358. 1998.

[178] http://www.teco.com.tw/en_version/theary01.asp.

[179] ITRI; Tong, Alex: Taiwan's Green Energy Industry - Status, Strength and Opportunities" 2012 http://de.slideshare.net/helenachn/taiwans-green-energy-ind-alex-tong-itri-2012-10-31.

Components, semiconductors[180]

The Taiwanese semiconductor industry is dominated by two foundry firms, Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC) which produce semiconductors for fabless companies worldwide. TSMC is the world's third largest semiconductor manufacturer (after Intel and Samsung) and the number one foundry company. UMC ranks second, directly behind TSMC. Thus, Taiwanese companies are the market leaders and hold a significant market share in the foundry sector. Leading fabless semiconductor companies in Taiwan are MediaTek and NovaTek, both with annual revenues over € 770 million (US$ 1 billion). Moreover, there are also firms specialised in the supply of chip packaging or test services.

The typical industry structure of disintegrated companies specialising in single steps of the production process is above all reflected in the semiconductor industry. This organisational approach has enabled companies to meet the challenges of ever-growing capital intensity and permanently carrying out investments in the latest production technology. The exploitation of scale-effects allows for carrying the enormous burden of capital costs. However, this business model is characterised by low margins and nearly all of the semiconductors are commodities. As long as Taiwanese foundries are mainly dependent on design and licenses for chip architectures, much of the value added within global production networks will be gained by foreign clients.

The strong specialisation of the Taiwanese EEI on semiconductors gives the country an edge with regard to the exploitation of scarce resources and scale effects. **However, this microeconomic effective strategy is risky in a volatile world and dynamic changes in technologies.** In particular, the fragmented global value chain in the production of semiconductors can turn out to become problematic. **In this respect, the Taiwanese initiative to increase expertise in the design and architecture of semiconductors will strengthen the position of the domestic semiconductor industry in global value chains.** US and European service providers and licensors will face tougher competition.

3.5 China

Table 3.13 reveals that the gross output[181] of China's EEI is enormous, greater than any other single region we analyse: over € 1.4 trillion, more than twice the output value of Europe's EEI. However, this metric, taken alone, paints an incomplete picture as much of the Chinese industry comprises of the assembly of high value components produced elsewhere. This explains why China's value added in this industry is 95 % of Europe's (€ 200 billion vs. € 211 billion; see **Table 3.14**).

One will also quickly note from **Table 3.13** that the difference between the values produced in the two regions is most pronounced in the EE2, which primarily includes final assembly of PCs and consumer electronics (EU EU2: 30.9 %, China EE2: 53,3 %). The difference is far less stark in the very high tech sector EE3. Although the EU-27's share of EE3 of EEI is remarkably low – compared with other competing economies – at 9.1 % as a share of gross output, the Chinese share of EE3 is even lower at only 5.2 %.

EEI growth in China has been nothing short of spectacular in since 1998: around 20 % in all three sub-sectors. However, the growth rate, while still high, has dropped to about half the peak rate in

[180] Department of Investment Services, MOEA: The Status of the Semiconductor Industry in Taiwan.
http://sourcing.taiwantrade.com.tw/db/IndustryOverview/15.Semiconductor.pdf
Deloitte: The virtuous semiconductor triangle. 2008
Taiwan Semiconductor Industry Association (TSIA): Overview on Taiwan Semiconductor Industry. 2012.

[181] Chinese statistics provide gross output instead of production. Both indicators are close together for manufacturing industries: Gross output comprises production plus / minus changes of stocks and sales of commercial goods.

that period (27.5 % in 2000 - 2005 vs. 13.8 % in 2008 - 2012). Thus, using average historical Chinese growth rates to impute future expansion is unrealistic; nevertheless, one should expect China's lead in sheer size to continue grow in the near future.

Measured in employment, the EEI in China dwarves Europe's by nearly a factor of 5 (>15 million EEI employees in China versus 3.3 million in the EU-27). In this dimension, China's growth was strong, but slowed down in recent years – just 4.5 % annually from 2008 - 2012. European employment in the EEI contracted significantly (-2.0 %) in the same period. Chinese growth in EEI employment has declined slightly in all sectors, least in EE1. For the EU-27 there was pronounced loss of workplaces in the EE2 and EE3.

However, for the duration of the period under investigation, the Chinese EE2 employment outperformed the other sectors by far at an annual rate of 11.6 %. It provides more than half of EEI's workplaces, although its contribution to total gross output is only around 50 %. This indicates clearly that China is a workbench for the assemblage of labour intensive large-batch products.

Table 3.13: Key figures for the Chinese and EU EEI

Sector	Indicator	2012[1)]		Annual average growth rates in %				
				1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
		Electrical and electronic engineering (EEI)						
China	Gross output, in current prices	bn. €	1449	22.8	27.5	21.7	13.8	21.5
EU-27			694	11.1	-0.9	3.2	-2.6	1.1
China	Employees	1,000	15769	-0.7	13.2	13.9	4.5	8.7
EU-27			3377	2.2	-1.7	0.5	-2.0	-0.8
		Electrical engineering (EE1)						
China	Gross output, in current prices	bn. €	601	17.3	24.2	30.0	16.4	22.1
EU-27			416	9.2	1.1	5.5	-0.1	2.8
China	Employees	1,000	6120	-2.1	9.9	12.9	3.8	6.9
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
		Electronic engineering (EE2)						
China	Gross output, in current prices	bn. €	773	27.9	29.5	17.2	12.5	21.6
EU-27			214	10.0	-3.1	-0.2	-6.1	-1.6
China	Employees	1,000	8593	2.9	17.5	15.5	6.1	11.6
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
		Electrical and Electronic components (EE3)						
China	Gross output, in current prices	bn. €	75.4	13.1	26.3	21.1	8.6	18.0
EU-27			62.9	29.7	-1.1	4.5	-4.9	2.9
China	Employees	1,000	1056	-6.5	9.5	9.5	-2.4	3.6
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6
1) Conversion rate 9 YUAN = 1 €.								

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Comparative price performance of EEI

Table 3.14 highlights differences between EEI and TM in China and the EU-27. First, EEI comprises of a larger fraction of total manufacturing in China than in Europe (15.8 % versus 13.1 % measured in value added, but 19.0 % versus 11.3 % measured in employment). Moreover, the Chinese EEI's labour productivity is below the average of domestic TM (-16.7 %). This contrasts to the EU EEI which enjoys significantly higher labour productivity (+16.3 %) relative to its domestic benchmark. Much of this comparative disadvantage for China is caused by low productivity of EE2.

The investigation into the evolution of the Chinese EEI supports the assessment that the sector is underperforming. Over the period under investigation, EE2's labour productivity did not keep the pace of growth for TM. The improvement of ULC relative to its benchmark stems from the fact that Chinese EEI wages increased half as fast as those in manufacturing overall. We conclude that increasing EE2 employment has played a significant role in the growing affluence of the Chinese working class.

Chinese EEI's price performance compared to the EU

Second, although Chinese workers are only about 20 % as productive as EU-27 ones (20.3 % in EEI and 28.4 % overall), this does not translate into competitive advantage for EU-27, because Chinese wages are extremely low (11.1 % of EU-27 in EEI and 12.1 % of EU-27 TM). Although EU-27 faces a general competitive disadvantage relative to China as measured in ULC (0.38 versus 0.70 in EEI and 0.31 versus 0.72), the EU-27 is relatively less disadvantaged in EEI labour than in TM.

Table 3.14: Comparative economic performance of the Chinese and EU EEI

Sector	Indicator	2012[1)]		Annual average growth rate in %				
				1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				China				
TM[2)]	Value added, in 2010 prices	bn. €	1266	14.9	19.0	21.8	19.8	19.2
EEI[3)]			200	21.9	22.6	26.9	17.6	22.0
TM[2)]	Employees	1,000	83128	-5.1	5.9	9.2	1.9	3.8
EEI[3)]			15769	-0.7	13.2	13.9	4.5	8.7
TM[2)]	Labour costs per employee	1,000 €	4.7	7.2	9.8	11.0	12.4	10.4
EEI[3)]			4.8	6.4	6.7	4.9	6.3	6.1
TM[2)]	Productivity[2)]	1,000 €	15.2	21.0	12.4	11.5	17.6	14.9
EEI[3)]			12.7	22.8	8.3	11.5	12.6	12.2
TM[2)]	Unit labour costs[3)]	€ / €	0.31	-11.4	-2.4	-0.5	-4.4	-3.9
EEI[3)]			0.38	-13.4	-1.5	-5.9	-5.6	-5.4
				European Union (27)				
TM[2)]	Value added, in 2010 prices	bn. €	1610	1.7	-0.3	-2.3	-1.2	-0.6
EEI[3)]			211	9.5	0.4	5.9	0.6	2.8
TM[2)]	Employees	1,000	29985	-0.3	-1.4	-1.6	-3.1	-1.6
EEI[3)]			3377	2.2	-1.7	0.5	-2.7	-0.8
TM[2)]	Labour costs per employee	1,000 €	38.8	2.9	2.5	5.5	3.2	3.1
EEI[3)]			43.4	3.4	1.6	1.6	3.9	2.2
TM[2)]	Productivity[4)]	1,000 €	53.7	2.0	1.1	-0.6	2.0	0.9
EEI[3)]			62.4	7.2	2.1	5.4	3.4	3.6
TM[2)]	Unit labour costs[5)]	€ / €	0.72	0.9	1.4	6.5	0.9	2.2
EEI[3)]			0.70	-3.6	-0.5	-3.2	0.5	-1.3

1) Conversion rate 9 YUAN = 1 €; 2) Total manufacturing; 3) Electrical and electronic engineering; 4) (Value added in 2010 prices) / employment; 5) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

In contrast to the Chinese EEI, the EU EEI has performed better than its domestic benchmark: productivity growth over the period was 3.6 % p.a. and exceeded the development of TM (0.9 %) by far, while labour costs increased by only 2.2 % over the whole period under consideration. ULC declined at an annual rate of -1.3 %. However, Chinese ULC declined at a much faster annual rate of 5.4 %, improving Chinese EEI's price competitiveness versus that of the EU by strong productivity gains, more than compensating for wage raises of 6.1 %.

Sectoral price performance

The Chinese EE1 is – as for the EU-27 – by far the largest sector of EEI. It grew strongly over the whole period, at an annual rate of 21.7 % for all value added at constant prices. This strong growth is in line with the development of the other sectors of the Chinese EEI. This growth is not only driven by foreign, but also domestic demand. EE1 produces a broad range of products necessary for investment in infrastructure, power generation, distribution, lighting, etc. Despite the strong growth of labour productivity by 13.8 % p.a., it is lagging far behind the EU with € 58,500 per annum and employee. However, Chinese wages more than outbalance this disadvantage and ULC are well below the EU-27 level, at only 40 %. This is even lower than for EE2 and EE3 in the comparison of the EU-27 with China. Chinese ULC improved over the whole period much stronger than for the EU EE1, indicating a relative loss in price performance for this sector, despite being, by virtue of its size, its state of technology and its performance in international trade, evaluated as globally competitive. (**Table 3.15**)

EE2 is, as mentioned above, a sector of Chinese EEI that did not keep pace with the growth of labour productivity and was lagging behind EE1 and EE3 as depicted in **Table 3.15**. Moreover, throughout the period productivity growth lagged behind, indicating a widening gap in labour productivity. The same is true for labour costs; sector wages are one third less than in EE1 and 13 % below EE3. Over the period the average annual wage increased half as fast. This indicates that EE2 loses attractiveness as employer and can only expand as long as an oversupply of labour exists willing to agree on ever lower relative wages.

EE3 is only of minor importance for the Chinese EEI. Although its growth – measured by value added at constant prices – was only somewhat higher than for the other sectors. As measured by the number of employees, EE3 is underperforming. Employment only increased at a rate of 3.6 % p.a. over the whole period, much less than EE1 at 6.9 % and EE2 at 11.6 %. This indicates that – in combination with average wages and labour productivity even below EE1 – a take-off is not yet manifest in the most recently available data. This upstream sector, of key importance for technological progress in EEI and other downstream industries, needs to be further developed to become internationally competitive.

Table 3.15: Sectoral performance of the Chinese and EU EEI

Sector	Indicator	2012[1)]		Annual average growth rate in %				
				1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical engineering (EE1)				
China	Value added, in 2010 prices	bn. €	94.3	16.7	20.6	31.8	18.3	21.7
EU-27			129.2	10.6	-0.2	2.7	1.1	2.2
China	Employees	1,000	6120	-2.1	9.9	12.9	3.8	6.9
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
China	Labour costs per employee	1,000 €	6.2	3.5	5.1	7.8	13.7	7.8
EU-27			43.4	3.5	2.1	2.1	3.3	2.6
China	Productivity[2)]	1,000 €	15.4	19.2	9.7	16.8	14.0	13.8
EU-27			58.5	8.0	1.0	2.1	2.3	2.6
China	Unit labour costs[3)]	€ / €	0.40	-13.1	-4.2	-7.8	-0.3	-5.2
EU-27			0.74	-4.2	1.2	0.0	1.0	0.1
				Electronic engineering (EE2)				
China	Value added, in 2010 prices	bn. €	89.6	27.7	23.4	23.3	17.0	22.1
EU-27			60.6	6.3	1.9	9.6	-1.6	3.1
China	Employees	1,000	8593	2.9	17.5	15.5	6.1	11.6
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
China	Labour costs per employee	1,000 €	3.8	8.0	6.7	2.6	-0.7	3.8
EU-27			43.2	3.1	0.6	0.5	1.8	1.3
China	Productivity[2)]	1,000 €	10.4	24.2	5.1	6.8	10.3	9.5
EU-27			68.8	4.5	4.4	9.5	1.7	4.7
China	Unit labour costs[3)]	€ / €	0.37	-13.0	1.6	-4.0	-10.0	-5.2
EU-27			0.63	-1.0	-3.7	-8.0	0.0	-3.2
				Electrical and electronic components (EE3)				
China	Value added, in 2010 prices	bn. €	15.3	20.7	28.0	22.8	16.0	22.3
EU-27			21.1	12.5	1.0	20.6	3.3	7.2
China	Employees	1,000	1056	-6.5	9.5	9.5	-2.4	3.6
EU-27			286	2.7	-2.3	0.8	-4.4	-1.6
China	Labour costs per employee	1,000 €	4.9	10.0	9.7	5.9	12.3	9.6
EU-27			44.6	4.1	2.2	2.0	4.5	3.1
China	Productivity[2)]	1,000 €	14.5	29.1	16.9	12.1	18.9	18.1
EU-27			73.6	9.6	3.4	19.6	8.0	8.9
China	Unit labour costs[3)]	€ / €	0.34	-14.8	-6.1	-5.6	-5.5	-7.1
EU-27			0.61	-5.1	-1.0	-14.9	-3.0	-5.3

1) Conversion rate 9 YUAN = 1 €; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Industry overview

Electronics and electric engineering industry[182]

China is well-known for its economic development structure led primarily by the government issuing official plans for a certain period which determine the focus of economic action and certain

[182] Van Aasche, Ari: China's Electronics Exports: Just a Standard Trade Theory Case. Policy Options 2006
APCO worldwide: Market Analysis Report: China's Electronics Industry. 2010.
Cho, John H.: Transforming China's Electronics Industry. A Roadmap for Increasing Business Value Through Collaboration and ICT Integration. CISCO White Paper. December 2009.

programmes of this period. In the beginning of China's industrialisation, the Chinese electric and electronics industry was based on low-cost labour and thin margins. Therefore, China has been attractive for foreign firms and received large amounts of FDI. This economic model is unlikely to sustain long-term growth; the Chinese government aimed at developing more high-end, high-technology industry and to move up the value chain[183]. However, as highlighted by the size and the economic performance of EE2, it is quite clear that this legacy has remained important, and even today contributes significantly to the creation of jobs in China.

The ways in which the government tries to encourage this development are, for instance, reduced tax rates for high tech companies and R&D tax incentives[184]. However, even today foreign invested companies account for the major share of Chinese trade and production of electronics[185]. Many foreign firms, mostly Taiwanese, have located their assembly platforms in China in order to benefit from low labour costs and tax incentives.[186]

However, in recent years Chinese exports have become more sophisticated and Chinese firms, such as Huawei, Haier and Lenovo, have been challenging Western market leaders[187]. Huawei and ZTE are two highly successful companies in the area of communication technology. Huawei is the largest manufacturer of telecommunications equipment worldwide since 2012, when overtook the Swedish company Ericsson. The product range of the Chinese employee-owned private firm includes mobile and fixed broadband networks, consultancy services, multimedia technology and the manufacturing of communications devices for consumers. Huawei is very focused on R&D and runs 16 research institutes in different countries. More than 70,000 employees, around 45 % of their staff, are engaged in R&D and the company's R&D investment amounted to roughly € 3.66 billion in 2012[188].

ZTE is the world's fifth-biggest telecommunications equipment maker and Huawei's domestic rival. It also ranks fourth worldwide as manufacturer of mobile phones[189]. However, Huawei's obscure relationship with Chinese politics has caused problems in the US market and brought about restrictions and reservations of potential clients for communication infrastructure.

In the personal computer market, China's most successful company is Lenovo. It ranks second worldwide (behind HP) in terms of units sold and has been the market leader in China for several years already. Lenovo's strong position in the Chinese market has been of great advantage for the company. Almost half of its revenues come from sales in China and the Chinese market is still growing as more and more people are able to afford consumer electronics and owning a PC has become commonplace[190]. Other representative firms of China's consumer electronics market are, for example Konka, which mainly produces TVs and other consumer electronics, and TLC, one of the biggest and most important state-owned consumer electronics makers in China.

Also in the market of consumer appliances, Chinese firms have made great progress on their way towards high-end production. Haier Group is the world's market leader in domestic white goods by sales volume and stands out by its focus on brand building and on competition on value instead of

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[183] Collaboration and ICT Integration. CISCO White Paper. December 2009.
[184] see below under 5.2.1.
[185] Van Aasche, Ari: China's Electronics Exports: Just a Standard Trade Theory Case. Policy Options. 2006.
[186] PricewaterhouseCoopers: Global reach: China's impact on the semiconductor industry: 2010 update.
[187] The Economist: "Chinese multinationals. Who's afraid of Huawei?" Aug 4th 2012.
[188] http://www.huawei.com/en/about-huawei/corporate-info/research-development/index.htm.
[189] http://uk.reuters.com/article/2012/04/25/zte-earns-idUKL3E8FN8Q220120425.
http://www.isuppli.com/Mobile-and-Wireless-Communications/News/Pages/Samsung-Displaces-Nokia-as-Top-CellphoneBrand-in-2012-and-Takes-Decisive-Smartphone-Lead-Over-Apple.aspx.
[190]

the lowest price. The company runs ten R&D centres around the world[191]. Globally, Haier's position is strongest in the US, where almost a third of all households own a Haier product (mostly washing machines and refrigerators), but the next step on the company's agenda is entering the European market.

Components, semiconductors[192]

With more than 45 % share[193] China is by far the world's largest semiconductor market, which constitutes a direct incentive to move production processes to China in order to be closer to clients. China's share in semiconductor production is significantly smaller. In 2011, Chinese electronic equipment production reached a global market share of 33 %; 25 % of which were semiconductors[194]. Although domestic semiconductor production is growing with many foundry companies popping up in China – among them one of the largest Chinese foundry companies, the Semiconductor Manufacturing International Corporation (SMIC) – China's semiconductor industry is still dominated by foreign-invested companies, such as Taiwanese TSMC. However, due to IP protection problems[195] many firms move fabrication plants to China which do not produce cutting edge technology but rather focus on low value-added, labour intensive semiconductor production and technology which is a few generations behind the latest technology[196].

3.6 India

Compared to China or other rapidly developing countries, the Indian economy is less focused on the manufacturing of hardware and concentrates more on the development of software and IT-related services. Therefore, the Indian EEI is relatively small. In 2012, the nominal EEI production value was € 45.3 billion; about 7 % of the EU-27 (**Table 3.16**). But also compared to its domestic manufacturing the Indian EEI is small. As a share of TM value added it only comes to 10.3 %. Despite the strong position of India in the area of IT software and services, the sectors EE2 and EE3 are not of outstanding importance. As measured by production, EE1's share of EEI fell slightly to 65 %, but remained much higher than for the EU EEI, which is also characterised by a high share of EE1. Throughout the whole period under consideration, EE1 grew at a similar rate as EE2, whereas EE3's growth trend was 1-percentage point higher, indicating an increase in importance. The contribution of EE2 and EE3 to EEI's production reached 26.9 % and 9.1 %, respectively. EE3 is of minor importance to India. However, it is of note that employment grew strongly in recent years.

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[191] Financial Times 2012: http://www.ft.com/cms/s/0/d0ab49ba-b2b2-11e1-9bd6-00144feabdc0.html#axzz2W54auEae.

[192] Lu, Allen: China's Pan-semiconductor Industry Landscape. SEMI China. 2012.
Deloitte: The virtuous semiconductor triangle. 2008.
PricewaterhouseCoopers: Exceptional relative performance China's impact on the semiconductor industry: 2012 update; http://www.pwc.com/gx/en/technology/chinas-impact-on-semiconductor-industry/assets/chinas-impact-on-semiconductor-industry-chapter-1.pdf.

[193] PricewaterhouseCoopers: Global reach: China's impact on the semiconductor industry: 2010 update.

[194] PricewaterhouseCoopers: Exceptional relative performance China's impact on the semiconductor industry: 2012 update; http://www.pwc.com/gx/en/technology/chinas-impact-on-semiconductor-industry/assets/chinas-impact-on-semiconductor-industry-chapter-1.pdf.

[195] see below.

[196] APCO worldwide: Market Analysis Report: China's Electronics Industry. 2010.
McKinsey: McKinsey on Semiconductors. Number2, 2012.

Table 3.16: Key figures for the EU and Indian EEI

Sector	Indicator	2012[1)]		Annual average growth rates in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
		Electrical and electronic engineering (EEI)						
India	Production, in current prices	bn. €	45.3	2.6	15.6	19.4	7.7	12.1
EU-27			635.8	9.5	-0.2	4.6	-1.2	1.8
India	Employees	1,000	574	-8.3	2.0	6.2	-1.3	0.4
EU-27			3389	2.2	-1.7	0.5	-1.9	-0.7
		Electrical engineering (EE1)						
India	Production, in current prices	bn. €	29.0	-1.2	19.2	18.7	6.5	12.3
EU-27			370.4	8.3	1.1	5.9	-1.1	2.5
India	Employees	1,000	377	-7.3	2.5	6.9	-2.6	0.5
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
		Electronic engineering (EE2)						
India	Production, in current prices	bn. €	12.2	7.6	7.7	25.6	8.3	11.5
EU-27			201.1	10.5	-1.9	1.5	-1.7	0.5
India	Employees	1,000	101	-12.7	-0.5	4.1	-3.2	-2.2
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
		Electrical and Electronic components (EE3)						
India	Production, in current prices	bn. €	4.1	14.2	14.9	7.9	15.2	13.3
EU-27			64.3	13.2	-1.0	7.5	-0.3	2.9
India	Employees	1,000	97	-4.5	3.9	6.0	8.2	4.3
EU-27			298	2.7	-2.3	0.8	-3.5	-1.3
1) Conversion rate 55 RUPEE = 1 €.								

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Comparative price performance of EEI

On average for the period under investigation, the Indian EEI grew at a similar pace as TM – as measured by value added in constant prices. However, during the early years it was lagging behind, while during the latter years it exceeded TM growth rates by far. The same pattern is shown by the development of employment. EEI's labour costs and labour productivity are higher than for TM's levels, by 40 % and 29 %, leading to a minor comparative disadvantage indicated by ULCs which developed between 1998 and 2012 in parallel. (**Table 3.17**)

Indian EEI's price performance compared to the EU

The EU EEI is a relatively larger fraction of TM. It comes up to 10 %. From 1998 to 2012, it grew at a much faster pace than TM and had gained importance, while Indian EEI grew roughly in line with TM, although at a higher trend rate. Indian labour productivity is only 25.3 % and 28.1 % of the EU's TM and EEI. However Indian wages are much lower, only 10.3 % and12.9 % of the EU levels for TM and EEI, respectively. ULCs are less than half of the EU-27. But the EU EEI closed the gap over the whole period: ULC declined at an annual rate of 1.1 %. The EU EEI not only improved its comparative price competitiveness in relation to its domestic TM, which suffered an increase in ULC, but also against the Indian EEI which also experienced an increase in ULC. (**Table 3.17**)

Table 3.17: Comparative economic performance of the EU and Indian EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				India				
TM[2)]	Value added, in 2010 prices	bn. €	128	-1.6	11.3	9.1	4.8	7.0
EEI[3)]			10	-8.8	11.9	18.8	4.7	8.0
TM[2)]	Employees	1,000	9439	-3.7	2.6	1.9	0.2	0.9
EEI[3)]			574	-8.3	2.0	6.2	-1.3	0.4
TM[2)]	Labour costs per employee	1,000 €	4.0	10.7	5.0	20.6	11.0	10.7
EEI[3)]			5.6	13.6	4.0	21.0	9.1	10.3
TM[2)]	Productivity[2)]	1,000 €	13.6	2.1	8.4	7.0	4.5	6.1
EEI[3)]			17.6	-0.5	9.7	11.8	6.1	7.6
TM[2)]	Unit labour costs[3)]	€ / €	0.29	8.4	-3.2	12.7	6.1	4.3
EEI[3)]			0.32	14.2	-5.2	8.2	2.9	2.5
				European Union (27)				
TM[2)]	Value added, in 2010 prices	bn. €	1610	1.7	-0.3	-2.3	-0.9	-0.6
EEI[3)]			212	8.9	0.1	5.3	1.2	2.7
TM[2)]	Employees	1,000	29985	-0.3	-1.4	-1.6	-2.3	-1.6
EEI[3)]			3389	2.2	-1.7	0.5	-1.9	-0.7
TM[2)]	Labour costs per employee	1,000 €	38.8	2.9	2.5	5.5	2.4	3.1
EEI[3)]			43.3	3.4	1.6	2.1	2.8	2.3
TM[2)]	Productivity[4)]	1,000 €	53.7	2.0	1.1	-0.6	1.5	0.9
EEI[3)]			62.7	6.5	1.7	4.8	3.2	3.5
TM[2)]	Unit labour costs[5)]	€ / €	0.72	0.9	1.4	6.5	0.7	2.2
EEI[3)]			0.69	-2.9	-0.1	-2.5	-0.3	-1.1

1) Conversion rate 55 RUPEE = 1 €; 2) Total manufacturing; 3) Electrical and electronic engineering; 4) (Value added in 2010 prices) / employment; 5) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Sectoral price performance

Fehler! Verweisquelle konnte nicht gefunden werden. has the same variables as above but the comparison is for India and the EU-27 by sub-sector and not between EEI and total manufacturing. Compared to the EU-27, all the EEI industries in India are very small in terms of value added. EE1 is by far the largest sub-sector of the EEI in India. In terms of value added, in 2012 the electrical engineering sector accounted for 60 % of EEI with a total value added of € 6.1 billion, which is only 5 % of the European sector.

In relation to its size, EEI in India employs many people. Therefore, labour productivity in all three sub-sectors is only a fraction of European labour productivity. In EE1 and EE2 labour productivity has grown much faster than in EU-27 with rates of 6.3 % and 13.5 % respectively over the whole period of 1998 to 2010. For EE1 strong growth of value added was sufficient not only to maintain but to expand employment. However, productivity growth was not sufficient to compensate for wage increases which ran up to 9.7 % p.a. on average for the whole period. Indian EE1 lost much of its price competitiveness. ULC increased at an annual rate of 3.1 %. This development narrowed the ULC gap between the Indian and the EU EEI and led to a slight improvement of EU EEI.

The price performance of the Indian EE2 was better because the growth of productivity compensated for wage increase. ULC improved slightly over the whole period, at an annual rate of 0.9 %. For the EU EE2, ULC improved even stronger. However, the EU EE2 is characterised by a significant reduction of employment and a muted financial performance, indicating that this improvement is strongly driven by a consolidation of the EU EE2.

Table 3.18: Sectoral performance of the EU and Indian EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical engineering (EE1)				
India	Value added, in 2010 prices	bn. €	6.1	-11.6	11.9	17.5	3.3	6.9
EU-27			130.7	10.2	-0.3	2.6	1.0	2.2
India	Employees	1,000	377	-7.3	2.5	6.9	-2.6	0.5
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.3
India	Labour costs per employee	1,000 €	5.3	13.3	2.0	19.6	10.7	9.7
EU-27			43.4	3.5	2.1	2.5	3.0	2.6
India	Productivity[2)]	1,000 €	16.2	-4.6	9.1	9.9	6.1	6.3
EU-27			59.2	7.7	0.9	2.0	2.2	2.5
India	Unit labour costs[3)]	€ / €	0.33	18.8	-6.5	8.8	4.3	3.1
EU-27			0.73	-3.9	1.1	0.5	0.8	0.2
				Electronic engineering (EE2)				
India	Value added, in 2010 prices	bn. €	3.1	-5.6	13.2	25.9	7.0	11.1
EU-27			60.6	5.3	0.9	7.4	0.9	2.9
India	Employees	1,000	101	-12.7	-0.5	4.1	-3.2	-2.2
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
India	Labour costs per employee	1,000 €	7.0	15.7	6.3	29.8	6.8	12.4
EU-27			43.2	3.0	0.7	1.4	2.6	1.7
India	Productivity[2)]	1,000 €	31.2	8.1	13.7	21.0	10.5	13.5
EU-27			68.8	3.5	3.5	7.3	4.4	4.5
India	Unit labour costs[3)]	€ / €	0.22	7.0	-6.6	7.2	-3.4	-0.9
EU-27			0.63	-0.5	-2.7	-5.6	-3.3	-2.7
				Electrical and electronic components (EE3)				
India	Value added, in 2010 prices	bn. €	0.9	4.6	9.5	8.3	7.2	7.9
EU-27			21.1	10.1	-0.2	21.8	2.9	6.5
India	Employees	1,000	97	-4.5	3.9	6.0	8.2	4.3
EU-27			298	2.7	-2.3	0.8	-3.5	-1.3
India	Labour costs per employee	1,000 €	5.2	16.3	8.3	16.0	7.0	10.7
EU-27			43.2	4.2	2.1	2.3	2.2	2.5
India	Productivity[2)]	1,000 €	9.1	9.5	5.4	2.2	-0.9	3.5
EU-27			70.8	7.2	2.2	20.8	6.6	7.9
India	Unit labour costs[3)]	€ / €	0.57	6.2	2.7	13.5	8.0	7.0
EU-27			0.61	-2.8	0.0	-15.3	-4.1	-5.0

1) Conversion rate 55 RUPEE = 1 €; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

As measured by value added, EE3 only comes up to 6.6 % of the Indian EEI. Compared with EE2 and EE1, wages and labour productivity are obviously lower. This contrasts with the findings from other competing economies where EE3, a sector that includes semiconductors, an area of high-tech products requiring qualified staff and is characterised by high labour productivity. The economic performance of the Indian EE3 is poor. ULC reached roughly 93 % of EU EE3. Throughout the period under consideration, price competitiveness had markedly worsened with labour productivity only increasing by 3.5 % p.a. while labour costs increased by 10.7 % annually. This development indicates that India does not and will not play a significant role in this high-tech business area. (Fehler! Verweisquelle konnte nicht gefunden werden.)

Industry overview

Several companies in the Indian EE1 sector that are mainly active in the field of energy generation have reached global importance. Suzlon Energy, for instance, develops, produces and installs wind turbines. It was the world's fifth largest manufacturer of wind turbines[197] at the end of 2011. Suzlon Energy aimed to solve the shortcomings of a market where every part of the process of installing a wind energy plant is taken over by another company. Therefore, Suzlon, takes care of the whole process of installing a wind energy park[198].

Bharat Heavy Electricals Limited (BHEL), a company owned by the Indian state, manufactures power plant equipment including gas and steam turbines, boilers, generators, pumps, sensors and controlling devices. Crompton Greaves (CG) is another Indian multinational company active in the market of power generation. Among its products are pumps and transformers, but also motors and signalling devices.

Two companies engaging in the production of consumer electrical equipment are Havells India Ltd and Bajaj Electricals Ltd (BEL). Havells produces, among other things, cables and wires, motors, fans, luminaries for domestic and industrial purposes and water heaters. Apart from lighting and consumer durables, Bajaj Electricals also supplies transmission line towers and telecommunications towers, poles and equipment for wind and solar energy.

A main factor driving growth in the EE1 sector in India is the continuously increasing demand for energy due to the on-going industrialising process. Thus, demand for power generation equipment is also rising constantly. Moreover, the sector is also strongly supported by the government and recently underwent a process of de-licensing (FDI has been allowed without limitations) and tariff reduction. The development of special economic zones facilitates exports worldwide which is likely to also spur growth[199].

An interesting trend from which the Indian EE1 sector is likely to benefit is the outsourcing of engineering services from the developed world to countries with significantly lower labour costs. Since India provides a large and cheap but well-trained work force (with most people speaking English) it is likely to be the destination for outsourced services of many companies, among them firms from the EU-27.

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[197] by cumulative installed capacity worldwide; BTM ApS "World Market Update; 2012; "http://www.suzlon.com/about_suzlon/l2.aspx?l1=1&l2=1.

[198] Schießl, Michaela: " Der Wind-Macher" Der Spiegel 24/2008 (09.06.2008) http://www.spiegel.de/spiegel/print/d-57359778.html.

[199] Kimura, Koichiro: "China and India's electrical and electronics industries: a comparison between market structures" in Industrial dynamics in China and India: firms, clusters, and different growth paths. - Basingstoke, Hampshire 2011.

As the Indian electronics industry grows fast it is likely to become more important for industry as a whole in India. One factor is the growing middle class and the rising demand for consumer electronics such as TVs, audio equipment, kitchen white goods and computers. Moreover, budget allocation for the defence sector is large while modernisation of this sector is mainly based on more extensive use of electrical and electronic devices. In 2012, the Ministry of Communications and Information Technology (MCIT) issued a document stating the preference of domestically manufactured electronic goods valid for any public entity in India. Thus it is and will be mainly the domestic industry benefitting from modernisation of government agencies and the military[200]. Bharat Electronics Limited (BEL), a state owned company, produces advanced electronic equipment mainly for the Indian Armed Forces. Its product range includes radars, opto-electronics, communication systems but also a low cost PC. **However, the poor economic performance disclosed above sheds some doubts on the success of a strategy to support a nationally protected semiconductor and electronics industry in the long-run.** There is a lack of competition as a driving force for an economic progress.

Successful private companies in the realm of electronics are, among others, Videocon, Sonodyne and Simmtronics. Videocon is mainly active in the market of consumer electronics and produces colour TVs, refrigerators, washing machines and other white goods and home appliances. For these products Videocon uses a multi-brand strategy and sells primarily in India. The company also produces mobile phones, both simple models and high end smart phones. Sonodyne develops and manufactures audio equipment for sale worldwide. Its products include audio devices for home use but also professional equipment for studios and concerts. Simmtronics is a global company offering chiefly computers and computer related products. Products include tablet PCs and desktop PCs, motherboards, graphics cards, LED monitors, SD cards and hard disk drives. The company also offers smart phones. Its motherboards are produced for companies such as Intel or AMD. Considering particular needs of its domestic market, India Simmtronics developed a solar PC and its tablet PCs are among the cheapest worldwide[201].

3.7 Brazil

The Brazilian EEI production reached € 60.2 billion in 2012. This equals a share of 6.9 % of the Brazilian TM. For the EU, EEI is more of importance as it account for 10 % of TM. Similar to the EU, EE1 is by far the largest sector with 55 % of production in 2012. Electronic engineering is second in this ranking with a remarkably high share of 42 %. EE3 is of minor importance only with a remainder of 3 % of EEI. The Brazilian EEI grew at a much stronger pace than the EU EEI. EE1 and EE2 increased production at annual average rates of 13.1 % and 13.0 % over the whole period. EE3 grew at 7.8 % p.a. (**Table 3.19**)

[200] Ministry of Communications and Information Technology: Notification 10.02.2012: “Preference to domestically manufactured electronic goods” The Gazette of India No 44: Extraordinary.
[201] Basit, Abdul: “World’s most affordable tablet launched in Dubai on demand” Khaleej Times 16.07.2012.

Table 3.19: Key figures for the EU and Brazilian EEI

Sector	Indicator	2012[1)]		Annual average growth rates in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
		Electrical and electronic engineering (EEI)						
Brazil	Production, in current prices	bn. €	60.2	34.9	11.5	13.4	15.6	13.8
EU-27			635.8	9.5	-0.2	4.6	-2.4	1.8
Brazil	Employees	1,000	514	4.5	2.7	10.2	11.1	5.3
EU-27			3389	2.2	-1.7	0.5	-3.9	-0.7
		Electrical engineering (EE1)						
Brazil	Production, in current prices	bn. €	33.3	23.2	14.3	18.8	8.8	13.1
EU-27			370.4	8.3	1.1	5.9	-1.1	2.3
Brazil	Employees	1,000	339	4.2	2.6	12.8	5.6	4.8
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.5
		Electronic engineering (EE2)						
Brazil	Production, in current prices	bn. €	25.6	47.3	9.1	8.3	6.7	13.0
EU-27			201.1	10.5	-1.9	1.5	-1.7	0.5
Brazil	Employees	1,000	160	6.2	3.0	6.0	6.5	5.1
EU-27			882	1.7	-2.4	0.1	-3.3	-1.6
		Electrical and Electronic components (EE3)						
Brazil	Production, in current prices	bn. €	1.2	16.6	13.8	10.5	-5.0	7.8
EU-27			64.3	13.2	-1.0	7.5	-0.3	2.9
Brazil	Employees	1,000	14	-1.5	2.3	5.5	-6.4	-0.2
EU-27			298	2.7	-2.3	0.8	-3.5	-1.3

1) Conversion rate 2.7 BRL = 1 €.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Comparative price performance of EEI

Growth of value added at constant prices is remarkably lower than for nominal production. This difference was caused by high inflation rates until the middle of the last decade. Since then inflation has become more moderate and growth differentials have narrowed. On average between 1998 and 2012, TM and EEI grew at the same pace, as measured by value added at constant prices. However, employment of EEI grew at a higher rate, in particular for the years after 2005. This development contrasts to the simultaneous moderation of output growth. EEI's labour productivity grew at an annual average rate of 0.9 % less strong than TM's. Simultaneously wage increases were below TM. Hence EEI's and TM's ULCs grew at a similar pace. (

Table 3.20)

Brazilian EEI's price performance compared to the EU

For TM as well as for EEI, wage increases outpaced the development of labour productivity by far. Price competitiveness of Brazilian manufacturing worsened throughout the period under consideration. Brazil is the worst performing of all competing economies. Most disturbing is the development for EEI for the years 2005 and beyond with an accelerated worsening of ULC. The EEI's ULC exceed the TM's ULC by 25 %.

Although the EEI ULC are higher for the EU than for Brazil, the comparative situation of the EU EEI is better. Its ULC as compared to its domestic TM is slightly lower, in contrast to Brazil. Moreover, the situation for EU EEI improved throughout period under consideration. The EU EEI's ULC improved at an annual rate of 1.1 % while for TM, ULC increased at a rate of 2.2 %.

Table 3.20: Comparative economic performance of the EU and Brazilian EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Brazil				
TM[2)]	Value added, in 2010 prices	bn. €	258	12.5	2.6	5.2	8.5	6.2
EEI[3)]			18	9.0	4.7	5.8	7.3	6.3
TM[2)]	Employees	1,000	6905	3.2	4.4	5.2	4.6	4.4
EEI[3)]			514	4.5	2.7	10.2	5.4	5.3
TM[2)]	Labour costs per employee	1,000 €	12.4	9.1	8.3	7.4	8.2	8.2
EEI[3)]			14.4	5.4	8.0	6.0	7.6	7.1
TM[2)]	Productivity[2)]	1,000 €	37.4	9.1	-1.7	0.0	3.7	1.7
EEI[3)]			34.5	4.3	1.9	-4.0	1.8	0.9
TM[2)]	Unit labour costs[3)]	€ / €	0.33	0.1	10.3	7.3	4.4	6.4
EEI[3)]			0.42	1.0	6.0	10.4	5.7	6.1
				European Union (27)				
TM[2)]	Value added, in 2010 prices	bn. €	1610	1.7	-0.3	-2.3	-0.9	-0.6
EEI[3)]			212	8.9	0.1	5.3	1.2	2.7
TM[2)]	Employees	1,000	29985	-0.3	-1.4	-1.6	-2.3	-1.6
EEI[3)]			3389	2.2	-1.7	0.5	-1.9	-0.7
TM[2)]	Labour costs per employee	1,000 €	38.8	2.9	2.5	5.5	2.4	3.1
EEI[3)]			43.3	3.4	1.6	2.1	2.8	2.3
TM[2)]	Productivity[4)]	1,000 €	53.7	2.0	1.1	-0.6	1.5	0.9
EEI[3)]			62.7	6.5	1.7	4.8	3.2	3.5
TM[2)]	Unit labour costs[5)]	€ / €	0.72	0.9	1.4	6.5	0.7	2.2
EEI[3)]			0.69	-2.9	-0.1	-2.5	-0.3	-1.1

1) Conversion rate 2.7 BRL = 1 €; 2) Total manufacturing; 3) Electrical and electronic engineering; 4) (Value added in 2010 prices) / employment; 5) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Sectoral price performance

The Brazilian growth of EEI – as measured by value added at constant prices – does not show similar large differences as compared with the EU. There is a significant effect of high inflation throughout the early years. Brazilian EE1 grew only at an average rate of 3.6 % over the whole period while the EU EE1 was only little behind at a 1.9 % p.a. Within the EU, growth was strongly supported by a more efficient labour input and productivity increased at an annual rate of 2.4 %, whereas for Brazil labour productivity declined. As a result, Brazil lost strongly in price competitiveness, while EU companies could build on a slight improvement. However, Brazilian ULC has remained below EU at a level of 65 %. (**Table 3.21**)

For EE2 the comparison for Brazil and EU is quite similar, although Brazilian EE2 enjoyed stronger growth, even in the more recent years. Labour productivity improved moderately but remained well below wage raises over the period under consideration and ULC increased significantly. Once more the EU EE2 was able to increase labour productivity well above wage increases and could improve price competitiveness as measured by ULC.

In terms of value added the relative sizes of the Brazilian sub-sectors are similar. But when looking at value added growth for the entire EEI, the difference between Brazil (6.3 % p.a.) and the EU-27 (2.7 % p.a.) is large, although, average growth in value added in EE3 was actually much lower in Brazil compared to Europe. Also, employment growth in Brazil was very much in line with growth in value added (or slightly above in EE1). Therefore, growth in labour productivity was negative in EE1 and well below the average growth in labour productivity in the EU-27. Also unlike in the EU-27, unit labour costs have actually increased in Brazil during the period from 1998 to 2012. This is due to very strong increases in labour costs towards the end of the sample period. In general it seems that in terms of growth rates Brazil was a larger competitive threat in the early 2000s than in the late 2000s.

Table 3.21: Sectoral performance of the EU and Brazilian EEI

Sector	Indicator	2012[1)]		Annual average growth rate in % 1998 - 00	2000 - 05	2005 - 08	2008 - 12	98 - 2012
				Electrical engineering (EE1)				
Brazil	Value added, in 2010 prices	bn. €	10.0	0.7	5.6	8.9	4.0	3.6
EU-27			130.7	10.2	-0.3	2.6	1.0	1.9
Brazil	Employees	1,000	339	4.2	2.6	12.8	5.6	4.8
EU-27			2210	2.4	-1.2	0.6	-1.2	-0.5
Brazil	Labour costs per employee	1,000 €	14.2	0.4	10.0	6.3	7.1	6.0
EU-27			43.4	3.5	2.1	2.5	3.0	2.3
Brazil	Productivity[2)]	1,000 €	29.6	-3.3	2.9	-3.5	-1.5	-1.1
EU-27			59.2	7.7	0.9	2.0	2.2	2.4
Brazil	Unit labour costs[3)]	€ / €	0.48	3.8	6.9	10.1	8.7	7.2
EU-27			0.73	-3.9	1.1	0.5	0.8	-0.1
				Electronic engineering (EE2)				
Brazil	Value added, in 2010 prices	bn. €	7.2	26.6	3.7	0.6	8.8	8.8
EU-27			60.6	5.3	0.9	7.4	2.9	2.9
Brazil	Employees	1,000	160	6.2	3.0	6.0	5.1	5.1
EU-27			882	1.7	-2.4	0.1	-1.6	-1.6
Brazil	Labour costs per employee	1,000 €	15.3	13.6	4.9	5.3	7.3	7.3
EU-27			43.2	3.0	0.7	1.4	1.7	1.7
Brazil	Productivity[2)]	1,000 €	44.8	19.1	0.7	-5.1	3.5	3.5
EU-27			68.8	3.5	3.5	7.3	4.5	4.5
Brazil	Unit labour costs[3)]	€ / €	0.34	-4.6	4.2	11.0	3.7	3.7
EU-27			0.63	-0.5	-2.7	-5.6	-2.7	-2.7
				Electrical and electronic components (EE3)				
Brazil	Value added, in 2010 prices	bn. €	0.4	1.9	1.2	8.0	-0.6	2.2
EU-27			21.1	10.1	-0.2	21.8	2.9	6.5
Brazil	Employees	1,000	14	-1.5	2.3	5.5	-6.4	-0.2
EU-27			298	2.7	-2.3	0.8	-3.5	-1.3
Brazil	Labour costs per employee	1,000 €	10.6	6.0	8.0	4.0	5.5	6.1
EU-27			43.2	4.2	2.1	2.3	2.2	2.5
Brazil	Productivity[2)]	1,000 €	31.2	3.5	-1.0	2.4	6.3	2.4
EU-27			70.8	7.2	2.2	20.8	6.6	7.9
Brazil	Unit labour costs[3)]	€ / €	0.34	2.5	9.1	1.5	-0.7	3.6
EU-27			0.61	-2.8	0.0	-15.3	-4.1	-5.0

1) Conversion rate 2.7 BRL = 1 €; 2) (Value added in 2010 prices) / employment; 3) (Nominal total labour costs) / (value added in 2010 prices).

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Brazilian EE3's economic performance is the worst in comparison with EE1 and EE2. In contrast to most of the other competing economies under investigation, labour costs and labour productivity are below the other sectors of the national EEI. Moreover, labour productivity declined over the whole period on average. This is a peculiar result for a sector that is driven by technological, labour saving progress all over the world. This indicates that the Brazilian EE3 is not competitive internationally.

Industry overview

Electrical and electronic engineering industry

Even though Brazil is a WTO member it uses high import tariffs in order to protect domestic industries, especially for the electro and electronics sector. Facing extraordinarily high import taxes on finished products, many electronics producers import components which are then assembled in Brazil. These then are categorised as made in Brazil and are not subject to import taxes. Therefore, more than 50 % of electrical and electronic imports are components instead of finished products[202]. Some major players in the electrical and electronics industry have opened up plants in Brazil, mainly to have a base in Latin America and to be close to this large market, but also in order to circumvent import tariffs. Siemens, for example, operates 14 manufacturing plants and 7 development centres in Brazil. Another example is Foxconn, the Taiwanese electronics manufacturing company which assembles products for many large and well-known firms such as Apple, HP and Sony which already operates four plants in Brazil and invested close to € 3.85 million ($ 5 million) in a new plant which it is currently installing. This shows that the electric and electronics sector in Brazil is mostly driven by foreign owned firms and FDI[203]. Nevertheless, the investigation into the EEI's price performance disclosed poor performance, highlighting insufficiently functioning markets and too little competitive pressure, necessary for the creation of globally successful industries.

Components, semiconductors[204]

Brazil had actually seen some development of a small semiconductor industry in the 1970s, but it completely vanished in the 1990s due to unsuccessful policy programmes. Since then the country sates its entire demand of semiconductors through imports. In order to reverse this development and to establish a semiconductor industry in Brazil, the government has implemented major tax incentives for foreign firms[205] and has founded the Center for Excellence in Electronic Technology (Ceitec). Ceitec is a publicly funded research centre aiming to forward semiconductor technology in Brazil and to become the first Latin American producer and seller of chips. In the CEITEC fab, around 250 million chips can be produced per year using 6-inch wafers.

Brazil was one of the first developing countries to start industrialisation at the end of the 1970s and can build on a globally successful aircraft industry on par with players from developed economies. Poor functioning markets, protectionism and corruption have always posed problems for a sustainable economic development. This seems to have a major impact on the evolution of the EEI. Under these framework conditions, it must be expected that foreseen public policies will not be able to flourish and succeed.

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[202] Louis Chan, Economist: "Big buzz in Brazil's electronics market". HKTDC Trade Quarterly. 2011.

[203] Culpan, Tim: "Foxconn Plans New Brazil Factories to Make IPads, IPhones" Bloomberg. 2012
http://www.bloomberg.com/news/2012-09-19/foxconn-plans-new-brazil-factories-to-make-ipads-iphones.html
Luk, Lorraine: "Foxconn to Build Fifth Brazil Plant". The Wall Street Journal 2012.
http://online.wsj.com/article/SB10000872396390444165804578005722309270246.html#

[204] Brazil Government: "The Digital Electronics Industry"; http://www.brasil.gov.br/sobre/science-and-technology/the-digital-electronics-industry/chips/; http://www.ceitec-sa.com/en/home/.

[205] see below.

4 The competitiveness of the EU electrical and electronic engineering industry

This chapter provides insights into the relevant aspects for a comprehensive assessment of the EU EEI's competitiveness. The chapter is structured in line with the Terms of References concludes with an initial assessment of the state of the industry and its sectors under investigation.

4.1 Performance and price competitiveness

The investigation of EEI performance and price competitiveness is based on two dimensions.[206]

First the comparative position of the industry and its development is studied over time. For this assessment a domestic sector is evaluated. For the EU EEI, EU-27 total manufacturing (EU TM) is selected. The result of this investigation is interpreted in the following way: total manufacturing is the sector which manufactures most tradable goods. Its international competitiveness is of decisive importance for the trade balance. Industries whose relative price performance compared to TM deteriorates will face structural pressure – at least in the long run – due to weakened international price competitiveness. If concurrently trade surpluses rise, due to the performance of total TM this effect may even be exacerbated. Further, industries with higher productivity growth are more attractive to the labour force, because it is these industries that can afford to pay higher wages without losing price competitiveness.

The second dimension involves the direct comparison of the industry under investigation with industries in competing economies, on the basis of key economic indicators. We consider the level of variables and their development over time, while holding exchange rates for each of the countries constant. This makes a factual assessment possible, equivalent to assessments which are carried out by companies in these countries. Fixing exchange rates allows us to separate the second dimension of the analysis from the pure price performance. Exchange rate fluctuations are taken into account in the assessment of the performance of international trade.

4.1.1 Comparative price performance

EEI is strongly dependent on a differentiated infrastructure and a sophisticated division of labour. EEI is a traditional industry in mature, developed economies. This is to a certain extent reflected in the size of the industry as compared to its domestic TM. As indicators for the size of the industry and its evolution the value added at constant prices and employment is used. Value added in constant prices comprises the value created by production and by technological progress. In particular, for electronics technological progress plays a major role for the value of the output. Usually the underlying capacities need not be expanded at the same pace. The number of employees as an indicator for the underlying production capacities is applied.

[206] The sectoral disaggregated database for the comparison of the EU-27 with seven competing economies was created for this study by Cambridge Econometrics.

The EU-27 and the US are economies with a longstanding tradition in (electrical) manufacturing. EEI's share of TM as measured by value added is about 13.2 % and 12.5 %, respectively. Japan, a developed economy that has accessed the global market in the early 1980s with a broad variety of products, cars, machinery and electronics, has a strong focus on the sector with around a quarter of TM's value added. For South Korea the share of EEI is at the same level, Taiwan is by far the economy with the highest focus of TM on EEI. The Chinese EEI that has developed into the global workbench for assembling electronics commands 16.4 % of the domestic TM. For the emerging economies India and Brazil the proportion is markedly lower. (**Table 4.1**)

The evolution of **EEI** as compared to total TM reveals that EEI is a strongly growing industry. For all of the competing economies but the US EEI grew at higher rates than TM. On average over the whole period under investigation from 1998 to 2012, EU EEI expanded at a rate that was 3.3 % p.a. higher than TM. Internationally, this more than proportionate growth in the EU most resembles the development in Japan and China. For South Korea and Taiwan the growth differential is by far more pronounced, indicating an accelerated concentration of TM on EEI.

Table 4.1: Assessment of EEI's comparative performance with major competing economies

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Variable	Indicator	EU-27	USA	Japan	South Korea	Taiwan	China	India	Brazil
Value added at constant prices	EEI / TM[1)]	13.2	12.5	25.4	25.2	47.5	16.4	9.2	6.8
	EEI's relative growth[2)]	3.3	-1.7	3.4	12.4	9.3	3.0	0.5	0.0
Employment	EEI / TM[1)]	11.3	11.4	24.7	21.0	34.2	17.9	7.2	7.3
	EEI's relative growth[2)]	0.8	-2.3	-0.6	-1.9	2.3	4.5	0.8	0.8
Labour productivity	EEI / TM[1)]	116.7	109.9	102.9	119.6	138.7	91.6	127.0	92.9
	EEI's relative growth[2)]	2.5	0.7	4.0	14.5	6.7	-1.9	-0.3	-0.7
ULC	EEI / TM[1)]	96.0	112.6	111.3	83.1	79.4	128.1	111.4	130.1
	EEI's relative growth[2)]	-3.3	-0.5	-3.7	-10.1	-5.6	-1.2	0.0	-0.1

1) Relative size of EEI in % 2012; 2) Difference of average annual growth rates (percentage points) over the period 1998 - 2012 for: EEI - TM.

In spite of stronger output growth – as measured in constant prices - for EEI the employment record does not show a similarly consistent picture. For the US, Japan and South Korea the evolution of the number of workplaces as compared to TM is negative, indicating an above average evolution of labour productivity.

For most competing economies, EEI's labour productivity is higher than for total TM and stronger growth is observed over the entire period. The exceptions are China and Brazil with lower labour productivities and a less than proportionate development over time. India's development was also low. For South Korea and Taiwan EEI plays a unique role both with regard to the level as well as the evolution of labour productivity.

Labour costs together with wages constitute ULC. For the EU-27, South Korea and Taiwan the ULC for EEI are below the TM average. Their performance over the entire period is favourable compared to TM, indicating that - ceteris paribus - their relative price position improved. For all other economies, the ULC are above the TM average.

To conclude: The relative cost position of the European EEI in general is comparable to overall TM; ULC are below the TM average and performed better over the whole period. Only for Taiwan and South Korea, EEI's position and evolution were better. ULC for Japan and the US are higher than in the EU. In particular for the US the relative improvement of ULC was only muted.

Next, the comparative performance of EEI's three sectors is investigated. Here the benchmark is EEI. The most striking observation is that the sectors' weight within total EEI differs strongly between competing economies. The electrical engineering sector (EE1) is of outstanding importance for the EU-27, India, Brazil and Japan with shares of around 60 % of EEI's value added. In between are the US and China with shares close in the 40 %s. For all of these economies EE1 is the prominent sector of EEI. Only for South Korea and Taiwan EE1 is of much smaller relevance. (**Table 4.2**)

In spite of these differences the growth of EE1 – as measured by value added at constant prices – is below EEI's averages for all of the competing economies. Once more, most striking are South Korea and Taiwan. Over the whole period under consideration, EE1 lost much of its former importance. For Taiwan, this loss is reflected in a decline of its share in EEI's employment, whereas for South Korea the opposite development took place with regard to employment. As a comparison of South Korean's shares in value added and employment unveils, the South Korean EE1 is remarkably labour intensive. The opposite holds for the Chinese EE1 - compared with its domestic benchmark - labour intensity is below the average.

To understand the level and evolution of EE1's labour productivity, it is important to have in mind that this sector is not to the same extent driven by technological progress as EE2 and EE3. Since technological progress strongly increases the real value of output and, in turn, the growth of labour productivity was well below the average of EEI, which was to be expected. The only exception is China, but China's structure of EEI is different from the competing countries with regard to the relations of factor input: Only in China, labour productivity was higher and grew more strongly than for the domestic benchmark. For all other economies with the exception of South Korea and Taiwan labour productivity was lower for EE1 than the domestic economies' EEI averages. For both of these outliers, labour productivity was remarkably low and further deteriorated over the period under consideration.

Finally, the level and evolution of ULC provide insights regarding the price performance of EE1 compared to its domestic benchmark. As for all competing economies ULC in the EU are above the benchmark, but at a moderate level, comparable to Japan. For the US, ULC are around one fifth above the average. In South Korea and Taiwan, the difference is pronounced, ULC exceed the average by around 60 %, and increased substantially over the whole period. For China, India and Brazil, the ULC are slightly above their benchmarks. With the exception of China the comparative price performance worsened slightly.

For EE1 it is concluded that the main indices relative to the benchmark in the EU are comparable to those of important competitors such as Japan, with ULC slightly below the average over EEI. While there was a slight rise, it was less pronounced than for the US and Japan. EE1's employment record improved slightly as compared to domestic EEI. If one

takes into account that the performance of EU EEI against TM was positive in contrast to Japan and the US, the overall comparative performance of EE1 is assessed as good.

Table 4.2: Assessment of EE1's comparative performance with major competing economies

Variable	Indicator	EU-27	USA	Japan	South Korea	Taiwan	China	India	Brazil
Value added at constant prices	EE1 / EEI[1)]	61.5	42.3	57.0	19.0	7.2	47.2	66.5	61.5
	EE1's relative growth[2)]	2.8	-2.1	-0.6	-12.3	-11.1	-0.3	-0.2	-0.5
Employment	EE1 / EEI[1)]	65.2	54.2	60.9	32.7	14.1	40.2	71.7	65.5
	EE1's relative growth[2)]	0.4	0.0	1.5	2.6	-3.8	-1.5	0.7	0.4
Labour productivity	EE1 / EEI[1)]	94.4	78.1	93.6	58.0	50.9	117.4	92.7	93.9
	EE1's relative growth[2)]	-1.0	-2.2	-2.2	-15.2	-7.2	1.3	-0.9	-0.9
ULC	EE1 / EEI[1)]	96.0	126.7	105.8	162.6	159.4	95.0	104.3	106.4
	EE1's relative growth[2)]	1.3	2.5	2.1	10.6	6.0	-0.6	0.4	1.0

1) Relative size of EE1 in % 2012; 2) Difference of average annual growth rates (percentage points) over the period 1998 - 2012 for: EE1 - EEI.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The electronic engineering sector **EE2** is of minor importance for the EU-27. Its share of total EEI is just 28.6 %. It grew roughly at the average of EEI, while the development of employment was below average. Labour productivity improved more strongly than for EEI on average, which led to a considerable reduction of ULC. The underlying reason for this better price performance compared to total EEI is consolidation in some of its product groups, e.g., consumer electronics. Japan's EE2, a sector that dominated global markets in consumer electronics up to the mid-1990s, is likewise in a phase of consolidation: The reduction of employment in EE2 even substantially exceeded the development in total EEI. The comparative price competitiveness of the US EE2 is remarkably low. In contrast to Japan, South Korea and Taiwan - the most important competing economies in consumer electronics - and the EU-27 with strengths in telecommunication equipment – the US EE2's labour productivity is in-line its domestic EEI's average. ULC as compared to the domestic benchmark is above average and slightly improved over the whole period under consideration. For most of the important competing nations it was the opposite. (**Table 4.3**)

EE2 is of outstanding importance for China. Its value added share of EEI reached around 45 % recently, but its labour productivity is much lower than the average for the Chinese EEI. Despite this poor level of productivity, EE2 price competitiveness is comparatively good. The ULC are above the EEI average, indicating that this sector builds its competitiveness above all on low wages, much lower than the already low Chinese average wage. Business models of subcontractors such as Foxconn are based on an oversupply of unqualified labour. It seems that the basis of this business model is eroding over time, because more recent figures indicate a reduction in the number of workplaces.

Table 4.3: Assessment of EE2's comparative performance with major competing economies

Variable	Indicator	EU-27	USA	Japan	South Korea	Taiwan	China	India	Brazil
Value added at constant prices	EE2 / EEI[1)]	28.5	23.9	18.2	37.5	30.7	44.8	26.5	35.7
	EE2's relative growth[2)]	0.2	-1.4	-0.7	-0.6	0.9	0.2	1.4	1.5
Employ-ment	EE2 / EEI[1)]	26.0	23.9	14.8	29.5	23.2	51.5	16.1	30.6
	EE2's relative growth[2)]	-0.8	-0.4	-2.0	2.0	-1.3	2.4	-3.2	-0.3
Labour produc-tivity	EE2 / EEI[1)]	109.7	100.3	122.6	127.4	132.2	87.1	164.9	116.5
	EE2's relative growth[2)]	1.1	-1.0	1.5	-2.9	2.3	-2.2	4.9	1.7
ULC	EE2 / EEI[1)]	91.0	107.6	85.8	82.2	80.6	106.3	72.9	87.6
	EE2's relative growth[2)]	-1.6	-0.2	-0.9	-1.0	-2.9	0.8	-2.9	-1.9

1) Relative size of EE2 in % 2012; 2) Difference of average annual growth rates (percentage points) over the period 1998 until latest available year for: EE2 - EEI.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The electronic and electrical component sector, **EE3**, contains semiconductors, the most important products with regard to innovation in a broad range of industries. Its weight of EU EEI is well below of most other competing economies with the exception of China, India and Brazil. For the whole period under consideration EU EE3 grew more strongly than its domestic benchmark and gained shares of total EEI's output. This more than proportionate growth is a typical pattern for the competing economies. Only for India and Brazil EE3 lost importance. For both of these countries the comparative economic performance was poor and worsened over the whole period. This contrasts to the relative development of ULC that improved for all other competing economies. (**Table 4.4**)

South Korea and Taiwan, the by far smallest economies under investigation, show the highest level of specialization with 41.9 % and 62.1 % share of the respective domestic EEI's value added. However, with regard to their economic performance both of these countries are in a range close to the other economies with a noteworthy stake in EE3. The EU-27 shows a relative strong comparative position. The ULC declined more than for all other competing economies and its recent level in relation to its domestic benchmark is at the lower end. Only the US provides a different picture, as labour productivity exceeds the average level by around 50 %. This is a clear indication for the outstanding position of the US semiconductor industry that is at the leading edge of technology and can build on its strengths in product areas with few global competitors, such as PC processors. In contrast to this, the South Korea focuses on commodities such as DRAMs and Taiwan specializes in contracting business for the production of semiconductors. In Japan, on can observe an emphasis on know-how driven market niches, thereby the country has achieved a dominant position in some areas.

Table 4.4: Assessment of EE3's comparative performance with major competing economies

Variable	Indicator	EU-27	USA	Japan	South Korea	Taiwan	China	India	Brazil
Value added at constant prices	EE3 / EEI[1)]	9.9	33.8	24.8	41.9	62.0	7.9	7.1	2.8
	EE3's relative growth[2)]	3.8	6.7	2.4	2.6	3.8	0.7	-2.0	-3.3
Employ-ment	EE3 / EEI[1)]	8.8	22.0	24.3	37.8	62.7	8.3	12.3	3.8
	EE3's relative growth[2)]	-0.5	0.5	-1.7	-2.6	1.9	-3.5	1.6	-3.2
Labour produc-tivity	EE3 / EEI[1)]	112.9	153.6	102.2	110.6	99.0	95.5	57.5	73.0
	EE3's relative growth[2)]	4.4	6.5	4.3	5.9	1.7	4.3	-3.6	-0.1
ULC	EE3 / EEI[1)]	88.3	61.1	97.1	91.5	102.8	94.2	161.4	117.8
	EE3's relative growth[2)]	-3.9	-4.9	-4.2	-0.6	-0.8	-1.5	3.8	0.3

1) Relative size of EE3 in % 2012; 2) Difference of average annual growth rates (percentage points over the period 1998 until latest available year for: EE3 - EEI.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Concluding this investigation of the comparative position of EEI, it is observed that the price position of the industry in Europe is a relatively good and has improved over the whole period under consideration. ULC are somewhat below the TM's average. Only for the smaller economies, South Korea and Taiwan, the comparative ULC are even lower. However these economies focus to a large extent on EE2 with its much lower comparative ULC. The EU-27 focuses on EE1 and EE2 that provide 90 % of EEI's value added. The remainder of 10 % for EE3 is remarkably low as compared to most of the competing economies. Only for China, India and Brazil the shares are lower.

The comparison of EEI and its sub-sectors with their benchmarks did not provide a clear picture on comparative advantages and disadvantages, with one remarkable exception: In the US, the competitiveness of EE3 surpasses all other competing economies substantially.

4.1.2 Performance and international price competitiveness of the EU EEI

Here the EU EEI and its sectors are compared with its competitors. The EU serves as benchmark. For each of the seven competing economies the most recent levels of key indicators were calculated as ratios for an assessment of size, productivity and ULC. The annual average growth rates for the whole period covered by time series are taken to obtain differences. From this we can – for instance – directly conclude whether the EU-27 grew faster (indicated by'-') or the competing economy did (indicated by'+').

The comparison of **EU EE1** with the other competing economies with regard to its size reveals that it is by far the largest. Next in this ranking are the US and Japan with 75.3 % and 69.0 % of the EU EE1's value added (**Table 4.5**). Over the whole period under investigation it grew much stronger then both of the developed economies, while there was even stronger growth in most of the developing economies. The growth of EU EE1 can be explained to a large extent by the robust development of domestic demand. Over the whole period, the US and the Japanese markets declined, whereas EU-27 manufacturers benefited from a growth trend. Moreover the EU EE1 firms were more successful in foreign markets with on average higher growth rates.

In line with the better growth performance, the EU EE1's employment record is better than the record in the US and Japan. While on average over the whole period the EU EE1 lost only 0.3 % p.a. employment, the US and Japanese sectors lost 5.6 % and 0.9 % p.a. The differentials are depicted in **Table 4.5**. The developing economies with the exception of Taiwan – with only a marginal stake in EE1 – show higher employment growth.

The first impression of the EU EE1's economic performance is poor: labour productivity is lagging substantially behind the levels in Japan and the US. For South Korea, labour productivity is around a quarter higher than for the EU. This phenomenon has already been discussed in the competing economies reports in Chapter 3. It is a well-known phenomenon that has been reported for other industries and for the EU economy at the macro level. Even more puzzling is that this phenomenon is not reflected in wage level differentials between the EU and competing economies. As a consequence, EU ULC are much higher. It is assumed that the levels are less decisive for price competitiveness than the evolution of the key indicators over time. The differences in levels might be explained by hidden factors, structural industrial differences, as well as different approaches of national statistical offices. Anyway, the EU's performance with regard to output and sales in global markets suggests that the substantial disadvantages indicated by differences in the levels have not resulted in a correspondingly negative effect. It is assumed that changes over time better reflect the relative development of price competitiveness.

Investigating price performance over the whole period does not provide a clear cut picture of differences between the developed and developing economies. As compared to the US and Japan, the EU labour productivity increased strongly at an annual average rate of 2.5 %, whereas for the US it only improved at a pace of 2.1 %, while the Japan had a stagnation. US wage growth exceeded labour productivity and led to an increase of ULC, whereas for the EU it was the opposite. This resulted in a reduction of the EU's disadvantage with regard to higher ULC at an annual rate of 1.4 % in comparison to the US. On the other hand, declining Japanese wages together with the observed moderate increase in labour productivity led to an even stronger decline in ULC. Therefore, the ULC gap between the EU and Japan widened.

With the exception of Taiwan, ULC of emerging economies are at levels between 40 % and 65 % of the EU level. They grew faster than in the EU, caused by wage growth exceeding the rise of labour productivity. As a result, competitive advantages due to lower wages are diminished. Only in China, the EEI gains price competitiveness because of strong labour productivity outpacing (substantial) wage increases.

The ULC for the EU EE1 – the most comprehensive and available indicator for price competitiveness - improved against most competing economies, with the exception of Japan and China. This is a positive development concerning competitiveness. This finding is further confirmed by the firm level analysis in Chapter 4.5.2 which finds an improvement of the profit ratio, although it was at the lower end at the beginning of the period under investigation.

Table 4.5: Assessment of the EU EE1's performance and international price competitiveness

Variable	Indicator	USA	Japan	South Korea	Taiwan	China	India	Brazil
Value added at constant prices	CC / EU-27[1)]	75.3	69.0	10.3	2.2	50.4	5.6	6.4
	CC's relative growth[2)]	-5.8	-3.0	2.3	-3.2	15.2	6.7	0.6
Employ-ment	CC / EU-27[1)]	30.2	52.2	8.4	5.7	273.5	24.7	13.5
	CC's relative growth[2)]	-5.3	-0.5	2.3	-0.5	7.2	3.5	5.3
Labour produc-tivity	CC / EU-27[1)]	249.3	132.3	122.4	37.6	18.4	22.5	47.3
	CC's relative growth[2)]	-0.4	-2.5	-0.1	-2.7	7.3	3.0	-4.7
ULC	CC / EU-27[1)]	65.9	57.4	38.7	85.8	46.5	43.6	61.0
	CC's relative growth[2)]	1.4	-1.5	1.3	1.7	-5.6	3.2	8.1

1) Size of competing country's electrical engineering industry (CC EE1) as a percentage of EU EE1, 2012; 2) Difference of average annual growth rates (percentage points) 1998 - 2012 for: CC EE1 - EU EE1.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

For **EE2,** the international comparison with respect to size discloses that once more the EU EE2 is largest – with the exception of China - as shown in **Table 4.7**. This result is explained by the definition of the sector. The weakness of the EU-27 in computers and related equipment is more than outbalanced by its strengths in medical equipment, sub-sectors where the EU27 is – as measured by size – even considerably larger than the US. All other competing economies are lagging behind (**Table 4.6**).

Table 4.6: Sub-sectoral structure of EE2's

Sub-sector	EU-27	USA	Japan
Computers and peripheral equipment	10.8%	23.1%	31.1%
Communication equipment	32.7%	34.0%	37.8%
Electromedical equipment	8.6%	4.2%	10.5%
Medical and dental instruments	47.8%	38.7%	20.6%

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Again, the EU-27 shows the highest growth momentum as compared with the other developed economies, but is lagging behind the emerging economies. The evolution of the domestic market and substitution of imports by domestic production explain to a certain extent the better performance of the EU-27. The EU-27 domestic market moderately grew over the whole period under consideration, whereas the US was close to stagnation and the Japanese market even declined. Imports grew faster than the domestic market, but this was a lesser problem for the EU-27 with its much lower market penetration of foreign suppliers than for the US. The EU EE2 employment declined over the whole period under consideration at an annual rate of around 2 %, but this negative development was even worse for the US and Japan, with rates around 5 %. The differentials for the periods under consideration are depicted in **Table 4.7**. The emerging economies show significant increases in employment. China's growth outpaces all competing economies by far.

As above, the EU EE2's labour productivity is well below those of the US and Japan. Labour productivity of South Korea is even higher, and has on average over the whole period under consideration grown at a high double digit yearly rate. Taiwan, India and China are following suit with relatively high increases in labour productivity, whereas for the EU-27, Japan and the US only minor development occurred. Wage increases play a major role for the three developed economies. For the US, rises in wages outpaced productivity growth, whereas for the EU-27 wage increase were lower, improving relative price competitiveness as measured by ULC. The ULC gap narrowed for the EU-27: The US ULC increased to 65.2 % of the EU-27 level. On the other hand, productivity growth and low wage rises led to a further improvement of the Japanese price performance as compared to the EU-27. Likewise the other Asian economies with an ICT focus gained price competitiveness. Once more, India and Brazil show a poor economic performance of their EE2. For both of these economies, there are serious market access barriers and local content requirements in place that protect domestic production to a certain extent.

Table 4.7: Assessment of the EU EE2's performance and international price competitiveness

Variable	Indicator	USA	Japan	South Korea	Taiwan	China	India	Brazil
Value added at constant prices	CC / EU-27[1)]	91.7	46.8	43.2	20.3	101.7	4.7	7.9
	CC's relative growth[2)]	-5.9	-3.7	13.4	8.6	15.1	7.6	2.3
Employment	CC / EU-27[1)]	33.3	31.8	18.9	23.5	876.6	13.9	15.8
	CC's relative growth[2)]	-4.5	-2.8	2.9	3.2	12.3	0.8	5.6
Labour productivity	CC / EU-27[1)]	275.1	147.1	228.0	86.4	11.6	33.9	49.8
	CC's relative growth[2)]	-1.3	-0.8	10.2	5.1	1.9	6.8	-3.5
ULC	CC / EU-27[1)]	65.2	54.7	23.0	49.8	61.2	35.9	59.0
	CC's relative growth[2)]	1.5	-1.5	-7.3	-4.4	-1.2	2.9	8.0

1) Size of competing country's electrical engineering industry (CC EE2) as a percentage of EU EE2, 2012; 2) Difference of average annual growth rates (percentage points) 1998 - 2012: CC EE2 - EU EE2.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The ULC for the EU EE2 indicator for price competitiveness improved relative to the US, India and Brazil only. The latter countries are – as shown in the respective country reports – of minor importance for an assessment of competitiveness on global markets for EE2 products. The US is an economy with companies of significant market power and technological supremacy in the area of EEI with global production networks that only to a certain extent depend on US based production. Local disadvantages might be to a lesser extent relevant and can be outbalanced by outstanding products and dominance in markets. Therefore, the changes in price performance are interpreted as less important than for EE1. Further background for this is provided by the firm level analysis carried out in Chapter 4.5.3, which depicts a clear trend for the EU EE2 with strongly declining profitability – from above average levels as compared to competing economies at the beginning - to below average levels at the end of the period under consideration. Only the performance of India and Brazil is worse. The firm level results for the US are in contrast to the results of the international comparison of price competitiveness. The US companies outperformed companies from all other competing economies with regard to profitability.

While for EE1 and EE2, the international comparison has not disclosed major differences for **EE3** we find a quite different picture. Differences in the sizes of the sector are most obvious: US EE3 is of outstanding importance, with more than three times the output of the EU, followed by Japan, and even the small economies of South Korea and Taiwan produce roughly 1.4 and 1.2 times larger output of EE3.

The EU EE3 strongly outperformed the US and Japan with regard to growth of value added. This is to a large extent explained by strong domestic demand that grew at an annual average rate of 3.2 % over the whole period under consideration, whereas exports decreased. For the US, domestic demand stagnated and simultaneously imports gained market shares. However, the US was able to counter growing pressure in the domestic market by increasing exports. For Japan, the domestic situation was even worse with a shrinking market while exports stagnated.

South Korea and China's value added at constant prices grew at average high double digit rates over the whole period, even the differences as compared to the EU-27 - as depicted in **Table 4.8** – are of double digit magnitudes. Taiwan's growth was only somewhat below this pace. The growth performances of India and Brazil are poor, taking into account the overall strong growth of these economies.

In line with the better growth performance, the EU EE3 shows a better employment record than the US and Japan, that shed more of their respective employment. Most remarkable is the employment record of South Korea. In contrast to soaring output, EE3 reduced its workforce at an annual average rate of 3.0 %. In the EU-27, the reduction was only 1.3 % p.a. All other developing economies expanded their workforce, even India and Brazil.

The outstanding strength of the US is indicated by a 4 -times higher labour productivity than the EU. Next in this ranking is South Korea with a productivity level roughly twice as high as for the EU-27, followed by Japan. For the three developed economies, changes in labour productivity were not very different. For the emerging economies, different developments are observed. South Korea displayed remarkable annual average productivity growth with rates of more than 22.4 % over the whole period, followed by China with roughly 11.8 % p.a., well above the level for the EU-27 at 7.9 %. Within this environment it is remarkable that Taiwanese productivity increased only at the same magnitude as the EU-27. Labour productivity for Brazil and India fell strongly in line with the development in output performance and employment growth. This phenomenon has been already discussed in the detailed country reports and the loss in competitiveness has been highlighted.

The ULC for the EU EE3 worsened against Japan and the US over the whole period. The driving factor for the changes was different wage trends. The most remarkable improvement is reported for South Korea, based on its productivity gains. Taiwan's price performance is less convincing. Despite strong growth, ULC only improved in line with the EU-27 and the ULC level is of the same magnitude as Japan's. Taking low Taiwanese wages into account, this might be explained by Taiwan focusing on semiconductor contracting, a low margin business.

The EU EE3 was able to grow at a somewhat higher pace than the US and Japan, driven by domestic demand. Exports decreased over the period under investigation. This contrasts to growing exports of the US, China, South Korea and Taiwan. Only the Japanese EE3 – handicapped by an overvalued Yen – suffered from stagnating exports. This poor performance in international markets in combination with the comparably small size of the EU EE3 indicates that –irrespective of changes in price competitiveness - there might be some problems beyond ULC. In fact, the firm level analysis shows that the EU EE3 was poor in profitability for most of the period under investigation. However, in recent years the situation has markedly improved. But structural indicators for short- and long-term funding indicate a tight financial situation (Chapter 4.5.4).

Table 4.8: Assessment of the EU EE3's performance and international price competitiveness

Variable	Indicator	USA	Japan	South Korea	Taiwan	China	India	Brazil
Value added at constant prices	CC / EU-27[1)]	372.5	183.6	138.7	119.1	51.8	3.6	1.8
	CC's relative growth[2)]	-1.4	-5.0	12.2	7.1	11.1	-0.2	-6.9
Employment	CC / EU-27[1)]	90.9	160.3	75.0	192.1	436.2	32.6	6.0
	CC's relative growth[2)]	-3.8	-2.4	-1.7	6.3	6.4	5.6	2.7
Labour productivity	CC / EU-27[1)]	409.7	114.6	185.1	62.0	11.9	11.1	29.2
	CC's relative growth[2)]	2.9	-2.4	14.5	0.2	3.9	-6.2	-9.8
ULC	CC / EU-27[1)]	38.2	64.0	26.4	65.7	56.0	82.0	82.0
	CC's relative growth[2)]	-0.9	-2.0	-4.1	0.5	-0.7	12.4	13.0

1) Size of competing country's electrical engineering industry (CC EE3) as a percentage of EU EE3, 2012; 2) Difference of average annual growth rates (percentage points) 1998 - 2012: CC EE3 - EU EE3.

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

4.1.3 Conclusion

Investigating the performance of EEI and its international price competitiveness, it is necessary to differentiate between the developed economies, the US, Japan and the EU-27, and the developing economies which are catching up given a strong growth regime.

The analysis disclosed that the EU EEI can benefit – as compared to its domestic TM – from higher labour productivity and productivity gains. This is reflected in below average ULC and a better price performance over the whole period under investigation. For the US and Japan, the situation is less favourable with higher ULC. However, the evolution over time shows a similar pattern as in the EU-27, the price performance as compared to the respective domestic TM improves, though only marginally for the US.

The sector EE1, electrical engineering that is closely linked to the machinery and transport equipment industry – a segment where the EU commands a leading position in the global market – has one of the highest shares of its domestic TM. With the exception of China, labour productivity is below the level of the respective domestic EEI for all competing economies and growth of productivity is less than proportionate. The relative situation of the EU EE1 compared to EU EEI is more favourable than for Japan and the US. For South Korea and Taiwan EE1 is only of minor importance and further loses ground. Only for China, India and Brazil EE1 is a relevant sector. In particular the Chinese economic performance indicates an imposing catching up process.

The direct comparison of the EU with competing economies disclosed that the EU EE1 showed much stronger development of value added and employment than the US and Japan. To a certain extent this was caused by a better growth of domestic demand, but also by much higher export growth rates. This result underpins the phenomenon that level differences in productivity and ULC are not by themselves decisive arguments. The EU is lagging far behind in both of these indicators. Only relative to the US, India and Brazil the huge gap could be reduced. It is concluded that the price competitiveness of EE1 is satisfactory.

Electronic engineering is a sector with remarkable structural differences. The EU and the US command strong shares in medical equipment. For the EU, this share comes up to 55 % for the US up to 43 % and for Japan around 30 %. The EU commands only a 10 % share for computers and peripherals of EE2 domestic production, whereas for Japan the share is 30 % and the US lies in between. Only for communication equipment, the shares are comparable among the three developed economies, between 30 % and 40 %. These structural differences are challenges for a meaningful assessment of price competitiveness. On average for these sub-sectors the comparative assessment relative to its domestic EEI is positive, with labour productivity well above the benchmark and ULC improving over the period under consideration. For the US, the comparative situation is worse, for Japan it is much better.

The direct comparison of the EU EE2 with competing economies also provides remarkable differences in productivity and ULC. Compared to the US, the EU performed better, while against Japan it lost some price competitiveness. However, it must be taken into account that sub-sectors within the sector are in a phase of consolidation: While for the EU employment declined at an annual rate of only 1.6 % p.a. over the whole period, the respective change rates for the US and Japan are 6.1 % and 4.4 %. These developments suggest that growth of labour productivity is driven by the closure of the least efficient production sites. In this respect it becomes important to look to the Asian economies. South Korea, Taiwan and China show enormous growth in output, productivity and more moderate, but still significant increases in the workforce. Simultaneously ULC decline. This suggests that the differences between the developed economies are of minor importance. Most striking is the development in Asia with strongly growing capacities. Even the latest available figures do not show any sign of moderation in improving price competitiveness. This suggests a continuation of the growing importance of Asia for the production of EE2 products, namely computers and communication equipment.

EE3 is the most important sector for technological progress, in particular with the production of semiconductors. For the EU EEI, the sector contributes only one tenth of value added. This is well below the portion of EE3 within the EEI of the US, Japan, South Korea and Taiwan. In spite of higher growth rates of real output than EEI for all competing economies - with the exception of India and Brazil – the development of employment was muted. The comparison of EE3 with its respective domestic EEI discloses one striking result: US labour productivity is roughly 60 % above its national benchmark. No other competing economy delivers a similar figure. The EU-27 is next in this ranking, the ULC are below its domestic benchmark and showed a better development over the whole period.

The direct comparison unveils remarkably high differences with regard to size. The US EE3 sector is by roughly a factor of 3.7 larger than the EU sector as measured by value added, for Japan, South Korea and Taiwan the respective figures are 1.8, 1.4 and 1.2. China only came up to around 0.5 in 2012. With regard to the breath-taking growth rates, even a more moderate growth will bring Chinese output to the EU-27 level within a couple of years. The growth differentials between the developed economies and the Asian emerging economies are remarkably high. Although the EU EE3 grew more strongly than the US and the Japanese sector, its growth was by far lower than for the Asian economies. As for EE2 it becomes clear that the weight of production shifts to emerging Asia. The loss of workplace for the EU-27 was 1.3 % p.a. for the whole period under consideration. The respective figures for the US and Japan are around 5.4 % and 4.0 %, respectively. South Korea – despite strong growth – lost even more employment than the EU, however Taiwan and China increased employment at annual average rates close to 8 %.

4.2 Performance in international trade

This chapter provides results regarding the trade performance of the EU-27 and the most important competing economies in the markets for EEI products. Moreover, key-figures for some sales markets are presented that have close relationships with the EU-27, Russia and the Middle East and North African region (MENA).

The trade statistics applied for this purpose are based on time series denominated in EUR. As far as original data used different currencies annual average exchange rates were applied for conversion. The currently available database is not complete for 2012, therefore only time series from 1998 up to 2012 were used for the analysis.

A first impression is provided by global exports. The shares of EEI and its sectors as a percentage of TM are calculated for the total period under investigation. For EEI, the share was stable up to the middle of the last decade. The years after this, EEI lost some of its former weight and fell by around three percentage points. The underlying explanation is provided by the recovery after the slump of global trade in 2009 caused by the financial crisis. While exports of total manufactured goods experienced strong growth up to 2011, and the development of EE1 was quite similar, EE2 and EE3 experienced a moderate recovery only in 2010; and 2011 was close to stagnation. (**Table 4.9**)

Table 4.9: EEI and its sectors in global exports

Sector	Units	1998 - 2000	2004 - 2006	2009 - 2011
		Annual average values		
TM[1)]	**€ billion**	**4684**	**6473**	**8295**
EEI	**% of TM**	**25.6%**	**25.2%**	**22.8%**
EE1	% of TM	7.3%	7.3%	7.1%
EE2	% of TM	13.0%	13.2%	11.3%
EE3	% of TM	5.2%	4.7%	4.4%
1) TM = Total manufacturing.				

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The EU-27 commands a strong position in global markets for machinery and transport equipment. EE1 is a sector that is – with most of its sub-sectors – closely related to this competitive European cluster. Its position in world trade is reflected in a high share of global EE1 exports. Moreover, its weight steadily grew over the whole period under investigation. For Japan and the US, shares steadily declined. These lost shares were appropriated by emerging economies. The most recent share of South Korea's EE1 exports is only 2.8 %, but if one takes into account that the output of the South Korean EE1 sector is only one tenth of the EU-27 (as highlighted in the chapter on price competitiveness), there must be underlying strengths of the Korean industry even if this sector is of much lesser relative importance for the South Korean EEI (**Table 4.10**).

The biggest challenge for the EU is the emerging importance of China. In recent years it had topped the EU-27's exports. Its weight in EE1 exports increased threefold over the whole period under consideration. As shown in the preceding chapter on price competitiveness, EE1 economic performance was positive. The comparative analysis disclosed that EE1 labour productivity is above the average of EEI and ULC were roughly in line with the domestic development. The Chinese EE1 sector had a better economic performance than EE2 and provides better working conditions as indicated by above average wages. The direct comparison of the EU EE1 and the Chinese EE1 reveals that China increased its price competitiveness much more than the EU by a more pronounced reduction of ULC.
The Indian and Brazilian exports of EE1 enjoyed high growth. But their shares of total EE1 trade remain marginal. The evolution of the price performance as analysed in the preceding chapter discloses lost competitiveness.

Together with China, South Korea is the main challenger for the EU EE1.

Table 4.10: EE1 and its major competing economies in international trade

EE1	Units	1998 - 2000	2004 - 2006	2009 - 2011
		Annual average values		
World exports	**€ billion**	**345**	**474**	**595**
Competing economies				
EU-27	Shares	13.2%	14.4%	15.7%
USA	Shares	11.2%	8.5%	7.6%
Japan	Shares	8.4%	6.8%	6.3%
South Korea	Shares	1.3%	1.6%	2.8%
Taiwan	Shares	2.9%	2.7%	2.2%
China	Shares	4.8%	10.3%	16.3%
India	Shares	0.1%	0.2%	0.4%
Brazil	Shares	0.3%	0.5%	0.5%
RoW	Shares	57.7%	55.1%	48.2%

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

Sector EE2 comprises heterogeneous product groups. Beyond information and communication equipment as well as mass-manufactured consumer electronics, EE2 contains medical equipment and instruments. The latter product group is exposed to low-wage competition from emerging economies to a lesser extent. The developed economies have remained centres for R&D as well as production. Therefore the content of the exports of the countries under investigation differs strongly, although information and communication technologies are the driver for regional changes in worldwide EE2 exports.

The US and, in particular, Japan suffered major losses in their global market presence. The EU EE2 did not suffer as much from growing competition of emerging economies, because its stake in consumer electronics, PCs and communication terminals was lower. Its strength in medical equipment and instruments was to a lesser extent affected. Losses in global trade could be contained.

The fact that South Korean companies took over Japanese market shares is not reflected in the respective exports, South Korean shares of world exports declined likewise. This is explained to a large extent by the Asian electronics cluster with cross-border deliveries within value chains. Above all, China serves as a workbench with a large low-wage labour supply. However, as disclosed in the chapter on price performance, the sector EE2 lost as compared to its domestic benchmark as well as directly compared to other competing economies' EE2 in price competitiveness. It can be assumed that Chinese soaring exports will slow down driven by more favourable framework conditions in other Asian emerging economies that replace China as a low-wage workbench. China will focus more and more on high-tech components, as for instance components for communication technologies. Already today, in this market segment Chinese companies are leading and command a strong position in leading technologies and companies from developed economies suffer from tough competition (**Table 4.11**).

Table 4.11: EE2 and its major competing economies in international trade

EE2	Units	1998 – 2000	2004 - 2006	2009 – 2011
		Annual average values		
World exports	**€ billion**	**615**	**856**	**937**
Competing economies				
EU-27	Shares	9.7%	9.6%	8.9%
USA	Shares	9.7%	6.6%	7.2%
Japan	Shares	7.0%	4.8%	2.4%
South Korea	Shares	5.0%	4.4%	3.3%
Taiwan	Shares	0.9%	1.2%	1.3%
China	Shares	8.4%	22.7%	29.0%
India	Shares	0.3%	0.3%	0.3%
Brazil	Shares	0.3%	0.3%	0.2%
RoW	Shares	58.9%	50.1%	47.4%

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The EU EE3 is much smaller than EE3 of most important competing economies. As measured by value added, the US EE3 is 3.6 times larger, the Japanese EE3 is more than 2 times and the South Korean EE3 1.5 times larger. The share of roughly one tenth of global exports during the early years of the period under consideration was remarkably high. The time series suggest that there was strong growth in the era of the New Economy Bubble. The EU EE3 maintained its strong position up to 2006. In contrast to global trade, the EU suffered a major setback already in 2007, even before the financial crisis affected the real economy. EU EE3 did not recover and in the most recent years it only commands a share of around 4 % of global exports. Having in mind the size of the sector as compared to competing economies the low share is not surprising (**Table 4.12**).

Table 4.12: EE3 and its major competing economies in international trade

EE3	Units	1998 - 2000	2004 - 2006	2009 - 2011
		Annual average values		
World exports	**€ billion**	**248**	**304**	**365**
Competing economies				
EU-27	Shares	10.7%	10.7%	4.3%
USA	Shares	17.1%	11.6%	9.6%
Japan	Shares	14.9%	11.2%	9.1%
South Korea	Shares	7.4%	7.3%	7.5%
Taiwan	Shares	5.8%	7.8%	9.9%
China	Shares	3.4%	8.0%	14.3%
India	Shares	0.0%	0.0%	0.1%
Brazil	Shares	0.1%	0.1%	0.0%
RoW	Shares	40.5%	43.3%	45.2%

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

4.2.1 *The EU EEI's regional trade performance*

The investigation into the regional development of international trade applies the averages of the first three and the last three years to better understand changes in regional trade relations. The averages serve to dampen the volatility in annual figures.

The EU-27 commands a strong position in international trade with EE1 products, with a long-term trade surplus. During the early years of the period under investigation it was only 1.5 % of the trade volume (exports + imports). It grew up to 12.8 %, i.e., € 23.7 billion on average per annum, for the most recent period. Table 4.13 depicts a general trend in world trade: The traditional close trade links between developed economies lose some of their importance in exchange for increasing trade relations between developed and emerging economies. At the turn of the millennium the US was by far the most important sales market with a quarter of EU-27 exports. The deliveries to the US market grew at a moderate average annual rate of 2.8 %%, whereas total EU EE1 exports increased at a rate of 6.1 %. The Japanese market with its hidden access barriers further lost relevance. Note that the EU-27 imports from both of these economies which accounted for nearly half of foreign deliveries fell to around a quarter in the most recent years. The trade of the EU-27 with both of these countries shifted from a large deficit to a roughly balanced outcome.

The less tight trade relations between developed and emerging economies are caused by two driving factors, the enormous growth differential between these country groups and the creation of global value chains.

The EU-27 trade with other competing economies developed quite differently. The trade with China soared at annual average rates for exports and imports of 15.2 % and 11.5 %, respectively. It is of note that the EU exports grew much faster than imports on average over the whole period under investigation. Although the trade deficit of the EU EE1 with China grew strongly up to € 15.1 billion, its relation to the trade volume fell from 55 % down to 37 %. The trade with South Korea turned out to be more or less balanced over the whole period with quite similar growth rates of 6.0 % p.a. and roughly in line with the EU EE1's total trade growth. In contrast, EU trade with Taiwan shows a deficit, but trade flows only increased at a meagre 1 % to 1.5 % p.a. India is the only Asian economy under investigation with which the EU enjoys a trade surplus while trade flows grew at double digit rates. EU trade with Brazil achieves a slight surplus, but growth was only moderate.

For the EU-27, the trade with neighbouring regions is of major importance for the surplus with EE1 products. Middle East and North Africa (MENA) has maintained its relative weight as a sales market for EU-27 products, and its importance is of similar magnitude as the US market, which up to now has remained the most important destination. The Russian federation – not a relevant sales market during the early years under consideration – has developed into one of the leading markets. The trade surpluses with both of these markets account for much of the EE1's surplus in foreign trade, around 70 % on average for the years 2010 to 2012.

Table 4.13: EU EE1 trade with competing economies and selected sales markets

Country / region	Averages 1998 - 2000 € billion	Averages 1998 - 2000 Shares	Averages 2010 - 2012 € billion	Averages 2010 - 2012 Shares	Changes in shares
			Exports		
United States	11.4	25.2%	16.8	16.1%	-9.1%
Japan	1.8	4.0%	2.8	2.7%	-1.2%
Brazil	1.2	2.6%	2.7	2.6%	-0.1%
China	1.8	4.0%	13.1	12.5%	8.6%
India	0.7	1.5%	3.1	3.0%	1.5%
South Korea	1.0	2.2%	2.9	2.8%	0.6%
Taiwan	0.9	1.9%	1.0	1.0%	-0.9%
Mexico	0.8	1.7%	1.8	1.7%	0.0%
Russian Federation	1.0	2.2%	7.8	7.4%	5.2%
MENA	5.9	13.1%	13.9	13.3%	0.2%
Sub-total	26.5	58.4%	65.8	63.1%	4.7%
Global Total	45.3	100.0%	104.4	100.0%	
Country / region	**Averages 1998 - 2000 € billion**	**Averages 1998 - 2000 Shares**	**Averages 2010 - 2012 € billion**	**Averages 2010 - 2012 Shares**	**Changes in shares**
			Imports		
United States	14.0	31.7%	12.4	15.3%	-16.4%
Japan	7.8	17.8%	7.4	9.1%	-8.7%
Brazil	0.2	0.4%	0.4	0.5%	0.1%
China	6.1	13.9%	28.2	35.0%	21.0%
India	0.3	0.6%	1.2	1.4%	0.8%
South Korea	1.2	2.8%	2.8	3.5%	0.7%
Taiwan	1.4	3.2%	1.8	2.2%	-1.0%
Mexico	0.4	1.0%	1.1	1.4%	0.4%
Russian Federation	0.1	0.2%	0.3	0.4%	0.1%
MENA	1.8	4.1%	4.7	5.8%	1.7%
Sub-total	33.3	75.7%	60.2	74.5%	-1.2%
Global Total	44.0	100.0%	80.7	100.0%	

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The EU-27 commands a weak position in international trade with EE2 products, with a long-term trade deficit. During the early years of the period under investigation it was 27.6 % of the trade volume (exports + imports). It dropped down to 28.1 %, i.e., € 71.2 billion on average per annum, for the most recent period. Considering that EE2 is to a large extent composed of consumer electronics and other electronics manufactured in extremely large batches, it is not surprising that the trade balance is negative, as Europe imports a large amount of such products primarily from Asia. Table 4.14 unveils a general trend in world trade: At the turn of the millennium the US was by far the most important sales market with almost one quarter of EU-27 exports. The deliveries to the US market grew at a moderate average annual rate of 1.4 %, whereas total EU EE2 exports increased at a rate of 3.1 %. The Japanese market further lost relevance. The EU-27 imports from both of these economies which accounted for 43.8 % of foreign deliveries fell to around a quarter in the most recent years. (Table 4.14)

The EU-27 trade with other competing economies developed quite differently. The trade with China soared at annual average rates for exports and imports of 3.7 % and 16.0 %, respectively. The EU imports skyrocketed whereas the trade deficit of the EU EE2 with China grew up to € 76 billion and its relation to the trade volume declined from -59.1 % down to -89.6 %, due to the fact that the imports increased by more than eight times. The EU trade with Taiwan is striking, with a decline of exports of 6.2 % p.a. The trade deficit of € 5.9 billion on average of the most recent years exceeds EU-27 exports 10 times. India is the only Asian economies under investigation with which the EU enjoys a trade surplus of € 0.8 billion, as the exports have grown by a noteworthy rate of 10 % in the period under investigation. The EU-27 trade with Brazil shows a slight surplus, but growth was only relative moderate.

The EU-27 trade with neighbouring regions, on the other hand, conveys a surplus for EE2 products. Middle East and North Africa (MENA) maintained its relative weight as a sales market for EU-27 products (10.1 % in 1998 – 2000 and 13.3 % in 2010 – 2012). The Russian federation – not a relevant sales market during the early years under consideration – has developed to one of the most important destinations.

Table 4.14: EU EE2 trade with competing economies and selected sales markets

Country / region	Averages 1998 – 2000		Averages 2010 - 2012		Changes in shares
	€ billion	Shares	€ billion	Shares	
			Exports		
United States	14.7	24.7%	17.9	19.7%	-5.0%
Japan	3.8	6.4%	3.9	4.3%	-2.1%
Brazil	0.9	1.5%	1.5	1.6%	0.1%
China	2.6	4.4%	4.4	4.8%	0.4%
India	0.5	0.8%	1.9	2.1%	1.2%
South Korea	0.7	1.2%	1.3	1.4%	0.2%
Taiwan	1.5	2.5%	0.6	0.7%	-1.8%
Mexico	1.0	1.8%	1.0	1.1%	-0.6%
Russian Federation	1.7	2.8%	8.9	9.8%	7.0%
MENA	6.0	10.1%	12.1	13.3%	3.2%
Sub-total	33.5	56.2%	53.5	58.7%	2.5%
Global Total	59.6	100.0%	91.1	100.0%	
Country / region	Averages 1998 – 2000		Averages 2010 - 2012		Changes in shares
	€ billion	Shares	€ billion	Shares	
			Imports		
United States	28.7	27.4%	19.9	12.3%	-15.1%
Japan	17.2	16.4%	5.4	3.4%	-13.1%
Brazil	0.1	0.1%	0.2	0.1%	0.0%
China	10.1	9.6%	80.4	49.6%	39.9%
India	0.1	0.1%	1.1	0.7%	0.6%
South Korea	5.7	5.5%	6.5	4.0%	-1.5%
Taiwan	9.5	9.0%	6.5	4.0%	-5.0%
Mexico	0.8	0.8%	3.7	2.3%	1.5%
Russian Federation	0.0	0.0%	0.1	0.0%	0.0%
MENA	2.1	2.0%	2.1	1.3%	-0.7%
Sub-total	74.4	70.8%	125.9	77.6%	6.7%
Global Total	105.0	100.0%	162.3	100.0%	

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

The EU-27 commands a weak position in international trade with EE3 products, with a long-term trade deficit. During the early years of the period under investigation it was 19.5 % of the trade volume (exports + imports). It dropped down to 40.7 %, i.e., € 22.9 billion on average per annum, for the most recent period. Table 4.15 reflects a general trend in world trade: At the turn of the millennium the US was by far the most important sales market with 22.5 % of EU-27 exports. The deliveries to the US market declined at a high average annual rate of 7.0 %, whereas total EU EE3 exports declined at a lower rate of 3.2 %. The Japanese market lost in terms of exports even more than the US (7.3 %). The EU-27 imports from both of these economies, which accounted for more than 40 % of foreign deliveries, fell to a quarter in the most recent years. (Table 4.15)

The EU-27 trade with other competing economies developed quite differently. Trade linkages with China increased by 19.3 % p.a., while imports only grew moderately by 2.4 %. The trade deficit of the EU EE3 with China therefore grew strongly up to about € 14 billion and its relation to the trade volume gained weight from 3.45 % up to 76.7 % at the end of the period under investigation, caused by an eleven-fold increase of imports. The EU trade with Mexico is mostly characterized by the decline of the EU exports of 5.5 %. Nevertheless, a trade surplus of € 0.1 billion remains. In the early years, India was next to China one of the two Asian economies under investigation with which the EU enjoyed a trade surplus. This has changed throughout the period: The EU accounts for a trade deficit of € 0.2 billion with India, given that EU imports soared at an annual average rate of 16.2 %. The EU trade with Brazil started out with a slight surplus, which has declined over the years.

For the EU-27 the trade with neighbouring regions becomes less important. Although there exists a trade surplus in the trade relations to MENA, exports and imports have declined by 2.5 % and 3.9 %, respectively. It has maintained its relative weight as a sales market for EU-27 products (7.6 % in 1998 – 2000 and 8.4 % in 2010 – 2012). The Russian federation is neither a relevant sales market nor is it a provider of import goods. Particularly noticeable in this sector is the fact that the imports did not change on average over the years. This finding contrast strongly to exports that fell by more than one third, comparing the period 2010 to 2012 with 1998 to 2000.

Table 4.15: EU EE3 trade with competing economies and selected sales markets

Country / region	Averages 1998 - 2000		Averages 2010 - 2012		Changes in shares
	€ billion	Shares	€ billion	Shares	
			Exports		
United States	6.0	22.5%	2.2	12.9%	-9.6%
Japan	1.3	4.9%	0.4	2.7%	-2.2%
Brazil	0.4	1.4%	0.2	1.3%	-0.2%
China	1.5	5.8%	2.1	12.8%	7.0%
India	0.2	0.8%	0.2	1.5%	0.7%
South Korea	1.0	3.9%	0.6	3.5%	-0.4%
Taiwan	1.5	5.5%	0.8	4.7%	-0.7%
Mexico	0.4	1.4%	0.2	1.0%	-0.4%
Russian Federation	0.2	0.8%	0.4	2.2%	1.4%
MENA	2.0	7.5%	1.4	8.4%	0.9%
Sub-total	14.5	54.6%	8.5	51.1%	-3.4%
Global Total	26.5	100.0%	16.7	100.0%	
Country / region	Averages 1998 - 2000		Averages 2010 - 2012		Changes in shares
	€ billion	Shares	€ billion	Shares	
			Imports		
United States	9.8	24.9%	2.9	7.4%	-17.5%
Japan	6.1	15.5%	3.0	7.6%	-7.9%
Brazil	0.1	0.2%	0.0	0.0%	-0.2%
China	1.4	3.4%	15.9	40.3%	36.9%
India	0.0	0.1%	0.4	0.9%	0.8%
South Korea	2.5	6.3%	3.1	7.8%	1.5%
Taiwan	2.2	5.5%	3.7	9.3%	3.8%
Mexico	0.2	0.4%	0.1	0.3%	-0.1%
Russian Federation	0.0	0.1%	0.0	0.1%	0.0%
MENA	0.9	2.2%	0.5	1.2%	-0.9%
Sub-total	23.1	58.7%	29.7	75.0%	16.4%
Global Total	39.3	100.0%	39.6	100.0%	

Source: EUROSTAT; Cambridge Econometrics; Ifo Institute.

4.2.2 *Perspectives for the Russian Federation and other Eastern economies*

Russia's current population amounts to 141.44 million.[207] According to the annual report of the Russian government, GDP increased by 3.4 % in 2012. Compared to other industrial countries the public debt is quite low (10 % of GDP). The Russian budget is almost balanced, with a deficit of 0.06 %. On the other hand, the inflation rate was 6.6 % in 2012 and wages and salaries increased by 8.4 %. Foreign direct investments amounted to around € 38 billion, the outflow of capital

[207] http://de.statista.com/statistik/daten/studie/19330/umfrage/gesamtbevoelkerung-in-russland/

declined down to € 41 billion from € 60 billion in 2011. The main risk to the Russian economy is the general slowdown of world economic growth and Russia's dependence on the oil and gas sectors. According to the Russian Ministry of Economics the Russian GDP is expected to increase by 2.4 % in 2013 and 3.7 % in 2014, respectively. For 2015 and 2016, the growth rates of 4.1 % and 4.2 %, respectively, are expected. Furthermore, large revenues of around € 8 billion from privatization are planned for the current year.[208]

The EU is the most important trade partner of Russia. Around half of the foreign trade volume has been generated with the EU. With the accession to the World Trade Organisation in 2012, Russia has agreed to improve market access and to reduce its import tariffs. The average tariff rate is expected to decline from currently 10 % down to 7.8 %.[209] This agreement is expected to stimulate investment and growth both in the EU as well as in Russia. It is of vital importance especially for the European automotive industry that these trade barriers are dismantled.[210]

The EU EEI exports to Russia increased from on an annual average of € 1.0 billion for 1998 to 2000 up to € 7.8 billion for the period 2010 to 2012. This equals a growth rate of 5.2 %. The imports grew at a slower pace: They increased at an average annual rate of 0.1 % and accounted for a volume of € 0.3 billion.

Russia represents an important market for European enterprises, especially in terms of outdoor lightings. The current market volume of LED lamps in Russia is estimated at € 1.4 billion. The booming city of St. Petersburg for example wants to equip its streets and external lighting for buildings with energy-saving and LED lamps up to 2020. Extensive procurement activities are carried out under this program. European producers are well-placed to succeed in St. Petersburg, as they have reached a good reputation by their performance in system engineering which culminated with the decoration of the Eiffel Tower, an important reference project. Philips of the Netherlands launched a joint-venture with the Russian manufacturer Optogan for a pilot project on the application of LED for public lighting in St. Petersburg.[211]

Industrial companies in Russia have started to satisfy their energy needs with their own power generation facilities. Their economic development is being hampered by poor public supply and they heavily invested in gas and diesel generators of up to 25 MW. This market grew by 4.6 % in 2011. The market for gas and diesel generators for combined heat and power generation has developed well and provides bright perspectives. In contrast to this, investment in the expansion of public energy supply infrastructure accounted for a moderate growth rate of only 1.5 %, which is not sufficient to satisfy growing demand.[212]

Russia has to modernize its power generation stations and distribution network and to increase capacities. Numerous European groups and other foreign firms, like Siemens, Alstom, General Electric, Voith Hydro und Andritz Hydro are involved in key national projects. However, the Russian government demands local partners. Companies are expected to procure a noteworthy share of total contract value from Russian manufacturers. Siemens and Silowye Maschiny are currently establishing a factory for production and maintenance of gas turbines in St Petersburg. General Electric is also about to establish a factory for turbine production in Russia. There are Russian

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[203] http://www.rheinneckar.ihk24.de/international/downloads/Anl_CEE/RUS/0110r/459228/russ_news.html;jsessionid=7AE993D4976519A4477BC30EC4FC231B.repl1

[209] http://www.rheinneckar.ihk24.de/international/downloads/Anl_CEE/RUS/0110r/459228/russ_news.html;jsessionid=7AE993D4976519A4477BC30EC4FC231B.repl1

[210] http://www.auswaertiges-amt.de/DE/Aussenpolitik/RegionaleSchwerpunkte/Russland/Russland-und-EU_node.html

[211] http://www.gtai.de/GTAI/Navigation/DE/Trade/maerkte,did=811796.html

[212] http://www.gtai.de/GTAI/Navigation/DE/Trade/maerkte,did=811776.html (2013).

producers of turbines and generators that benefit from investment in power generation, but they have to rely on the support of foreign companies.[213]

The Ministry of Energy of the Russian Federation announced a long-term plan for the investment in power generation and distribution in the autumn of 2012. It has not yet been made publicly available. Only some figures have already been published: € 100 billion for new nuclear and hydro power stations, € 60 billion for combined-heat-power plants. Enormous efforts have to be undertaken to expand and upgrade power distribution. Around 90,000 km new lines are planned to be built, this equals an investment amount of € 120 billion.

Likewise the public transportation system has to be expanded and upgraded. Russia owns the second largest railway network in the world, with 85,000 km. It plans to invest € 125 billion up to 2030 in transportation infrastructure, among them high-speed tracks, some of them dedicated to be already available for the Olympic Winter Games 2014 and the World Soccer Championship 2018.[214] Usually Russian companies will be awarded contracts in public procurement procedures. However, due to quality and technology requirements European manufacturers will have good opportunities as specialized subcontractors.

If one focuses on the needs of Russia for upgrading and expanding its infrastructure and to achieve the standard of living of developed countries, there is enormous long-term growth potential. However, the Russian and other Eurasian markets are highly competitive. Companies from China and other Asian economies have been tapping the markets not only for electronics, but also for electrical engineering products, areas where EU firms traditionally command a strong position in international markets, in particular power generation and distribution, factory automation and transport equipment. They provide state-of-the-art technology and quality. Moreover, they can offer favourable financing terms.

In addition, Russia has reduced its dependency on Europe, by intensifying its Asian trade relations. Growing exports of gas and oil to, as well as imports of manufactured goods from China indicate a successful transformation. **These days EU companies that once were the dominant foreign suppliers in Russia have to work hard to maintain their position in the market, and it must be expected that competitive pressure, in particular from China will further grow.**

A promising development of the region depends on maintaining political stability, a more efficient public authority, as well as reduction of fraud and corruption. Additionally, Russia's economy - as well as other economies of the region - is strongly dependent on global commodity markets. In this respect Russia is vulnerable and could suffer setbacks. In spite of these threats the region remains promising in the long-run.

This is one of the few regions where EU EEI enjoys a structural trade surplus that has been growing over the period under investigation. **Public policies and corporate strategies should be pursued to fully exploit these markets' opportunities.**.

4.2.3 Perspectives for the Middle East and North African markets (MENA)

The Middle East and North Africa[215] (MENA) is an economically heterogenous region that consists of oil-rich economies in the Gulf as well as of resource limited countries like Egypt, Morocco and

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213 http://www.gtai.de/GTAI/Navigation/DE/Trade/maerkte,did=780940.html (2013).
214 http://www.zvei.org/MaerkteRecht/Aussenwirtschaft/Seiten/Infrakstruktur-in-Russland-wird-ausgebaut.aspx
215 The Mena Region includes: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, West Bank and Gaza, Yemen.

Yemen. Today, 70 % of world oil reserves lie in the MENA Region. Despite the rich oil and gas reserves of the region, 23 % of the 300 million inhabitants are living on less than $ 2 a day.

More than two years after the start of the Arab Spring in January 2011, the political and economic situation for much of the MENA countries remains fragile. The call for secularity, freedom and the end of authoritarianism in Tunisia and Egypt spread to other countries in the region and has led to instability and unrest. Within MENA those countries without oil and gas are confronted with serious economic challenges: A growing population that has to be fed by imported food, a negative current account and a lack of foreign exchange. Moreover, markets do not function satisfyingly, caused by corruption, a lack of accountability and transparency. This hampers economic development, foreign investment and explains high unemployment rates, especially among the younger generation. As long as these challenges remain unsolved, emigration is expected to continue.[216]

The EU has strengthened the economic and political cooperation with the southern and eastern Mediterranean states: Numerous association agreements and negotiations concerning a free trade agreement are the most important steps in this process.[217] MENA has become an important trade partner of the EU. The share of total EU EEI exports to MENA amounts to 13.3 % on average for 2010 to 2012 after 13.1 % for the for the early years of the period under investigation from 1998 to 2000. The EU-27 exports increased at an average annual rate of 6.3 % p.a. up to € 13.9 billion. The EU EEI imports grew slightly faster, from on average € 1.8 billion for the years 1998 to 2000 up to € 4.7 billion on average for 2010 to 2012,increasing at a rate of 7.1 %. Like Russia, MENA is one of the few regions where the EU EEI achieves a trade surplus.

As in Russia there is strong long-term demand for power generation, transmission and distribution stations. According to the Arab Union of Electricity (AUE) there will be an increase of power generation capacity from currently 150 GW to 215 GW in 2015 and 280 GW in 2020, which equals an increase of capacities by more than 80 %. The annual energy production of the Arab countries is expected to rise by 100 % up to 1.843.280 GWh.

By 2020, the United Arab Emirates aim to build four nuclear power stations valued at € 15 billion (US $ 20.4 billion) each with a capacity of 1400 MW. Other countries such as Kuwait, Bahrain, Jordan and Egypt also consider establishing nuclear power stations. Furthermore, the expansion of renewable energies is at the top of the Arabic agenda. Almost all Arabic countries are involved in solar energy.[218]

There is growing investment in concentrated solar power (CSP) generation plants worldwide. Until recent years, they were especially built in Southern Europe and the USA, although North Africa and the Middle East offer high potential for this technology. According to a report of the Fraunhofer Society the region is expected to benefit economically from a heavy investment in this technology. European plant developers and equipment manufacturers show much interest in engaging in North Africa and the Middle East.

[216] http://www.oecd.org/mena/49036903.pdf
[217] http://www.bdi.eu/Nordafrika-und-Mittlerer-Osten.htm
[218] http://www.gtai.de/GTAI/Navigation/DE/Trade/maerkte,did=71490.html (2010).

Table 4.16: Forecasted power generation and available capacities of Arab countries

	Expected Power Generation (in GWh)			Forecast for power generation capacities (in MW)		
Country	2010	2015	2020	2010	2015	2020
Egypt	137,569	185,047	244,702	21,650	28,897	37,902
Algeria	43,650	60,944	85,015	7,870	10,929	15,241
Bahrain	13,243	22,226	29,695	2,580	4,330	5,800
Iraq	125,000	226,000	365,000	14,800	22,500	37,600
Yemen	7,698	10,067	10,687	1,186	1,551	1,647
Jordan	15,408	20,918	28,616	2,423	3,297	4,499
Qatar	k,A,	k,A,	k,A,	k,A,	k,A,	k,A,
Kuwait	57,472	89,106	105,088	10,719	16,763	19,755
Lebanon	12,325	14,995	18,244	2,360	2,871	3,493
Libya	36,477	75,978	90,263	6,929	12,472	14,991
Morocco	25,968	35,751	50,142	4,305	5,992	8,359
Oman	15,844	22,621	31,313	3,371	4,742	6,580
Palestine Area	4,072	5,054	6,657	845	989	1,261
Saudi-Arabia	239,404	327,662	394,623	42,491	53,942	61,966
Sudan	9,000	33,368	47,376	2,762	6,926	9,325
Syria	43,075	55,000	70,300	7,670	10,700	13,270
Tunisia	14,590	19,110	22,940	2,740	3,660	4,380
UAE	92,277	154,121	242,619	16,210	25,169	35,399
Total	**893,072**	**1,357,968**	**1,843,280**	**150,911**	**215,730**	**281,468**

Source: Arab Union of Electricity (AUE), Bundesverband der Deutschen Industrie (BDI)

The report of the Fraunhofer Society was prepared for the Clean Technology Fund of the World Bank which aims at fostering the development of CSP stations in the Middle East and North Africa. The investigation in five of the countries (Egypt, Algeria, Jordan, Morocco and Tunisia) shows that the success and also the acceptance of CSP stations significantly depend on the integration and participation of the local manufacturers. Furthermore, the manufacture of CSP stations in the MENA region are expected to account for an average local value added up to 60 %. Up to 2025, between 60000 and 80000 workplaces could be created. The European plant developers and component suppliers expect enormous medium-term growth opportunities in this market.[219]

When the idea of producing electricity in the deserts of the Middle East and North Africa appeared in 2009, the participants of the so called “Desertec” were convinced of the success of this project. Hardly three years had passed when two German (Bosch and Siemens) companies withdrew their

[219] http://www.isi.fraunhofer.de/isi-de/e/projekte/csp-manufacturing_314978_mr.php

participation. Recently, the co-founder Desertec has also dropped out of the project, complaining about companies not operating in line with its principles of maximum environmental compatibility and local value added. But there are also other reasons for the exits: Investors are said to be fed-up with internal quarrels regarding the aim and the strategy to be followed. In addition, major global events have negatively affected the plans: The Arab spring as well as the global financial crisis seriously damaged the project. Furthermore, the turnaround in energy policy in Germany turned out to be counterproductive. The boom in green electricity is expected to satisfy the electricity need in Europe, so that the electricity produced by Desertec is no longer economically feasible.[220]

Although MENA experienced high economic growth during the last decade, the lack of a dynamic private sector prevented the participation of broad parts of the population in the development. Non-functioning markets, skill mismatches and the crowding out of private enterprises by state-owned enterprises (SOE) are among the factors which cause this deficiency.[221] Empowering people to improve the quality of their lives is an important strategy for fighting poverty.[222] **In line with a young and growing population the long-term growth potential of the region is – in principle - promising. However, major, political reforms are necessary to trigger the wealth creating evolution.**

4.3 Technological competition

This chapter comprises two different sections. The first one tackles the performance of the EU-27 and competing economies in the area of international technological competition based on statistics made available by the US and the EU patent offices, USTPO and EPO. The second section provides qualitative insights in areas of technologies that are perceived to be of crucial importance to meet future challenges. In this respect public policies are discussed that are dedicated to spur technological progress.

4.3.1 Patent analyses

Data availability and limitations

Patents are an important indicator of technological inventiveness, demonstrating a company's or sector's ability to transform R&D activities into technological inventions[223]. Patents may, in turn, lead to wealth-generating innovations introduced on the market and commercialized. Patent data allow us to make international comparisons with regard to the technological ingenuity in a certain industry or sector.

From Eurostat we have the following data available:

- Number of **patent applications to the EPO** *(European Patent Office) by priority year at the national level by sector of economic activity (NACE Rev. 1 class derived through concordance with IPC) from 1990 - 2009*. Using this data, we have calculated the number of EPO patent applications in the EU-27 and competing countries (United States, Brazil,

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220 http://www.sueddeutsche.de/wirtschaft/erneuerbare-energien-desertec-stiftung-steigt-aus-wuestenstrom-projekt-aus-1.1709378, (30 June 2013). http://www.faz.net/aktuell/wirtschaft/unternehmen/nach-dem-ausstieg-der-desertec-stiftung-die-industrie-steht-zu-desertec-12267507.html; (1 July 2013). http://www.stern.de/wirtschaft/news/oekostrom-aus-der-wueste-projekt-desertec-steht-auf-der-kippe-2032494.html; (1 July 2013).

221 http://www.oecd.org/mena/49036903.pdf

222 http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/MENAEXT/0,,menuPK:247619~pagePK:146748~piPK:146812~theSitePK:256299,00.html

223 Patent largely correspond to technological inventions, even though non-technological inventions such as new software or business models can be patented in the American patent system (USPTO).

China, Japan, South Korea, Taiwan and India) for the EEI industry as a whole as well as for each of its 3 sectors.

- Number of **patents granted by the USPTO** *(US Patent and Trademark Office) by priority year at the national level by NACE (Rev. 1) sector of activity*, which has allowed us to compute the number of USPTO patents granted in the EU-27 and competing countries for the EEI industry and its sectors from *1990 - 2006*.

However, patent statistics also demand a number of caveats, which need to be taken into account when interpreting the data:

- First of all, *companies' IPR strategies* can alter or distort patent data. For example, in the beginning of the 1990's, some EU and US multinationals used a very offensive IPR strategy (often qualified in the literature as "minefield strategy"), according to which large numbers of patents were filed around important 'technological crossroads' to obstruct competitors' technological progress. This led to an artificially high number of patents during that period, and arguably to an overstatement of these companies' degree of technological inventiveness. Inversely, some companies often prefer a strategy of secrecy where they do not apply for patents for valuable new inventions, as the information in the patent becomes public. Also, patent applications are often too expensive or create too much of an administrative burden for smaller companies. This in turn causes an artificial understatement of their actual state of technological creativity. Finally, secrecy strategies also impact upon the type of technological invention: for incremental and process innovations, patents can be counterproductive, because it is very difficult to identify non-authorized applications. In radical product innovations, in particular in consumer goods, non-authorized use is much more difficult 'to hide'; therefore patents are indispensable.
- Secondly, due to the *"home market bias"* we need to be careful when making an international comparison of the number of patent applications/granted at a certain patent office. If we compare the number of EU-27 patent applications to the EPO to the number of US patent applications to the EPO, the EU-27 will have a "home market advantage", as US companies are primarily oriented towards their home market and will therefore most likely apply first for patents to the USPTO, and eventually at a later stage to the EPO. Due to this home market bias, the EU-27 will score better than the US with regard to the patent applications to the EPO.
- In order to correct for this "home market bias", we will investigate also the number of EU patent applications to the USPTO. However, in Eurostat we only have data on the number of patents *granted* by the USPTO. This complicates any comparison between the number of patent <u>applications</u> to the EPO and the number of patents <u>granted</u> by the USPTO as patents granted are situated "downstream" compared to patent applications. Therefore, when comparing patents granted and patent applications we need to take into account the following issues:
    - o The absolute number of patents granted is always lower than the number of patent applications, as some applications will not be granted.
    - o The time window for comparison is different: given current backlogs at USPTO, it takes at least 2 years before a decision is taken on a patent application, therefore USPTO time series demonstrate an unavoidable time-lag of at least 2 years as compared to their EPO counterpart.

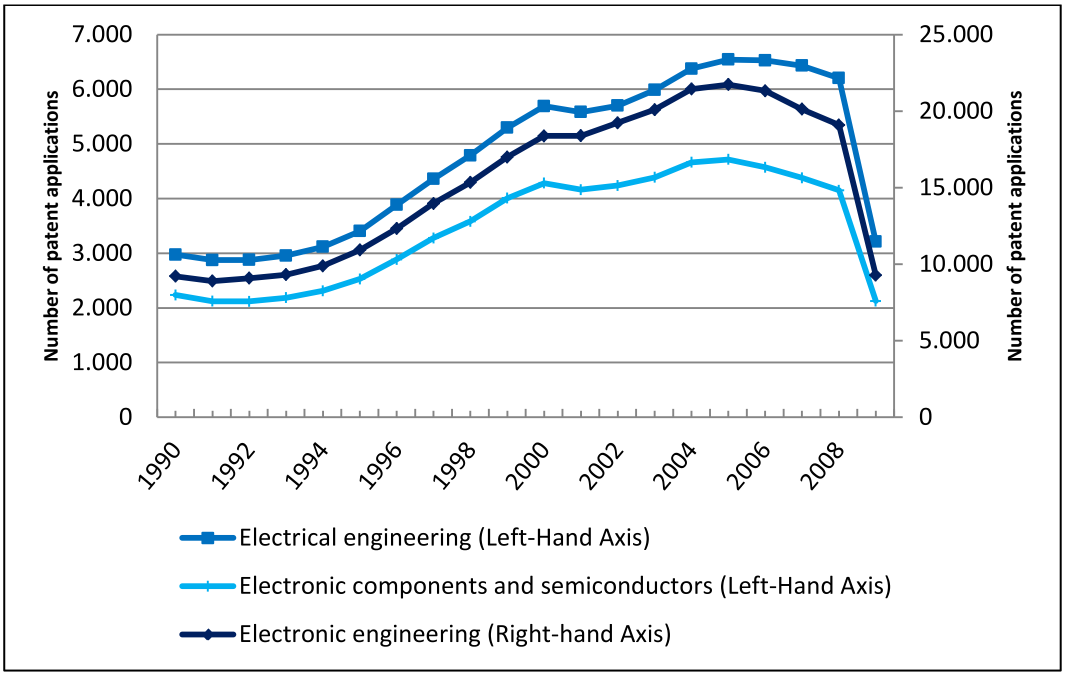
It should also be borne in mind that IPR regulation and scope is slightly different in the US compared to the EU. EPO applications refer almost exclusively to technology, while in the US non-technological inventions such as 'new business methods' can be patented.

We have computed the number of patents in each of the EEI sectors by aggregating the number of patents over the applicable NACE (Rev. 1) sectors. There is no danger of double-counting, as the Eurostat data we use for our computations are constructed on the basis of the methodology which was developed and described by Schmoch[224] et al. (2003). The authors clearly indicate that the patent data can be aggregated for the NACE sector codes that they distinguish, among which are the different EEI NACE sector codes.

Results

Figure 4.1 shows the evolution of the number of patent applications at the EPO in the 3 EEI sectors. Similarly, **Figure 4.2** displays the number of patents granted by the USPTO between 1990 and 2006. Both figures present the total number of patent applications by / patents granted to the EU-27 and the 7 competing countries (Brazil, China, India, Japan, South-Korea, Taiwan, US).

Figure 4.1: Evolution of the total number of patent applications at EPO in competing countries [1)] and EU-27 in the 3 EEI sectors



Remark: the decline of patent applications for the most recent years is caused by the long duration of application procedures.

Source: Eurostat; calculations by IDEA.

[1)] Brazil, China, India, Japan, South-Korea, Taiwan, US.

Firstly, we observe an almost continuous growth in the number of patent applications and granted patents in the EEI industry between 1990 and 2000. However, from the year 2000 onwards, the number of patent applications at the EPO still grew overall, but at a much slower pace, with stagnation or small declines in individual years. Similarly, the number of patents granted by the USPTO stopped growing at the start of the new millennium. This period of zero-growth was followed by a decline in the number of patents both in the patent applications (from 2006 onwards) at the EPO and patents granted at the USPTO (from 2005 onwards). Taking into account the fact that it can take years before a decision is taken on a patent application, the decline in EEI patent

[224] Schmoch U., Laville F., Patel R. & R. Frietsch, 2003, "Linking Technology Areas to Industrial sectors", Final report to the European Commission, DG Research.

applications at the USPTO should already have started at least 2 to 3 years before (from 2003 onwards).[225]

Secondly, in terms of absolute numbers, the patent applications in the EEI at the EPO by the competing countries and the EU-27 amounted up to 32,989 patents at the peak in 2005, the majority of which was applied for in EE2: about 65 % of all EEI patent applications in 2005 was in EE2, 20 % in EE1 and the remaining 15 % in EE3. **Table 4.17** gives an overview of the evolution of the relative shares of the 3 clusters over time in the total number of EPO patents. The data indicate that these shares have been relatively stable over time, with EE3 losing somewhat in importance (minus one percentage point) in favour of mainly EE2.

Table 4.17: Average share of each sector in the total number of patent applications at EPO by the competing countries [1)] and EU-27 between 1990-2009

Sectors of electrical and electronic engineering	1990-1994	1995-1999	2000-2004	2005-2009
Electrical engineering	20.5%	20.2%	19.7%	20.8%
Electronic engineering	64.3%	64.7%	65.6%	65.0%
Electronic components and semiconductors	15.2%	15.1%	14.6%	14.2%

Source: Eurostat

[1)] Brazil, China, India, Japan, South-Korea, Taiwan, US.

Similarly, at the USPTO, 67,657 EEI patents were granted in 2002, of which 65 % in EE2 and 17 % both in EE1 and EE3. The evolution of the shares of each sector in the total number of USPTO patents granted is displayed in **Table 4.18**. From this table it becomes clear that the share of EE1 has declined (by 2 percentage points) in favour of both EE2 (plus 1 percentage point) and EE3 (also plus 1 percentage point). **Figure 4.2** shows that the patenting in the 3 EEI sectors had very similar dynamics, except for the EPO patent applications in the electronic components & semiconductor and EE1s, which were characterized by a small dip in 2001.

The sectoral distribution of patents / patent applications by EPO and USTPO points to a large concordance. Taking into account that for most of the competing economies under investigation EE1 is by far the largest sector, it becomes obvious that research intensity measured by the number of patents / patent applications per output unit that EE1 is much below the average of EEI, whereas EE2 and EE3 are relatively similar to eachother.

Table 4.18: Average share of each sector in the total number of patent applications at EPO by the competing countries [1)] and EU-27 between 1990-2009

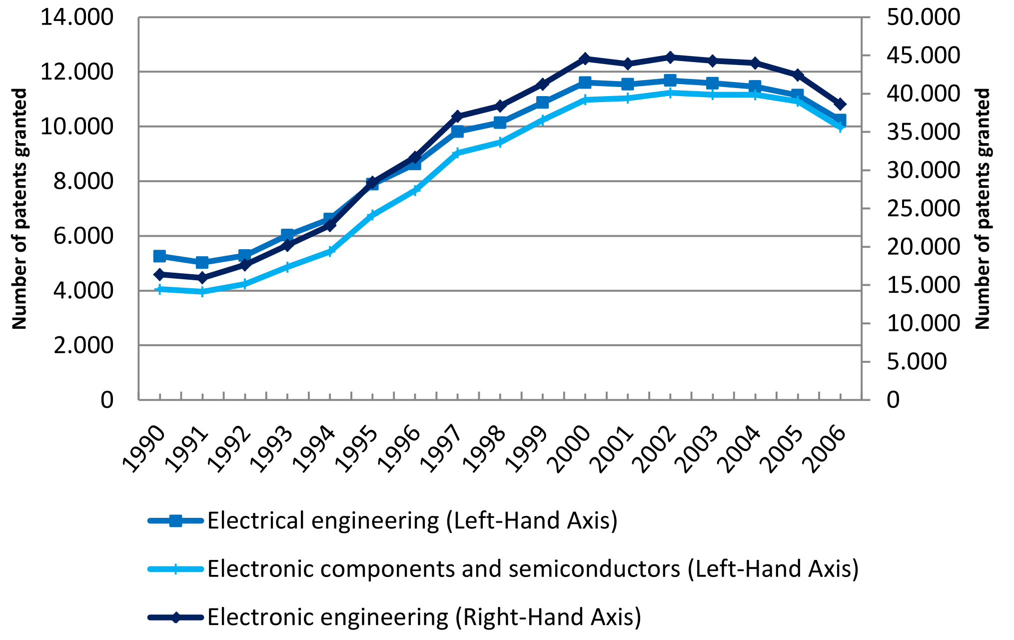
Sectors of electrical and electronic engineering	1990-1995	1996-2001	2002-2006
Electrical engineering	19.5%	17.5%	17.3%
Electronic engineering	64.8%	66.2%	65.9%
Electronic components and semiconductors	15.7%	16.3%	16.8%

Source: Eurostat

1) Brazil, China, India, Japan, South-Korea, Taiwan, US.

[225] The decline at the end of the reported years is above all a statistical phenomenon caused by the long-lasting procedures until patents are granted and patent applications are accepted by patent offices.

Figure 4.2: Evolution of the total number of patents granted at USPTO in competing countries [1)] and EU-27 in the 3 EEI sectors



Remark: the decline of patents for the most recent years is caused by the long duration of application procedures.

Source: Eurostat

[1)] Brazil, China, India, Japan, South-Korea, Taiwan, US.

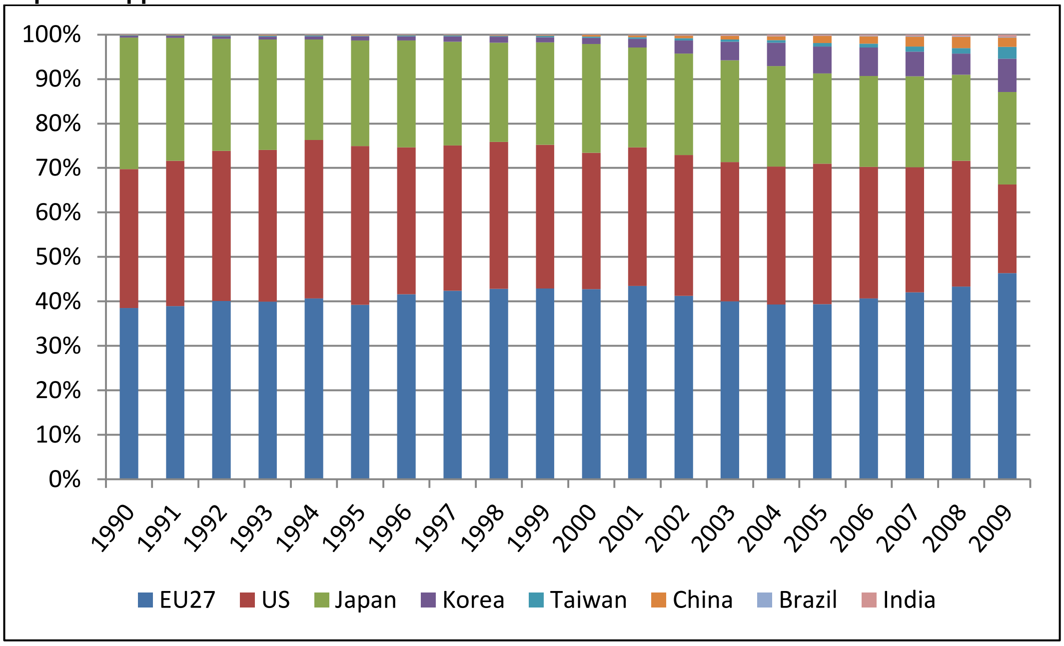
Figure 4.3 and **Figure 4.4** show the evolution of the EU-27 and the competing countries' shares in the total number[226] of patent applications (EPO) and patents granted (USPTO) in the EEI industry. With regard to the patent applications at the EPO, we observe that the EU-27 has maintained its dominant position between 1990 and 2004 and even increased its share from 2005 onwards. In 2009, the EU-27's share in the total number of EEI patent applications amounted to 46 %, compared to 39 % in 1990. In contrast, the US and Japan have lost ground: both countries had a 30 % share in the total number of EPO patent applications in 1990, which declined to a 20 % share in 2009. On the other hand, emerging economies like Korea, Taiwan and China increased their shares markedly: Korea's share increased from 0.3 % to 7.5 % between 1990 and 2009.

When we look at the patents granted by the USPTO, we find that EU-27 has lost ground, with a share that decreased by 4 percentage points between 1990 and 2006. Overall, the US maintained its position in its home market, but it could not sustain the increase in the share it had built up in the second half of the 1990's. Japan's position fell back to a larger extent than the US or the EU, as its share declined by 10 percentage points over the time period under consideration. As was the case for the EPO, Korea, Taiwan and China have increased their shares at the USPTO: again, Korea leads the pack as it increased its contribution of granted patents from 1.3 % in 1990 to 7 % in 2006.

In general, one can say that the EU has better resisted the surge of the rising economies on its own home market (EPO) than the US on their own market (USPTO).

[226] "Total number of patents" refers to the sum of all patents:
- that have been applied for at the EPO by the EU-27 and the 7 competing countries.
- that have been granted by the USPTO to the EU-27 and the 7 competing countries.

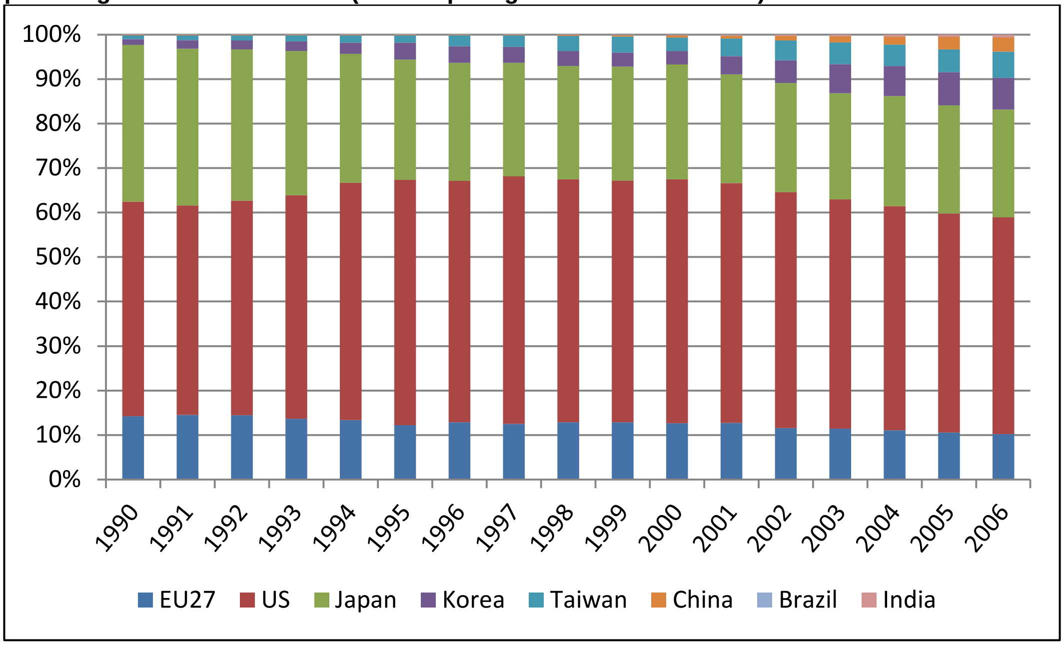
Figure 4.3: EEI industry: Evolution of the share of patent applications in the total number of patent applications at the EPO [1)]



Source: Eurostat; IDEA.

[1)] for competing countries and EU-27.

Figure 4.4: EEI industry: Evolution of the share of patents granted in the total number of patents granted at the USPTO (for competing countries and EU-27)



Source: Eurostat; IDEA.

In **Figure 4.5** we provide an overview of the gross output and value added in EE1, EE2 and EE3, in the EU-27 and the US. We compare these data with the right-hand side of the figure, where we display the total number of patents in each EEI sector that were applied for by the EU-27 at EPO and the total number of patents granted to the US by the USPTO.

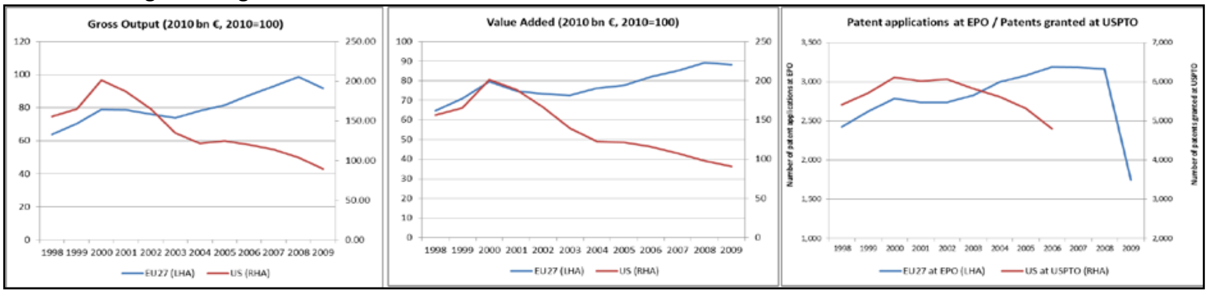
First of all, we see that generally in all 3 sectors, the dynamics in gross output and value added are quite different in the EU and the US. In the EU, there has been an overall increase in gross output and value added between 1998 and 2009, with a peak in 2008. In EE2 and EE3 gross output and value added have doubled between 1998 and 2008 in the EU-27; in EE1 there has also been a general increase, though less markedly than in the other 2 sectors. In the US, gross output and value added have increased between 1998 and 2000, followed by a decline until 2004 that was caused by the New Economy Bubble collapsing. In EE1 this decline was further prolonged, whereas in EE2 and EE3 there was a short recovery.

If we match the gross output and value added data to the patent data, we see that for the EU-27, generally, the number of patent applications at EPO have similar dynamics to the gross output and value added. This is especially the case for EE1 and EE2 and to a lesser extent for EE3. This indicates that the evolution in the number of EEI patent applications in EU-27 at EPO has been supported by the sectorial dynamics in gross output and value added; this is a well-known phenomenon from investigations in other industries.

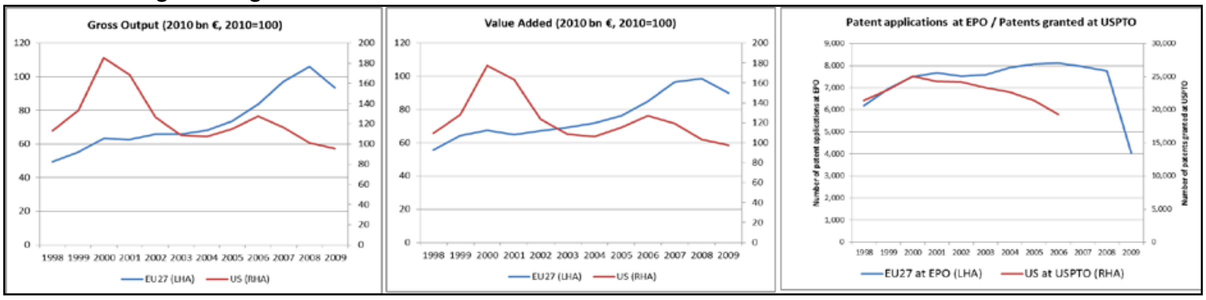
For the US, we find that the number of granted patents has been growing until 2000, followed by stagnation in 2002 and a decline afterwards. We see that the patent dynamics in the US have followed sectorial dynamics in output and value added where there has been a slight "delay" in the decrease of patents granted. This is explained by the fact that patents granted are oriented "downstream" with regard to patent applications and given current backlogs at USPTO, USPTO time series demonstrate an unavoidable time-lag of at least 2 years as compared to patent applications. We can conclude that EEI patent dynamics in both the US and EU-27 have been supported by dynamics in gross output and value added and have not been driven by major changes in patenting intensity.

Figure 4.5: Gross Output and Gross Value Added EE1, EE2 and EE3 in EU27 and US; Total number of EU-27 patent applications [(a)]

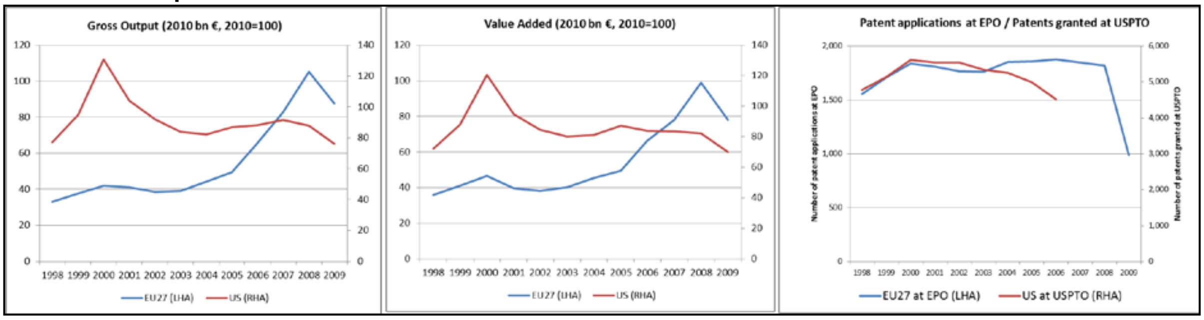
Electrical engineering



Electronic Engineering



Electronic components and semiconductors



Source: Eurostat; EPO; USTPO; CE; calculations by IDEA.
(a) (LHA=Left-Hand Axis; RHA = Right-Hand Axis

Result of EPO patent statistics analysis

Looking at **EE1** we observe that the EPO shares for each country have remained relatively stable, which could be related to the fact that this sub-sector is characterized by more mature technologies. We find that the EU-27 has a dominant position, with a nearly 50 % share. Furthermore, the EU-27 has been able to maintain this position over the last 20 years. The US follows in second place, accounting for 30 % of the EPO electrical engineering patent applications. Japan covers the remaining 20 % share.(**Table 4.19)**

The other two sectors, characterized by less mature technologies, underwent more changes and shifts in shares.

EE2 seems to be indeed more dynamic, with shifting shares and less dominant positions. The EU-27 accounted for 40 % of the EPO patent applications in electronic engineering between 2005 and 2009. It has increased its position by about 3 percentage points between 1990 and 2009. Japan and the US have fallen back by about 6 percentage points over this period, while the emerging economies Korea, China and Taiwan have built up their shares.

Finally, the EU-27 has also enlarged its relative patenting position in the (EPO) **EE3**: between 2005 and 2009, it accounted for 42.6 % of patent applications in the sector. Similarly to EE2, the US and

Japan lost ground, both losing more than 6 percentage points over the period 1990 - 2009. Also here, Korea, China and Taiwan have won ground: especially Korea has expanded its position, from 0.5 % to nearly 7 % between 1990 and 2009.

To conclude, we find that the EU-27 companies in EE1 managed to continue their dominant position in their home market, showing no significant shifts among competitor countries. In EE2 and EE3, Asian countries like Korea and Taiwan are on the rise: these competitors are constantly gaining innovativeness and substitute for Japanese and US patents in recent years. Although one has to take into account that for patent applications at EPO, EU companies possess a home field advantage the slight increases in the shares of patent application for EE2 and EE3 supports the assumption that in spite of growing competitive pressure and some losses in global market the EU position in R&D has remained strong and the pace of technological progress in these areas has not slowed down.

Table 4.19: Average percentage shares of patent applications in the total number of patent applications at the EPO, per sector in percent

	Electrical Engineering				Electronic Engineering				Electronic components and semiconductors			
	1990 - 1994	1995-1999	2000-2004	2005-2009	1990-1994	1995-1999	2000-2004	2005-2009	1990-1994	1995-1999	2000-2004	2005-2009
Brazil	0.07	0.08	0.08	0.08	0.05	0.07	0.08	0.11	0.04	0.05	0.07	0.10
China	0.13	0.14	0.14	0.14	0.11	0.14	0.60	2.07	0.11	0.14	0.66	2.29
EU27	48.65	48.66	49.07	49.42	36.85	39.23	39.30	39.82	39.33	42.21	41.61	42.61
India	0.02	0.02	0.03	0.03	0.02	0.05	0.18	0.35	0.01	0.04	0.18	0.36
Japan	20.87	20.22	19.86	19.81	26.98	23.72	23.06	20.36	28.39	25.66	25.25	21.97
Korea	0.42	0.53	0.61	0.69	0.58	1.22	3.28	6.32	0.58	1.14	3.41	6.75
Taiwan	0.26	0.25	0.24	0.22	0.18	0.18	0.43	1.31	0.22	0.23	0.48	1.49
US	29.57	30.10	29.97	29.61	35.23	35.40	33.07	29.64	31.31	30.53	28.35	24.43

Source: Eurostat

Table 4.20: Average percentage shares of patents relative to the total number of patents granted at the USPTO, per sector

Sector	**Electrical Engineering**			**Electronic Engineering**			**Electronic components and semiconductors**		
Year / Region	**1990-1995**	**1996-2001**	**2002-2006**	**1990-1995**	**1996-2001**	**2002-2006**	**1990-1995**	**1996-2001**	**2002-2006**
Brazil	0.06%	0.06%	0.06%	0.04%	0.04%	0.04%	0.03%	0.03%	0.03%
China	0.12%	0.40%	2.15%	0.10%	0.29%	1.95%	0.10%	0.36%	2.20%
EU27	16.69%	15.78%	13.40%	13.06%	12.13%	10.48%	12.97%	12.00%	10.40%
India	0.02%	0.08%	0.31%	0.02%	0.10%	0.49%	0.02%	0.09%	0.40%
Japan	26.84%	23.79%	23.17%	32.87%	25.33%	24.29%	35.80%	28.23%	25.64%
Korea	1.79%	2.91%	5.98%	2.33%	3.46%	6.42%	2.80%	4.23%	7.99%
Taiwan	1.69%	3.78%	5.73%	1.10%	2.70%	4.54%	1.55%	4.37%	6.21%
US	52.79%	53.20%	49.21%	50.48%	55.94%	51.80%	46.73%	50.69%	47.11%

Source: Eurostat

Result of USPTO patent statistics analysis

The relative EU-27 / country shares in the patents granted at the USPTO are displayed in **Table 4.20**. Starting with **EE1**, we see that this sector is more dynamic than in the EU and that the US, Japan and EU-27 have all lost ground, which has been "won" by the emerging economies Korea, Taiwan and China. The US accounted for 50 % of all granted patents in the sector between 2002 and 2006, followed by Japan with 23 % and the EU-27 with 13 %. Korea alone took up 6 % of all patents granted in the sector.

In **EE2**, we notice a similar evolution. However, in this sector, we observe that the US has been able to maintain its technological position, taking up 50 % of the patents granted between 2002 and 2006, whereas the EU-27 and Japan have been characterized by declining shares. In the second half of the 1990s, the US increased its share by 5 percentage points but it lost this ground again between 2002 and 2006, resulting in a share which is at the same level as at the beginning of the 1990's. Japan lost 6 percentage points between 1990 and 2006 while the EU-27 lost about 2.5. Again, Korea and Taiwan gained ground in this sector.

Finally, **EE3** data indicate that the EU-27 lost about 2.5 percentage points share in the total number of patents granted by the USPTO. The US has maintained and reinforced its dominant position, but similar to EE2, it could not maintain its increased share: the US built up its share from 47 % to 51 % between 1990 and 2001, but lost this ground again afterwards. Like the other EEI sectors, Japan lost heavily, with a 10 % decline in its share. In contrast, the emerging economies, Korea, Taiwan and China, all increased their shares, taking up 16 % of all USPTO patents granted in the sector between 2002 and 2006.

The EU-27 electrical engineering sector, which has a strong innovative position in terms of EPO patent applications and is regarded as EU-27 EEI's powerhouse, actually performs quite poorly outside the EU (in terms of USPTO patents granted). The EU-27's share in USPTO EE1 patents is 10 percentage points lower compared to Japan, and it declined over the period under investigation. This questions the long-term innovation potential of EU-27 EE1 outside the EU as well as its world-wide competitive position. EE1 is the only sector of EEI that commands a trade surplus and is perceived as competitive in global markets. The reduced share of patents for EU companies might be caused by growing high-tech competition from emerging economies and not by a fading interest in global markets, but it still indicates a growing headwind in the sector that experienced a better employment record than EE2 and EE3.

In EE2 and EE3, the EU-27's relative position in comparison to Japan and the US was analogous to that in EE1, but at a much lower level, indicating a challenge to its position in the international leading edge technology competition. In all 3 sectors, the EU-27 has lost ground to the emerging economies Korea, Taiwan and China. Moreover, to the fact should be highlighted that the US – the global powerhouse of innovation in the sectors EE2 and EE3 has lost some of its former importance in the most recent years reported both at USPTO, its home field patent office, as well as in the EU at EPO.

4.3.2 Technology areas

In the following, areas for the application of technologies are presented that are perceived as important by policymakers to meet societal challenges and / or are expected to develop strongly in the future. These areas of technologies are closely related to EEI and could provide growth stimuli. In this context, later on public policies are discussed that are dedicated to further the pace of innovation.

Electro-mobility technologies

Light weight construction

A particular technology area that holds great potential for savings of vehicle weight and reduced CO2 emissions is the area of **carbon fiber reinforced plastics (CFRP)** in manufacturing of automobile bodies. This kind of light and rigid material is a promising technology to solve many problems of the future of the automobile OEMs, especially with regard to reduced vehicle weight. It is planned to incorporate this technology in electric cars, especially BMW's upcoming i3 is made of CFRP. But also other automobile OEMs are testing the material. One of its main challenges is still in the automation for cost-effective implementation of high volume. The once very high price of up to 3,000 Euros per kilogram of fiber already decreased significantly due to technological progress. Today standard fibers are around 15 to 20 Euros.

European manufacturers are the leaders in this segment. The Wiesbaden SGL Group, for example, is one of the worldwide leading manufacturers of carbon-based products. Moreover, it is currently is the major European producer of carbon fibers that recently built a joint venture with BMW for carbon fibers on the US West Coast and is in contact with several other automobile OEMs. International competitors are the US Morgan Crucible and the Japanese Toyo Tanso, which are engaged in the production of carbon fiber composites and serve as suppliers to the automotive industry.

Batteries

In recent years many advances have been made in **battery technology**. Continued improvement of specific electrochemical systems and the development of new battery chemistries have led to great progress. Research and development for secondary batteries is very much driven by the automotive industry. As key technology of electro-mobility, the development and production of high energy density batteries is the decisive issue. Although there are global strong R&D efforts to further improve technologies for batteries and accumulators, no breakthrough progress has been made to overcome the drawbacks of batteries for electro-mobility. Considering the different technologies, lithium-based batteries are regarded to offer the greatest potential. [227]

The European automotive industry needs to make much progress in the development of the key technology of storage batteries to keep up with international competition. Although Japan still holds the leading position in the global automotive Lithium ion battery market, according to a forecast by Roland Berger about 70 % of the market will be dominated by five players: AESC (20 %; JP), followed by LG Chem (15 %, KR), Panasonic Sanyo (13 % JP), A123[228] (11 %; USA) and SB LiMotive (9 %; GER / KR). To make way for a serial production of suitable batteries of electric cars in Europe, strategic alliances are forged with companies along the supply chain to develop efficient and competitive energy storage technology. Several car manufacturers co-operate with companies of the battery industry, like Tesla and Panasonic. A more detailed assessment of the competitive situation of batteries in Europe is found under 2.1.5 Accumulators and Batteries.

Electric motors

In case of **electric motors,** especially manufacturers in mature EU Member States have gained an ever growing share of value added from this category as described in 2.1.2 Electrical motors, generators and transformers. Main drivers of technological development are seen in the industry and its applications, such as machining and moving of parts, driving chemical processes. Further advances are expected to occur by other applications in transports and logistics, moving goods and passenger on conveyors, escalators, etc. Servo-motors have gained importance in the course of the past decades with growing automation of processes and efforts to ease the use for consumers for instance in automobiles.

Important automobile players engaged in the production of electric cars and the development of appropriate electric motors and/or hybrid engines are found in Europe (e.g. Mercedes, BMW, and

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[227] Fraunhofer Institut (2012).

[228] Acquired by Johnson Controls in 2012.

Fiat) as well as in Asia (e.g. Toyota, Nissan, Honda, and Mitsubishi) and the US (e.g. Ford, Chevrolet, and Tesla). At least so far, Toyota is the only manufacturer who has taken the (Prius III) development into its own hands, while other OEMs usually obtain electric motors or hybrid engines from specific suppliers. Mercedes, for example, gets the E-400 hybrid engine for the Mercedes S Class from its German supplier ZF-Sachs and for the Smart ED with pure electric drive from the British Zytek. This opens great potentials for diversified suppliers as they have the opportunity to distinguish themselves in the field of electric motors.

Semiconductor technologies

As outlined in the semiconductor section in 2.3.1 Electronic components, the **semiconductor technology** can be broken down into the four major component families, which are integrated circuits (used in almost all electronic equipment), discrete (diodes, power transistors, rectifiers, etc.), opto (displays, lamps, laser transmitters, infrared devices, etc.) and sensors. The European share of the global production of SC fell from 14% in 1998 to less than 10% in 2011. Even worse, EU-27 exports of semiconductors plunged from about one tenth of global trade at the beginning of the period under consideration to less than one twentieth during the more recent years. A bright spot – as compared to other sub-sectors – was the development of labour productivity at an annual average rate of 8.0 % over the whole period. However, as compared with the other competing economies this pace of improvement was in the range of the most important competing economies.

Another important area of semiconductor technologies devices is in **lighting equipment**, whereas the state of technology and the rate of progress differ strongly between light sources. The incandescent filament light bulb is a mature technology and will be further replaced by more efficient and environmentally friendly technologies, such as LFL or HID. These technologies are already well established and technological progress has become evolutionary. The SSL technology is in an early stage and the **energy savings** potential is enormous.

The initial step for the manufacture of a SSL source is to pull a single crystal based on – in most cases – sapphire, in contrast to silicon predominantly applied in ICT components. Production is capital and energy intensive. Qualified staff is required. As compared with ICT the starting material is much more expensive and the single crystal is smaller. This step is followed by cutting it into wafers and by depositing epitaxial layers in a Metal-Organic Chemical Vapor Deposition (MOCVD) process. This procedure is, with regard to know-how, the key process for the production of LEDs. After further operations including the application of contacts the wafer is diced into chips that are encapsulated for protection.

This overall upstream manufacturing process is crucial. Capital intensity, product and process know-how are decisive for the branch to stay on the leading edge of technology. In this area Asian economies have benefitted from their focus on the production of ICT products. With backlighting, Asian companies have gained first mover advantages and can count on spin-offs and spill-overs from the manufacture of semiconductors for the ICT industry. Progress in SSL technology has led to a widened range of applications. These days nearly all areas of lighting can be covered, limitations exist primarily due to high investment expenditure. However, large batch-production will allow for the exploitation of scale effects and accelerate dissemination of LED lighting.

In the area of light control and control systems Europe is on the leading edge of technology. The SSL technology requires high-performance controls for longevity and full exploitation of opportunities to save energy. This will provide opportunities for midstream companies. However, small players in the value chain are challenged by technological and quality requirements.

Upstream companies are exposed to global competition among large international active groups. Basic research and highly specialized experts on the leading edge of technology are as decisive as good access to funding large investments in tangible and intangible capital. A sound financial performance is crucial because long pay back periods are a challenge for upstream companies. According to the 2010 EU Industrial R&D Investment Scoreboard, the European semiconductor industry is declared Europe's most R&D-intensive industry with a higher R&D intensity compared to other highly R&D-intensive sectors such as biotechnology, software and telecom equipment. The European semiconductor sector also managed to prevail over foreign competitors from the US and Japan in terms of R&D intensity. The scoreboard notes that one reason for this may partly be related to the niches European semiconductor companies are operating in and partly to their size, as smaller companies generate less sales over which to spread the cost of R&D.

Energy storage and infrastructure

Besides the impact of batteries on the success of electro-mobility, high capacity batteries in stationary energy storage solutions offer prospects for an immense market growth as they will be a fundamental part of the total storage solution of renewable energy in the years to come.[229] Renewable energy sources, such as tidal, solar and wind-generated power, produce electricity intermittently and require stationary energy storage systems for a better utilization of power generating capacities. Applications for stationary storage batteries can be categorized in two groups: energy applications, like peak shaving or load levelling, and power applications, like frequency and voltage regulation. There are already many examples of large-scale stationary batteries in the field. The most widespread stationary battery used today is based on lead acid technology.[230]

According to the EU Commission[231] another important area to improve efficiency of alternative power generation is in improving the energy infrastructure. Therefore existing electricity grids and metering should be upgraded by so-called ***smart grids***, which allow for a two-way digital communication between suppliers and consumers, where intelligent metering and monitoring systems have been integrated. As smart grids can manage direct interaction and communication among suppliers and consumers, they provide the possibility to directly control and manage individual consumption and thus an efficient use of energy.

4.4 Labour force and skills

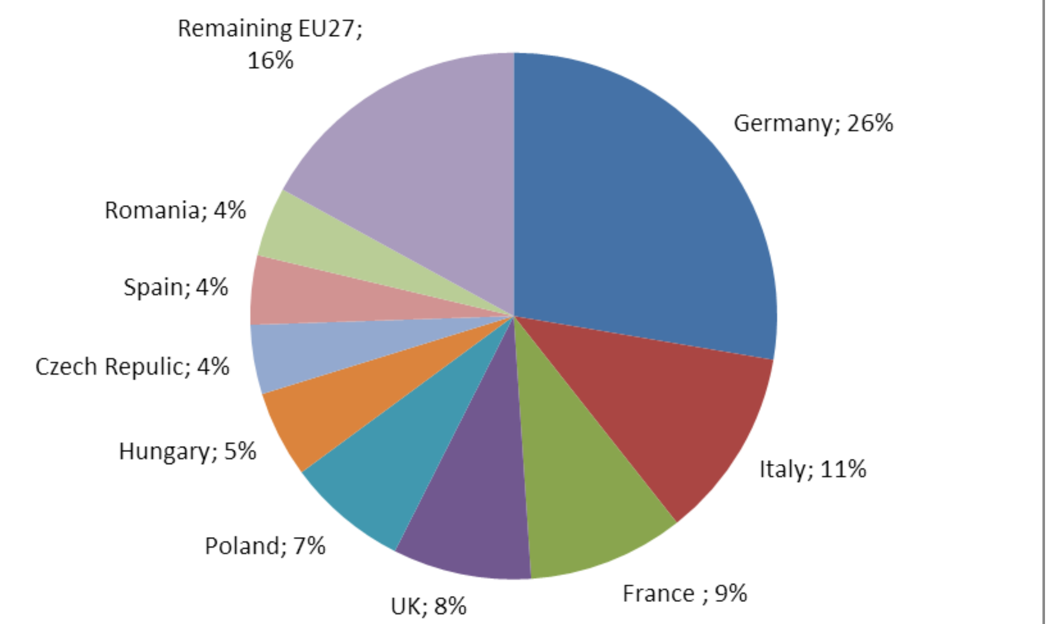
A growing body of literature suggests that competitiveness of enterprises relies critically, not only on access to a skilled and competent workforce, but also on the ability of the enterprises to utilise the skills of the workforce to enhance innovation (Mittelstadt, 2008; European Commission, 2012; Marsden, 2012; Nieuwenhuis, 2010; Shapiro, H. & Andersen, 2012. For example, a recent UK research paper (Mason, G. & Bishop, K., 2010) assesses the impact of the recession on employer-provided training intended to fill identified gaps in adult skills in five different sectors – among them electronics and related engineering – and concludes that unless training levels can be raised for employees at all levels of qualification in these sectors, growth in competitiveness may be hindered by gaps in adult skills.

[229] Fraunhofer Institut (2012). Technologie-Roadmap Energiespeicher für die Elektromobilität 2030.
[230] Batteries used for stationary use and grid storage. Batteryuniversity. http://batteryuniversity.com/learn/article/batteries_for_stationary_grid_storage
[231] COM(2011) 202 final.

4.4.1 The demand side: Current and future employment in the sector

Overall 3.03 million people aged 15 to 74 are currently employed in the electronic and electrical industry in EU 27.[232] Employment in EEI is not evenly distributed among EU's Member States. **Figure 4.6** below shows different Member States' shares in total EEI employment in EU27. As the figure indicates, Germany alone accounts for more than ¼ of the sector's employment, France, Italy and the UK between them for yet another ¼, while the remaining Member States account for less than ½ of employment in the sector.

Figure 4.6: Share of total European employment in Electrical and Electronic Engineering[233], 2011



Source: Eurostat, Labour Force Survey, own calculations

If we want to judge the importance of the sector for national labour markets, however, we have to look at the share of employment in the industry of total employment per country. **Figure 4.7** below shows EEI's share of employment at the national level. This share varies between 0.3 % (Greece) and 3.8 % (Hungary).

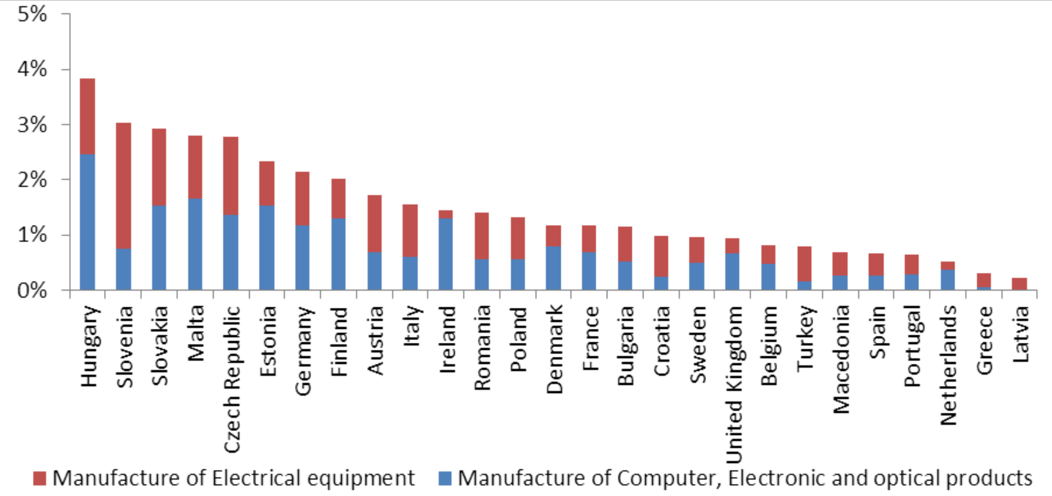
The electrical and electronic engineering sector contributes significantly to national employment in a number of smaller Member States. This is the case in Slovenia, Slovakia and Malta. In these three countries the sector accounts for 3 % or more of total employment. At the other end of the scale, the sector's share of employment is negligible in Greece and Latvia. Across EU27, the EEI sector employs accounts for 1.4 % of total employment[234].

[232] NACE (Rev.2) 2-digit breakdown, 26 & 27. Figure for 2011. Source: Eurostat SBS. This and following figures are from Eurostat unless otherwise referenced.

[233] NACE 26 and NACE 27 combined.

[234] 2011. Eurostat LFS, own calculation. Data from Cyprus, Latvia, Lithuania, and Luxembourg are missing.

Figure 4.7: Employment in Electrical and Electronic Engineering as a share of total employment in EU Member States and candidate countries, 2011

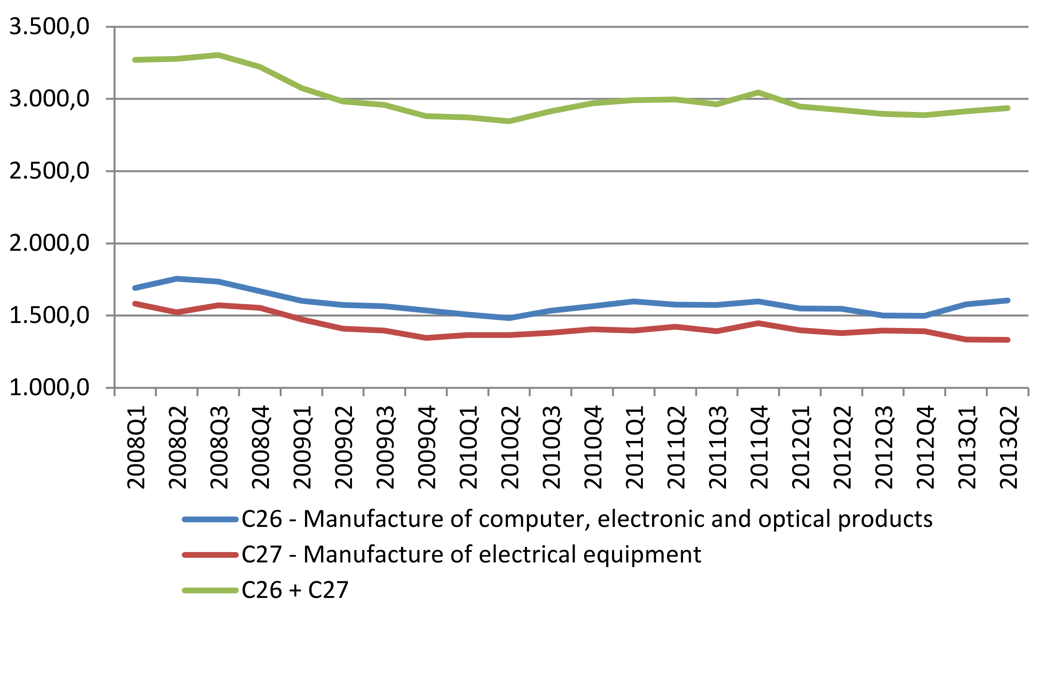


Source: Eurostat, Labour Force Survey, own calculations. Luxembourg, Lithuania, Cyprus are left out due to missing data. For Latvia, only data for electrical equipmen is avalilable.

Trends in employment

Between 2008 and 2012, total employment in EEI in EU-27 decreased by 9.7 %. **Figure 4.8** shows the trend in total employment in EEI in EU27 since 2008.

Figure 4.8: Total employment in Electrical and Electronic Engineering in EU27, thousands[235]



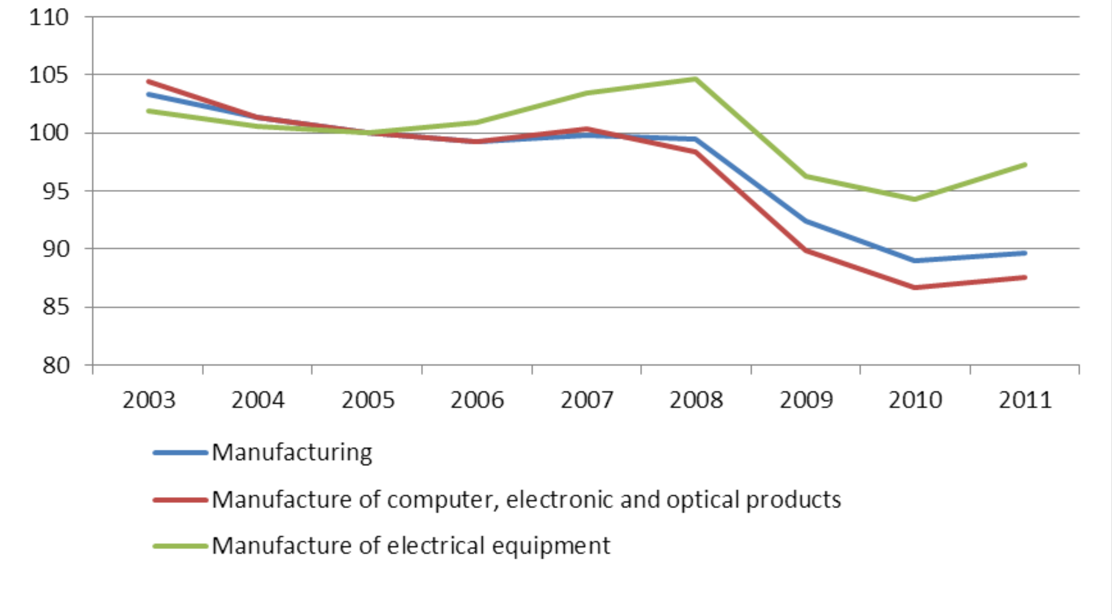
The main loss of workplaces in EEI took place between late 2008 and mid-2010, when employment in EEI in EU27 dipped to 2.85 million following the financial crisis. Subsequently, employment recovered, but has since remained stagnant at a level around 3 million. Further, whereas employment in electrical engineering and electronic engineering displayed parallel fluctuations in

[235] NACE 26, 27 comprise most but not all of EEI as defined in Table 2.1. However, for labour market analyses a definition congruent with EEI is not available.

the years from 2008 to 2012, it appears that the two sectors have recently started diverging: employment in electronic engineering is on the rise, while employment in electrical engineering slightly decreased.

Comparing the development of employment in EEI to the overall development of employment in manufacturing (**Figure 4.9**), EEI employment follows a general trend in employment in manufacturing. However, employment in manufacture of electrical equipment increased from 2005 – 2008 followed by a drop while being on a higher level than both TM and the manufacture of electrical computer, electronic and optimal products.

Figure 4.9: Employment trends in Electrical and Electronic Engineering and total manufacturing, EU27 2005 =100

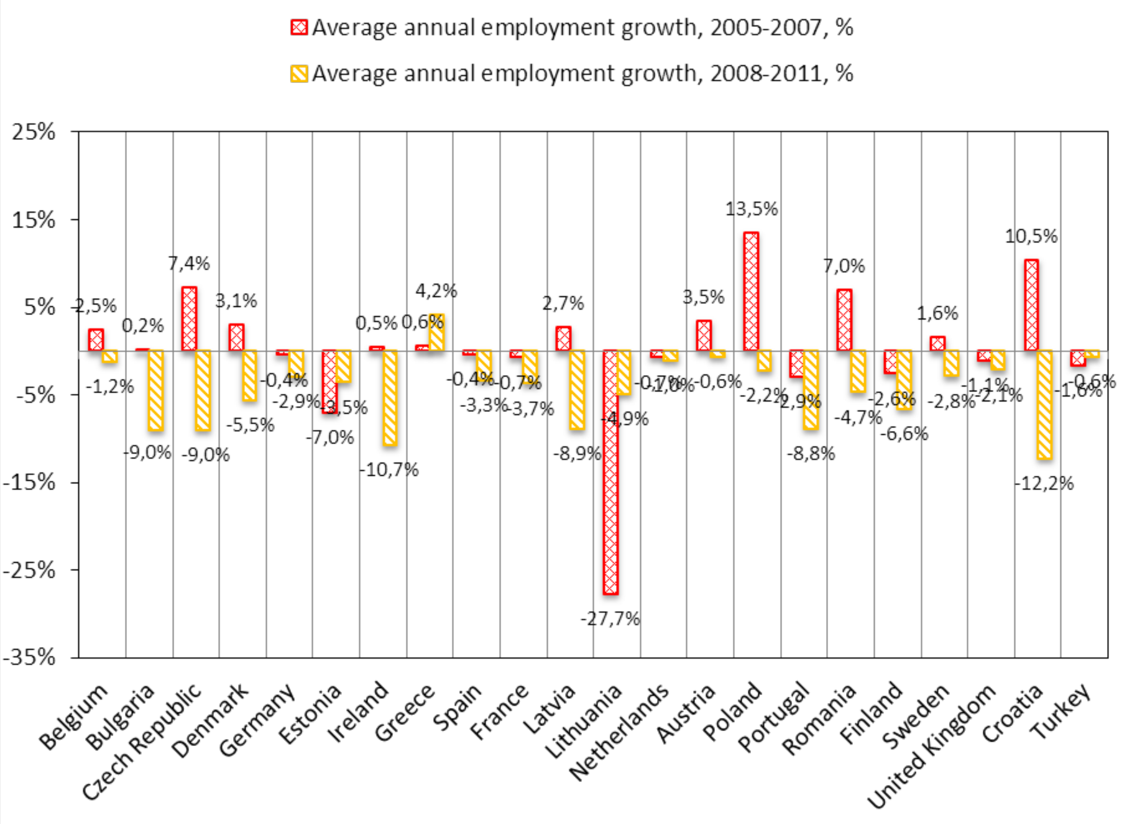


Source: Eurostat, Labour Force Survey, own calculations.

Beneath the overall employment trends in EEI, the situation at national level is much more complex and varied. (**Figure 4.10)** The figure clearly illustrates that there has been a considerable geographical change in the employment in sub sector computer, electronic and optical prior to the crisis. A few countries, notably the Czech Republic, Poland, Romania and Croatia, experienced positive employment growth (more than 5 %) prior to the financial crisis. This growth coincides with a wave of outsourcing of manufacturing operations from the old Member States to this group of countries. In other countries, employment growth was lower (Belgium, Denmark, Latvia and Sweden). Lithuania and Estonia experienced large scale employment losses already before the crisis. These countries are very small, and the closure of one major operation in the sub sector could cause percentage changes of this magnitude.

Following the crisis, all countries except Greece have experienced job losses in the industry. Hence, it can be concluded that job losses in the industry have been strongly affected by the global financial crisis and accelerated the overall downward trend. The recovery was not sufficient to outbalance former layoffs.

Figure 4.10: Average annual employment growth in Manufacture of Computers, electronic and optical products in EU and accession countries



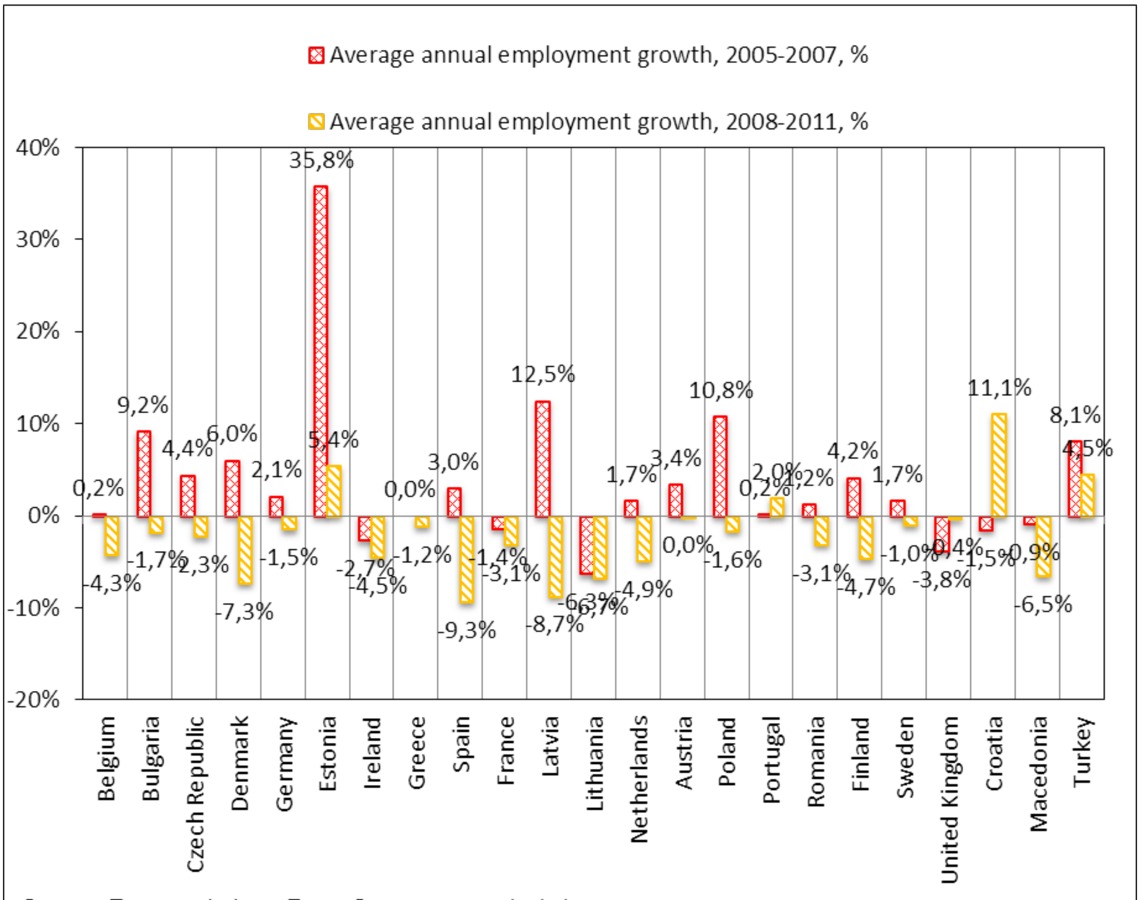
Source: Eurostat, Labour Force Survey, own calculations. Some countries are missing due to break in time series.

The situation in manufacture of electrical equipment

Figure 4.11 shows changes in employment in manufacture of electrical equipment in a number of European countries prior to and after the onset of the financial crisis.

The overall picture is similar: Employment increased prior to the crisis followed by a decline post-2008. Again we see the most positive employment growth rates in countries that have been receivers of outsourced or relocated production facilities (Bulgaria, Estonia, Latvia and Poland, but also Turkey). Of these countries, only Estonia and Turkey have experienced (slightly) positive growth rates after 2008. Once more former levels of employment have not been reached, although the employment record was less negative for the period under consideration between 1998 and 2012. The figures disclose that job losses and creation is quite unevenly distributed across Europe.

Figure 4.11: Average annual employment growth in Manufacture of Electrical equipment in EU and accession countries



Source: Eurostat, Labour Force Survey, own calculations.

Occupational structure and qualifications

According to a recent sector analysis (Alphametrics and Ismeri Europa, 2009), LFS data indicate that the occupational structure in electrical engineering is quite similar to that in electronic engineering.

The coincidence of positive output and negative employment growth is closely linked to an increase in productivity. As we have seen earlier, the EEI sector has experienced a steady growth in productivity. The introduction of automated production methods has facilitated productivity increases in EEI like in all manufacturing industries since the turn of the century. In addition, the increasing modularity of products, especially in electronic engineering, has also contributed to lowering costs associated with assembly, and at the same time decreased the demand for manual workers in such operations. Hence, the productivity growth has been accompanied by a shift in the occupational structure of companies and an upwards shift in the skills and qualifications of the workforce.

The European Skills Panorama[236] presents the results of a major forecasting exercise undertaken by Cedefop (European Centre for the Development of Vocational Training) to project medium-term skill needs and skill supply in Europe[237]. The figures for electrical engineering and instruments and for electronics are presented in **Table 4.21** and **Table 4.22** below.

[236] EU Skills Panorama, http://euskillspanorama.ec.europa.eu/

[237] EU without Bulgaria, Romania and Malta, but including Norway.

Table 4.21: Electrical Engineering & Instruments. Numbers employed (1000s) and anticipated change in numbers employed, 2010-2020 (%), all education levels.

Country	% Change	2000	2010	2020	Replacement Demand 2020, 1000s	Expansion Demand 2020, 1000s
EU27	4	1839	1703	1768	472	65
Latvia	33	3	3	4	1	1
Bulgaria	26	36	38	48	11	10
Lithuania	25	5	4	5	1	1
Spain	18	107	72	85	22	14
Slovakia	11	28	27	30	6	3
Germany	8	503	425	460	137	35
Poland	8	188	239	258	37	19
Hungary	7	63	58	62	12	4
Romania	7	102	199	213	29	14
Czech Republic	4	83	90	94	25	3
Denmark	0	15	10	10	4	0
Greece	0	12	9	9	2	0
Luxembourg	0	2	3	3	1	0
Malta	0	1	1	1	0	0
Slovenia	0	19	19	19	5	0
Finland	-5	17	20	19	5	-1
United Kingdom	-5	169	81	77	32	-4
France	-6	132	85	80	22	-5
Italy	-6	202	196	184	53	-12
Netherlands	-7	23	15	14	4	-1
Sweden	-7	33	27	25	9	-2
Austria	-16	36	43	36	9	-7
Belgium	-16	25	19	16	4	-3
Portugal	-22	29	18	14	4	-4
Ireland	-50	7	2	1	0	-1

Source: EU Skills Panorama, http://euskillspanorama.ec.europa.eu/. Cyprus and Estonia are missing in this table in the EU Skills Panorama. The green colour indicates countries with forecast net growth (the second column) in the sector; no colour indicates a stable or stagnant situation; while the red colour indicates forecast net job losses. As the tables clearly illustrate, the job situation in the sector can be expected to develop very unevenly across Europe.

Table 4.22: Electronics. Numbers employed (1000s) and anticipated change in numbers employed, 2010-2020 (%), all education levels. Source: EU Skills Panorama

Country	% Change	2000	2010	2020	Replacement Demand 2020, 1000s	Expansion Demand 2020, 1000s
EU27	-2	1841	1537	1511	437	-26
Latvia	100	2	1	2	0	1
Hungary	30	84	87	113	18	26
Netherlands	23	58	48	59	14	11
Bulgaria	21	51	39	47	11	9
Estonia	14	7	7	8	2	1
Denmark	11	26	19	21	7	2
France	9	197	137	150	36	13
Romania	7	15	30	32	4	2
Slovakia	5	15	21	22	4	1
Belgium	0	23	14	14	3	0
Czech Republic	0	37	40	40	11	-1
Greece	0	5	4	4	1	1
Germany	-1	417	358	353	117	-5
Finland	-3	46	36	35	9	-1
Austria	-4	31	24	23	5	-1
Ireland	-4	45	25	24	5	-2
Sweden	-7	65	43	40	14	-3
Portugal	-8	15	12	11	3	-1
Spain	-8	86	38	35	11	-3
Italy	-10	150	147	133	41	-14
Poland	-11	158	252	225	40	-26
United Kingdom	-24	282	140	107	55	-34
Lithuania	-25	10	4	3	1	-1
Slovenia	-25	12	8	6	2	-1

Source: EU Skills Panorama, http://euskillspanorama.ec.europa.eu/. Cyprus, Luxembourg and Malta are missing in this table in the EU Skills Panorama.

As the tables clearly illustrate, the job situation in the sector is expected to develop very unevenly across Europe.

Concerning electrical engineering, an overall job growth (+4%) is forecast for 2020.

- Net job growth is forecast in ten Member States, among them Germany, Spain and eight new Member States;
- A stable situation is expected in five small but otherwise quite different countries; and
- Job losses are forecast in ten Member States, including very significant job losses (as concerns volume) in the countries with a large electrical engineering industry, notably
    - the UK and France, but also Italy, Sweden and Austria.

Concerning electronics, overall job losses (-2%) are forecast for 2020

- Net job growth is forecast in a mixed group of nine Member States, among them the Netherlands, Denmark, and France, and six new Member States.
- A stable situation is expected only in Belgium

- Job losses are forecast in fourteen Member States, including again very significant job losses in some of the countries with a large electronic engineering industry, notably Germany, Italy, Poland, and the United Kingdom.

Hence, the direction of the forecast trends for each of the sub-sectors (Electrical engineering and electronic engineering) is exactly opposite to the most recently observed short term trend (see **Figure 4.8**): Employment in electrical engineering is forecast to increase up to 2020, while employment in electronic engineering is forecast to decrease until 2020, and the most recent figures display the opposite. This is probably due to the base time series used for the forecast, which only goes up until 2008. Hence, whilst the forecasts provide information about expected geographical and structural changes in the sector, the exact projected employment figures should be used with care.

The forecasts are broken down by education (three qualifications levels)[238]. In **electrical engineering**, at the low education level, the situation at EU-27 level is expected to remain unchanged, but at national level, the situation varies considerably. Again, job losses are prominent in large Member States with large industries. At the medium level of education, an overall decrease in the number of jobs is forecast (-7 %) across EU-27. Again the forecast job losses are most prominent in the large Member States. Finally, at the high educational levels, a 26 % increase in the number of jobs is forecast, with growth in jobs for this kind of staff in all Member States except Austria, Denmark, and Hungary, where the situation is forecast as unchanged; and Belgium, Portugal, and Sweden, where the number of jobs for the higher educated in Electrical Engineering is expected to decrease.

The forecasts for **electronics engineering** follow a similar trend, however, the expected increase in jobs for those with high education levels is less pronounced: At EU-27 level, the number of this type of jobs is expected to grow by only 7 %. When interpreting these figures, it should be borne in mind that “high education level” includes not only university graduates with a Bachelor’s, Master’s or PhD degree, but also persons with a vocational qualification above upper secondary level, such as the German or Austrian Meister or the Swedish advanced technicians.

Overall, the employment forecasts indicate that the **EEI** sector is undergoing a major restructuring, with **jobs requiring few qualifications moving towards the new Member States and out of Europe entirely**, while **growth** will mostly take place in jobs requiring **advanced qualifications** and skills.

4.4.2 The supply side: Labour force with relevant qualifications

The skill needs of the EEI sector at a given time can be fulfilled by recruiting staff with relevant skills or by upgrading the skills of the existing workforce. As a consequence, both the recruitment base delivered by initial education at all levels and the continuing training system should be geared to delivering the right skills for the sector.

[238] The EU Skills Panorama uses the International Standard Classification of Education, ISCED. The six levels in ISCED are grouped into three, where the low level denotes any education below or at lower secondary education; the medium level encompasses upper secondary education and post-secondary non-tertiary education; and the high level denotes tertiary = higher education. See http://euskillspanorama.ec.europa.eu/Glossary/

Initial education

The European supply of *initial education* at different levels has been studied and documented extensively in recent years,[239] as has the supply of *key competences* (Cattaneo & al., 2009) and STEM skills[240] (BusinessEurope, 2011), (EURYDICE, 2011).

First, there is concern that throughout Europe, the current initial science education in primary and secondary schools does not sufficiently qualify and motivate children to embark on vocational or higher education which can lead to jobs in technology-intensive sectors ((EURYDICE, 2011), (Feani, 2012)).

Second, there is currently increasing political focus on the role of VET systems in delivering a skilled workforce with relevant skills and competences, and in particular the delivery methods that can strengthen the competences of Europe's skilled workforce. In this respect, considerable activities are directed towards the dual vocational education systems of Germany, Austria, the Netherlands and Denmark, where education takes place alternately in the workplace and in vocational schools, and where the social partners play a decisive role in governance of the entire VET system.

From the perspective of the EEI sector there exists a necessity to adjust VET programmes, which are linked up to traditional occupational structures, to new technologies, process and product innovations in a timely manner to meet the challenge of rapid technological changes. A separate, but nonetheless serious, issue is related to the generally low esteem of VET qualifications in most European countries, compared with general academic qualifications. This is a considerable barrier against achieving VET excellence (European Commission, 2012).

As the trends and projections presented above have indicated, in the electrical engineering sector (and to a lesser extent also in the electronic engineering sector), substantial growth in the demand for highly skilled staff is expected. In addition to the statistical figures for labour demand, it should be observed that many of the emerging technologies have direct implications for EEI. This is valid particularly for developments in advanced manufacturing, robotics and in the use of big data. These trends call for highly specialised staff in a number of fields who are able to work across disciplinary barriers.

OECD statistics provide insights into the number of graduates by field of education subdivided according to broad fields of study of the ISCED classification[241]. The development in the number of graduates with relevant qualifications is shown in **Figure 4.12**. It indicates that the number of graduates in the six fields of study increased from 2000 to 2007. Since 2008, stagnation has set in, and in some fields, notably engineering, manufacturing, and construction, computing, and physical sciences, the numbers of graduates are decreasing. This is potentially threatening to the competitiveness of the European EEI sector, as enterprises may have to give up recruiting sufficiently skilled staff or alternatively recruit from abroad.

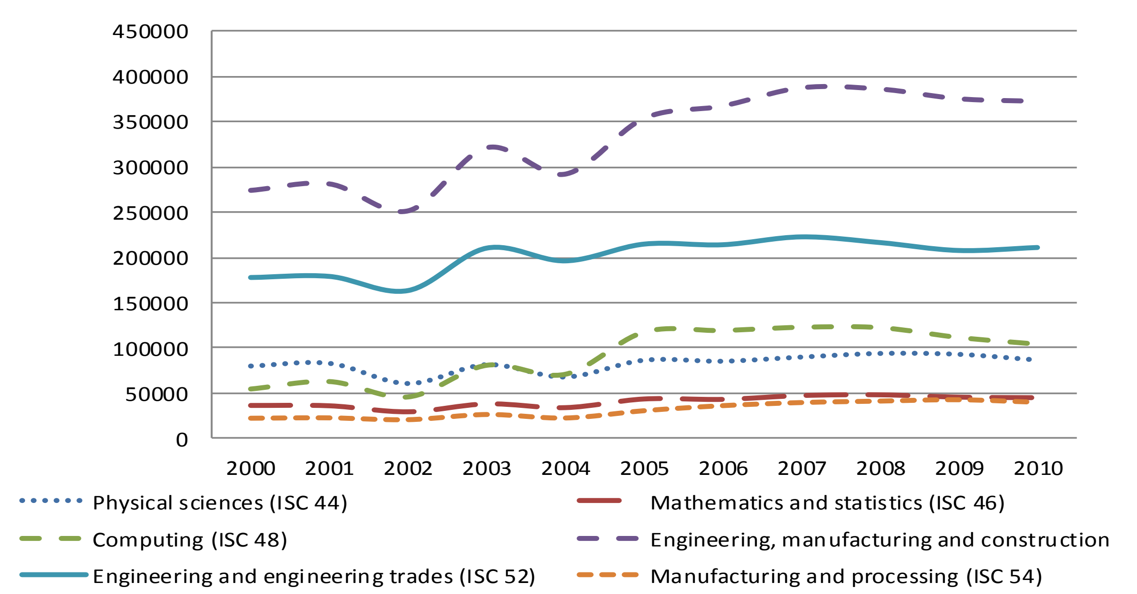
In contrast to the decrease in numbers of graduates with relevant specialisations in the EU, the number of graduates has increased in some of the competing countries, notably Korea, United States and Canada. For the remaining important competing economies no information on this subject is available. (**Figure 4.13**)

[239] In addition to the quoted sources, Cedefop,see: http://www.cedefop.europa.eu/EN/about-cedefop/projects/forecasting-skill-demand-and-supply/forecasting-skill-demand-and-supply.aspx and

[240] Science, Technology, Engineering and Mathematics.

[241] OECD Stats Table: Graduates by field of education. Web link: ttp://stats.oecd.org/index.aspx?r=808997#. For an overview of the ISCED classification, see UNESCO. 2006. International Standard Classification of Education: ISCED-1997. http://www.uis.unesco.org/TEMPLATE/pdf/isced/ISCED_A.pdf

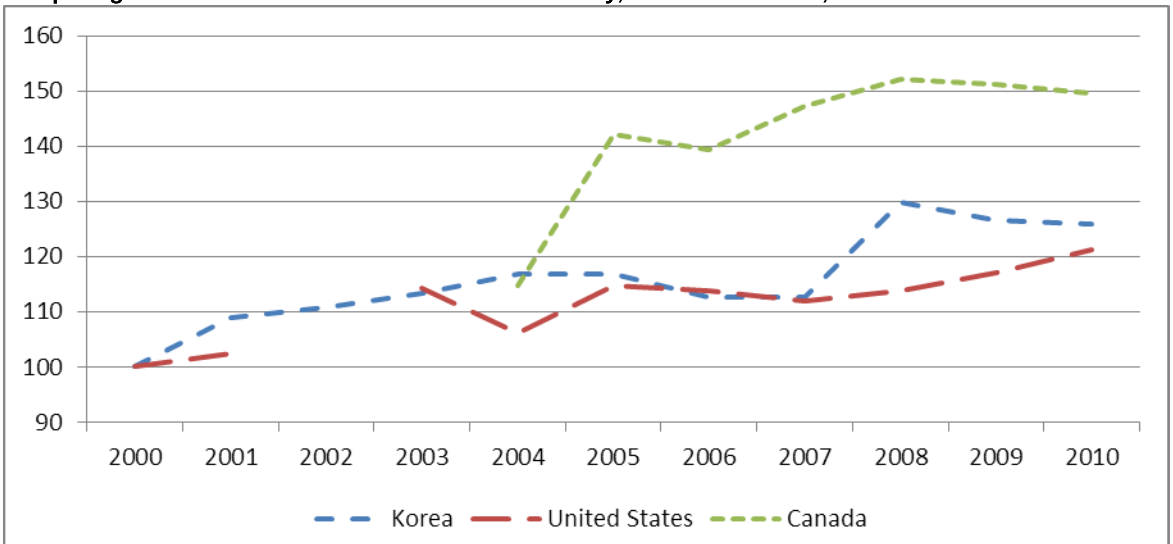
Figure 4.12: The development in the total number of graduates in relevant fields in 21 EU Member States and candidate countries[242] by field of study 2000-2010 [1)]



Source: OECD.stat, own calculation

[1)] ISC 44 to ISC 54 accumulated.

Figure 4.13: The development in the total number of engineering graduates in three competing countries in the six relevant fields of study, 2000-2010. Index, 2000=100[243]



Source: OECD.stat, own calculations. Data missing for the US in 2002.

Training opportunities

Due to the demographic profile of European engineers and the rapid technological changes in the sector, competence development of the workforce is imperative if EEI is to remain competitive. To a certain extent, workplace learning and supplier-driven learning can take care of competence development. However, a number of studies ((Oxford Research, 2005), (Mittelstadt, 2008) (Fuchs,

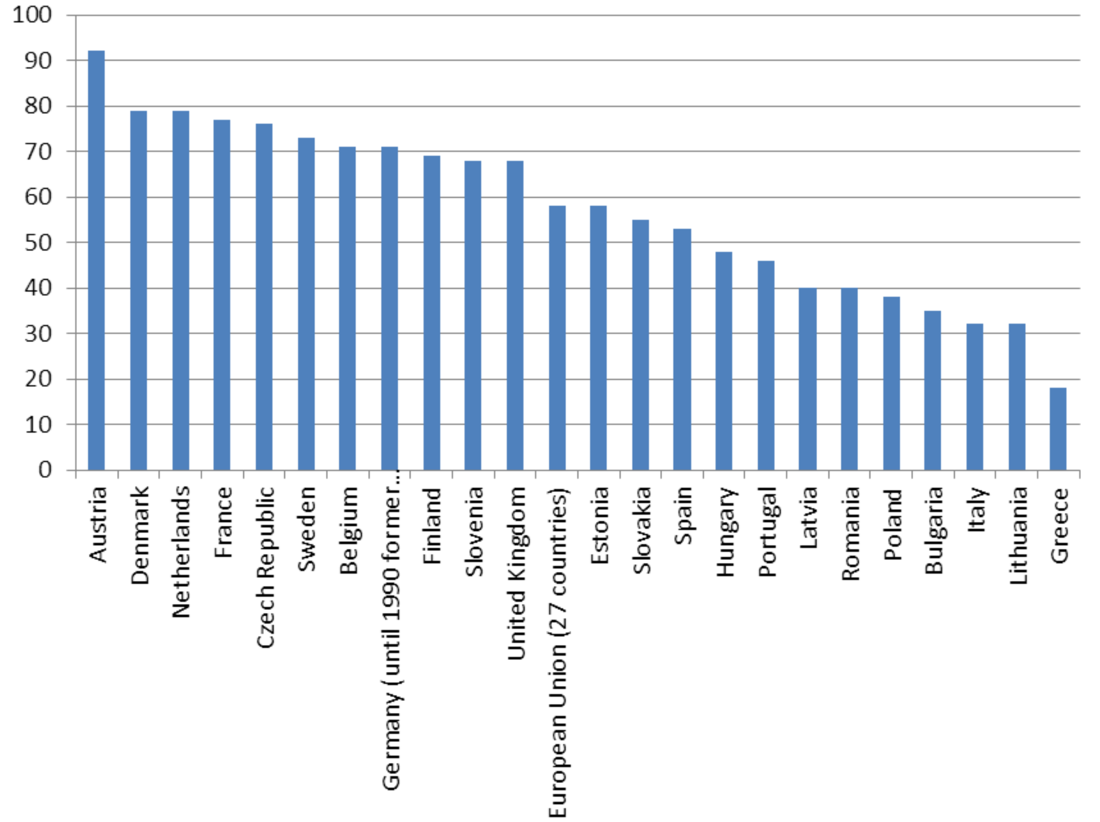
[242] Data are missing from the non-OECD members: Bulgaria, Cyprus, Estonia, Latvia, Lithuania and OECD. Slovenia only became OECD member in 2010. Data series are incomplete for Austria, Belgium, Denmark, Greece, Ireland, Luxembourg, Portugal and the UK.

[243] Data for 2002 for US and Canada is missing.

2012) (Guizzo & Deyle, 2012) (Male, Bush, & Chapman, 2011) (National Academy of Engineering of the National Academies, 2005)) point to a need for updating the workforce in skills related to specific technologies. This includes technologies to improve energy efficiency, recycling technology, robotics, additive manufacturing ("3d-printing"), big data. In addition some of the studies call for greater familiarity with business principles and models and language skills.

Most enterprises in Europe employ continuing vocational training of their staff, but there are significant national differences, as **Figure 4.14** indicates. Regrettably, data from the last European continuing vocational training survey have not yet been made available. However, in 2005, it was evident that the enterprises in the Southern and Eastern Member States lagged significantly behind the enterprises in the original Member States and Scandinavia.

Figure 4.14: Percentage of all enterprises providing continuing vocational training, 2005



Source: Eurostat CVTS, own calculations. Data for Ireland , Malta, Cyprus, and Luxembourg missing. NACE rev. 1.1, DK (Manufacture of machinery and equipment n.e.c.) and DL (Manufacture of electrical and optical equipment)

The companies in the survey, that declared that they did not train their staff, were given the opportunity to choose between eight possible reasons for not training. The reasons are shown in **Table 4.23** below. It is noticeable that most of the enterprises appeared at the time to be satisfied with the skills and competences of their staff, but also that a third of the non-training enterprises stated that they did not have the time to allow the staff to participate in training.

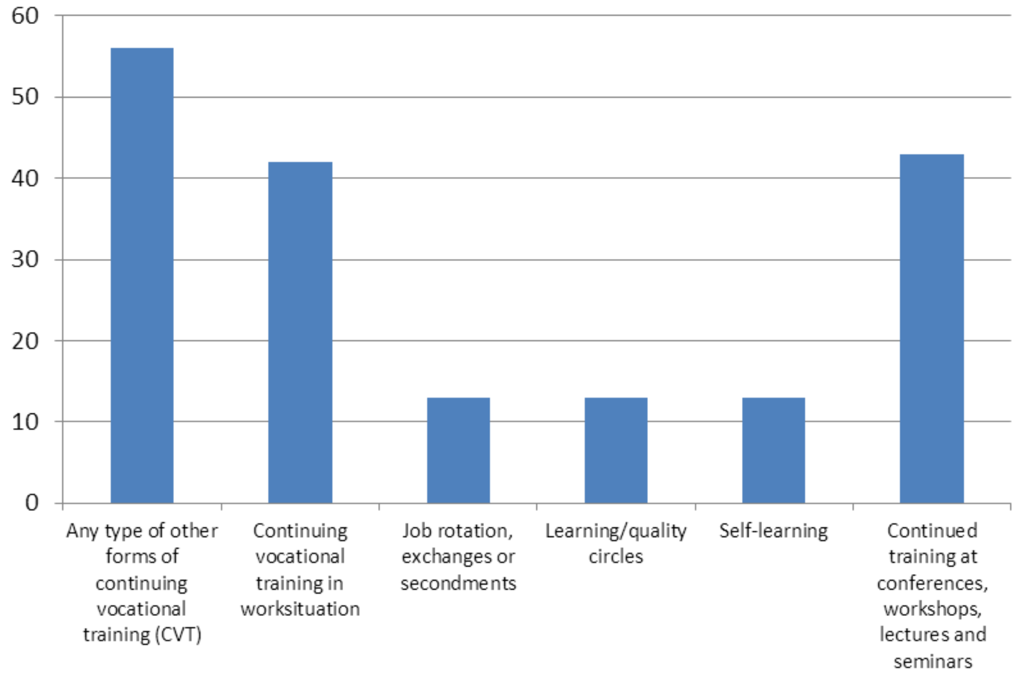
Table 4.23: Reasons given by manufacturing enterprises for not training staff, 2005. Ranked according to frequency.

Reasons given by enterprises	% of enterprises surveyed
The existing skills and competences of the persons employed corresponded to the current needs of the enterprise	74
People recruited with the skills needed	52
No time	30
Too expensive	25
Other reasons	21
Lack of suitable CVT courses in the market	17
More focus on initial vocational training than on continuing training	10
Difficult to assess enterprise's needs	10
Major training effort realised in a previous year	9

Source: Eurostat CVTS. NACE rev. 1.1, D (Manufacturing)

Enterprises in the EEI sector were asked which types of competence development they apply in addition to or instead of staff participating in formal continuing vocational training. The replies for the EEI sector are shown in **Figure 4.15**. As the figure indicates, the enterprises in the sector mainly use traditional means for competence development (vocational training in a training institution or in the workplace, participation in conferences etc.), and to a lesser extent more 'experimental' forms of learning such as job rotation, learning circles and self-learning.

Figure 4.15: Forms of training in EEI enterprises, 2005 1)

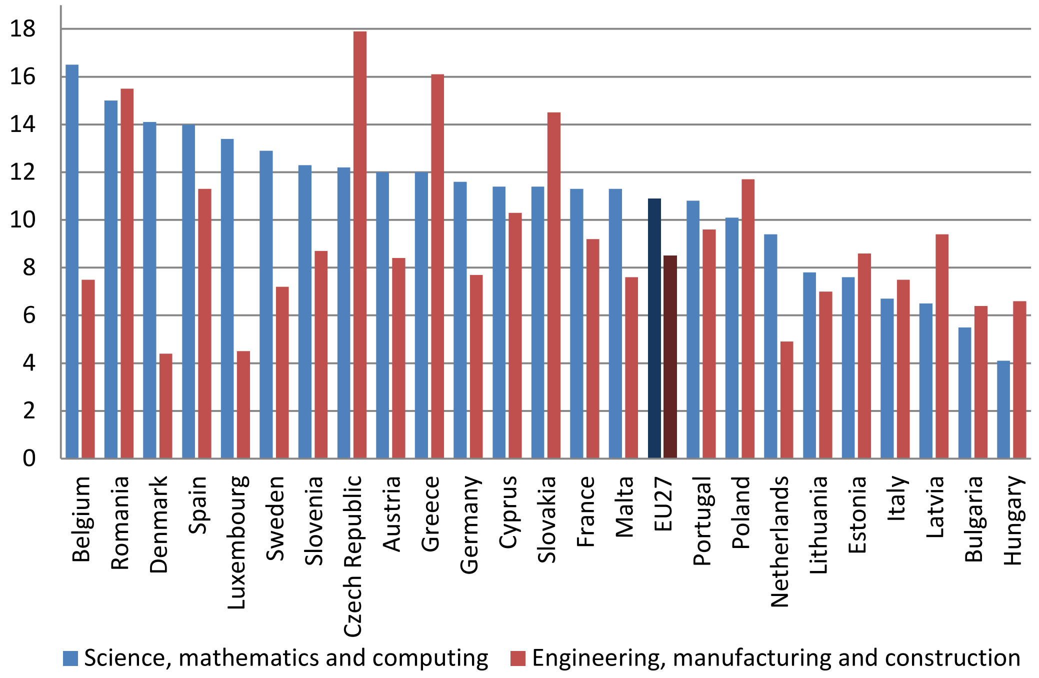


Source: Eurostat CVTS, own calculations. NACE rev. 1.1 , DK-DL (Manufacture of machinery, equipment n.e.c.; and electrical and optical equipmentManufacture of machinery, equipment n.e.c.; and electrical and optical equipment). Data missing from Cyprus, Ir

1) % of enterprises responding to CVET survey.

Finally, Eurostat provides insight into the subjects of job-related training, albeit not at company or sector level, but at individual level, see **Figure 4.16**, which details individual job-related participation in job-related training in science, mathematics and computing, and in engineering, manufacturing, and construction.

Figure 4.16: Individuals participating in job-related training in STEM subjects, % of respondents in Labour force survey. Ranked by participation in courses in science, mathematics and computing.



Source: Eurostat LfS, own calculation. Data missing from Cyprius and Ireland.

Again, it is evident that there is room for improving the situation with respect to continuing training in some of the new Member States. But also, quite surprisingly, the share of employees who have participated in training in topics related to engineering, manufacturing and construction is quite low in Denmark, Luxembourg and the Netherlands.

Summary

To sum up, overall the labour market and skills situation for the EEI sector is quite uneven across Europe. Labour markets in the sector are very different from East to West and from South to North, indicating that different business models are in play, as well as different educational systems. Compared with the main competing economies, the European Member States appear complacent when it comes to educational policies and in particular strategies for increasing STEM skills in the population and the number of higher education graduates with relevant specialisations.

The science education in primary and secondary schools does not sufficiently qualify and motivate children to embark on vocational or higher education which can lead to jobs in technology-intensive sectors.

- EEI requires, like all manufacturing industries, a broad range of qualifications. This fact has been widely recognised only recently. Traditionally, public policies have always focused on high qualifications and academics. Basic skills in maths, language and technologies are required to fulfil the numerous tasks in manufacturing and services. In this respect, initiatives by stakeholders of EEI and public authorities are directed towards dual vocational education systems. However, low societal esteem of VET puts the success into question.
- Demographic trends in combination with reduced interest of young people in STEM qualifications will have a strong negative impact on the supply of adequately educated

young academics and technicians just in this segment of the labour market where a growing demand by EEI companies is expected in coming years. The gap between demand and supply will widen.

Demographic and societal developments aggravate the efforts of the EU EEI to maintain its traditional good competitive position in qualified labour supply vis-à-vis other competing economies. Much effort on all levels of qualifications is needed.

4.5 International financial performance of EU-27[244] [245]

4.5.1 Sample selection

The firm level data on EEI companies for the competing countries USA, Japan, South Korea, Taiwan, China, Brazil and India, is available in the *ORBIS database*. The sample of companies in each of these competing countries was limited to the most important, with a maximum of 250 companies per competing country. As indicated earlier, since for most of these companies only consolidated[246] accounts are available, a consistent comparative analysis requires using consolidated accounts for the EU companies as well.

So for **each of the competing countries and for the EU-27**, we have selected the **top 250 companies for the EEI industry as a whole and for each of the three sectors**. The sample selection in ORBIS for the EEI industry and sectors was done on the basis of **a top-down search on the relevant NACE codes in ORBIS**. The top 250 companies in the EEI industry and sectors were selected by the operating revenue of 2010.

In the following analyses, we have displayed the averages for each ratio, as the Orbis database only provides aggregate data for the top 250 companies per country and per sector. Therefore, we could not compute median values.

4.5.2 Electrical engineering (EE1)

Profitability ratios

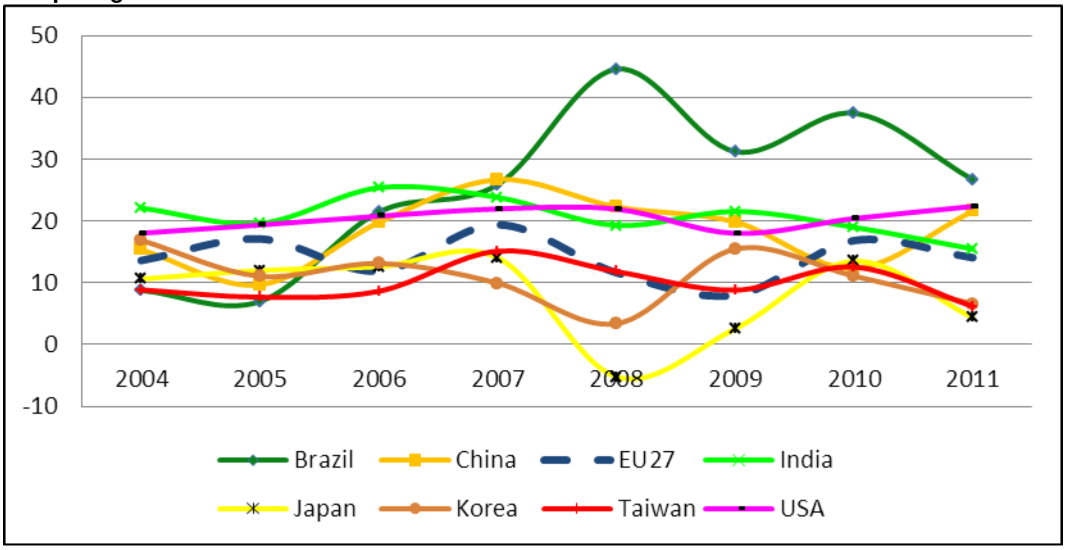
The evolution of the 3 profitability ratios in the EU-27 and the competing countries is displayed in **Figure 4.17**, **Figure 4.18** and **Figure 4.19**. The average return on shareholders' funds of the top 250 companies in **EE1** was the largest in Brazil between 2007 and 2011. Overall, the return on shareholders' funds of the top-250 Brazilian companies increased substantially between 2005 and 2008 but then returned to more typical levels in 2011. Throughout that same period, the Japanese top players in the sector have realized the lowest returns of all competing countries, with negative returns in 2008. In comparison to all 7 competing countries, the returns that were achieved by the EU-27 top 250 companies can be ranked in the middle with an average return of 14.1 % between 2004 and 2011 (see **Table 4.8**). The movement in these returns was quite dynamic, with increases between 2004 – 2005, 2006 – 2007 and 2009 – 2010 and dips in 2006 and 2009.

[244] We refer to Annex II.1 for an elaborate description of the selection, calculation and definition of the indicators that we have used for the firm-level analyses. The Annex also includes more details on the sample selection.

[245] The firm-level analyses include data on weighted average values. Data on median values is not available for the competing economies.

[246] For Brazil, China and India, we have also included unconsolidated account data in our top –250 samples for each sector, as most Orbis company data in these countries (in the EEI sectors) is unconsolidated. If we would have excluded all the unconsolidated accounts, we would have had too little observations in our samples – moreover, we would have excluded some of the most important EEI players in these countries. Therefore, the top-250 samples for Brazil, China and India include both unconsolidated and consolidated account data.

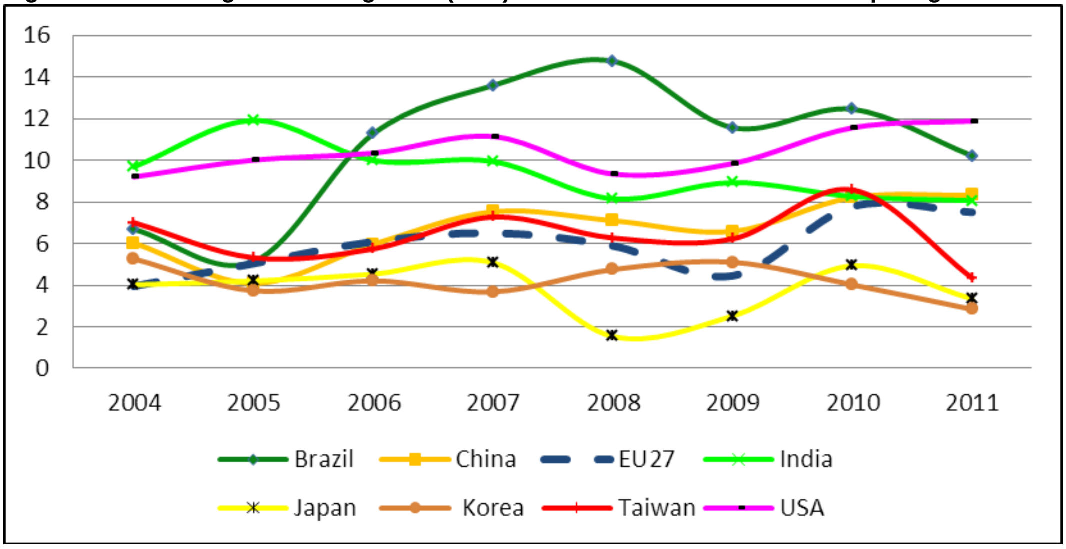
Figure 4.17: Average return on shareholders' funds[247] (in %) in EE1 in the EU-27 and competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

The average EBIT and profit margins in EE1 were the highest in Brazil, the USA and India, which is confirmed in **Table 4.8**. The US top players seem to have been able to realize the most stable profit and EBIT margins, whereas especially the Brazilian EBIT and profit margins appear to be more volatile. **Table 4.8** shows that, on average, the EU-27 top 250 EE1 companies realized profit- and EBIT margins that were rather low in comparison to these top-performing countries, but better than for Korea and Japan. However, the relative position of the EU-27 companies in comparison to the competing countries seems to have improved over time: in 2004 and 2009, the EU-27 was one of the worst performing countries in terms of EBIT and profit margins. In 2011, the EU-27's performance had markedly improved, as the profitability ratios in the sector were close to those of India and China.

Figure 4.18: Average EBIT margin248 (in %) in EE1 in the EU-27 and in competing countries

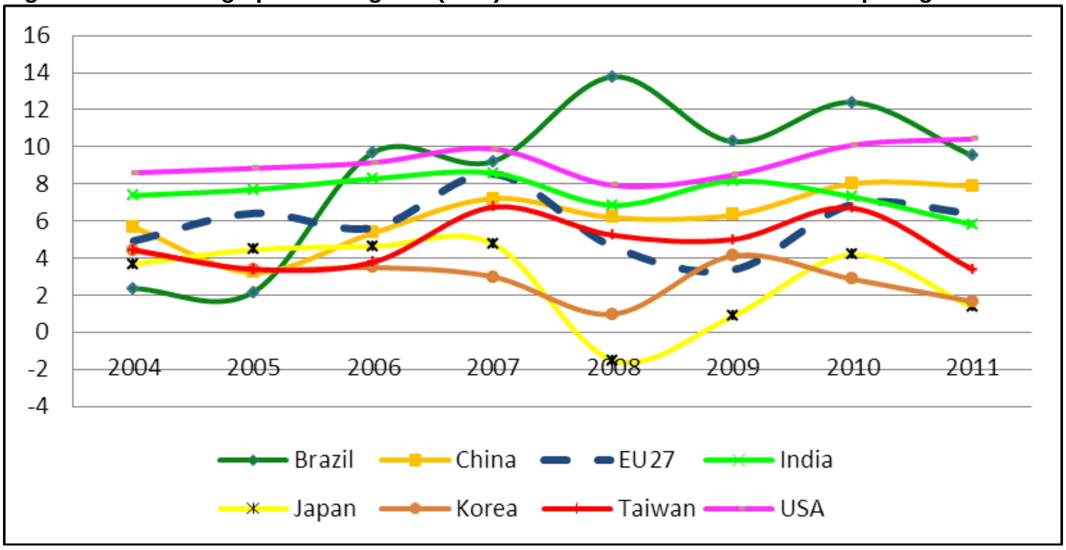


Source: Own calculations on the basis of Amadeus/Orbis data

[247] Formula = (profit/loss before tax / shareholders' funds)*100.

[248] Formula = (EBIT / operating revenue) *100 with "EBIT" = operating profit or loss = all operating revenues – all operating expenses.

Figure 4.19: Average profit margin[249] (in %) in EE1 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

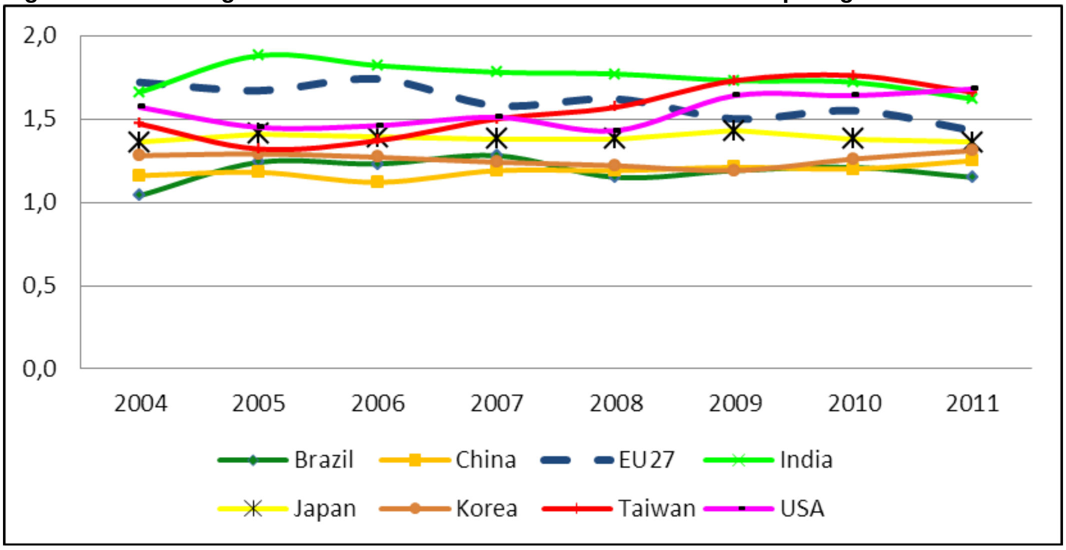
Structure ratios

Table 4.8 shows that the average current ratio in the EU-27 EE1 is one of the best, together with that in India, Taiwan and the US (see **Figure 4.20**). However, the EU-27 current ratio has worsened over time, whereas the US and Taiwanese average current ratios have increased over time and surpassed the level of the EU-27 current ratio in 2009. Also, whereas Brazil was performing very well in terms of profitability, it is not doing well in terms of financial structure.

Similarly, the EU-27 is not doing well in terms of solvency; in comparison to countries like India, Taiwan and the US. So it seems that, in comparison to the competing countries, the top EU-27 players have a better financial structure with respect to their short-term obligations (current ratio), in contrast to their longer-term liabilities (solvency ratio). However, the solvency ratio is still on average 39.3 % in the EU-27, which is above the “financially healthy” value of 33 % for the solvency ratio.

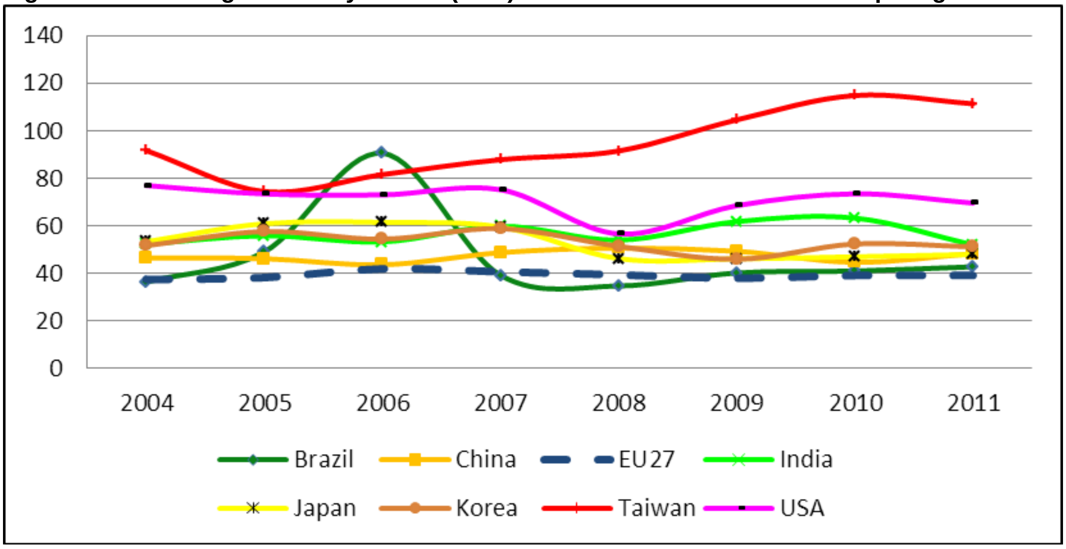
[249] Formula = (profit/loss before tax / operating revenue) *100 with “profit/loss before tax” = operating profit/loss + financial profit/loss.

Figure 4.20: Average current ratio[250] in EE1 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 4.21: Average solvency ratio[251] (in %) in EE1 in the EU-27 and in competing countries



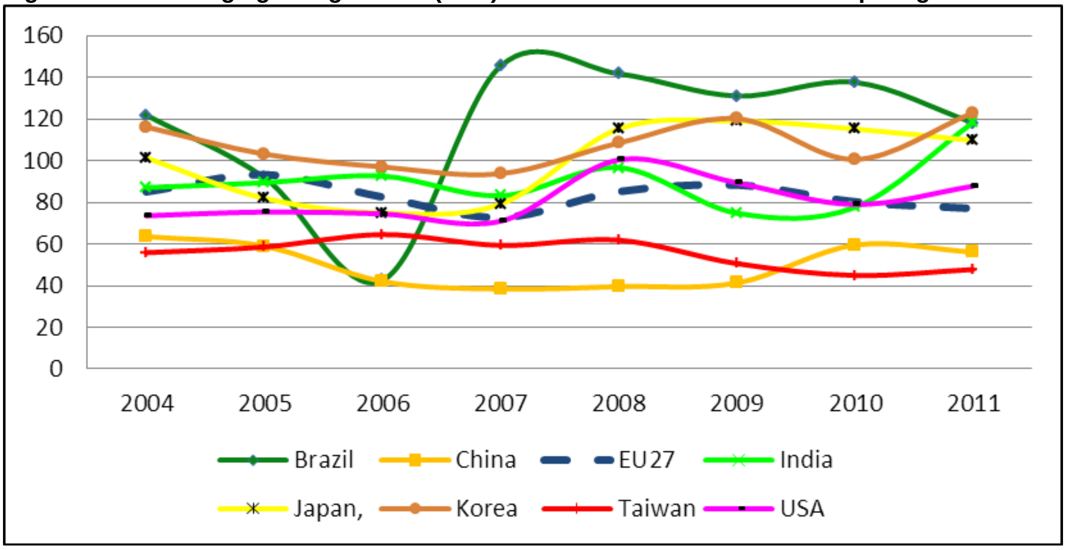
Source: Own calculations on the basis of Amadeus/Orbis data

The top-250 electrical engineering companies in China and Taiwan have the best average gearing ratio, whereas the Brazilian companies seem to be the most financially vulnerable, which confirmes our findings for the current ratio. The EU-27 companies are positioned “in the middle”, as the average gearing ratio (2004 - 2011) of 83.1 % lies just above that of the US (see **Table 4.8**).

[250] Formula = current assets/current liabilities.

[251] Formula = (shareholders’ funds / (non-current liabilities + current liabilities)) *100.

Figure 4.22: Average gearing ratio[252] (in %) in EE1 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Overview table

Finally, **Table 4.8** gives a complete overview per ratio and per country of the average values between 2004 - 2011 and the changes in these averages. Overall, Brazil, India and the US are the best-performing countries in terms of average profitability in EE1. The top 250 Brazilian companies in EE1 have also been able to realize substantial increases in their profitability ratios. Even though the average profitability ratios of the top Chinese companies in EE1 were not among the highest, these companies have presented a significant improvement in their profitability. The EU-27 companies are positioned at the lower end with regard to the average profitability. However, the profitability ratios have evolved positively over time– especially the average EBIT margin of the top EE1 companies has improved over the period.

In terms of financial structure, the US, Taiwanese and Indian electrical engineering companies in our sample have the most solid financial structures. The Taiwainese companies in EE1 have also been able to improve their already strong financial structure over time. US companies have improved their position with regard to their short-term financial structure, but have not been able to do the same for their long-term financial structure. The Chinese companies are performing very well in terms of leverage (gearing ratio) and have been able to improve their financial structures over the period. The top EU-27 companies in EE1 had a good average performance in terms of their coverage of their current liabilities, even though this position worsened over the period under consideration. Also the average coverage of the longer-term debt obligations was low in comparison to the 7 competing countries we analyse here; additionally the solvency ratio did not progress over time. Finally, the average gearing ratio in the EU-27 did improve, indicating that the EU-27 companies have been able to reduce their average degree of financial leverage.

[252] Formula = ((non-current liabilities + loans) / shareholders' funds) * 100.

Table 4.24: Overview table Electrical Engineering (EE1) (a) (b) (c) (d)

	Return on shareholder funds (in %)		EBIT margin (in %)		Profit margin (in %)		Current ratio		Solvency ratio (in %)		Gearing ratio (in %)	
	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent
Brazil	25.4 *(1)*	158% *(1)*	10.7 *(1)*	47% (3)	8.7 *(2)*	131% *(1)*	1.2	1%	46.8	-29%	116.3	50%
China	18.4	14% *(2)*	6.8	54% (1)	6.2	68% *(2)*	1.2	6% *(3)*	47.3	2% *(3)*	49.9 *(1)*	5% *(3)*
EU-27	**14.1**	**9%**	**5.9**	**52% (2)**	**5.9**	**18%**	**1.6 *(2)***	**-13%**	**39.3**	**0%**	**83.1**	**-10% *(2)***
India	20.8 *(2)*	-23%	9.4 *(3)*	-22%	7.5 *(3)*	-16%	1.8 *(1)*	-7%	56.6 *(3)*	7% *(2)*	90.0	9%
Japan	8.1	-24%	3.8	-3%	2.8	-35%	1.4	-1%	52.9	-19%	99.6	31%
Korea	11.0	-35%	4.2	-22%	3.0	-40%	1.3	0%	53.0	-5%	107.8	6%
Taiwan	10.0	12% *(3)*	6.4	7%	4.8	30% *(3)*	1.6 *(3)*	23% *(1)*	94.7 *(1)*	37% *(1)*	55.4 *(2)*	-22% *(1)*
USA	20.4 *(3)*	10%	10.4 *(2)*	19%	9.2 *(1)*	16%	1.6 *(3)*	11% *(2)*	70.9 *(2)*	-4%	81.4 *(3)*	12%

Source: Own calculations on the basis of Amadeus/Orbis data

(a) Per ratio, we have indicated the ranking of the best 3 performing countries, in terms of averages over the period 2004 – 2011, between brackets and in italics.

(b) Per ratio, we have indicated the ranking of the best 3 performing countries, in terms of the change rates 2010 - 2011 versus 2004 - 2006, between brackets and in italics.

(c) The computations of the averages were based on the averages in the graphs above.

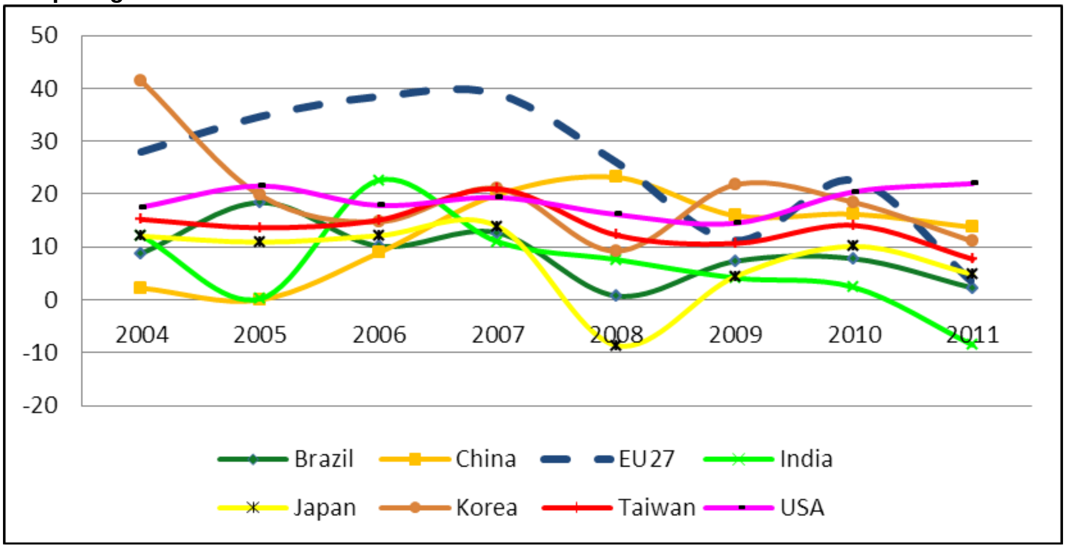
(d) Gearing ratio: a high gearing ratio means that the company is financially more vulnerable. Therefore we would like to note that an increase in the gearing ratio (a positive change rate) means a deterioration and a decrease in the gearing ratio (a negative change rate) means an improvement in the gearing ratio.

4.5.3 *Electronic engineering (EE2)*

Profitability ratios

In EE2, the EU-27 top 250 companies were the best-performing companies in terms of return on shareholders' funds, EBIT margins and profit margins between 2004 and 2008. However, since the start of the crisis, these profitability ratios have all decreased substantially, especially in 2008, 2009 and 2011 – since then, the EU-27 companies have lost their leading position in this respect to other countries: in 2011, the US, Chinese and Korean companies have taken up leading positions in terms of profitability in EE2.[253] This performance of the top 250 EU-27 companies in the sector is consistent with the detailed sector analysis in Chapter 2. Overall, the top US EE1 companies have been able to maintain and improve their strong position over time, resulting in a leading position in 2011. For instance, Apple's branding and high performance strategy has turned out to be noteworthy profitable.

Figure 4.23: Average return on shareholders' funds[254] (in %) in the EE2 in the EU-27 and in competing countries

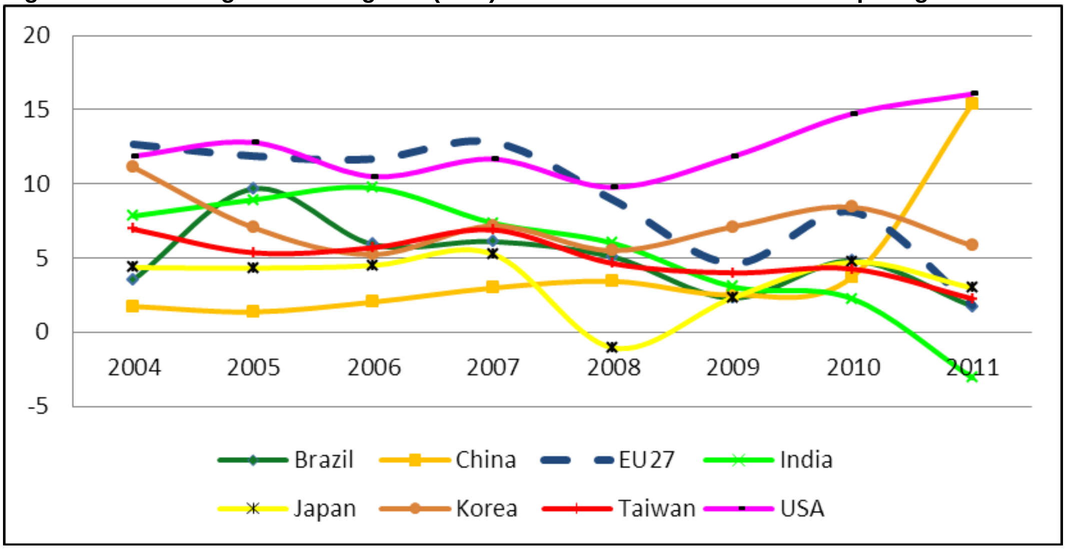


Source: Own calculations on the basis of Amadeus/Orbis data

[253] The extraordinary profitability up to succeeded by a major slump suggests that the EU companies pursued a cash cow approach.

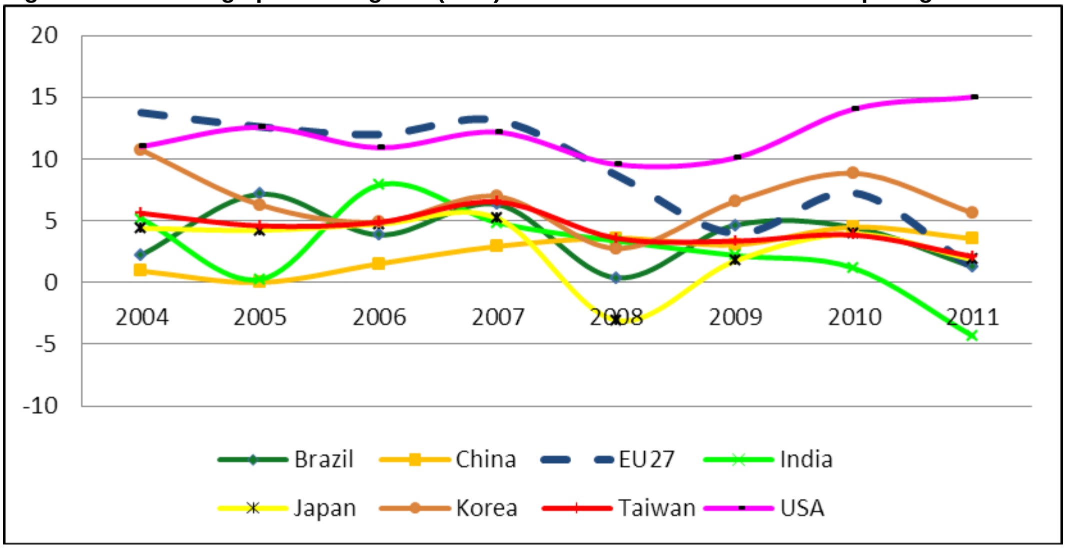
[254] Formula = (profit/loss before tax / shareholders' funds)*100.

Figure 4.24: Average EBIT margin[255] (in %) in EE2 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 4.25: Average profit margin[256] (in %) in EE2 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

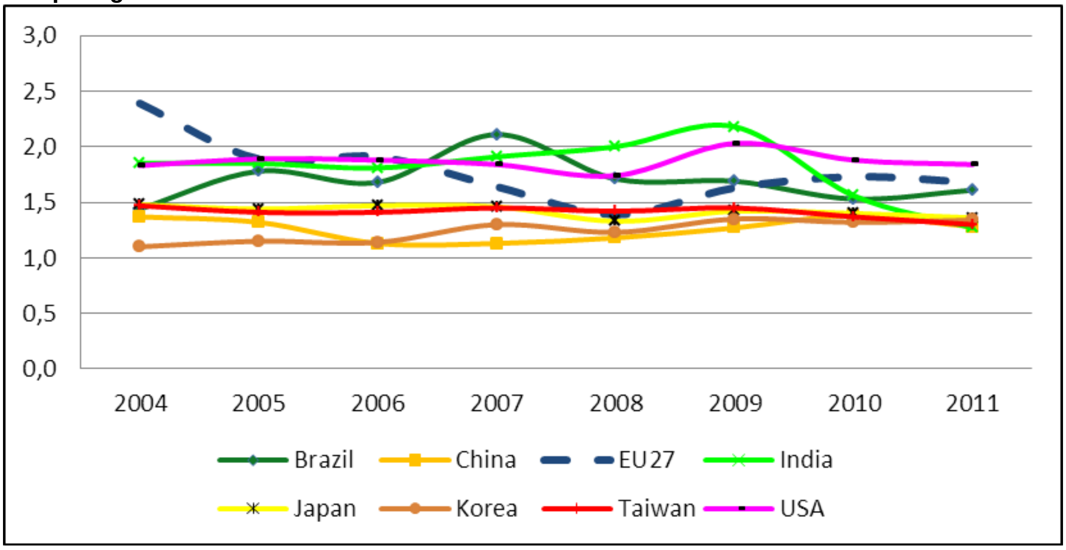
Structure ratios

In terms of financial structure ratios, the EU-27 companies had a good relative position in terms of the average current ratio, but this position worsened throughout the period, showing that the top EU-27 companies' ability to service their short-term debts deteriorated in comparison to the competing countries. Moreover, these EU companies also performed poorly in terms of solvency (vis-à-vis the competing countries), indicating that their financial structure was also quite weak to service their long-term debts. The electronic engineering companies in the competing countries have much stronger positions in this regard. Especially US companies perform well for both of these structure ratios.

[255] Formula = (EBIT / operating revenue) *100 with "EBIT" = operating profit or loss = all operating revenues – all operating expenses.

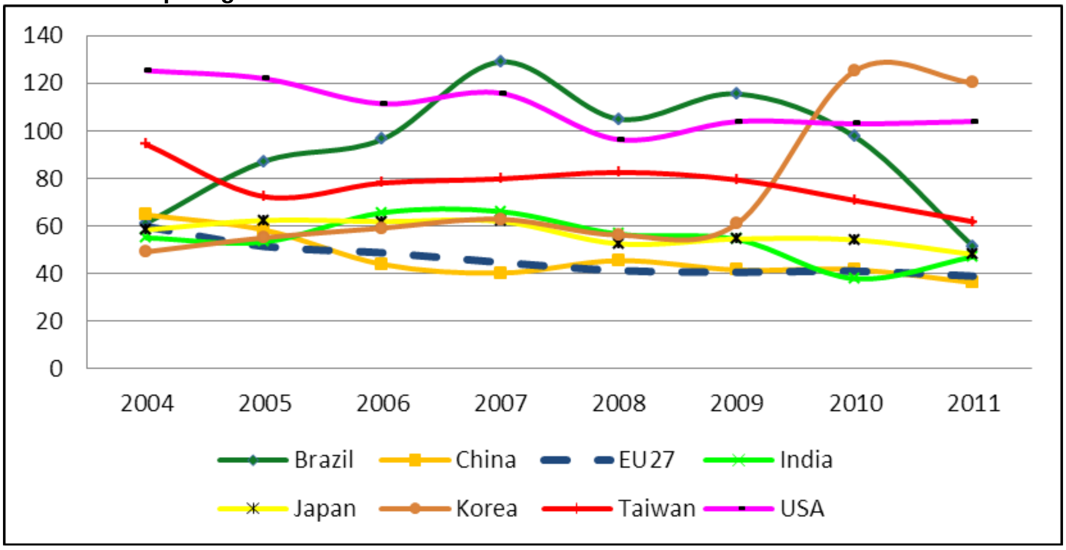
[256] Formula = (profit/loss before tax / operating revenue) *100 with "profit/loss before tax" = operating profit/loss + financial profit/loss.

Figure 4.26: Average current ratio[257] in the electronic engineering sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 4.27: Average solvency ratio[258] (in %) in the electronic engineering sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

In terms of financial leverage (the gearing ratio in **Figure 4.28**), EU-27 electronic engineering companies were the best of their class between 2004 – 2007. In 2008, there was a marked deterioration in the gearing ratio, whereas competing countries like Korea and the US have been able to improve or maintain their average gearing ratio, indicating that the electronic engineering companies in these countries have a better equity “cushion”, being able to service their debts in times of crisis.

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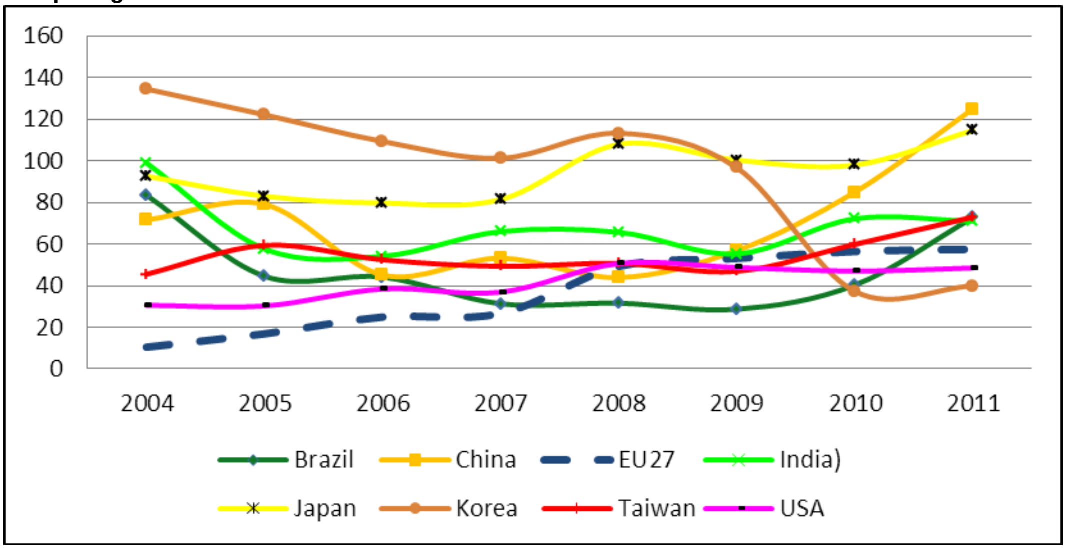
[257] Formula = current assets/current liabilities.

[258] Formula = (shareholders’ funds / (non-current liabilities + current liabilities)) *100.

Figure 4.28: Gearing ratio[259] (in %) in the electronic engineering sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Overview Table

Overall, **Table 4.9** shows that the US top-250 companies are the best performing companies, both in terms of profitability and financial structure. **The EU-27 electronic engineering companies have also performed well in terms of average profitability ratios. However, these companies were greatly affected by the global economic crisis, as can be seen in the large negative change rates in the profitability ratio** whereas Chinese companies have realized a strong growth in their profitability and US companies have been able to maintain or increase their profitability further (EBIT and profit margins).[260]

In terms of average structure ratios, the top-250 EU-27 companies in electronic engineering were not performing well, in comparison to the 7 competing countries. The crisis has had a negative influence on the current and gearing ratios of the EU-27 companies. Also, the EU-27 companies have a relatively weak position with regard to the solvency ratio, indicating that they are less solvent than their counterparts in all other competing countries.

[259] Formula = ((non-current liabilities + loans) / shareholders' funds) * 100.

[260] The EU companies shed around one fifth of their staff between 2008 and 2012. However, this reduction had not yet had an impact on the financial performance (see: Chapter 2.2).

Table 4.25: Overview table Electronic Engineering (EE2) [(a) (b) (c) (d)]

	Return on shareholder funds (in %)		EBIT margin (in %)		Profit margin (in %)		Current ratio		Solvency ratio (in %)		Gearing ratio (in %)	
	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent
Brazil	8.5	-60%	4.9	-49%	3.8	-35%	1.7	-4%	92.9 *(2)*	-9% *(2)*	47.1 *(3)*	-2% *(2)*
China	12.5	304% *(1)*	4.1	459% *(1)*	2.5	393% *(1)*	1.3	4% *(2)*	46.6	-30%	70.0	61%
EU-27	**25.4 *(1)***	**-62%**	**9.1 *(2)***	**-59%**	**9.1 *(2)***	**-67%**	**1.8 *(3)***	**-17%**	**45.9**	**-25%**	**36.9 *(1)***	**227%**
India	6.4	-127%	5.3	-105%	2.6	-136%	1.8 *(2)*	-23%	54.5	-27%	67.6	2% *(3)*
Japan	7.5	-36%	3.4	-12%	2.9	-35%	1.4	-6%	56.8	-16%	94.7	25%
Korea	19.7 *(2)*	-42%	7.2 *(3)*	-9% *(3)*	6.6 *(3)*	-1% *(3)*	1.2	18% *(1)*	73.6	125% *(1)*	94.3	-68% *(1)*
Taiwan	13.7	-26% *(3)*	5.0	-46%	4.3	-41%	1.4	-7%	77.4 *(3)*	-19%	54.6	27%
USA	18.7 *(3)*	12% *(2)*	12.4 *(1)*	31% *(2)*	11.9 *(1)*	26% *(2)*	1.9 *(1)*	0% *(3)*	110.2 *(1)*	-13% *(3)*	41.4 *(2)*	44%

Source: Own calculations on the basis of Amadeus/Orbis data

(a) Per ratio, we have indicated the ranking of the best 3 performing countries (in terms of averages over the period 2004 - 2011) between brackets and in italics.

(b) Per ratio, we have indicated the ranking of the best 3 performing countries, in terms of the change rates 2010 - 2011 versus 2004 - 2006, between brackets and in italics.

(c) The computations of the averages were based on the averages in the graphs above.

(d) Gearing ratio: a high gearing ratio means that the company is financially more vulnerable. Therefore we would like to note that an increase in the gearing ratio (a positive change rate) means a deterioration and a decrease in the gearing ratio (a negative change rate) means an improvement in the gearing ratio.

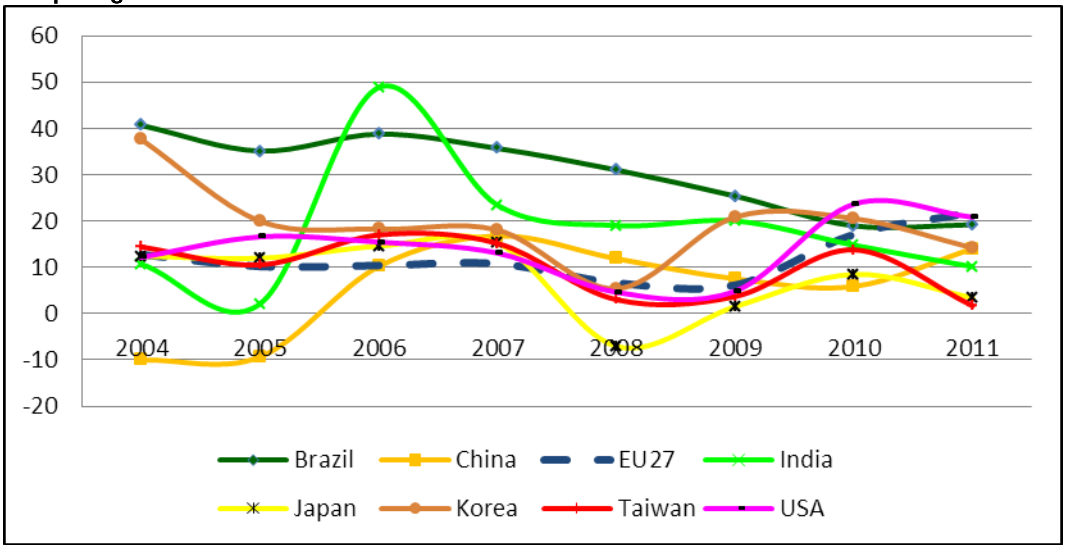
4.5.4 Electronic components and semiconductors (EE3)

Profitability ratios

The visual investigation of profitability for EE3 firms provides a result as compared to EE2 and EE1, a higher volatility in profit figures. This might be caused by sales markets fluctuations in demand and supply as well as by investment cycles of the semiconductor industry.

Brazilian companies in EE3 have realised the best returns on shareholders' funds and EBIT/profit margins, although these profitability ratios have all decreased between 2008 and 2010. The relative position of the EU-27 companies in terms of profitability was at the lower end before 2010. However, since 2010, the top-250 companies have achieved an increase in all 3 profitability ratios: in 2011 the EU-27 companies had realized the highest average return on shareholders' funds, and the third best profit and EBIT margins. US companies in the sector have achieved a similar leap, resulting in the highest profit and EBIT margins in 2011.

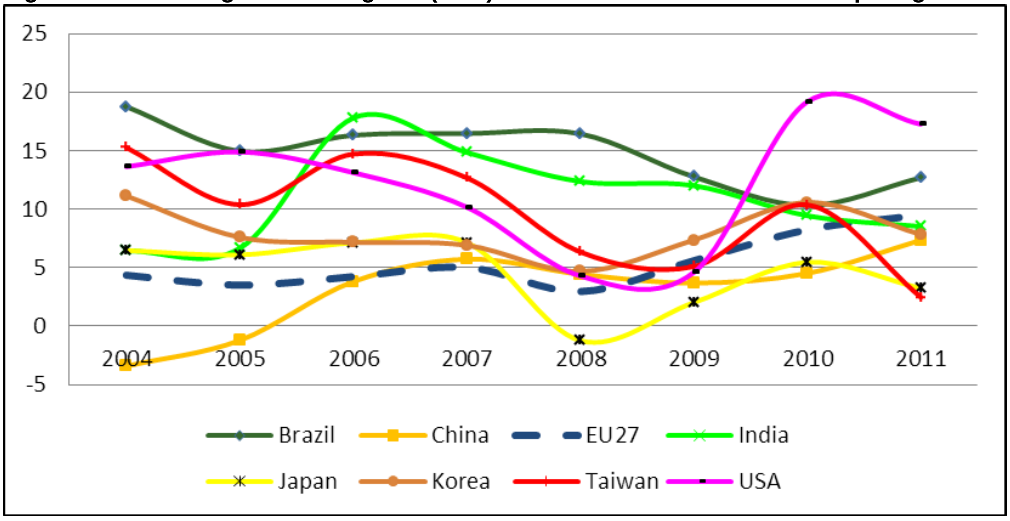
Figure 4.29: Average return on shareholders' funds[261] (in %) in EE3 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

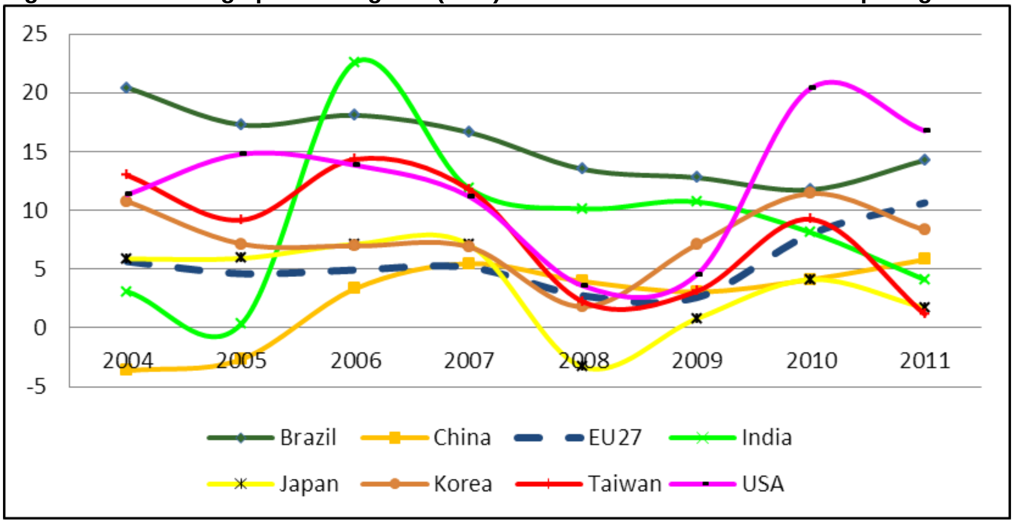
[261] Formula = (profit/loss before tax / shareholders' funds)*100.

Figure 4.30: Average EBIT margin[262] (in %) in EE3 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 4.31: Average profit margin[263] (in %) in EE3 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

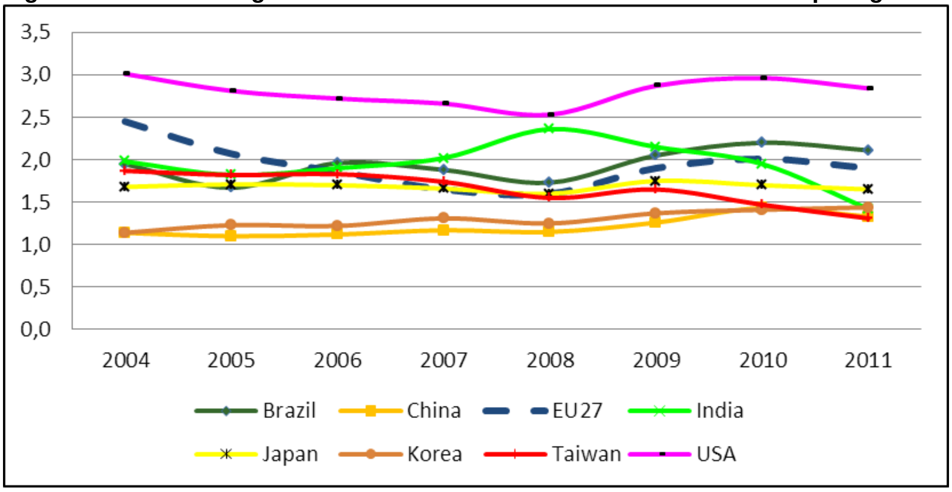
Structure ratios

The top-250 US companies in the sector clearly have the best structure ratios, in comparison to the EU-27 and the other competing countries. The top-250 EU-27 companies in the sector have a good performance with respect to the average current ratio. However, as was the case for EE1 and EE2s, the EU-27 companies have low solvency ratios in comparison to the companies in the competing countries. The gearing ratio for these EU-27 companies is also worse than for the competing countries, where it has deteriorated (and thus increased – a higher gearing ratio means that the companies are more financially vulnerable) between 2008 – 2010. Korean companies in the sector have made the inverse movement, resulting in good gearing ratios in the last 2 years (2010 – 2011).

[262] Formula = (EBIT / operating revenue) *100 with "EBIT" = operating profit or loss = all operating revenues – all operating expenses.

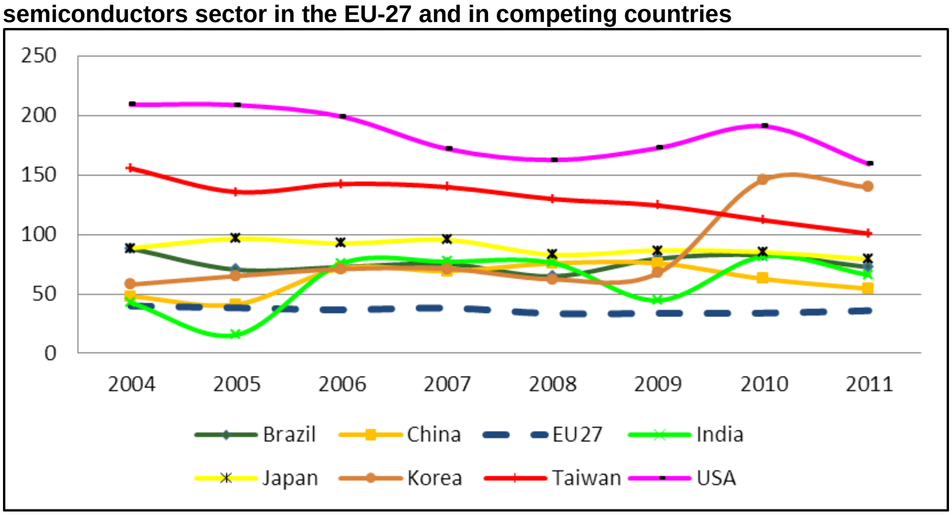
[263] Formula = (profit/loss before tax / operating revenue) *100 with "profit/loss before tax" = operating profit/loss + financial profit/loss.

Figure 4.32: Average current ratio[264] in EE3 in the EU-27 and in competing countries



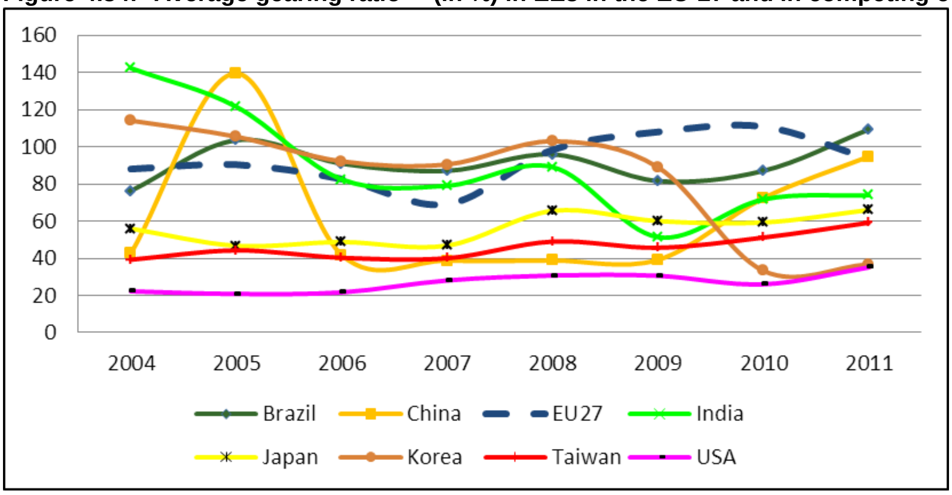
Source: Own calculations on the basis of Amadeus/Orbis data

Figure 4.33: Average solvency ratio[265] (in %) in the electronic components and semiconductors sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 4.34: Average gearing ratio[266] (in %) in EE3 in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

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[264] Formula = current assets/current liabilities.

[265] Formula = (shareholders' funds / (non-current liabilities + current liabilities)) *100.

[266] Formula = ((non-current liabilities + loans) / shareholders' funds) * 100.

Overview Table

On average, over 2004 - 2011, Brazilian companies in EE3 had achieved the best average profitability ratios. However, these companies were negatively affected by the crisis, as can be seen by the negative change rates in **Table 4.10**. The EU-27 companies were on average not performing that well in terms of profitability; however, they have caught up with their competitors, as can be observed by the large positive changes in the three profitability ratios. Also the top-250 Indian and US companies have done well in terms of profitability, although the Indian companies have been confronted with decreases in their returns on shareholders' funds and profit margin.

The average structure ratios for the sector show that the US companies clearly have the best financial structure with regard to shareholders' funds and liabilities. In comparison to the competing countries; the EU-27 companies are characterized by a good average current ratio, though this worsened between 2004 and 2011. They also had low average solvency ratios, which also decreased slightly over time. In terms of dynamics, Korea performed very well with the largest improvements in most structure ratios.

Table 4.26: Overview table Electronic components and semiconductors (EE3) [(a) (b) (c) (d)]

	Return on shareholder funds (in %)		EBIT margin (in %)		Profit margin (in %)		Current ratio		Solvency ratio (in %)		Gearing ratio (in %)	
	Average (2004 -2011)	**Change rate (2010-2011) versus (2004-2006) in percent**	**Average (2004 -2011)**	**Change rate (2010-2011) versus (2004-2006) in percent**	**Average (2004 -2011)**	**Change rate (2010-2011) versus (2004-2006) in percent**	**Average (2004 -2011)**	**Change rate (2010-2011) versus (2004-2006) in percent**	**Average (2004 -2011)**	**Change rate (2010-2011) versus (2004-2006) in percent**	**Average (2004 -2011)**	**Change rate (2010-2011) versus (2004-2006) in percent**
Brazil	30.6 *(1)*	-50%	14.8 *(1)*	-31%	15.6 *(1)*	-30%	1.9 *(3)*	16% *(3)*	75.7	1%	91.5	9% *(3)*
China	5.9	-427%	3.1	-2243%	2.4	-598%	1.2	23% *(1)*	62.3	9% *(3)*	63.5	12%
EU-27	**12.0**	**75% *(1)***	**5.4**	**120% *(1)***	**5.5**	**84% *(1)***	**1.9**	**-8%**	**36.3**	**-9%**	**92.6**	**17%**
India	18.6 *(3)*	-39%	11.0 *(3)*	-13%	8.9 *(3)*	-30%	2.0 *(2)*	-11%	59.8	65% *(2)*	88.9	-37% *(2)*
Japan	7.6	-54%	4.5	-34%	3.7	-54%	1.7	-1%	88.2 *(3)*	-11%	56.2 *(3)*	24%
Korea	19.4 *(2)*	-31% *(3)*	7.9	7% *(3)*	7.6	19% *(3)*	1.3	19% *(2)*	85.0	121% *(1)*	83.0	-66% *(1)*
Taiwan	9.9	-45%	9.7	-52%	8.0	-57%	1.7	-24%	130.0 *(2)*	-26%	46.1 *(2)*	34%
USA	13.9	51% *(2)*	12.1 *(2)*	31% *(2)*	12.1 *(2)*	39% *(2)*	2.8 *(1)*	2%	184.1 *(1)*	-15%	26.9 *(1)*	42%

Source: Own calculations on the basis of Amadeus/Orbis data

(a) Per ratio, we have indicated the ranking of the best 3 performing countries (in terms of averages over the period 2004 - 2011) between brackets and in italics.

(b) Per ratio, we have indicated the ranking of the best 3 performing countries, in terms of the change rates 2010 - 2011 versus 2004 - 2006, between brackets and in italics.

(c) The computations of the averages were based on the averages in the graphs above.

(d) Gearing ratio: a high gearing ratio means that the company is financially more vulnerable. Therefore we would like to note that an increase in the gearing ratio (a positive change rate) means a deterioration and a decrease in the gearing ratio (a negative change rate) means an improvement in the gearing ratio.

4.5.5 *The EEI industry: conclusions[267].*

To conclude, we summarize our observations for each EEI sector, regarding the EU-27's relative performance vis-à-vis the 7 competing countries.

In **EE1**, the EU-27's top 250 companies have lower average profitability ratios compared to Brazil, India and the US. However, these profitability ratios have increased over time, especially the average EBIT margin for EE1. The EU-27's performance compares favourably in terms of the coverage of the current liabilities (current ratio) but poorly regarding the coverage of the longer-term liabilities (solvency ratio). Furthermore, both the current and the solvency ratios have decreased over time.

In **EE2**, the EU-27 top companies have lost their leading position in terms of profitability: between 2004 – 2007 the EU-27 companies had the highest profitability ratios in comparison to the competing countries; however, all profitability indicators decreased considerably from 2008 onwards, whereas competing countries such as the US and Korea improved their profitability. In terms of financial structure, the EU-27 companies had the lowest average solvency ratio, which deteriorated throughout 2004 – 2011. Also the degree of financial leverage (gearing ratio) of EE2 companies in the EU-27 was characterized by the largest fall in comparison to the competing countries.

In **EE3**, the EU-27's performance between 2004 – 2009 with regard to the average profitability ratios was poor in comparison to the competing countries. However, since 2009, the average profitability ratios have improved substantially, resulting in a "top-3" position for the EU-27 companies in 2011 with regard to EBIT, profit margins and the return on shareholders' equity. In terms of financial structure, EE3 companies in the EU-27 have the worst solvency ratios of all countries for almost the entire period. Their coverage of short-term debts is better, but the degree of financial leverage is low in comparison to the competing countries, especially the US.

4.6 Structural change and geographic cohesion

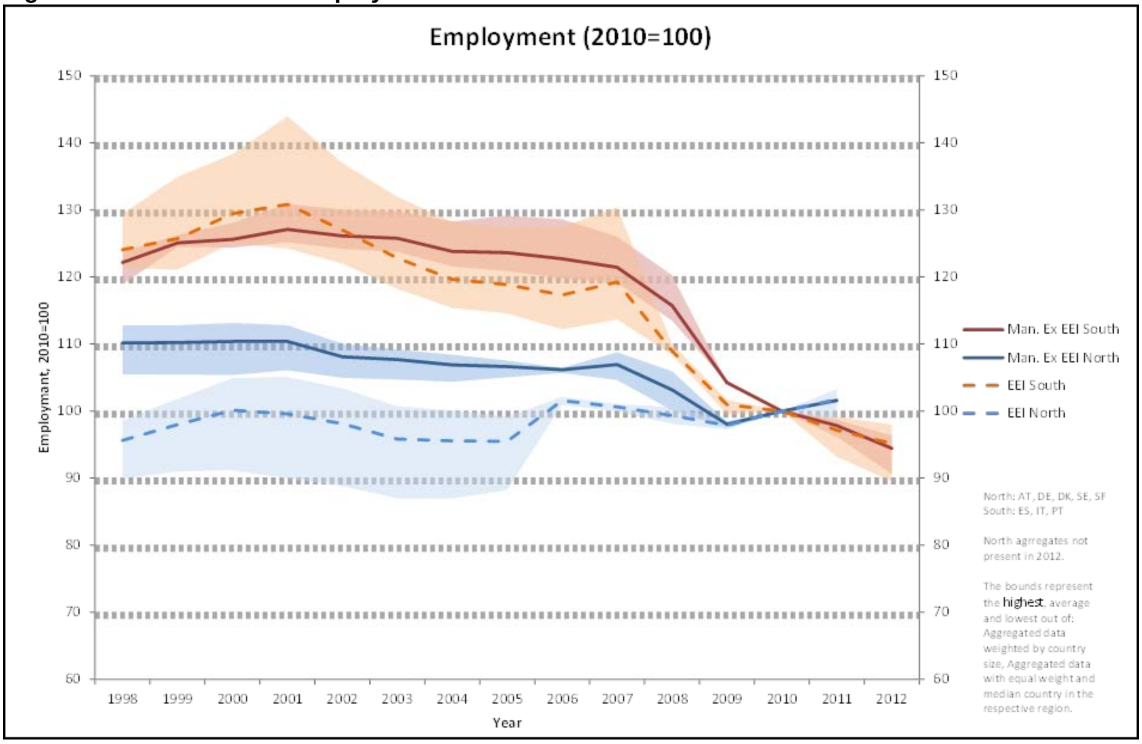
This chapter provides some information on the impact of ULC on changes in price competitiveness based on a quantitative analysis. The results have to be further elaborated together with the findings of the detailed investigation in the evolution and performance of EEI's sectors and sub-sectors and evaluated in comparison with competing economies.

Impact of price competitiveness on changes in employment

The investigation in the EU EEI in Chapter 2 has shown that within many sub-sectors the regional distribution of production locations has changed during the period under investigation. While in many cases northern economies and CEE benefited from a growing concentration of production, in particular southern countries lost some of their former importance. This development had already started before the global financial crisis hit the EU economy in 2009; it had begun at the turn of the millennium. During the period 2008 to 2012 this development accelerated. This pattern shows that the financial crisis is not responsible for this development; in particular the loss of employment. Next, we analyse the impact of price competitiveness on the growing concentration of production in northern economies and CEE. The core indicator applied for this purpose is ULC and its explanatory variables.

[267] We have included the summary graphs and the overview table on the profitability and structure ratios in the EEI industry (in total) in the EU-27 and the competing countries in Annex II.5.

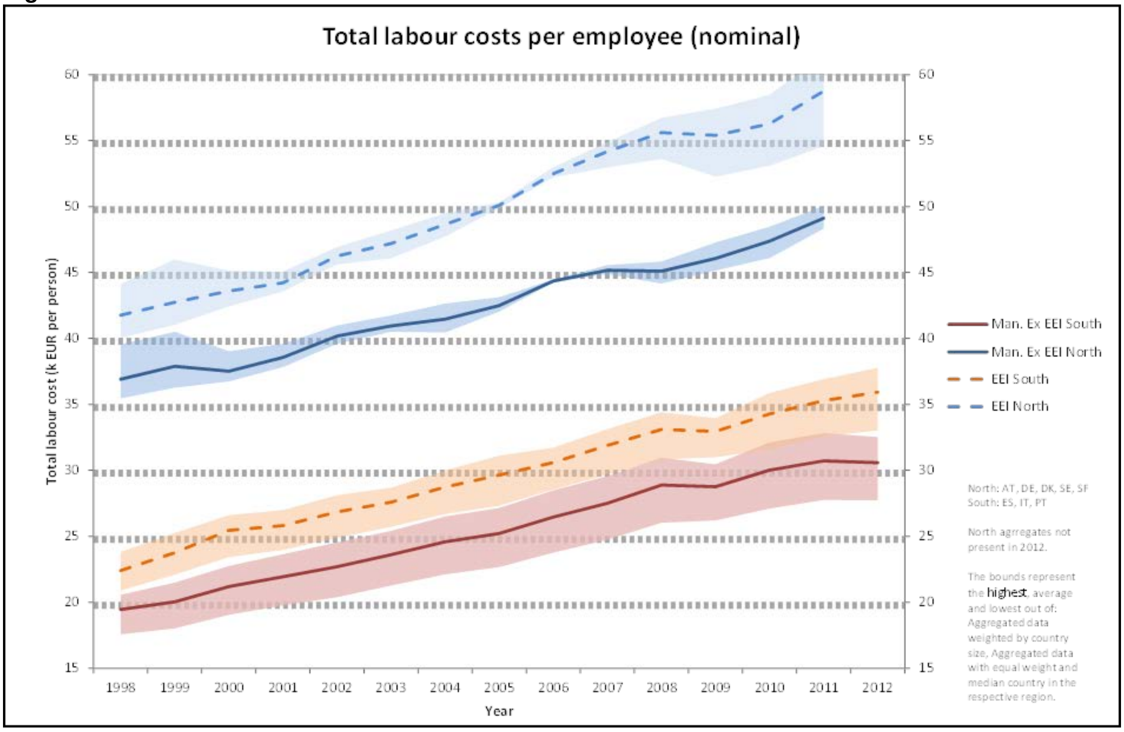
Figure 4.35: Evolution of employment in northern and southern economies of EU-27



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The labour cost per employee has been steadily growing over the last 14 years in both, manufacturing and EEI, in the northern and southern economies. When looking first at the sectors, EEI employees are more costly than the average for total manufacturing. This gap is about € 9,000 per employee in the northern economies and about € 5,000 in the southern economies.

Figure 4.36: Evolution of labour costs in northern and southern economies of EU-27



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The spread between north and south regions remains steady, around € 23,000 per employee for EEI and € 19,000 EUR for total manufacturing. The growth rates of total labour costs per employee in the regions are more similar in the EEI sector than for total manufacturing. While the costs per worker in the EEI sectors grew on average 3.7 % p.a. for northern economies without Germany and 3.5 % for southern economies between 1998 and 2011, the growth for total manufacturing was of 3.0 % and 3.6 %, respectively. When calculating the growth rates, we excluded Germany from the north region, as it presents much lower average growth rates (1.1 % for manufacturing, as well as EEI, from 1998-2011). So it is apparent that both regions (when excluding Germany) are performing more similar, in particular for EEI and to a lesser extent for TM.

Table 4.27: Evolution of labour costs in northern and southern economies of EU-27

Region	**Annual average growth rates**		
	1998-2007	**2008-2011**	**1998-2011**
	Total manufacturing without EEI		
North ex. Germany	**3.1%**	**2.6%**	**3.0%**
Germany	1.0%	1.6%	1.1%
South	**3.9%**	**2.8%**	**3.6%**
	Electrical and electronic engineering		
North ex. Germany	**4.0%**	**2.8%**	**3.7%**
Germany	1.5%	0.2%	1.1%
South	**4.0%**	**2.5%**	**3.5%**

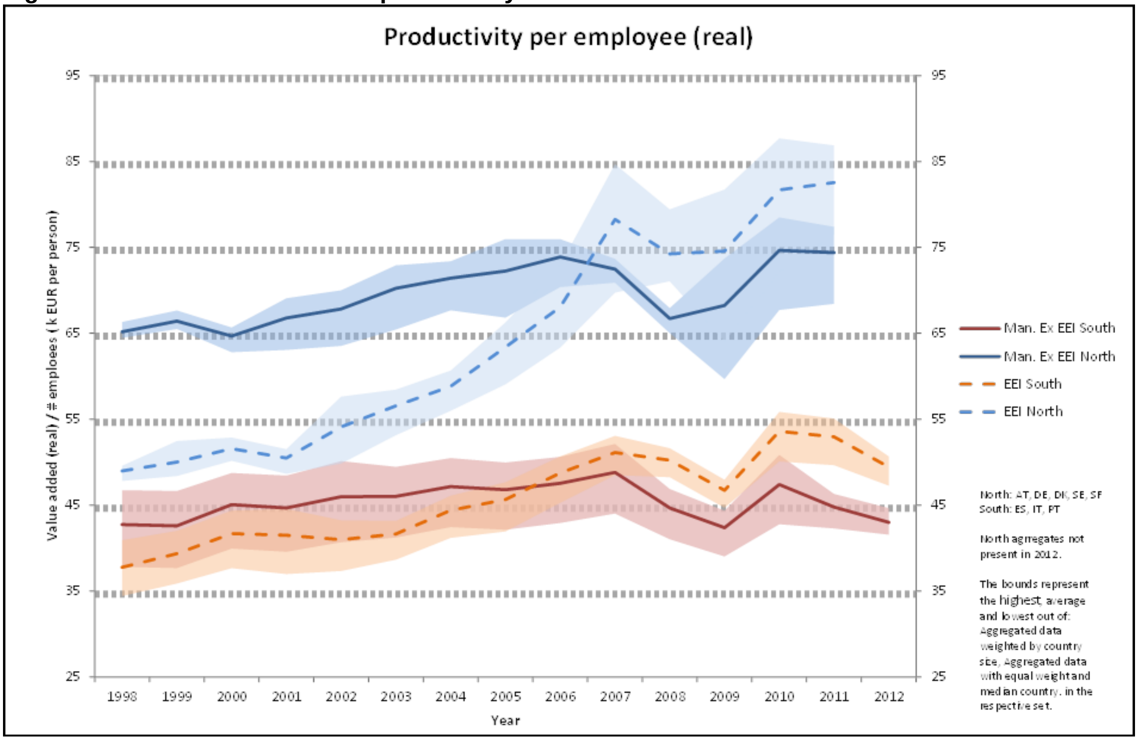
Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Growing labour costs need not be a threat for price competitiveness, as long as it is compensated by increases in productivity. If the ratio of both growth rates for northern economies is above southern economies they have improved their position. This analysis will be provided in the next subsection.

The productivity in EEI is growing faster than in total manufacturing in real terms and in both regions. Comparing the regions, it is disclosed that productivity of southern economies has remained flat in real terms for total manufacturing over the last 14 years. After the end of the financial crisis there was a brief recovery that caused a spike in labour productivity. In later years capacity utilization of manufacturing shrank and caused a decline in productivity. As a consequence further lay-offs are likely. For EEI the development of the most recent period is quite similar, although for all of the period under consideration labour productivity followed a steeper upward trend.

For the northern economies labour productivity shows a secular upward trend, although the development was interrupted by the global financial crisis in 2009. After 2010 a spike in labour productivity is observed and then a moderation of productivity growth followed (**Figure 4.37**). The respective growth rates are depicted in **Table 4.28**.

Figure 4.37: Evolution of labour productivity of northern and southern economies of EU-27



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Table 4.28: Labour productivity of EU-27's northern and southern economies

Region	Annual average growth rates		
	1998-2007	2008-2011	1998-2011
	Total manufacturing without EEI		
North ex. Germany	**1.1%**	**2.1%**	**1.4%**
Germany	0.8%	-1.5%	0.1%
South	**1.6%**	**-2.3%**	**0.4%**
	Electrical and electronic engineering		
North ex. Germany	**7.2%**	**0.0%**	**4.7%**
Germany	2.1%	2.8%	2.3%
South	**3.5%**	**1.0%**	**2.8%**

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

When looking at the elasticity calculated by the percentage change of labour productivity over the percentage change of labour costs per employee it is revealed that northern economies gained price competitiveness in both sectors as compared to southern economies. An elasticity above 1 indicates that growth in productivity is higher than for labour costs, resulting in an improvement of ULC. In total manufacturing the elasticity for 1998 - 2011 for northern economies is 0.5 that means that for every 1 % increase in labour costs, productivity increases by only 0.5 percentage points. For southern economies the indicator stands at 0.10 and indicates an even worse development of price competitiveness. For EEI this difference is greater: 1.3, indicating a reduction of ULC for the northern economies, whereas the elasticity of 0.8 for southern economies indicates growing ULC. (**Table 4.29**)

Table 4.29: Elasticity of labour productivity over labour costs per employee

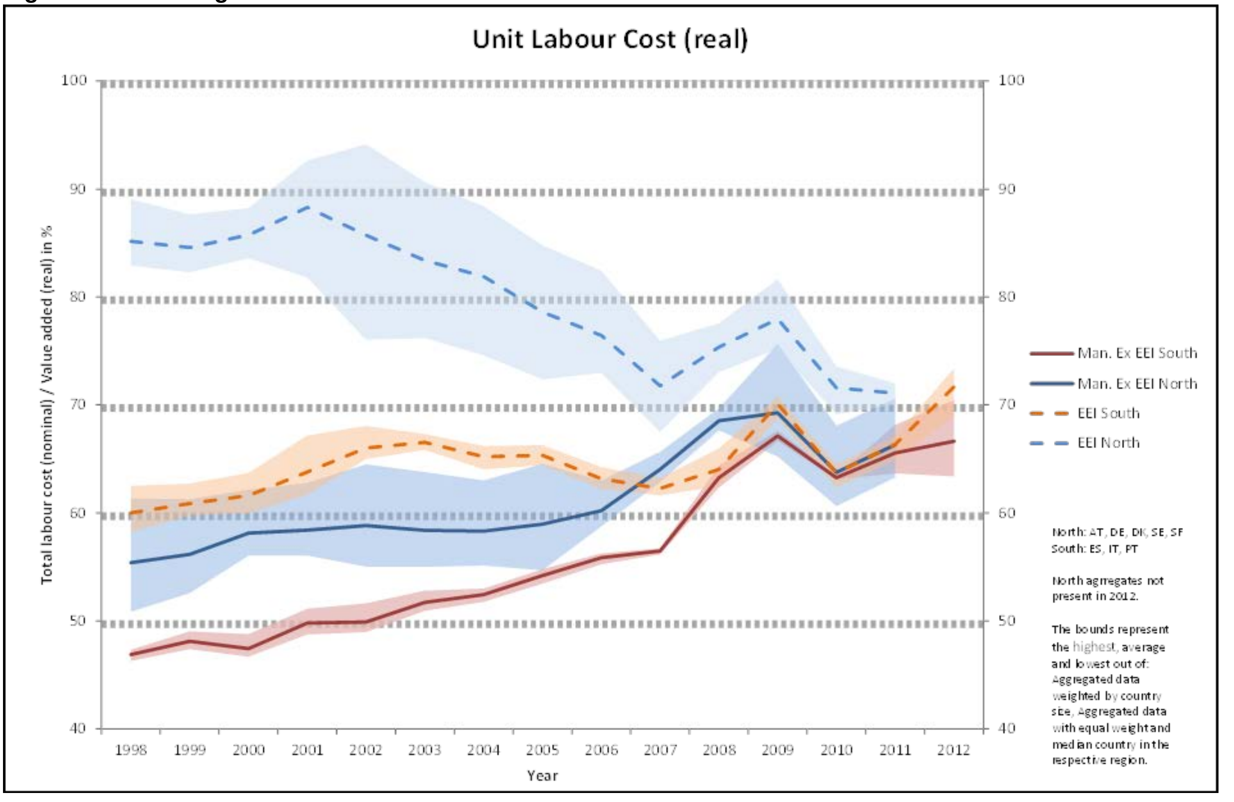
Region	Sector	Indicator	1998 - 2007	2008 - 2011	1998 - 2011
North w/o Germany[1)]	Manufacturing ex EEI	Elasticity: % Labour productivity / % Labour costs	**0.4**	**0.8**	**0.5**
Germany			0.8	-1.0	0.0
South[2)]			**0.4**	**-0.8**	**0.1**
North w/o Germany[1)]	EEI	Elasticity: % Labour productivity / % Labour costs	**1.8**	**0.0**	**1.3**
Germany			1.4	14.3	2.1
South [2)]			**0.9**	**0.4**	**0.8**
1) AT, DK, SE, SF 2) ES, IT, PT					

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The unit labour costs (ULC) indicate how relevant labour costs are in value added. A growing unit labour cost indicates a decrease in price competitiveness as a higher share of the value added is dedicated to pay labour costs, and less remains for the coverage of other costs, such as depreciation, interest rates for debts, costs of equity etc.

It has turned out that ULC are higher for EEI than for total manufacturing on average. The northern economies gained price competitiveness as compared with southern economies. For EEI, ULC declined noteworthy throughout the period under investigation, whereas for southern economies ULC had increased. For manufacturing without EEI the situation is not that clear. However, as depicted in the increase of ULC for northern economies was less pronounced than for southern economies with an upward trend for ULC. Throughout the period 1998 to 2007 only Germany performed better in the development of ULC for total manufacturing. This was the period when labour market reforms were carried out and wage increases were well below those in other Member States. (**Figure 4.38**)

Figure 4.38: Changes in ULC of northern and southern economies of EU-27



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

4.7 Overall assessment of the electrical and electronic engineering industry

This chapter is dedicated to providing an initial summary of the results presented in the IR, giving some initial conclusions and suggesting how to strengthen EEI which is part of an international, highly competitive European cluster. The conclusions and suggestion should be understood as food for thought and discussions with the Commission and the steering committee.

The object of investigation

EEI is a heterogeneous industry with three sectors and numerous sub-sectors. A large portion of the industry's output comprises intermediary products, above all in EE1 and EE3. For EE2, a large portion of the market is final products, consumer electronics and terminals.

The three sectors are categorized in the following way:

- EE1, electrical engineering (~ 60 % of weight) – produces to large extent products – many of them intermediary products – that are closely related to capital goods industries and transport equipment. In this respect EE1 is part of a worldwide competitive European Cluster. Numerous other manufacturing industries are likewise dependent on EEI's supply. Beyond manufacturing construction, civil engineering, mining, the service industries and utilities, in particular power generation and distribution are important clients of EEI. With batteries, accumulators and domestic appliances private households are an important group of customers.
- EE2, electronic engineering (~ 30 % of weight) – comprises a less heterogeneous product programme, manufacturing of computers and peripheral equipment, communication equipment, consumer electronics and electrical and electronic equipment for medical applications. The last sub-sector is highly competitive and has performed better than other

sub-sectors of EE2. The US and the EU are leading in the global supply by quantity as well as the state of technology.

- EE3, electrical and electronic components (~ 10 % of weight) – an upstream industry that delivers a broad range of intermediary goods to a wide range of quite different clients. The products are fed into value chains. Frequently they are assembled into more complex components and delivered further downstream, until they reach final goods manufacturers. These downstream linkages can be within EEI, but also via other industries. Within EE3 semiconductors play an outstanding role. These products are labelled as key enabling technologies, because they are widely applied in nearly all areas of the economy and contribute substantially to the technological progress in downstream industries. One important high-tech interface between the semiconductor industry and downstream clients are embedded systems that combine specific hardware components with firmware. These embedded systems have become pivotal for the performance clients' product and hence important for EU companies success in global markets. Interdisciplinary system engineering is one of the strengths of the EU manufacturing and has contributed much to the international competitiveness of downstream industries.

To a noteworthy extent the three sectors are part of a value chain, where EE3 is on top, while EE1 and EE2 are linked in using upstream products and upstream technological progress for own innovations. In this respect EEI is in itself an economic model that incorporates important value and innovation chains along different tiers of value creation. EEI is *pars pro toto* a subject of investigation for the dissemination of know-how and new techniques from the source to the final product. EEI shows the typical pattern, starting with a dynamically evolving key-enabling technology, with its use for different applications spreading all over the economy:

- EE3 is an upstream sector driven by a high pace of technological progress, based on semiconductors with cross-sectional applications. The nature of technological progress is growing efficiency, cost reduction and providing new opportunities. The evolution of technological progress and production resembles the technological progress function of N. Kaldor closely. Theoretically, a more capital intensive production increases labour productivity over-proportionately until steady-state equilibrium is reached. As long as the technological progress does not come to an end, this equilibrium is shifted to new potential output levels. This is a suitable approach to analyse the evolution of the semiconductor industry. With each process and product innovation it has become more capital intensive, while the long-term trend in labour productivity exceeds that of all other industries. The real output of the sector grows strongly while a less than proportionate increase of input causes a reduction of unit costs. These are understood as the baseline for the growth of revenues in nominal terms, while the real value creation is measured at constant prices. As a consequence, EE3 shows by far the highest growth rates in productivity (measured in real terms) with an annual average rate of 7.9 % for the years from 1998 to 2012 (EE1: 2.5 %; EE2: 4.5 %), while employment declined at average annual rates of -1.3 % nearly as much as EE2, whereas the latter sector was affected by the closure of capacities in the area of consumer goods, where Europe lost much of its former production (EE1: -0.3 %; EE2: -1.6 %).
- EE2 is a downstream sector that produces final as well as intermediary goods. Electronics and to a large extent semiconductors are key components that are pivotal for the performance of products. Here the empirical findings do not suit the expectations suggested by theory that well. The development of labour productivity was even worse than for EE1. This can be attributed to the difficult situation of the sector in international competition. The sector is in a phase of consolidation, in which much of the consumer electronics and communication terminals are no longer manufactured in the EU-27. These

mass-manufactured products with a high rate of innovation lost their former importance for EE2.

- EE1 is a downstream industry that during the phase of the New Economy Bubble was discredited as “Old Economy”. It is an engineering sector par excellence, although – with regard to its heterogeneity – this is a strong simplification. It was the best performing sector of EEI over the whole period under consideration with regard to international competition. This was to be expected because it is part of the internationally strong European production cluster of the metal industry, with a focus on machinery and transport equipment. However, the strength of EE1 is founded on its capability to successfully incorporate EE3 products and applications into its own machinery and transport equipment to supply cutting edge technologies and investment goods to world market.

Competitiveness of EU EEI and its sectors in international markets

At the turn of the millennium EU EEI was on eye level with the US, the leader in global trade, with a market share of roughly one tenths each. While the EU-27 was able to maintain this position in the era of growing supply from emerging economies, the US lost around one third of its share. Over the whole period China surpassed all other nations and is now the leading economy.

The better performance of EU EEI is based on the strong position in **EE1** in international markets, relative to the other sectors. These days China has become second in this ranking behind the US. Only for EE1, there is an EU trade surplus and trade indicators have improved over the whole period. Firm level data analysis disclosed an improvement of profitability and a balanced financial situation, as compared both to competing economies as well as compared to EE2 and EE3.

For **EE2** the situation in international trade is different. The external trade relation is characterized by a persistent and growing deficit. This is explained by the loss of production of mass-manufactured consumer electronics and communication terminals. For some product groups, there is no production left within the EU-27. Over the whole period under investigation the situation worsened. At the turn of the millennium firms’ profitability was high but it declined until the most recent available years, and in contrast to EE1 the financial situation is difficult. The negative evolution of EE2’s profitability in recent years is in contrast to the development of Chinese firms and the ability of US companies to keep profitability unchanged. There is an exception to this poor performance, which is medical equipment. Here European and US companies are leading in world markets and set the pace of technological progress.

For **EE3** the situation in international trade is even worse. The sector’s weight of EEI is extremely low for the EU compared to the most important competing economies. Its importance has declined over the whole period under investigation and has declined even more strongly with regard to its role in international trade. Its share of global exports decreased from one tenth during the early years under investigation down to one twentieth in the more recent past. In contrast to a general trend of growing international trade relations, it was quite the opposite for EE3: exports shrunk at average annual rates of 2.1 % between 1998 and 2012, imports declined at 0.2 % p.a. The shrinkage of exports indicates a stronger focus on the needs of clients within the EU-27 which are quite different from mass-manufactured electronics. The reduction in imports is explained by declining client industries. As compared to the profitability of companies in competing economies, the profitability of EU EE3 firms is poor. In recent years, though, profitability has somewhat improved. But this might have been caused by a reduced presence in more competitive international markets. This development might also be caused by investment restraint. There are indications that the semiconductor industry refrained from heavy investment in new fabs within the EU-27 due to costs of capital considerations.

Technological progress and employment

The pattern of high growth in real output and simultaneous poor employment record in the high-tech semiconductor industry might be attributed to the difficulties the EU EE3 was confronted with over the past decade. However, the comparison with the other competing economies, in particular those perceived to be the most competitive in this area shows a similar pattern, i.e., for the developed nations US and Japan, but also for South Korea, Taiwan and China with its skyrocketing growth rates: The employment record of EE3 is worse than for total EEI. The explanation was in input factor saving technological progress, or more precisely for the production of semiconductors it was labour saving progress associated with growing capital intensity.

This finding suggests that positive effects on employment of a high paced technological, labour saving progress depend on its feeding through along the entire value and innovation chain down to the production of final products. In this respect, focussing only on the interrelation of technological progress and employment in the high-tech industry is too narrow. The less technology driven downstream industries / sectors have to be taken into account, as well. Within the study this was implicitly done within an innovation cluster. EEI comprises sectors along the entire value and innovation chain. For a more comprehensive view, the machinery and transport equipment industry, as well as consumer goods industries, as for instance domestic appliances, that use semiconductors, embedded systems etc., have to be taken into account. However, to understand the general principles of the interaction along the value chain, the scope of the study is exemplary.

Technological progress and downstream linkages

An important result of the investigation is the impact of technological progress on downstream linkages and value chains. The linkages of EE1 and EE3 have deepened over the whole period. This has been mostly an evolutionary process driven by growing integration and miniaturisation of electronic components used as intermediary inputs for a broad range of products. (This is one example for the meaning of key enabling technology: cross-sectional relevance, driving the dissemination of high-tech into all areas of the economy. But only within downstream industries, here EE1, the necessary steps are taken to exploit the whole potential – for instance semiconductors – and only there we find positive employment effects).

An important interrelation has been identified between EE1 and EE3 that goes beyond miniaturisation and growing integration (Moore’s law), labelled “Beyond Moore”. This refers to the integration of different technologies and concepts, for instance the integration of digital and analogous data / information processing, or the detection, measurement and processing of any technical or natural measure on a single electronic component. These mixed-technologies have gained much importance, substantially changed how firms co-operate and accelerated the pace of innovation.

Most obvious has been the SSL technology that is about to revolutionize the sub-sector. Semi-conductors have become light sources and have started to disseminate into all areas of lighting. This technology emerged during the 1990s in LCD screens as backlighting. The linkages of EE1, more related to application, and EE3, the provider of the enabling technology, have become much closer with respect to the value created and the innovation chain. This example highlights the potential that remains embodied in these industries.

Race for technological leadership, manufacturing industries and employment

The discussion on international competitiveness is narrowly focused on certain high-tech industries. There is no nation – in particular if we look at the EU-27 and the seven competing economies – that does not emphasise its support for so-called key enabling technologies.[268] If one understands the concept of competitiveness only as competition among nations, this will be a zero-sum game that leads to redistribution of wealth from less to more successful nations. The advantage of global competition lies in the fact that a regional redistribution of production in a wider sense is driven by comparative advantages, be it natural resources or more advanced, man-made input factors for the production of goods and services, such as know-how, capital, competitive industrial clusters etc. The optimization of the allocation of resources with regard to regional advantages incorporates the potential to increase welfare for all participating nations.

This basic view on international competition should be applied to one of the most challenging suggestions for public policies, dedicated to strengthening the position of the EU-27 in the global race for the lead in semiconductor technologies. This topic goes beyond the subject of investigation of the study on EEI. It has to take into account the equipment industry as well as service providers for the architecture and the design of semiconductors.

There is no question that the EU must stay on the leading edge of technology and production of semiconductors to the benefit of the European economy, in particular its strong internationally competitive industries which are of major importance to maintain a balanced foreign trade. The disadvantages of technological progress on semiconductors outside Europe on EU downstream industries has been made obvious, for instance in lighting.

Investment in high-tech industries

The alternatives to strengthen the EU-27 position in international competition were discussed with experts of the industry. Without any preference, prejudice and regard to issues of finance they are stressed below:

- Investment in a next generation 450 mm Fab would provide Europe with the most advanced process technologies and the potential for the production of more advanced semiconductors. It would offer new opportunities for innovations in downstream industries. Such a Fab is highly capital intensive and will have higher capacities. This would reduce marginal costs further through parallel processing of more chips per wafer. The following detriments to locating such a facility in the EU were mentioned: higher capital costs, energy costs and the great distance to major clients with large volume demand. Transport costs are not perceived as decisive. Moreover, non-EU economies offer preferential investment conditions which the EU-27 is not able to provide due to (self-imposed) State Aid rules. Two questions have to be discussed: The EU semiconductor industry has – since the turn of the millennium – focused on the demand within the Single Market and reduced its footprint in global markets as indicated by time series on international trade. Is a reversal of this tendency envisaged and possible? The second question is dedicated to the existence of a competitive cluster for the manufacturing of commoditized semiconductors within the EU-27 as compared to non-EU locations.
- A more limited alternative could be the upgrading of already existing 300 mm Fabs with the latest process technology required for the production of more advanced semiconductors to provide some opportunity for downstream industries to stay in the lead. This might be less challenging with respect to initial funding, but would be associated with higher marginal production costs compared to a 450 mm Fab. This disadvantage might be mitigated by lower capital costs. This approach would to a degree enable development of technologies adequate to the specific needs of EU-27 downstream industries that are not only characterized by smaller batch sizes, but also by the combination of different

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[268] Quote those studies which surveyed international activities

technologies that are labelled “More-than-Moore”. This broader approach concerns technological areas where the EU is on the leading edge internationally, embedded systems and power electronics. This concept must not be implemented by the large enterprises alone, but might also integrate smaller, specialized manufacturers.

- A third approach could start with those areas of technology and fields, where Europe commands a strong position in the global semiconductor value creation: e.g., the specialized machinery industry with its know-how driven companies specializing in IC architecture or service providers for IC design. The initial objective should be to maintain or increase the rate of technological progress to hold or get an edge over non-EU competitors. Such positions will make EU firms indispensable in the engineering and construction of new Fabs and has proved to be successful in the recent past. Correspondingly, the catching up process in areas where the EU-27 is not in a favourable position could be launched and aided by targeted R&D projects. Here, the EU-27 can exploit its strong position in research, interdisciplinary and pan-European co-operation, as demonstrated by the semiconductor triangle Nijmegen-Eindhoven-Leuven, Grenoble and Dresden.

Regional convergence and the competitiveness of EEI

The EU is a large economic area with substantial differences in the availability, quality and price of input factors. In the course of the investigation of the regional distribution of EEI’s production networks, it has become obvious that the utilization of different wage levels has been an important tool for companies to reduce costs. There are sub-sectors, for instance domestic appliances, for which a clear regional shift of employment has been observed. This has contributed to a more or less satisfying employment record for EEI. Within the EU, wage differentials have provided firms with the strategic option of making use of regional comparative advantages. This has to be seen in contrast to the wave of fast track relocation of workplaces, observed for instance in the US and similar in Japan. However, the hollowing out of manufacturing has not been such a topic on the European political agenda yet, although manufacturing has lost noteworthy weight of the EU-27 gross domestic product.

With regard to the future development, EU and regional policies and measures aiming at convergence must therefore bear regional differences and comparative advantages in mind. Wages in low-wage Member States are currently somewhat higher than in non-EU emerging economies, whereas labour productivity gaps are much less pronounced.[269] Changes in price competitiveness may have significant consequences due to the international division of labour. A worsening of the price performance of Member States that build on their comparably low wage levels endangers the current state of employment.

The EU objective – as defined in Horizon 2020 – to increase the share of EU-27 manufacturing of total gross domestic product of 20 % can only be reached if manufacturing does not only trust in high-tech or key-enabling industries. Most of the employment is generated in other areas. However, the fertilisation of medium- to low-tech industries by high-tech industries via value and innovation chains will lead to employment improving perspectives, as long as the industries are able to maintain quality adjusted price competitiveness. A sustainable convergence policy should take into account that workplaces get lost to the advantage of employment outside the EU. The hollowing out of the US manufacturing sector and the current laborious efforts to reverse that development should be taken as a warning example.

[269] Quote Study on the competitiveness of the EU mechanical engineering

Manufacturing and trade balance

EEI is a global industry. Most important has been EE1 with its growing trade surpluses contributing to an overall roughly balanced trade account. With manufacturing perceived by policymakers as a provider of workplaces and welfare, the foundation is laid for an open and internationally oriented economy. The comparative advantages of the EU-27 have led production to focus more on capital goods and transport equipment goods. However, many consumer industries have shut down many of their EU production locations, with only few exceptions, as for instance domestic appliances. These industries with comparative advantages within the EU should be further embraced. In the era of globalisation, regions have to specialize in certain areas, as for instance Asia in case of consumer electronics. A loss of competitiveness in the industries, where the EU-27 currently is in the lead globally, would induce or exacerbate structural deficits in the trade balance, and would need to be compensated by other positions in the current account. To sustain the EU-27 competitive position R&D policies and initiatives have to aim at both the differentiated and by its volume important domestic demand as well as the responsiveness to global needs and developments, to benefit from much stronger growth in third country markets than in the EU.

5 Impact of regulatory and other framework conditions on the electrical and electronic engineering industry

5.1 Openness of international markets

5.1.1 Overview

Since multilateral negotiations through the WTO to reduce trade barriers have stalled, governments have focused on bilateral Free Trade Agreements (FTA). The US first initiated an FTA with Korea in 2007, but the agreement was only approved by the US Congress and the Korean National Assembly in late autumn 2012.[270] To a large extent the delay was caused by the resistance of US lobbyists. As of 2013 a total of at least 14 trade agreements have been put into force. The most significant of these, the North American Free Trade Agreement (NAFTA) between the US, Canada and Mexico created a large market with a lot of growth opportunities. Production networks have been regionally expanded; in particular, Mexico has further industrialized and taken over considerable production formerly performed in the US.

The European Union has pursued bilateral treaties with numerous countries. By 11 July 2011, the FTA with Korea was put in force. Virtually all tariff and non-tariff barriers were abolished in a comparably short period of negotiations. As of 2013 a total of 35 trade agreements have been enacted.[271] These focus especially on neighbouring European economies, North Africa and the Middle East. Many of these FTAs will integrate the economies and improve relations of the EU with its neighbours.

The EU traditionally has strong relationships with Latin America, as reflected by FTAs with Chile, Peru, Columbia and with the numerous smaller Central American economies. However, the EU is negotiating an FTA with MERCOSUR (Argentine, Brazil, Paraguay and Uruguay), by far the largest market in the region. Negotiations resumed in 2010, but the outcome remains unclear. **It is important to ease access to this large emerging market in order to compete to with Asian manufacturers who have expanded their presence in Latin America throughout the past decade. These procure urgently needed commodities, minerals and foodstuff, and provide manufactured goods in exchange.**

More recently the EU has been reinforcing activities with overseas economies, above all in Asia. Negotiations with India were launched in 2007. The FTA with Singapore has been concluded; only negotiations on investment protection have yet to be finalised. The EU is negotiating with the ASEAN economies of Malaysia, Thailand and Vietnam.

The recently announced Transatlantic Trade and Investment Partnership (TTIP) might become a groundbreaking agreement owing to its size and its potential impact. The US and the EU are by far the world's largest developed economies generating approximately 50 % of global economic output. This agreement will affect not only bilateral trade, but also trade with third countries.[272] **Most**

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270 http://www.ustr.gov/trade-agreements/free-trade-agreements/korus-fta

271 http://rtais.wto.org/UI/PublicSearchByMemberResult.aspx?MemberCode=918&lang=1&redirect=1

272 Francois, Joseph (CEPR); Reducing Transatlantic Barriers to Trade and Investment An Economic Assessment, London, March 2013 http://trade.ec.europa.eu/doclib/html/150737.htm.

benefits are expected to come from reducing non-tariff barriers, because average customs duties are already low. Import tariffs on industrial goods between EU and the US are similar, averaging 2.8 %. However some product groups with higher tariffs will benefit greatly from trade liberalization. Nevertheless there are many obstacles to overcome before a settlement is reached, including agreement over agriculture products.[273]

Simultaneously the US government is intensifying trans-pacific trade relations via the Trans-Pacific Partnership (TPP). TPP negotiations began in 2008, and will include the US, Australia, Brunei, Canada, Chile, Japan (only joined the negotiations in July 2013), Malaysia, Mexico, New Zealand, Peru, Singapore and Vietnam. The US is striving for an agreement that reaches beyond trade issues to include political settlements. [274] Most recently South Korea has announced it intentions to join the US led initiative. The TPP is high on the agenda of the Obama administration. TPP leaders are actively negotiating on all facets of free trade: intellectual property, cross-border trade in services, temporary entry, environment, market access, state-owned enterprises, investment, financial services, sanitary and phytosanitary issues, government procurement, labour, e-commerce, legal issues, technical barriers to trade and rules of origin. The statement by the US Trade Representative on Korea's announcement of TPP participation underscores the efforts of US to reach a comprehensive agreement: "President Obama, the other TPP leaders and their teams are currently working actively to complete the negotiations. Given that prior to entry any new member needs to complete bilateral consultations with current TPP members and those members need to complete domestic processes, as appropriate, the possible entry of any new country would be expected to occur after the negotiations among the current members are concluded."[275]

The proliferation of bilateral FTA initiatives has further complicated negotiations to reach a multilateral agreement to reduce trade barriers within the Doha Round. Moreover, the bilateral FTAs will be different for each of the partner countries. As a consequence they will liberalize international trade less than one multilateral agreement.

Revival of the Doha Round is unlikely and, thus, the EU must pursue bilateral agreements to reduce market access barriers. FTAs have become a strategic tool for governments to give their businesses an edge in global competition through eased market access. The scope of negotiations has expanded to include non-tariff barriers like technical codes.

There might be public interest to finalize as many FTAs as possible, so as to demonstrate measurable success. But FTA quality will be more important to the dismantling of trade barriers than the number of agreements.

Trade barriers caused by technical provisions are of particular importance to EEI – they guarantee the safe, secure and eco compliant use of its products. Full system compatibility without any interference to other appliances must likewise be guaranteed. CEN (European Committee for Standardisation) and CENELEC (European Committee for Electrotechnical Standardisation) are the umbrella organisations of 33 European national standards bodies. This cooperation has created the world's largest integrated market for EEI – technical regulation based on the Suppliers Declaration

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[273] Felbermayr, Gabriel et al. (CESifo); Dimensionen und Auswirkungen eines Freihandelsabkommens zwischen der EU und den USA, München; January 2013. http://www.cesifogroup.de/ifoHome/research/Projects/Archive/Projects_AH/2013/proj_AH_freihandel_USA-GER.html

[274] Wallach, Lori; Beachy, Ben; Obama's Covert Trade Deal; in: New York Times; June, 2, 2013. http://www.nytimes.com/2013/06/03/opinion/obamas-covert-trade-deal.html?nl=todaysheadlines&emc=edit_th_20130603.

[275] Office of the United States Trade Representative; Statement by U.S. Trade Representative Michael Froman on Korea's Announcement Regarding the Trans-Pacific Partnership; Washington, DC; November 2013; http://www.ustr.gov/about-us/press-office/press-releases/2013/November/Froman-statement-TPP-Korea.

of Conformity (SDoC) and non-mandatory standards. ETSI's (European Telecommunications Standards Institute) covers an even broader set of 62 member organisations. These bodies also co-operate closely with international standardization organisations to reduce technical trade barriers with third countries. The **Dresden Agreement** lays the most important foundation to international cooperation in this respect.[276] As a result, around three quarters of European standards are also IEC standards, agreed to by its 88 member countries and nearly all of them are harmonized standards, supporting EU legislation. (Table 5.1)

Table 5.1: International standardisation organisations of relevance for EEI

Product scope	European bodies	International bodies
Mechanical	CEN	ISO
Electrical, electronic	CENELEC	IEC
ICT	ETSI	ITU

Source: Ifo Institute.

The abolition of technical barriers to trade not only reduces costs for compliance, certifying and testing for European players, but also eases access for foreign players tapping the European market. Hence, it is important to create a level playing field for all suppliers. This implies that all products must comply with European regulations, but compliance is difficult to assure, because of deficient monitoring within the EU. This has been widely recognised, and non-compliant products are likely to go undetected (see: Chapter 5.3). Market surveillance has not kept pace with the development of the Union's regulatory framework. Ineffective monitoring within the European Union is a major cause of the prevalence of non-compliant products on the market.[277]

International cooperation with standardization bodies of emerging economies has become an area of general interest. Not to reinvent the wheel, US and European organisations support emerging economies in their efforts to set up the framework for a modern economy that relies on safe, secure and eco-compatible products. Moreover, the US and Europe compete to provide support and simultaneously reduce technical barriers to trade for their own companies. European initiatives have been identified in Russia and India to support the creation of an advanced regulatory system for technical provisions. As a consequence there is public interest to support these initiatives.

The EU semiconductor industry commands a strong international position in products for complex applications. These multi-functional semiconductors (MCO) integrate a variety of components integrated in a single unit and are of pivotal importance for innovation in downstream industries. These MCOs, a technology trajectory, labeled "Moore-than-Moore", combining different technologies in one single package, are semiconductors. However, they do not meet the current definition of products classified as semiconductors in the Harmonized System (HS).This has implications for international trade of MCOs and aggravates exports. MCOs are not classified under the semiconductor family but according to their functions. Hence they are found elsewhere in the Harmonized System. This leads to:

- Import duties for some of these products on markets that are significant for the major players.
- Significant complications in finding an appropriate definition for the product scope of free trade agreements.
- An increased administrative burden for classification both for industry and authorities (Binding Tariff Information, rulings, etc.)

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[276] CEN, CENELEC; Dresden Agreement http://www.cenelec.eu/aboutcenelec/whoweare/globalpartners/iec.html

[277] European Commission; Brussels; Executive Summary of the Impact Assessment – Accompanying the document: Product Safety and Market Surveillance Package; Brussels 2013, Commission Staff Working Document SWD(2013) 34;13) 34.

EU initiatives to tackle these problems could contribute to a reduction of barriers to trade, and the EU semiconductor manufacturers with their strengths in these market segments would benefit from eased access to third markets. A definition of MCOs has been approved by the World Semiconductor Council in 2012 and should be. The World Semiconductor Council supports the use of this definition for a duty free agreement and for an amendment of the Harmonised System.

5.1.2 United States

In contrast to the Single Market the US market is characterized by noteworthy regional differences in technical provisions and measures taken to guarantee safety in the workplace, consumers' health and the protection of the environment. This complicates market access for foreign manufacturers, because framework conditions vary from state to state.

An important aspect of the US framework conditions is product liability. These laws are primarily dedicated to the safety of consumers and only affect certain products. But there is concern that – in the future – the legal scope might be expanded to include capital goods too. The Foreign Management Legal Accounting Act (FMLAA) requires a US representative to bear responsibility in a US court, in case of a suspected violation. If this is the case the FMLAA could become a barrier to trade even in those areas where European companies command a strong position in international electrical engineering markets.

The US technical regulatory system is different from the EU's. EU certificates of conformity are not admissible. In case that third-party testing is required conformity assessment must be carried out in concordance with US regulation US law does not require European exporters to apply Underwriters Laboratories (UL) certification. However, US companies frequently ask for such a certificate, even if it is not obligatory.

Of general importance is the National Electrical Code (NEC), a federal directive that is codified in state law. But in contrast to the EU there is no harmonization process and provisions differ from state to state. There are tough requirements that take into account that many buildings in the US are made of wood. The approval of installations is carried out by local authorities ("Fire Marshalls"), but their decision criteria lack transparency.

The compliance with the legislation on safety in the workplace is supervised by OSHA and AHJ. EU firms have reported difficulties meeting regulations. OSHA or AHJ representatives shut down non-compliant machines having only EU certificates.

"Buy American" clauses in public procurement procedures are an important topic for EU EEI companies, especially for the manufacturers of trains, commuter trains, public lighting and medical equipment, since public administration or private companies at least partly funded by public authorities represent the majority of clients. Even worse, "Buy American" clauses affect EU subcontractors of US clients that supply public institutions.

In the area of railroads recent rule changes will ease market access for European manufacturers of trains. Traditionally passenger trains are required to withstand a head-on crash with freight trains. European trains do so by absorbing energy in crumble zones at the vehicle ends. New rules will allow passenger trains built according to European design principles. Railroads contain a lot of electrical equipment and the changed regulation could contribute to an eased market access in this area of products. The new Federal Railroad Association (FRA) standard is consistent with those being applied internationally at present and provides opportunities for EU manufacturers.[278] However, “Buy American” could remain an insurmountable hurdle.

Similar to the EU the use of hazardous substances in electrical and electronic equipment is strictly controlled. In the US the use of certain chemicals for components of electrical products, such as lead for solders or flame retardants (mostly TBBPA) for printed circuit boards or cables concerns worker and consumer health and safety as well as suitability for recycling and environmental damage. There is no federal restriction or prohibition on the use of lead in electronics. Only two states, California and New Jersey, restrict the use of lead in manufactured electronic products[279]. Moreover, California’s Green Chemistry Initiative (GCI) aims to reduce the use of hazardous materials and make products and manufacturing processes safer by design[280]. Many other states, so far, have only developed legislation for the disposal of electronic waste[281].

The general objective of the US’ and EU’s regulatory framework to restrict the use of certain hazardous substances is similar: Safety in the workplace, consumers’ health and protection of the environment. For specific chemicals and other substances the EU RoHS 2 directive and the US Toxic Substances Control Act (TSCA) define maximum concentration values, which may not be exceeded[282]. Both rules are not congruent. The prohibition of certain chemicals, limit values etc. differ and products put on the market in both economic areas fall under different regimes and have to meet both provisions. The US TSCA and the EU Reach are too different to agree on a single unified standard.[283]

5.1.3 Japan

The access to the Japanese market is primarily hampered by soft factors and to a lesser extent by tariff or non-tariff barriers erected by provisions and technical requirements. These comprise cultural and behavioural specifics, such as the preference of Japanese to work for domestic companies, the language and the script. In spite of Japanese companies’ success in global markets Japan’s traditional closed society has not changed much. The so-called Japan Incorporated has been kept intact with close ties among Japanese businesses. This specificity is the most challenging barrier to access the Japanese market via distribution channels. Likewise investments in Japanese companies are difficult. These problems cannot directly by addressed by agreements and raise doubts over the guiding principle behind negotiations on an FTA with Japan - that only started 2013 – to create framework conditions for competition on a level playing field. It has been acknowledged that an abolition of non-trade barriers is quite difficult and a safeguard clause was agreed upon to suspend negotiations after one year, if Japan does not live up to its commitments.[284]

Of special interest for EU manufacturers are markets for electrical engineering products and medical equipment, where EU firms can build on technological leadership. In particular the opening-up of public procurement for Japan’s railways and urban transport systems could become beneficial.

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[278] Wright, Robert; Siemens cheered by changes to US train design rules; in: Financial Times 2013/6/18; p. 18.
[279] http://leadfree.ipc.org/RoHS_2-1-2.asp
[280] http://www.dtsc.ca.gov/LawsRegsPolicies/Regs/upload/SCP-Revised-Text.pdf.
[281] http://leadfree.ipc.org/RoHS_2-1-2.asp
[282] The EU RoHS 2 Directive entered into force on 21 July 2011and the deadline for implementation in national law was 2 January 2013; http://ec.europa.eu/environment/waste/rohs_eee/.
[283] California has adopted the EU RoHS and put it into force.
[284] European Commission (Memo); A Free Trade Agreement between the EU and Japan; Brussels 2013/6/17. http://europa.eu/rapid/press-release_MEMO-13-572_en.htm.

Initially Japan did not regulate the use of hazardous substances. Authorities started with the "Law for the Promotion of Effective Utilization of Resources" (2001). It was directed at products beyond electrical and electronic equipment.[285] This law induced companies to reduce or stop using certain substances. Only on 1 July 2006, a Ministerial Ordinance, the "Japanese industrial standard for Marking Of Specific Chemical Substances" (J-MOSS), a regulation with a narrower scope as the EU RoHS, comprising only six product groups, has been put in force. The substances concerned are the same as in the EU RoHS, but rather than mandating limits or absolute bans, it merely requires a warning label if certain levels of nominated toxic substances are exceeded. It is up to the client to decide which product he or she selects, as long as alternatives with lower levels of hazardous substances are available.[286]

Waste management and regulation in Japan is in place only for certain items, such as TVs and air conditioners. Items such as computers, mobile phones or batteries are not yet included. The Japanese, as a nation, are very enthusiastic about technology and electronic gadgets. According to the National Institute for Environmental Studies, an administrative agency, the amounts of e-waste are intolerably high. Japan only recently started to tackle the problem and find possible solutions such as recycling. For example, in June 2010 the government started a used mobile phone collection campaign and collected 570,000 unwanted phones within 100 days.

5.1.4 South Korea

Since the mid-1990 South Korea has become a leading high-tech economy with a strong position in international markets. Nevertheless, it has not abolished policies dedicated to attracting foreign businesses. The focus has remained on players leading in advanced technologies. Free Economic Zones[287] have remained an important tool. There are six locations in Korea where the government has established Free Economic Zones (FEZ)[288]. FEZs are installed in order to promote FDI as well as collaboration with foreign corporations and knowledge transfer. Businesses in the FEZs are provided with various advantages: In addition to regular tax breaks for foreign owned firms, companies in the FEZ enjoy a 100 % exemption from acquisition and property tax for 15 years. Moreover, foreign investors may lease state property for up to 50 years, and depending on size and investment they receive an exemption from the lease fee of 50 % to 100 %. FEZs are also rather deregulated. Firms enjoy greater liberty regarding workers' rights and other provisions. For instance, unpaid leave is permitted and can be used if workers strike. Firms are free to hire whomever they want, not bound by restrictions regarding disabled or elderly. Furthermore public documents are issued in foreign languages, and companies and employees receive administrative support. FEZs also provide a high quality infrastructure including schools and hospitals.

South Korea's greenhouse gas emissions have doubled since the late 1990s and Korea is more than other nations affected by climate change. In 2008 the government decided to actively tackle these problems and to foster growth through more environmentally friendly production, the reduction of carbon and greenhouse gases and the promotion of renewable energies[289]. Between

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[285] http://www.rohsguide.com/rohs-future.htm.

[286] http://home.jeita.or.jp/eps/jmoss_en.htm.

[287] Republic of Korea Ministry of Finance and Economy: Free Economic Zones in Korea. The Future of Northeast Asia; 2003; http://unpan1.un.org/intradoc/groups/public/documents/apcity/unpan018745.pdf

http://www.fez.go.kr/en/

http://unpan1.un.org/intradoc/groups/public/documents/apcity/unpan018745.pdf

[288] Incheon FEZ (2003); Busan/Jinhae FEZ (2004); Gwangyang FEZ (2004); Yellow Sea FEZ (2008); Saemangeum/Gunsan FEZ (2008); Daegu/Gyeongbuk FEZ (2008)

[289] OECD: Green growth in action: Korea; http://www.oecd.org/korea/greengrowthinactionkorea.htm

Oecd Development Centre: Sang In Kang, Jin-gyu Oh and Hongseok Kim: Korea's Low-Carbon Green Growth Strategy; Working Paper No. 310; 2012

http://www.oecd-ilibrary.org/docserver/download/5k9cvqmvszbr.pdf?expires=1368605035&id=id&accname

2004 and 2011 the South Korean government invested roughly € 5.8 billion ($ 7.6 billion) exclusively in research and development of renewable energy technology. In 2009 it installed a 5 year plan, the so-called Low Carbon Green Growth Plan, which focuses mainly on industrial regulation to reduce greenhouse gas emissions and create incentive mechanisms for businesses to develop green technologies and products. One such incentive is a "Low-carbon" certification from the Ministry of Environment, given to those Korean companies, which achieve the largest carbon emissions reduction[290]. This also serves as a way to inform consumers about the energy efficiency of certain products.

One of Korea's main comparative advantages in the beginning of its industrialization has been the large supply of cheap labour. Development drove the need for well-educated scientists, and many young men and women went to the US to receive their graduate education, often under the sponsorship of the Korean government. With the development of high quality technical and scientific universities and institutes, Korea is now able to educate its future leading scientists at home. Moreover, the government successfully lured many back, top scientists who had emigrated abroad. Today, one of Korea's main assets is a large pool of well-educated and productive workers, available at reasonable labour costs[291].

5.1.5 China

China's accession to the WTO has contributed to a reduction of barriers to trade and opened-up markets to international investors. The country has committed itself to the introduction of WTO conforming rules on international trade. In spite of this commitment, foreign investors' activities have remained under strict public control. The National Development and Reform Commission (NDRC) decides on industries and the kind of investment that foreign investors are allowed to make.[292] Industries are categorised as "encouraged" if FDI is welcomed and as "prohibited" if no FDI is allowed. Even for "encouraged" industries, framework conditions are by no means transparent. Frequently takeovers are not allowed and JVs are required by public authorities, e.g. in the power generation equipment industry.[293] The public approval of JV depends on Chinese industrial policy targets.

Although China committed itself to the World Intellectual Property Organization (WIPO) in WTO 2001, governmental enforcement of IPRs are neither sufficient nor transparent.[294] JVs in combination with the deficiencies in the protection of IPR raise risks for foreign investors to lose control over know-how. **It has to be pointed out that China - as member of the WTO - has to guarantee IPR in line with WIPO. This requires satisfactory surveillance and enforcement.**

In case of obligatory third-party testing, Chinese authorities do not accept European certificates. This is a concern for the manufacturers of radio and telecommunication equipment as well as medical equipment. Market access is complicated by a deficient and non-transparent Chinese regulatory system. A body identified by Chinese authorities has to carry out the task, but Chinese accreditation system does not sufficiently assure the quality of these bodies. The Chinese Compulsory Certification (CCC) procedure is expensive and time consuming. Chinese experts have

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=guest&checksum=2811A3310EE1D83496F244AA19488726
http://gggi.org/korea-leads-way-for-asias-green-growth/
[290] http://www.koreaittimes.com/story/26297/lg-electronics-earns-low-carbon-certification-first-home-air-conditioner
[291] Asian Development Bank Institute, Young-Hyun Lee: Workforce Development in the Republic of Korea, 2007
Tax and Global Guide to R&D Tax Incentives 2011/2012
[292] For the tasks of the NDRC see: http://en.ndrc.gov.cn/mfdic/default.htm.
[293] This classification is part of the overall industrial policy pursued by the NDRC, see: http://en.ndrc.gov.cn/hot/W020060531535875002958.jpg.
[294] Becker, K. and Ihrcke, J. (2007) "Study on the Future Opportunities and Challenges of EU-China Trade and Investment Relations - Study 1: Machinery", Brussels, p.29.

to travel to Europe if the production processes requires certification. Certification by Chinese experts raises the risk of economic espionage and piracy.[295]

The IT industry is of strategic interest for all economies. China pursues an active policy to create a supportive environment for domestic manufacturers by setting specific national provisions. The authorities strive to exploit the advantage of the large domestic market by the definition of Chinese standards, which deviate from international agreements. Among them are:

- In mobile handsets the Chinese wireless local area networks (WLAN) standard WAPI – set up in 2009 – has to be made available, although the internationally recognized Wireless-Fidelity (WiFi) standard developed by the Institute of Electrical and Electronics Engineers (IEEE), has been predominantly applied. Non-WAPI enabled Internet enabled mobile devices face problems getting public market approval.
- Another voluntary wireless standard was approved in February 2012, the Chinese Ultra-High-Throughput (UHT) / Enhanced-Ultra-High-Throughput (EUHT) standard. This is an alternative to the international IEEE 802.11n standard. US industry groups commented that the standard may not be compatible with either WAPI or the EEEI 802.11 and could restrict market access.
- At the end of 2011 China unveiled an encryption algorithm (ZUC standard) which was developed for use in 4G Long Term Evolution (LTE) by a quasi-governmental Chinese research institute. ZUC has been approved by the European Telecommunication Standards Institute (ETSI) 3rd Generation Partnership Project (3GPP) as one of three voluntary encryption standards in 2011. In early 2012 the Ministry of Industry and Information Technology (MIIT) announced that only domestically developed encryption algorithms, such as ZUC, would be allowed for network equipment and mobile devices comprising 4G TD-LTE networks in China.

Other non-tariff barriers concern mobile devices. On 10 April 2012 the MIIT issued the "Draft Mobile Smart Terminal Administrative Measure," which established a new regulatory framework for the mobile market. The measure contains numerous obligations, technical mandates etc. that go beyond usual requirements and pose high barriers on foreign suppliers. Currently the draft measure is under revision.[296]

The complexity and lack of transparency of China's regulatory and conformity assessment practices in the information and communication technology (ICT) sector contribute to an increasingly unpredictable business environment and hamper market access to foreign and foreign-invested companies in China. At present, there are two main issues of concern:[297]

- China's regulation on commercial encryption by Office of the State Commercial Cryptography Administration (OSCCA): China's approach to encryption differs markedly from the international practice, by handling encryption as a unified policy, under the direct supervision of Chinese leadership, encompassing both state and commercial security applications.
- The Multi-Level Protection Scheme (MLPS) was introduced by the Ministry of Public Security through an administrative decision on 22 June 2007 and requires all IT systems in China to be classified on different levels of security. As a result all users of ICT falling under high levels of security are required to purchase products of Chinese origin only.

[295] The regulation is based on the China Compulsory Certificate (CCC) that was only introduced 2003.
[296] UNITED STATES TRADE REPRESENTATIVE; 2013 Report on Technical Barriers to Trade; April 2013; pp. 53.
[297] European Commission, Directorate General Trade; IT Security - Chinese licensing practices and approaches to information deviating from the international standards and global practices; last update 8th November 2013; http://madb.europa.eu/madb/barriers_details.htm?barrier_id=085196&version=2,.

Initiatives have been taken by the EU Commission and Chinese authorities declared their willingness to change the discriminatory legislation. Little has changed yet, and the use of foreign certain commercial ICT products is still inhibited.

Several problems have been reported on non-tariff barriers in the area of medical devices. For example clinical tests must be repeated in China in order to register products there, although approval procedures in mature markets, such as the US or the EU have already been successfully concluded. Medical devices are classified as high risk (Class III) products – although this is not justified generally – and are subject to comprehensive and burdensome testing procedures. Moreover, Chinese authorities ask for an admission to the market in the country of origin, and the approval procedure has to be carried out in China once more to get the admission to the market. The registration of medical devices expires every five years, requiring an expensive re-registration procedure.[298]

Chinese initiatives to apply standards as industrial policies do not reflect the spirit of WTO membership. Conforming Chinese standards to international agreements should be a precondition to negotiations.

5.1.6 India

India is one of the most promising emerging markets due to its size and its growth potential. Much effort has been made to raise India's attractiveness as a location for research and development and FDI. But India remains a relatively closed economy. Especially small businesses but even large Indian groups and agriculture have always successfully pursued their interests to remain protected from international competition. Moreover, the Indian regulatory system lacks transparency. Application and approval procedures are lengthy and costly. The legal framework for setting-up businesses differs from state to state.

Import tariffs have remained extremely high for some product groups to protect indigenous manufacturers. Indian authorities have developed their own national standards and regulations instead of adopting internationally agreed standards. As a result, technical barriers to trade hamper market access. Market access is complicated further by time-consuming approval procedures.

In the area of telecommunication equipment, India pursues a domestic testing policy which requires a mandatory transfer of technology and source codes as well as burdensome testing and certification rather than accepting products tested in any accredited laboratory located in India or elsewhere in the world.[299]

Legal certainty remains a problem. India has not yet fulfilled all WTO obligations under the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS).

Generally speaking the Indian regulatory system is not yet adequate for an advanced economy. The Bureau of Indian Standards (BIS) has to increase efforts to meet the requirements of a more technological driven and complex manufacturing industry. The US[300] as well as the EU has offered support to Indian organisations to implement a technical code. A European initiative was launched in 2013 to intensify cooperation between Indian and European organisations (CEN, CENELEC and

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[298] UNITED STATES TRADE REPRESENTATIVE; 2013 Report on Technical Barriers to Trade; April 2013; pp 57.

[299] UNITED STATES TRADE REPRESENTATIVE; 2013 Report on Technical Barriers to Trade; April 2013; pp 66.

[300] In 2007 the American National Institute (ANSI) signed a Memorandum of Understanding with BIS and the Confederation of Indian Industry (CIII) to stablish and India – US standards portal http://www.standardsportal.org/usa_in/key_information/MoU.aspx.

ETSI) active in the area of standardization and technical provisions. Since 2013 a permanent representative is based in New Delhi. His tasks are to better understand the Indian technical code and to develop a network at administrative, technical and industry level.[301]

5.1.7 Russian Federation and other East European economies

At the end of 2011 the Eurasian Customs Union (ECU) was enacted to create a common economic zone between Russia, Belarus and Kazakhstan. The three countries have decided to setup common technological regulation. The technical regulatory system, formerly known as Gosstandard, is under revision and the Federal Agency on Technical Regulation and Technology (Rostechregulierovanie) is cooperating closely with the EU. Recently Rostechregulierovanie signed an agreement with CEN, CENELEC and the Customs Union of Russia, Belarus and Kazakhstan. The update of the technical code in concordance with the EU regulation could mimic NLF, though with 3rd party certification. This initiative supported by the EU will contribute to a reduction of non-tariff barriers to trade. Initial provisions concerning lighting and low-voltage equipment have only recently taken effect.

The major problem for foreign companies doing business in Russia are not formal restrictions to trade, but legal uncertainty and the poor enforcement of legislation by slow and understaffed bureaucracy, features that bilateral negotiations cannot address. Certification procedures remain time consuming and expensive, in spite of the cooperation in the area of technical regulation.

The long-term objective of Russia is to strengthen the political and economic co-operation among countries of the region. Beyond the three members of the ECU Kyrgyzstan and Tajikistan are expected to join the Union. A Eurasian Commission has been created modelled after the European Commission. Other countries could follow suit. Ukraine’s decision to participate in the Eurasian Union will be critical.

Currently the Ukraine is deciding between a tariff union led by Russia and an FTA with the EU, which carries with it tough political demands to strengthen democratic institutions. Likewise, Ukrainian people are divided over this issue, and a decision in either direction will raise difficulties. Georgia is also wavering in its decision to integrate toward the east or west.

The EU summit in Vilnius on 28 – 29 November 2013 has brought about some progress in the rapprochement of Eastern European economies to the EU. The EU-Republic of Moldova and EU-Georgia Association Agreements including DCFTAs have been signed. Some progress has been made in negotiations with Armenia, Azerbaijan and Belarus. However, the Ukrainian government decided to temporarily suspend the process of preparation for signature of the Association Agreement and DCFTA between the EU and the Ukraine.

The strengthening of East European countries’ economic ties with the EU will contribute much to societal and political changes asked for by Western politicians.

5.1.8 Middle East and North African economies

The region is quite heterogeneous with respect to its economic and political situation. This is reflected in international agreements on trade.

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[301] CEN, CNELEC; The Seconded European Standardization Expert in India (SESEI) http://www.cencenelec.eu/news/videos/Pages/vo-2013-001.aspx.

The Gulf Cooperation Council (GCC) comprises (with the exception of Yemen) the countries of the Arab peninsula: Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates and the Sultanate of Oman. They have agreed to create a common economic area. They introduced a duty of 5 % on third country imports, but further national tariffs are due. Imported products need a Certificate of Conformity (CoC); however, provisions are not challenging. International standards are obligatory to warrant an internationally recognised level of safety without any preference to US, EU or any other technical code. For third-party testing, European notified bodies, such as Intertec and SGS are accredited in the Middle East.

While technical barriers do not pose an excessive problem for market access, there are some informal hurdles that have to be taken into account. There is no obligation for a local representative within the UAE but it is indispensable de facto. By law, the relationship between foreign manufacturers and their local representatives is strictly regulated: The local representative is liable for any claim against the manufacturer of the imported goods. In case of a dispute between the foreign company and the local representative the representative may block further imports and is allowed to retain payments for goods already delivered.

These de facto requirements and lengthy administrative procedures hamper EU – GCC trade. Although the GCC suspended negotiations on an FTA in 2008, and they have not yet been resumed, the EU should work to improve the framework conditions for bilateral trade. A platform is available with the common Joint Action Programme[302].

Initiatives for an integration and rapprochement of Southern Mediterranean economies to the EU go back to the launch of the so-called Barcelona Process in 1995. They were re-launched in 2008 under “Union for the Mediterranean” (UfM). The Union comprises the EU plus Albania, Algeria, Bosnia and Herzegovina, Croatia, Egypt, Israel, Jordan, Lebanon, Mauritania, Monaco, Montenegro, Morocco, the Palestinian Authority, Syria, Tunisia and Turkey. The activities have suffered a major setback in course of the turmoil during the aftermath of the Arab Spring.

Only recently new initiatives have been undertaken. Morocco is the first economy where negotiations for a Deep and Comprehensive Free Trade Agreement (DCFTA) have started. The Commission has the mandate to start similar talks with Tunisia, Egypt and Jordan.

Trade liberalization requires more than bilateral agreements between the EU and countries of the region—intra-regional trade must also be liberalized. This will be an indispensable prerequisite to stimulate economic development and an urgently needed process of cohesion. A first step has been taken with the Agadir Agreement where concerned governments committed to liberalize internal trade. The Greater Arab Free Trade Area (GAFTA) has been understood as a starting point. Tariffs on Arab products have been removed, but a noteworthy number of products have been excluded from liberalization and non-tariff barriers have not been abolished. Intra-trade has not intensified, indicating that GAFTA is insufficient to stimulate cohesion and growth.[303]

5.1.9 Central and South America

Argentine, Brazil, Paraguay and Uruguay have been negotiating the creation of a Single Market, the MERCOSUR, for a long time, but not much progress has been made. Various interests of the countries involved, not only hamper the creation of a large Latin American economic area, but

[302] Joint Action Programme for Implementation of the GCC-EU Cooperation Agreement of 1988 - 2010-2013; http://eeas.europa.eu/gulf_cooperation/index_en.htm.

[303] Arab news; Greater Arab free trade: Higher hydrocarbon prices boost surplus http://www.arabnews.com/print/451429.

burden trade talks between the EU and MERCOSUR. After nine rounds of negotiations nearly no progress has been made. It was decided that the economic areas first tackle their internal problems and then restart negotiations, by the latest, at the end of 2013.[304]

Given the history of its members unsettled internal differences, it is questionable whether MERCOSUR is an adequate counterpart for the EU in trade negotiations. Moreover, conflicting interests in agricultural policies impede transatlantic negotiations.

5.2 Public policies

5.2.1 Industrial policies with focus on SMEs

As European companies face increasing international competition on product and factor markets, a self-sustaining culture of innovation is crucial for long-term economic growth. Besides efficient flows of technology within Europe, companies need ready supplies of finance and business skills, as well as protection for intellectual property and adequate incentives for entrepreneurial drive. Critical to such a culture of innovation are the small and medium-sized enterprises (SMEs) which have proved to be the engines of economic growth, and the principle sources of new employment. Start-ups and SMEs are identified in EEI-relevant areas, as for example in the field of Printed Circuit Boards (PCB) within the sub-sector 26.51.

Regarding the competitiveness of such SMEs, the European Commission initiated Europe 2020, which is the European Union’s ten-year growth strategy, under which several flagship initiatives are implemented. In particular, the initiatives aim at improving the business environment and supporting the development of a strong and diversified internally competitive industrial base.[305] It is especially the initiative for “An industrial policy for the globalisation era” which sets guidelines for industrial policy to improve the business environment of SMEs. The initiative mainly focuses on measures to promote more dynamic and internationally-competitive SMEs.

Important areas that affect sustainable long-term economic growth of SMEs are mainly identified with respect to the access to finance and markets as well as the promotion of entrepreneurship. Regarding access to finance, innovative financial instruments are continually gaining importance. Under the Europe 2020 initiatives most financial instruments provide both equity and loan guarantee facilities. In particular, instruments in the Competitiveness and Innovation Framework Programme (CIP) and the follow-up Programme for the Competitiveness of enterprises and SMEs (COSME) include an equity facility for growth-phase investment providing reimbursable equity financing, primarily in the form of venture capital through financial intermediaries to SMEs. Moreover, it includes a loan facility, providing direct or other risk sharing arrangements with financial intermediaries to cover loans for SMEs.

Regarding access to markets, Europe 2020 includes provision of growth-oriented business support services via the Enterprise Europe Network. The latter is an SME-orientated network of enterprises that provides comprehensive and integrated services to SMEs (like e.g. facilitation of cross-border partnerships, access to energy efficiency, climate and environmental expertise, and informing SMEs on EU legislation and promotion of EU funding programmes). It also supports SME businesses outside the EU market to successfully access third country markets. Therefore SMEs must be equipped with appropriate skills and knowledge of the third country regulatory framework as well. Comprehensive support services are provided by EU SME Centres. Moreover, the EU aims

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[304] http://ec.europa.eu/trade/policy/countries-and-regions/regions/mercosur/.
[305] COM(2010) 2020 final.

at facilitating international industrial cooperation by reducing differences in regulatory and business environments between the EU and its main trading partners.

Regarding the promotion of entrepreneurship, activities in this area encompass the simplification of administrative procedures and the development of entrepreneurial skills and attitudes, especially among new entrepreneurs. Concrete policy initiatives to foster entrepreneurship in the EU need to tackle simplification of company law (e.g. bankruptcy procedures) and allowing entrepreneurs to restart after failed businesses. Especially direct business access to capital markets and financing for start-up companies need to be improved.

In general, although EEI SMEs are numerically less represented than SMEs in other sectors, initiatives to facilitate financial and market access as well as entrepreneurial business activities are important factors to improve the overall business environment within in the EU EEI. It is especially the EEI SMEs that serves as important up-stream innovators in the provision of specialised high-tech solutions to bigger companies.

5.2.2 R&D and innovation policies

The impact of the subsequent programmes on the EEI is mainly in providing adequate framework conditions and subsidies for the implementation of EEI-specific technology fields. According to the interviews, the listed programmes show no clear problems posed by the public policy. JTIs, for example, were much less industry friendly in former times, whereas the role and the possibility of the industry to participate in designing appropriate programmes has steadily increased.

Electro mobility

In the EU there are several technology initiatives that affect the emergence of electro-mobility. Most of the EU's efforts in this area are on fostering the development and employment of electric motors, which are part of the 27.11 sector; in particular electric motors assembled in cars instead of usually applied internal combustion engines (ICE). In this context the EU launched the Public Private Partnership **European Green Cars Initiative** (EGCI), which primarily dedicates funding to research projects on electric and hybrid drives.[306] The priority of this initiative is on high-energy density batteries, advanced electric components, powertrain architectures and ICEs, specialised for the application in hybrid electric cars.

Another project affecting 27.11 products is the **Green eMotion** project[307], which is part of the EGCI launched within the context of the European Recovery Plan. Together with stakeholders from industry, the energy sector, electric vehicle manufacturers, and universities and research institutions, the project aims at fostering the conditions to successfully implement EU-wide electro-mobility. Here the projects main focus is on defining European standards and to establish demo-regions in the EU-27 for practical research on the field of electro-mobility.

Furthermore, the EU has strong focus on providing energy efficiency activities through its Joint Research Centre (JRC). Under the guidance of the Institute for Energy and Transport (IET) – one out of the seven scientific institutes of JRC – the EU has launched the voluntary **Motor Challenge Programme** in 2003. This is dedicated to support industrial companies in improving energy efficiency of motor driven systems.[308] Companies qualifying for the programme will receive aid, advice and technical assistance from the EU Commission in formulating and carrying out their

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[306] http://www.green-cars-initiative.eu/public/
[307] http://www.greenemotion-project.eu/home/index.php
[308] http://iet.jrc.ec.europa.eu/energyefficiency/motorchallenge

action plan. In the latter a company commits to undertaking specific measures to reduce energy consumption. Besides electric motors the programme modules comprised technology areas like compressed air systems, pumps, and fans.

Besides cars, EU electro mobility initiatives also tackle adjacent areas as in a case of the provision of appropriate **infrastructures**. Therefore the EU launched a transatlantic interoperability centre on e-mobility and smart grids with the US Department of Energy (DoE) in 2011.[309] Two centres were established, one at Argonne National Laboratories (US) and one at the JRC facilities in Ispra (ITA). Both centres aim at promoting research contact between EU and US scientists to address the interoperability issues between e-vehicles, smart grids and recharging systems.

With regard to infrastructures the EU Commission further launched Clean Sky JTI in 2008, which represents a PPP between the EU Commission and the industry. It is managed by the **Clean Sky** Joint Undertaking (CSJU) until 31 December 2017. The CSJU will deliver demonstrators in all segments of civil air transport, grouped into six technological areas called Integrated Technology Demonstrators, which are SMART Fixed Wing Aircraft (SFWA), Green Regional Aircraft (GRA), Green Rotorcraft (GRC), Sustainable and Green Engines (SAGE), Systems for Green Operations (SGO), and Eco-Design (ECO).[310] According to the 1st Interim Evaluation of the CSJU in 2010 the overall start of successful implementation was slower than expected and the prime objective of Clean Sky is to achieve demonstrator targets within time frame. Therefore streamlining programmes and focussing on advanced technology demonstration is recommended.[311]

Finally, the European Commission has also proposed a Directive for Alternative Fuels Infrastructure, which will enter into the final stage of legislative negotiations between the European Parliament and Council shortly. It aims at the promotion of a sustainable range of transport solutions and the build-up of interoperable, alternative fuels infrastructure in Europe as a means to stimulate sustainable growth, jobs and technology take up.

In spite of the focus of EU and Member States' policies to push electro-mobility by funding research projects the take up has been slow in recent years. The envisaged technology push has to be complemented by policies dedicated to stimulate the dissemination of advanced transport techniques. Battery technology has remained the Achilles heel for electro-mobility. This means that among other factors the insufficient charging infrastructure hampers the dissemination. Changing transport behaviours of people, car sharing and the combination of different transport means for travelling require an adaption of the currently available infrastructure to new emerging needs. However, public budgets have been tight in most Member States. Moreover, electric cars will remain handicapped by the price performance ratio for a foreseeable future. With regard to these framework conditions it will be extremely important to stimulate the dissemination of electro-mobility primarily by preferential rules on the road, in cities and on car parks. This will be necessary to provide manufacturers with possibilities to exploit scale effects by higher production volumes.

Semiconductors

Micro- and nanoelectronics

In case of the microelectronics the EU has implemented specific tools as for example the Joint Technology Initiatives (ARTEMIS for embedded systems and ENIAC in case of nanoelectronics) as well as new Framework Programme for research, called Horizon 2020. Joint Technology Initiatives

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[309] http://ec.europa.eu/dgs/jrc/index.cfm?id=1410&obj_id=14220&dt_code=NWS&lang=en
[310] http://www.cleansky.eu/content/homepage/activities
[311] Clean Sky - 1st IA-15-12-2010 Final Version, http://www.cleansky.eu/sites/default/files/documents/csju-first-interim-evaluation-20101215.pdf

like ARTEMIS and ENIAC are of cross-cutting nature and thus address developments in nanoelectronics and embedded systems, among a broad range of applications also for electric mobility. Horizon 2020 brings together all existing EU research and innovation funding initiative currently provided through the Framework Programme for Research and Technological Development (FP), the Competitiveness and Innovation Framework Programme (CIP) and the European Institute of Innovation and Technology (EIT). The EIT is a body of the European Union based in Budapest, Hungary that became operational in 2010 and which brings together higher education, research and business. It combines government and partnerships of education, technology, research, business and entrepreneurship (i.e. the Knowledge and Innovation Communities)[312], in order to foster the development and production of new innovations. Under Horizon 2020 funding will be provided for every stage of the innovation process from basic research to market uptake. However, in addition to individual national solutions and support programmes, there is need for coordinated EU-wide cooperation across the whole industrial value chain if a competitive EU semiconductor industry shall emerge.

One of the successful industrial policies dedicated for the creation of a high-tech cluster is **Silicon Saxony**. The establishment of a production site for processors supported by public funds has led to the growth of a globally competitive network of companies. The co-operation of the local university, Technical University of Dresden, semi-public research institutes and a large global manufacturer of semiconductors have provided an environment that led to a creation of a myriad of small know-how driven companies that play a pivotal role in the field innovation, be it product or process. Many of these firms are spin-offs from scientific research, while others are benefitting from spill-overs from the large manufacturing site. In spite of this favourable cluster local production of semiconductors is challenged by international competition, in particular in periods of poor global demand growing price pressure squeezes profitability of European locations suffering from high factor costs. The fabs, formerly a site of AMD have become part of GlobalFoundries Inc. (USA) owned by the Advanced Technology Investment Company (ATIC) an investment tool of Abu Dhabi. Fab 1 located in Dresden benefits from the favourable know-how environment, but simultaneously has to stay cost-competitive as compared with ATICs other production locations in Singapore and above all in the US.

Further successful European electronics clusters are found in **Grenoble** (France), **Eindhoven** (the Netherlands) and **Leuven** (Belgium). The Grenoble nanotech cluster is largely build around the Grenoble Institute of Technology (GIT), which is part of the Master Nanotech initiative[313]. Besides the GIT the cluster comprises the two institutes Ecole Polytechnique Federale de Lausanne (EPFL) (Switzerland) and the Politecnico di Torino (Italy). An important business player in the field of micro- and nano-electronics that is active in the Grenoble nanotech cluster is STMicroelectronics. The Eindhoven and the Leuven high-tech cluster are part of a geographical area of high-tech activity encompassing Eindhoven (Netherlands), Leuven (Belgian) and Aachen (German), which is also known as the Eindhoven-Leuven-Aachen triangle (ELAt).[314] The ELAT region has high concentration of outstanding knowledge centres like universities, higher technical education institutes and research centres, as well as the necessary physical structures such as incubators, research and industrial parks. It has acquired a strong European position in micro- and nano-electronics and life sciences.

The EU – although strong in basic research – faces some detriments in global competition. Europe is a high-cost location for production. In particular energy costs play an important role for the

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[312] http://eit.europa.eu/kics/
[313] http://nanotech.grenoble-inp.fr/index.jsp
[314] http://www.elat.org/

production of single crystals and wafers. This has turned out above all as disadvantageous in the market for large-batch manufactured semiconductors, which have become commodities in a global market that are sold via price. The level of factor costs and scale effects have are crucial for long-term success and the ability to survive phases of poor global demand. **Due to comparative advantages and close links to downstream industries with mass demand Asia will remain globally the most important region for the production of semiconductors.**

Photonics and lighting equipment

Tangible investment in EU production sites is – as compared internationally – low. R&D activities and research policies are fragmented within the EU.[315] The EU lighting equipment and lamps branch is challenged by global competition in this area and has to merge all its efforts to stay on the leading edge of development. For this purpose a Photonics Mirror Group has been created to co-ordinate activities initiated by a European Technology Platform (ETP) for photonics called **Photonics21** with national and regional activities.[316] Similar to data processing semiconductors the EU faces the detriment of comparative disadvantages vis-à-vis Asian competitors in light sources based on semiconductor technology.

The **SSL lighting technology** is yet in an early stage. Technological process is of crucial importance in product technology as well as in production technology. Up to now there is a large potential of this technology for new applications and improved light characteristics, for instance for biological efficient lighting, safety etc., as well as for cost savings in production processes. Technological process is closely related to growth of output. Hence the muted growth perspectives for the EU entail a disadvantage for the EU lighting equipment and lamps branch. Initiatives taken to meet environmental and climate goals set by the EU might be likewise applied to provide a favourable market environment.

The needed actions for R&D and industrial policies dedicated for the **lighting equipment** and lamps branch concern upstream technologies. Asia is in the lead as an early mover in backlighting and volume production. SSL is understood as key-enabling technology (KET) and policy makers around the globe focus on LED, OLED and PLED. The US, Japan, South-Korea, Taiwan and China provide massive support for R&D, development and deployment of these energy efficient lighting sources to accelerate the pace of technological progress and get an edge in the global market. While Asian countries are leading in mass manufactured LED the **US** has gained a strong position in light sources with specific light characteristics and has put much efforts on the development of PLED. **South Korea** is leading in the global market for advanced TV-LCDs and strongly pushes OLED technology, to maintain its edge in technological leadership.

India also is engaged in innovation policies related to lighting equipment. When the **Indian** government realized that the components industry, particularly the production of semiconductors, might be a future source of economic and technological advancement worth supporting the Ministry of Communications and Information Technology (MCIT) started its “Special Incentive Package Scheme to encourage investments for setting up semiconductor fabrication and other micro and nano technology manufacture industries in India” (SIPS) in 2007[317]. This package applies also to

[315] Photonics Unit, DG INFSO, Photonics Technologies and Markets for a Low Carbon Economy – Summary Report, Brussels 17°February 2012, p°9.

[316] To better co-ordinate public initiatives the Photonics Mirror Group has been created that brings together public authorities from national and regional ministries and the EU Commission, see: http://www.photonics21.org/mirrorgroup.php.

[317] SIPS I was in place from 2007 to 2010, the programme has prolonged (SIPS II)
Office of the Principal Scientific Adviser to the Government of India: “Catalyzing the Growth of the Semiconductor Ecosystem in India” 2009.
http://psa.gov.in/writereaddata/12583893781_CatalyzingtheGrowthoftheSemiconductorEcosysteminIndia.pdf

LCDs, OLCDs and photovoltaic (PV) cells; industries receive subsidies of 20 % or 25 %[318] of capital expenditure. However, starting in 2007 the programme came rather late for the semiconductor industry. Chip manufacturing already had settled in other parts of the world and the costs of building new fabs had increased to an extent that companies were more rarely building new ones.[319] Also, with foundry companies based mostly in Taiwan, China and South Korea, India has been less attractive as location. Therefore, the main industry using and profiting from the package has been the PV industry.

In spite of India's poor position in semiconductors, most global fabless semiconductor companies have a presence in India, first in order to exploit labour cost advantages but more and more also taking advantage of well trained staff. Recently companies are emerging in India offering semiconductor related services, such a testing and packaging[320].

Wind energy, CO2 reduction and other renewables

The demand and technology development of generators, which are also part of the 27.12 sector, are influenced by EU policies on energy and climate, especially funding research on **wind energy**. In their funding programmes the EU supports projects that provide advanced knowledge in components and systems for turbines and wind farms, the integration of wind power into the grid, wind resources forecasting, as well as demonstration of large scale systems for on- and off-shore wind farms.[321] Since generators are a significant part within the value chain of wind mill and turbine production, EU policies that address the development of wind energy production are expected to generate positive effects on those NACE 27.11 products as well. With respect to the successful implementation of offshore wind energy (besides gas and electricity connections, and carbon capture and storage), the European Energy Programme for Recovery established in 2009 provides financial support to selected strategic projects.

General policies on energy efficiency are also implemented in the **USA**. With energy needs and CO2 emissions being a growing concern research on **energy efficiency** and **CO2 reduction** is on the rise. For instance the Center for Energy Efficient Electronics Sciences (E^3S), which is funded by the National Science Foundation (NSF), is a consortium of elite American universities (such as UC Berkeley, MIT and Stanford) and is also supported by private companies, for example by IBM, Intel and Hewlett Packard. The Center's research aim is to find new ways of reducing energy consumption of electronic devices by radically changing and improving the underlying physics, chemistry, and materials science of electronic systems[322].

Similar approaches have already been launched in **Japan**, where the Center for **Low Carbon** Society Strategy (LCS) is an independent institution within the JST (Japanese Science and Technology Agency) and engages in finding ways to turn Japan into a low carbon society. However, the Center does not so much engage in research on green energy and technology itself but rather works on ways how existing technology can be used in order to reduce CO2 emissions and rely mainly on renewable energies[323].

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[318] Depending on whether a company is operating in a SEZ

[319] The analysis of the Indian semiconductor industry in Chapter 3.6 revealed a quite poor economic performance.

[320] Office of the Principal Scientific Adviser to the Government of India: "Catalyzing the Growth of the Semiconductor Ecosystem in India" 2009
http://psa.gov.in/writereaddata/12583893781_CatalyzingtheGrowthoftheSemiconductorEcosysteminIndia.pdf

[321] EU Commission, Research & Innovation, Energy, "EU Support for Wind Energy", http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=research-wind-support

[322] https://www.e3s-center.org/

[323] http://www.jst-lcs.jp/en/documents/publishes/item/s00_summary_en.pdf; http://www.jst-lcs.jp/en/

Other renewables, like solar energy are mentioned in the previous paragraph on “Photonics and lighting equipment”. Additionally, public support to accelerate the development of **photovoltaic solar energy** to an energy technology that can be implemented at a very large scale is organized under the **EERA Joint Programme on Photovoltaic Solar Energy**.[324] EERA is an alliance of leading organisations in the field of energy research, which aims to improve EU energy research capabilities via sharing of world-class national facilities in Europe and the joint realization of pan-European research programmes (EERA Joint Programmes). The programme primarily focuses on cost reduction of PV systems, through enhancement of performance, development of low-cost, high-throughput manufacturing processes, and improvement of lifetime and reliability of PV systems and components. However, trying to establish an internationally competitive solar energy industry within Germany showed no sustainable long-term success for the production of solar panels within the country. Because of generous government incentives programmes, Germany once has become the largest market for solar power in the world. But since the German governments wants to cut back subsides faster than was planned and Chinese companies in the meantime manufacture solar panels in large-scale much cheaper, this will endanger German solar manufacturers to go out of business.

Smart grids

Specific policy initiatives aiming at the deployment of **smart grids** in Europe mainly tackle the standardization of smart grids, data privacy and security issues, regulatory incentives, as well as support for innovation.[325] Since many smart grid products are produced within the 27.12 sector, R&D policies are expected to have a significant impact on the entire sector.

For support of smart grids the EU Commission launched the **European Technology Platform for Smart Grids** in 2005.[326] This initiative called Smart Grids ETP is the key forum for policy and research and development for the smart grids sector in Europe, and provides the linkage between EU-level related initiatives. The latter are the **SET-Plan** and the **European Electricity Grid Initiative** (EEGI), to name two most important ones. While the SET-Plan[327], which is the European Strategic Energy Technology Plan, aims at acceleration of the development and deployment of cost-effective low carbon technologies, the EEGI[328] is one of the European Industrial Initiatives that intends a nine-year European research, development and demonstration (R&D&D) programme to accelerate innovation and the development of the electricity networks. Under this particular programme, the coordination and support action called GRID+[329] has been launched to provide operational support for the EEGI.

Regarding the successful deployment of smart grids, especially its EU-wide expansion, Projects of Common Interest (PCI) and cross-border projects will have a positive impact. According to the final report on the evaluation of smart grid energy infrastructure project proposals carried out by an EU Expert Group, which evaluated several cross-country smart grid initiatives, most of the project evaluations were concluded positively by monetary and non-monetary benefits.[330] However, smart grid projects and investments are not uniformly distributed across Europe.[331] While the great

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[324] http://www.eera-set.eu/index.php?index=24
[325] COM(2011) 202 final
[326] European Technology Platform for the Networks of the Future, http://www.smartgrids.eu/.
[327] http://www.smartgrids.eu/node/19
[328] http://www.smartgrids.eu/node/20
[329] http://www.gridplus.eu/about
[330] http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/reqno_jrc79968_jrc_79968_final_online.pdf
[331] http://ses.jrc.ec.europa.eu/sites/ses.jrc.ec.europa.eu/files/documents/ld-na-25815-en-n_final_online_version_april_15_smart_grid_projects_in_europe_-_lessons_learned_and_current_developments_-2012_update.pdf

majority of projects (93 %) are in EU15 countries, EU12 countries are still lagging behind significantly.

On 14 October 2013, the European Commission has adopted a list of 248 key energy infrastructure projects. These have been selected by twelve regional groups established by the new guidelines for Trans-European energy infrastructure (TEN-E). These "Projects of Common Interest" (PCI) will benefit from faster and more efficient permit granting procedures and improved regulatory treatment. They may also have access to financial support from the Connecting Europe Facility (CEF), under which a € 5.85 billion budget has been allocated to TEN-E infrastructure for the period 2014-20. For a project to be included in the list, it has to have significant benefits for at least two Member States; contribute to market integration and further competition; enhance security of supply, and reduce CO2emissions. The list of PCIs will be updated every two years.[332]

Similar innovation policies for **smart grids** on the international level are found for the **USA**. The independent and non-profit Electric Power Research Institute (Epri) conducts research in the realms of renewable energy, electricity distribution, energy efficiency, electric transportation and environmental responsibility. Financial support mostly comes through membership contributions, primarily from electric utilities but also include government agencies and other organisations[333]. In 2012 Epri spent roughly € 35.0 million on projects related to the environment and € 66.5 million on work related to power delivery and utilization. Another € 46.7 million were spent in the area of power generation and roughly € 105.9 million flowed towards the field of nuclear power. Technology innovation activities received funding of € 22.0 million[334]. The Epri **Smart Grid** Resource Center is running a seven year project to demonstrate innovative ways of organizing electric distribution and to assess possible problems of smart grids[335]. Moreover Epri maintains an **Electric Transportation** program which focuses on researching electric and plug-in hybrid vehicles and which has played a leading role in the development of these vehicles[336].

China is also engaged in fostering the R&D of smart grids. Even though, so far, there is little concrete action taken, some projects have gained shape. China's national energy agency SGCC reacts to pressing needs of better energy distribution across the country and is improving and enlarging the **national power grid**. As one of the first countries it will implement an economy-wide smart grid. SGCC is investing € 131 billion in the project. [337]

Cross-cutting manufacturing

An important public private partnership (PPP) in the field of industrial technologies that covers a range of different fields in manufacturing is **Factories of the Future**.[338] The research programme is financed jointly by industry and the European Commission under the Seventh Framework Programme and grants a 1.2 billion Euro to support the manufacturing industry in the development of new and sustainable technologies. The PPP was launched with the European Economic Recovery Plan in 2008 and was implemented through coordinated calls in Framework Programme 7, jointly by DG Research and Innovation and by DG Connect.

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[332] http://ec.europa.eu/energy/infrastructure/pci/pci_en.htm
[333] http://www.epri.com/Pages/Default.aspx
[334] www.epri.com/About-Us/Documents/Governance/EPRI%202012%20CFS%20(SECURED).pdf
[335] http://smartgrid.epri.com/
[336] http://www.epri.com/Our-Work/Pages/Electric-Transportation.aspx
[337] Mathews, John A. and HaoTan: The transformation of the electric power sector in China. Energy Policy 52 (2013), P. 170–180.
[338] Factories of the Future, European Commission. URL: http://ec.europa.eu/research/industrial_technologies/factories-of-the-future_en.html

The PPP's focus is on increasing the technological base of European manufacturing, therefore is aims at generating a new model of production systems (e.g. networked and learning factories) and ICT-based production systems to increase a factory's capability of optimising its performance with a high degree of autonomy and adaptability. It also aims at fostering the production of sustainable manufacturing tools and processes that increase cost efficiency, handling and assembling of products. The PPP is important for EEI as it includes advanced manufacturing processes and technologies, photonics, mechatronics for advanced manufacturing systems, robotics and ICT.

5.3 The regulatory system of the Single Market

The creation of the Internal Market lies at the heart of the European Union. It is founded on the four freedoms: the movement of (1) goods, (2) workers, (3) capital and (4) the establishment and provision of services in all Member States. A major step forward was made with the Single European Act, adopted in 1986. It provides a definition for the Internal Market and states the Union shall adopt measures with the aim of establishing or insuring the functioning of the Internal Market. In this Chapter the focus is on the functioning of the free movement of goods, established by a harmonisation of the legislation. European directives are transposed into national law. Products compliant in one Member State can build on the presumption of conformity within the EU and face no restriction in free trade within the Internal Market.

5.3.1 New Approach and New Legislative Framework

The standardisation bodies CEN, CENELEC, ETSI are non-profit organisations that have been created and are 95% funded by industry for the provision of technical services. They have become officially recognised bodies for developing and defining European standards strengthening EU policy on the completion of the Internal Market, European Standardisation Organisations (ESOs) (Regulation (EU) 1025/2012, of 25 October 2012 on European standardisation).[339] Their traditional task focuses on the development of technical standards, beyond, ESOs develop standards in response to market needs. When they receive a mandate from the European Commission they streamline standards development to meet EU policy objectives. The outcome is European standards that harmonize requirements across the EU and support companies to meet requirements laid down in EU directives.

By following the requirements of specific harmonized European standards - which are the result of a close public-private partnership - companies are granted the **presumption of conformity** to the European regulation for their products. They know that their products comply with relevant legal requirements applying to the product and can trade them in all Member States. The use of these standards can save companies much time when deciding strategies and assessing benefits and risks for trading in Europe.

Economic operators have to ensure the conformity of their products with essential requirements of the relevant directives if they envisage to placing their products on the Single Market. The **New Approach Directives** allows two different procedures for companies: Conformity is facilitated by the application of harmonised standards for the design of products. This might not be possible for innovative products which follow new technological concepts. However, the New Approach does not deter product innovations by mandating harmonized standards. Companies are allowed to deviate and follow different approaches to demonstrate the conformity of products with essential requirements.

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339 For their contribution to the reduction of technical barriers to international trade see: Chapter 5.1

The Communication to the Council and the European Parliament entitled "Enhancing the Implementation of the New Approach Directives" issued by the European Commission on 7 May 2003 was dedicated to further improve the framework conditions set by technical provisions. In its Resolution of 10 November 2003 the Council confirmed the necessity of extending the scope of its principles and recognised the need for a clarification of provisions for conformity assessment, accreditation and market surveillance. On 13 August 2008 the **New Legislative Framework** (NLF) came into force. It consists of three pieces of legislation, a Decision and two Regulations[340]:

- Decision 768/2008/EC – repealing Council Decision 93/465/EEC - on a common framework for the marketing of products aims to create common definitions, obligations for economic operators, conformity assessment procedures, safeguard mechanisms and CE-marking. This Decision provides for a menu of modules, enabling the legislator to choose a procedure from the least to the most stringent, in proportion to the level of risk involved and the level of safety required. **Legislation may depart from common principles and reference provision laid down in this Decision on account of specificities of the sector concerned. Any such departure should be justified.**
- Regulation (EC) 765/2008 – repealing Regulation (EEC) 339/93 – is complementary to the above mentioned Decision. It sets out the requirements for accreditation and market surveillance. It covers further elements not yet part of existing legislation, such as the organisation and operation of accreditation of conformity assessment bodies. It provides a framework for the market surveillance of products comprising controls on products from third countries. It lays down principles of the CE marking. The Regulation was put into force on 1 January 2010.Although the provisions of the Decision are immediately applicable they will only be operational if already existing Directives will be revised to meet the new framework conditions. The NLF is a horizontal measure dedicated to removing remaining obstacles to free circulation of products and to further ease intra-EU trade.

The NLF is an internal market measure to strengthen the effectiveness of the Union's legislation on product safety, its implementation mechanisms and ensure a greater consistency throughout all economic sectors. The Framework is also part of the Union's policy to simplify regulations and the reduction of administrative burdens. Its effective implementation brings about a modernised and simplified legal environment for the companies, strengthens the safety of products available on the market, and ensures a better functioning internal market through, inter alia, equal treatment of economic operators on the market.[341]

Currently the alignment of Harmonisation Directives to Decision 768/2008/EC is under discussion. In 2011 the Commission acknowledged shortcomings in the current legislation that has manifested as a significant number of **non-compliant products** still reaching the market, the unsatisfactory performance of **notified bodies** and **inconsistencies** in the legislation, making its application unnecessarily complicated. The Commission launched an initiative on the simplification of the legal framework.[342]

[340] A third measure of the NLF is Regulation (EC) No 764/2008 laying down procedures relating to the application of certain national technical rules to products lawfully marketed in another Member State.

[341] Directorate Enterprise and Industry; State of the Implementation of the New Legislative Framework (NLF); Brussels, 14 September 2010.

[342] EUROPEAN COMMISSION; NEW LEGISLATIVE FRAMEWORK (NLF) ALIGNMENT PACKAGE (Implementation of Goods Package) COMMISSION STAFF WORKING PAPER IMPACT ASSESSMENT Accompanying document to the 10 PROPOSALS TO ALIGN PRODUCT HARMONISATION DIRECTIVES TO DECISION No 768/2008/EC; SEC(2011) 1376 final, Brussels, 21.11.2011

The scope of the initiative comprises numerous directives of relevance for EEI: the Low Voltage Directive 2006/95/EEC, the Electromagnetic Compatibility Directive 2004/108/EC, the ATEX Directive 94/9/EC, the Lifts Directive 95/16/EC, the Pressure Equipment Directive 97/23/EC, the Simple Pressure Vessels Directive 2009/105/EC, the Measuring Instruments Directive 2004/22/EC, the Non-automatic Weighing Instruments Directive 2009/23/EEC, the Civil Explosives Directive 93/15/EEC and the Pyrotechnic Articles Directive: Directive 2007/23/EC.

The current discussion takes place against the backdrop that 92% of the economic operators surveyed believe that their sector is affected by free circulation of non-compliant products. For instance, non-compliant electronic products falling under the scope of the LVD present the risk of electronic shocks. Compliant firms are affected by rogue players in this market who are able to undercut fair prices by saving compliance costs.

For products falling under eight of the ten relevant directives, product certification by Notified Bodies (NoBo) is required before they can be placed on the market. For the products falling under the LVD and EMC, third-party certification is unnecessary. Notified bodies“ (NoBos) by accredited “conformity assessment bodies (CABs),” which tends to replace the old concept of NoBo, since Regulation 765/2008, play an important role in checking safety and compliance of products. However, there is a problem with NoBos. 84% of the economic operators using NoBos who responded to the public consultation complain on their quality of services. Even NoBos themselves shared this view.

5.3.2 *Environmental policies*

An important environmental policy, which significantly affects the EEI industry, is the REACH regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals. It is a wide-ranging EU legislation intended to manage and control risks to human health and the environment caused by the use of chemicals, which took effect on June, 1 2007. It is important for the EEI industry as electrical and electronic products and materials, parts and assemblies must meet its requirements. As set out in Article 1(2), the regulation establishes a dynamic list of chemical substances (on their own, in mixtures or in articles) subject to different conditions applying to their manufacture, placing on the market and use. The regulation intends to ensure that most of the commonly used substances as well as any new substances are registered. A license must be applied for to use substances that are of particular concern (belonging to the SVHC category, standing for Substances of Very High Concern), which could result in significant costs and competitive disadvantage for the industry that manufactures in Europe. Additionally, according to Article 1(1) the REACH Directive 1907/2006 aims at ensuring the promotion of alternative methods to assess the hazards of substances, as well as the free circulation of substances on the internal market, while simultaneously enhancing competitiveness and innovation.[343]

An important challenge for the EEI industry stemming from REACH is the possible obsolescence of products due to the very high cost of registration and, in particular, for the authorization of substances belonging to the SVHC category. Hence, as increases in costs usually are not absorbed internally they result in price increases at later stages. Besides this challenge the EEI industry also needs to increase its efforts to search for alternatives to SVHC substances. The REACH regulation’s high complexity and the uncertainty about further substance restrictions - as well as conveying the regulation’s recommendations on appropriate risk management measures for

[343] REGULATION (EC) No 1907/2006, concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), 18 December 2006.

chemical substances which includes the authorization requirement - poses a significant obstacle for future investments.

Above mentioned concerns on REACH have been acknowledged by the Commission and laid down in the REACH review.[344] Specific recommendations have since been made, designed to further improve the implementation of the regulation. The Commission is currently working on implementing those recommendations and, in particular, improving the predictability and transparency of the procedures for dealing with the management of risks arising from chemicals. Stakeholders suggest that the length of time required to bring into effect sound risk management measures (typically 2.5 to 3 years) under REACH gives industry ample time to adjust its investment strategies.

Another important environmental regulation affecting the EEI industry is the Restriction of Hazardous Substances directive (RoHS), which restricts the use of certain hazardous substances in electrical and electronic equipment. It went into effect on February, 13 2003. This regulation generally restricts the use of six hazardous materials in the manufacture of electronic and electrical equipment. Those hazardous materials are: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ether. Initially, the RoHS was linked with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC. The latter provides targets for the collection, recycling and recovery of electronic and electrical products and is part of a legislative initiative to solve the problem of toxic e-waste. With the revisions to the RoHS directive, however, WEEE and RoHS have been separated from each other.

On 1 January 2013 the RoHS 2 directive came into force, which is an evolution of the original RoHS regulation. While it addresses the same substances as the original directive, it improves regulatory conditions and legal requirements for the review of the list of restricted substances with the explicit requirement of ensuring coherence with REACH. It also improved the legal clarity in the area of exemptions by introducing better structured procedures and criteria.

5.3.3 Assessment of the legal framework set by environmental regulation

Although related, REACH, RohS and WEEE are not consistent with each other today. In Chapter 5.3.2 the importance of the directives for all of EEI's products has been outlined. Revisions of WEEE and RohS put new requirements on companies to further reduce environmental pollution, to reuse waste material and to reduce hazards for consumers and workers.

Broadly speaking the EEI's stakeholders fully agree with the policy targets, but they are disappointed by the kind of legislation, which in contrast to the objectives of the NLF – to create a coherent, less bureaucratic regulatory system so as to ease compliance – has become more challenging. The interest of the legislature to cover not only products with primary electric and electronic functions - but also products where the electric and electronic function is only secondary – has led to an expansion of the scope of recasts and entailed associated problems.

EEEs fall under the scopes of REACH and RoHS. The overlapping of both directives has caused concern and sometimes led to contradictory requirements. The legislature tries to clarify[345]: "When overlaps occur, the strongest restriction (i.e. the lowest maximum concentration) should be applied.

[344] European Commission; Report from the Commission to the European Parliament, the Council and the Committee of the Regions. – Accompanying the document: General Report on REACH; Brussels 5 February 2013, Commission Staff Working Document SWD(2013) 25).

[345] DG Environment; RohS 2 Frequently asked Questions (FAQ) Guidance Document; 12 December 2012 http://ec.europa.eu/environment/waste/rohs_eee/events_rohs3_en.htm.

Furthermore, exemptions from the substance restrictions in RoHS 2 may not be granted if they result in a weakening of the environmental and human health protection afforded by REACH." This instruction might function in theory, but does not provide any concrete guidance to design compliant products. Especially for smaller enterprises this recommendation might be confusing. They lack sufficient expertise and require external consultancy to design products compliant with these clarifications.

In practice, the overlap is increasingly causing confusion. The REACH Review already presents a first contradiction relating to the use of cadmium in electrical contacts[346]. Further contradictions are building up in the area of the phthalates (DEHP, DBP, BBP), which are included in the Annex XIV REACH list of substances subject to authorisation (expiring date: February 2015). RoHS examines new restrictions of these substances in EEE on the basis of a new substance evaluation methodology that is not aligned with REACH. Following a negative opinion of REACH scientific bodies (RAC and SEAC) on a Danish Annex XV restriction proposal for these phthalates, Denmark introduced a national restriction. Another example of increasing overlap is that Sweden has proposed an Annex XV dossier to restrict the use of lead and its compounds in consumer articles, which can be placed in the mouth by children or are intended for consumer use.[347] This initiative does not explicitly exclude electrical and electronic equipment, while RoHS already restricts the use of lead for EEE since 1 July 2006.

Currently the Commission is developing a common understanding to help manage this interface. This effort shall ensure that all Union rules relating to the use of chemical substances in electrical and electronic equipment is consistent and well-coordinated. The issue will shortly be presented to the authorities of the Member States for their consideration.

In order to make decisions impacting CO2 emissions, it is critical to bear in mind the objectives of economic agents. Investors are concerned about the economic efficiency of their machinery and equipment purchases in a competitive setting, including the use of inputs like electricity. Energy efficiency gains importance in decision making with growing energy intensity of production processes.

That said, it is suggested to carefully select those products and markets for further activities under the Ecodesign Directive that have the potential for sufficiently large energy savings, thus, the directive asks for a minimum market size of 200,000 units before requiring implementation. However, policy makers should also take into account the marginal costs for an increase of "one unit resource savings" in their decisions to select the relevant products for further activities.

The Ecodesign Directive exemplifies an effective policy approach to reach the EU 20-20-20 targets. Its potential for energy savings has not yet been exploited by far, as indicated by the backlog of implementation measures, as shown in the preceding chapter. More emphasis should be taken to reduce this backlog of existing implementation deficits. This would contribute more to reaching policy targets than adding new concepts.[348] The guiding principle of the NLF to strive for a coherent regulation shall be respected as implementation proceeds. Incoherent regulation and frequent changes in the regulation - not taking into account the efforts and investments carried out by companies will weigh on companies' competitiveness**.**

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[346] European Commission; Report from the Commission to the European Parliament, the Council and the Committee of the Regions. – Accompanying the document: General Report on REACH; Brussels 5 February 2013, Commission Staff Working Document SWD(2013) 25), p. 11.

[347] http://echa.europa.eu/documents/10162/80f7edca-b6c1-4433-8734-854594530db2.

[348] A life-cycle approach taking into account resources used during production and product materials might be striking from a scientific standpoint, however, feasibility and the value-added for the EU 20-20-20 Targets are questionable.

5.3.4 “Market surveillance

The harmonized European regulation contributes to the competitiveness of European manufacturers by the reduction of measures to meet provisions in different Member States, testing and certification. The Internal Market allows for the exploitation of scale effects. Likewise, the harmonized European regulatory framework eases market access also for non-EU competitors. For instance US manufacturers’ access to the EU market is much easier than market access for EU manufacturers to the US. The non-harmonised US regulatory systems with noteworthy differences between states ask for much effort to identify non-tariff barriers and design products in concordance with relevant provisions.[349]

The EU-market, by its size and openness, is highly attractive for third countries’ manufacturers. Whether subject to self-certification or mandatory third party certification, non-compliant products can easily be placed on the market. The problem is paramount in the area of intermediary goods, machinery and equipment.

Non-compliant products pose risks for workers’ health, as well as the users of products and the environment. Moreover, the design and manufacture of non-compliant products is not burdened by costs, caused by all measures necessary to meet EU provisions. This leads to an unfair competition.

Counterfeit products pose an additional problem for EU manufacturers. Both of these problems have long been major concerns for EU companies, because market surveillance has been deficient and too few non-compliant products have been identified. This well-known deficit benefits manufacturers who deliberately release non-compliant products on the market, as well as those who do so without understanding EU regulations.

Market surveillance has never been sufficient within the EU. There is a lack of monitoring resources at the Member State level, as well as varying degrees of enforcement in different Member States, to create a level playing field, by quickly identifying most of non-compliant products. Further legal enforcement is necessary to safeguard the objectives pursued by European directives on environmental protection, health and safety in the workplace.

Although the regulation of market surveillance and accreditation has been revised and put into force with the introduction of Regulation 765/2008 on 1 January 2010, the situation is not improving yet. It is vital that Member States step-up cooperation and build up resources dedicated to market surveillance in order to reduce the competitive advantage awarded to non-compliant producers.

The Commission has acknowledged the problems and launched a Product Safety and Market Surveillance Package (PSMSP) on 13 February 2013.[350]

- A proposal for a new Regulation on Consumer Product Safety (CPSR)
- A proposal for a single Regulation on Market Surveillance for Products (MSPR) - unifying and simplifying existing fragmented legislation.
- A multi-annual plan for market surveillance of 20 individual actions that the Commission will undertake over the next three years.

[349] Berden, K. et al. (2009) “Non-Tariff Measures in the EU-US Trade and Investment – An Economic Analysis”, Rotterdam.

[350] http://ec.europa.eu/enterprise/policies/single-market-goods/internal-market-for-products/market-surveillance/index_en.htm.

The Commission's initiative has been welcomed by manufacturing industry representatives, among them Orgalime, the EU's umbrella organisation of EEI. The initiative picks up requirements formulated by stakeholders of the EEI.[351][352]

The PSMSP is expected to increase transparency of legislation. The current set of rules is spread across the General Product Safety Directive (GPSD), Regulation 765/2008 and a range of sector specific regulation based on Decision 768/2008. The whole system has caused problems for market surveillance authorities and economic operators, aggravated by overlaps in the current legal system. The new set of rules will be merged in two regulations (see above). Instead of directives that have to be transposed into Member States' law the two regulations are European legal acts directly obligatory for all Member States. This might contribute to more stringent procedures and a better co-ordination between authorities of different Member States.

Complaints on deficient market surveillance concern primarily goods for professional applications, intermediary products, capital goods etc. Market surveillance for consumer products is to a lesser extent a problem. Both of these markets segments show quite different characteristics.

5.4 European energy policy

The EU flagship initiative "Resource efficient Europe" in Europe's growth strategy Europe 2020, specifies targets to shift the EU towards a more resource efficient and low-carbon economy. In doing so, EU economic growth shall be decoupled from resource and energy use and become more efficient with CO2 emissions. More precisely, greenhouse gas emissions shall be reduced at least by 20 % compared to 1990 levels, the share of renewable energy in final energy consumption shall be increased to 20 %, and energy efficiency shall improve by 20%.[353] Those targets are also known as "20-20-20" targets.

A successful and smooth transformation of the EU economy for a sustainable future requires a set long-term reliable framework conditions. This is, in particular, true for energy policy. Investments in power generation and transmission create a capital stock to be used for decades. Misdirected investments would cause enormous costs and contribute to a further increase of the high energy costs within the EU, compared to the rest of the world. This has been acknowledged and led the EU to prepare for a new 2030 framework for climate and energy policies. It will be built upon the EU 20-20-20 targets, policies and tools stemming from previous experiences, together with changes that have taken place in the recent past. Most challenging are:

- The difficulties experienced in internationally binding agreements on climate mitigation. The most recent Warsaw Climate Conference has again highlighted the challenge in reaching such agreements, although agreement to further advance the Durban Platform was reached. The EU expects an international agreement by the end of 2015. If this does not happen, EU businesses will face higher competitive pressure in international markets.
- Developments on EU and global energy markets, including the relation to renewables, unconventional gas and oil, as well as nuclear. In particular the US shale gas revolution that caused falling energy prices is increasing the urgency to fight the malfunctioning of the EU energy markets to contain price increases.

[351] Orgalime Position Paper (together with ANEC, the European consumer voice in standardisation); Call for an effective pan-European market surveillance system, 22 April 2009, Brussels; http://www.orgalime.org/position/call-effective-pan-european-market-surveillance-system.

[352] Market Surveillance Industry's support Platform; The 10 Key Actions for an Effective Market Surveillance; http://machinery-surveillance.eu/page/manifesto.

[353] COM (2010) 2020 final.

- Budgetary problems for Member States and businesses caused by state debt and banking crisis. Mobilising funds for long-term investments, especially in power generation and distribution, has become more difficult. It has become increasingly important to select projects by economic criteria: maximum energy saving per euro spent.

As long as renewable energy sources are not cost-competitive, the objective of a more sustainable energy system must go hand in hand with the need for a fully liberalized and integrated energy market. This would lead to a more efficient allocation of resources and reduce profit margins. However the authors of the 2030 Framework for Climate and Energy Policies are optimistic that some renewable energy technologies will have matured enough to compete with traditional energy sources.[354] This implies subsidies of alternative technologies could be reduced. Based on technological progress and scale effects - the EU 20-20-20 targets can be reached. However, the challenges mentioned above have to be met.

Main policy measures to achieve the "20-20-20" targets are financial instruments for EU and national public and private funding (as e.g. provided under the R&D framework programme, Trans-European Networks (TENs) or via the European institutions like the European Investment Bank (EIB)) as well as the use of market-based instruments aiming at increasing market efficiency (e.g. emissions trading or revision of energy taxation). Other priorities include: provision of an EU internal energy market, the promotion of different renewable energy sources in the Single Market, upgrading Europe’s networks (esp. Trans-European Energy Networks (TEN-E)), and implementation of a European-wide super smart grid.

Coupled with **energy efficiency** measures, the European energy system would become by far more efficient. Energy efficiency contributes to EU energy policy objectives, including security of supply, environment sustainability and cost effectiveness. Its outstanding importance has been highlighted by the International Energy Agency (IEA) in the latest issues of the world economic outlook:

- In its World Energy Outlook 2012, the International Energy Agency emphasized the significant potential of energy efficiency and energy savings measures for both, gaining time for a global climate change agreement and for boosting cumulative global output to 2035 by EUR 13.8 trillion (USD 18 trillion) by 2035, with biggest gains in India, China, the US and EU.[355]
- In its respective report for 2013, the IEA highlights the importance of energy efficiency to mitigate the impact of high energy prices: However, much of the economic potential for energy efficiency is set to remain untapped in 2035 unless market barriers can be overcome.

The European Commission highlights in the Communication of the European Commission in a competitive and sustainable electrical engineering industry in the European Union that the EU EEI is not only one of the large industries of major importance for the EU’s international competitiveness but this industry is also critical to achieving the EU’s policy targets. Improving energy efficiency is one of the key targets. It asks for a comprehensive approach that concerns the whole chain starting with power generation, distribution and consumption.[356] The Communication puts much emphasis on the enormous losses in generation and distribution. The aged capital stock should be replaced by advanced technologies; however, replacement is cost prohibitive. Member States are called to

[354] European Commission; GREEN PAPER – A 2030 framework for climate and energy policies, COM(2013) 169 final; Brussels 27 March 2013.

[355] International Energy Agency (IEA); World Energy Outlook 2012 – Executive Summary; October 2012; p. 3; http://www.worldenergyoutlook.org/.

[356] COM(2009) 594 final; ELECTRA – For a competitive and sustainable electrical engineering industry in the European Union, pp. 6; http://ec.europa.eu/enterprise/sectors/electrical/documents/electra_comm/electra_comm_2009_0594_en.pdf.

ease approval procedures for the erection of new plants and the upgrading of power lines, especially cross-border.

It will be necessary to provide public support to renew power generation and distribution infrastructure so as to reach the EU policy targets and to contain energy costs that are already higher and growing faster than those of competing economies (**Figure 5.1**). This development has been caused some countries' massive investments in renewables and market interventions to encourage national sustainability. As the Commission further states, an important deficiency and threat for a successful policy lies in the malfunctioning of EU energy markets. **The opening up of power markets will be of key importance for simultaneously reaching the EU policy targets and maintaining or even improving the EU economy's international competitiveness.**

Energy consumption by industries, transports and buildings complement the above mentioned supply side measures. Policymakers have likewise focused on these energy consumers to reach the EU targets. With regard to growth rates of power demand ICT is critically importance. The Commission's Communication refers to the following areas, as there are industrial applications, transports and buildings. There is a close relationship of measures for increasing energy efficiency on the demand side and societal needs, as stressed in Electra II "The Smart World". Of the twelve "Smart ……" initiatives suggested, Smart Cities, Smart Grids, Smart, Buildings, Smart Lighting, and Smart Mobility have a strong focus on energy efficiency - get more from the energy consumed and simultaneously increase overall welfare.[357]

5.4.1 Integration of renewable energies into competitive markets

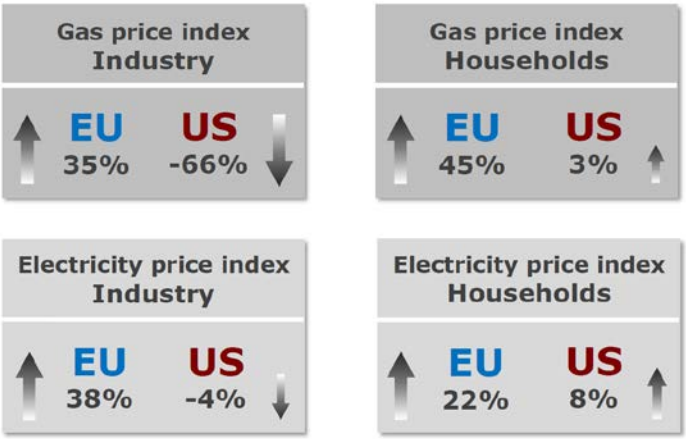
A major advantage of renewable energy sources are that they can be regenerated and thus provide energy that is almost inexhaustible. Also important, renewable energy generation is environmentally friendly. Yet their economic viability remains an issue. Since it is not yet clear which kind of energy sources will dominate future or whether eventually a mix of different energy sources will prevail, integration of renewables into competitive energy markets, in which they are allocated by price and less by government subsidies, is required. If renewables become economically competitive with traditional energy sources, the additional supply of renewable energy technologies will increase price competition among all energy sources. The competitiveness of renewables is important to ensure an efficient and affordable provision of energy in Europe.

Regarding the latest energy prices developments of the EU and the US shows the competitive position of both continents' with respect to energy production. While according to the recent EU's statement, the gas price index for industrial sectors has increased on average by 35 % during the period from 2005 to 2012; the same index has fallen by 66 % in the US. In case of households, during the same period the EU gas price index has increased by 45 %, but only 3 % in the US. The electricity price index developed similarly.[358] (**Figure 5.1**) These developments indicate a significant increase in energy costs within the EU raise concerns about the competitiveness of the current EU energy supply. This increases competitive pressure on EU energy-intensive sectors, which have their production facilities located within the European area. However, a nation's competitiveness does not only dependent on the price of energy, especially since the share of energy costs in total production costs varies across sectors. However, increasing energy prices pose a threat to all manufactures and energy-intensive EEI, as energy is an essential intermediate input in the value-

[357] ELECTRA II (2009), The Smart World – Making Europe smarter and more competitive. http://electra2020.eu/.
[358] Barroso, J. M.; Energy priorities for Europe, Brussels 22 May 2013; http://ec.europa.eu/commission_2010-2014/president/news/archives/2013/05/pdf/energy_en.pdf.

chain. Especially high-tech EEIs that focus on the production of semiconductors are particularly affected. This is due to the high energy intensity required per mass of material processed.

Figure 5.1: Trends in energy price indexes, 2005–2012



Sources: Presentation of J.M. Barroso to the European Council (22 May 2013), IEA

The strong declines in energy prices in the US are attributed to a large extent to the emergence and large-scale utilization of new technologies in extracting natural gas and oil deposits, namely hydraulic fracturing or 'fracking.' During fracking, water mixed with sand and chemicals is injected into a wellbore at high pressure to create small fractures. Along these fractures fluids such as shale gas may migrate to the well. These technologies are used to make the US more and more independent from oil and gas imports, enabling the US to supply domestic businesses more and more independently with affordable energy. The increasing domestic supply of energy extracted at low costs thus is driving down US energy prices further, and may also have an impact on world energy prices as well. Lower energy prices and lower energy costs for US businesses and private households mean lower production costs of US businesses compared to their foreign competitors as well as lower consumption costs for US households. In how far this development puts the US in a more competitive situation in the long-run is not yet clear, especially, since lower production costs can reduce incentives to improve energy efficiency.

5.4.2 Trans-European Networks – Energy (TEN-E) and demand-sided measures

With regard to Europe's growth strategy, Europe 2020, the EU Commission aims to provide the necessary energy infrastructure to establish an integrated European-wide energy market and to enable the EU to meet its "20-20-20" energy targets. Within the internal market, the provision of energy should be supplied efficiently and at affordable prices for businesses and consumers throughout the EU. Therefore energy networks need to be technologically updated and expanded within Europe to absorb energy from renewable sources and ensure secure supplies. In particular, modernisation of high and extra-high voltage transmission networks and low-to-medium voltage distribution network is advised. Following the Electra II recommendations, Europe's meshed alternating current (AC) grid network, which has reached its current limits, requires upgrading.[359] Moreover, burying energy transmission networks in sensitive areas below ground and upgrading of 400kV grids need to be implemented. But also low-to-medium voltage distribution networks must become technologically up to date. Since an increasing number of renewable energy sources are coming online, an active power distribution mechanism - managing supply of different sources and demand of different customers - is required.[360] Therefore the successful implementation of adaptive

[359] Electra II - The Smart World (2012), p.12
[360] Electra II - The Smart World (2012), p.13

control systems for energy distribution, known as smart grids, is becoming more and more important. A crucial element of these new technologies is that control system operations must evolve to ensure reliable supply.

Although most of the aforementioned policy measures are supply-side orientated, the EU also focuses on ways to stimulate the demand side. According to the EU Commissions' efforts to establish an internal energy market, the role of consumers in the electricity market is pronounced. Here the EU Commission supports EU Member States in providing consumers with adequate incentives to use electricity when it is cheapest and most plentiful. Consumers can contribute to ensuring sufficient energy flow at peak times and this will help to avoid costly investments in new power plants.[361] According to an EU staff working document the demand response programmes can be designed as price- or incentive-based.[362] In both cases demand-side flexibility is incentivized through different types of reward schemes. In the first case, consumers respond to a retail price structure that differentiates between time periods, like real-time pricing where consumers are charged with wholesale market prices that vary on hourly basis or critical peak pricing where very high "critical peak" prices are charged during certain hours. In case of incentive-based systems customers are given load-reduction incentives that are separate from their retail electricity rate and which may be fixed or time-varying. Here customers are subsidised to reduce their electric load during pre-selected time periods specified in advance.

As incentive-based demand response programmes, are usually implemented by large industrial and commercial customers, like energy-intensive sectors, an overall demand-sided incentive-based approach needs to address all types of customers, industry, commercial and household. Since some specific tailor-made solutions for energy-intensive industrial consumers already exist, appropriate solutions should be open for industry participation. In case of commercial customers, for which heating and cooling is the main source of energy consumption, response schemes should ensure interoperability of heating and cooling control systems and management systems for energy efficiency. In case of households, standardized technological solutions are required. Household appliances should be able to organize energy use temporarily according to the customer's preferences and respond to load or price signals. Here smart metering systems, which record energy consumption and enable shifts of consumption to low-price periods, are promising incentive-based demand systems.

5.4.3 Smart cities and communities

In 2012, the European Commission launched the Smart Cities and Communities European Innovation Partnership (SCC-EIP).[363] The SCC-EIP is a partnership across interdisciplinary areas of energy (e.g. energy production, distribution and use), mobility and transport, and information and communication technologies (ICT) with the objective to reduce energy consumption and greenhouse gas as well as other polluting emissions. This intersection of different areas is a consequence of the Strategic Energy Technology (SET) Plan, which originally covered only the transport and energy sectors. Projects in SCC-EIP mainly focus on larger scale lighthouse projects aiming to trigger strategic EU-wide partnerships between companies from the three mentioned sectors. Throughout the SCC-EIP, cities will be given the opportunity to highlight their project plans to reduce greenhouse gas emissions and energy consumption to potential consortia. Also, under SCC-EIP the EU Commission will support horizontal activities and informing policies and market-oriented measures that can validate and accelerate commercial deployment. This partnership

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[361] http://ec.europa.eu/energy/gas_electricity/internal_market_en.htm

[362] Commission Staff Working Document (2013), Incorporating demand side flexibility, in particular demand response, in electricity Markets, retrieved: http://ec.europa.eu/energy/gas_electricity/doc/com_2013_public_intervention_swd07_en.pdf

[363] COM(2012) 4701 final

initiative can be regarded as a supply-side orientated policy measure as it fosters the framework conditions of EEI industries by reducing transaction costs of EU-wide coordination and improving the overall within-EU business environment. It also emphasizes the role of demand, as cities are integrated into the development and supply process of innovative solutions that meet their key areas of interest.

6 Perspectives for the EEI and recommendations

6.1 Impact of the global economic environment on EEI's perspectives

During the aftermath of the global financial crisis the Euro Area was hit by the state debt and banking crisis. It will take years until indebted households', governments', municipalities' and banks' balance sheets are put in order. Tight public budgets and the official requirements of the Bank for International Settlement on private banks to become crisis-resistant leaves little room to manoeuvre for policymakers and limits private businesses' fund raising. The long-term demographic trend in Europe provides another explanation for EU-27 growth perspectives, below most other large economies, except Japan.

The outlook for the EU EEI up to 2020 is based on the Ifo Institute's global international outlook. The Ifo forecast covers most large economies and the Euro Area. The scenario takes into account the likely evolution of major economies under the assumption that there will be a steady recovery from the crises without any further events causing another breakdown of the global economy. The quantitative forecast provides insight in expected trends, without reference to business cycles. **Table 6.1** presents the quantified scenario with figures for the evolution of major economies' gross domestic products and a consistent estimation for the development of global trade.

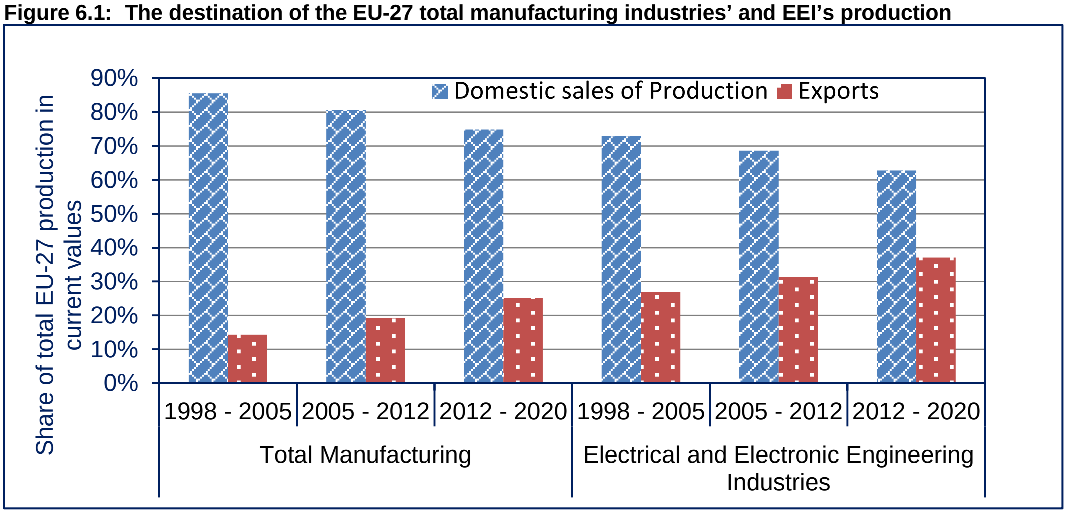
Table 6.1: Key figures for the global development up to 2020

Year	USA	Japan	China	UK	Euro Area	EU-27	India	Korea	Brazil	Russia	World trade
	Annual growth rates in %										
2012	2.2	1.8	7.8	0.2	-0.6	-0.5	4.1	2.0	0.9	3.5	2.4
2013	1.5	1.9	7.5	0.1	-0.4	-0.3	3.1	2.8	2.9	1.4	2.1
2014	2.2	1.8	7.5	1.4	0.9	1.0	6.0	4.2	3.1	2.8	4.2
2015	2.6	1.3	7.3	1.9	1.6	1.7	6.6	4.3	3.5	3.3	6.0
2016	2.5	1.0	7.2	2.3	1.9	2.0	6.6	4.3	3.5	3.3	5.7
2017	2.3	1.0	7.1	2.0	1.7	1.8	6.5	4.2	3.4	3.2	5.5
2018	2.1	0.9	7.0	1.8	1.6	1.6	6.4	4.1	3.3	3.1	5.2
2019	2.0	0.9	6.9	1.8	1.5	1.6	6.3	4.0	3.2	3.0	5.0
2020	2.0	0.9	6.8	1.7	1.5	1.5	6.2	3.9	3.2	3.0	5.0
	Annual average growth rate in %										
2012-2020	1.9	1.1	6.3	1.4	1.1	1.2	5.3	3.5	2.9	2.6	4.3

Source: Ifo institute.

Usually for private businesses the domestic market is by far the most important. This is also true for total manufacturing with its tradable goods, and in particular for EEI. However, there is a long-term tendency caused by the permanently growing international division of labour that domestic markets are losing importance. The welfare created by specialisation and the exploitation of comparative advantages is the driving factor behind this trend. **Figure 2.1** depicts the distribution of the EU-27 total manufacturing industries' and EEI's production differentiated by the EU-27 and third countries markets. The expected trend is clear. EEI is an industry with an above average focus on global markets. This trend is expected to continue in the future. This is the result of the forecasts presented above with a more dynamic development in overseas markets and – ceteris paribus – a continuation of the permanently growing international division of labour, which is reflected in the fact that world trade growth is notably stronger than growth in world gross-domestic product (GDP).

Figure 6.1: The destination of the EU-27 total manufacturing industries' and EEI's production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

To better understand the impact of global markets on tradable goods industries it is not sufficient to analyse growth rates that usually show exports being drivers for expansion and not the domestic demand. The sizes of the domestic sales and exports have to be taken into account. The product of the growth rate and the amount of sales indicates the **contribution to the growth** of production. **Table 6.2** provides both, the growth rates and the contribution to growth. While the growth rates for exports are much higher than for domestic demand, their contribution to growth is less striking. However it has gained importance by the overall stronger growth of exports. The exports' share of total production for EEI has grown by four percentage points up to 31 % between 2005 and 2012. For the years to come the export ratio will further increase up to 37 %. The situation will be driven by the factors mentioned above. Moreover, it is expected that the domestic demand, in particular from public authorities will remain depressed, because of the ongoing need to further consolidate public budgets. Growth will primarily be generated in non-EU markets.

The EU-27 performance in international markets over the whole period under investigation supports this result. In EE1 it was able to gain shares in international trade from 13.2 % during the early years up to 15.7 % for the more recent period, while the US and Japan suffered major losses. For EE2 the EU-27 had to take minor losses whereas the US and Japan, in particular, lost noteworthy shares in global trade. Only for EE3 the EU-27 performance in international trade was poor. This sector's companies have been concentrating more on domestic markets in recent years than in the past and retreated above all from international mass-markets.[364]

[364] For a detailed analysis see: Chapter 4.2

Table 6.2: The perspectives for EEI driven by domestic and by third countries demand

Indicator	1998 - 2005			2005 - 2012			2012 - 2020 1)		
	Share 2)	Growth 3)	Contribution to Growth 4)	Share 2)	Growth 3)	Contribution to Growth 4)	Share 2)	Growth 3)	Contribution to Growth 4)
Electrical and Electronic Engineering Industries in EU-27									
EU-27 Production	100%	2.5%	-	100%	1.2%	-	100%	1.3%	-
Domestic sales 5)	73%	0.8%	0.60	69%	0.4%	0.27	63%	-0.2%	-0.12
Exports	27%	6.9%	1.86	31%	3.0%	0.95	37%	3.9%	1.46
All values are current values; 1) Predicted data; 2) of electrical and electronic engineering production; 3) Annual average growth rates; 4) Growth * Share = contribution to production growth; 5) of EU-27 Production = Production – Exports									

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

6.2 Assessment of the framework, policies and recommendations

Europe has been strongly affected by the crises of the Euro Area Member States. The recovery in recent years was muted and the problems have not yet been overcome. One lesson learnt in recent years is that manufacturing industries have contributed much to the stabilization and countries with a strong manufacturing sector have performed better than other countries. This has been acknowledged by policymakers by another EU 20 % target: Policies shall be taken to improve the framework conditions for manufacturing industries to stimulate growth and to increase this sector's contribution to the EU-27 GDP up to 20 % in the long run.

An investigation in past developments highlights that this will require enormous efforts. At the turn of the millennium the manufacturing industries' share of GDP was 19 %, until just before the global financial crisis it had fallen 15 %. During the crisis it declined further caused by a slump in new orders, and more recently it has recovered and manufacturing's share is once more around 15 %.

Like other industries, EEI has been affected by the crisis and the muted recovery. The dampening effects of the on-going and necessary consolidation within the EU will affect EEI and weigh on its growth in years to come. Within the ceteris paribus scenario domestic sales will not contribute much to growth until 2020; stimuli will come mainly from third countries enjoying a more dynamic development. Changes might be possible if policymakers improve

- framework conditions (**supply side economics**) to prevent further losses of workplaces to more attractive locations outside the EU and
- by taking the right measures to reach the EU 20-20-20 targets that to a large extent can be subsumed under **demand side economics**.

EEI could strongly benefit from both of these policy areas, because it comprises a diversity of manufacturing processes, high-tech production as well as more traditional labour intensive production, strongly dependent on appropriate supply side conditions. **EEI is a high-tech industry strongly interlinked with downstream industries and by that the industry's value chains incorporates the potential to offer workplaces for different levels of qualifications as available in a pluralistic society.**

EEI supplies more products than any other industry that is pivotal to reach the EU 20-20-20 targets, such as power generation, distribution and power consuming products. Therefore a close communication and co-operation of the European Commission and the EU EEI representatives on an improvement of supply side and demand side conditions would not only be effective but efficient.

EEI supplies a comprehensive product programme urgently needed to reach the EU policy targets. Hence EEI's – ceteris paribus moderate growth – could shift to a more dynamic expansion if policy makers take further efforts on reaching their targets. However, the room for manoeuvring will remain limited by tight public budgets.

6.2.1 Supply side economics

Research and development

Horizon 2020, the Framework Programme for Research and Technical Development, Competitiveness and Innovation Programme, is critically important for EEI. Its emphasis on manufacturing has been appreciated by EEI. (**For detailed analysis of the programme, see: Chapter 5.2.2**) The whole innovation chain is in its scope, starting with basic research, prototyping, development and design of new products. More weight has been put on deployments that create jobs. However, a sustainable creation of workplaces will strongly depend on the available supply side conditions within the EU. Hence it has to be taken into account that with regard to price competitiveness there are some deficiencies within the EU. There is – in some sub-sectors – a fragile equilibrium in the international division of labour with low-wage locations. A distortion by inadequate public policies would be counterproductive for a chief objective pursued with the deployment of production within the EU, namely job creation.

Although the EU R&D explicitly focuses on supply side economics by emphasizing manufacturing industries, the initial distribution of the budget is not strictly focused on technological progress only, but takes social aspects into account as well:

- Science € 24.341 billion
- Industry € 17.015 billion
- Social concerns € 30.965 billion

Nearly half the budget is – in accordance with the title – dedicated for technology assessment.

Regulation

The EU legislation strives for a sustainable economy and sets strict provisions. The EU perceives itself on the leading edge, as exemplary for other economies. In fact the regulatory framework is challenging for companies. This has been acknowledged by the Commission with the New Legal Framework that has come into force in 2010. It is dedicated to create a coherent set of rules and reduce bureaucracy. In the end this will be very beneficial in particular for SMEs.

The Commission has launched a Product Safety and Market Surveillance Package (PSMSP) early 2013. This initiative has been appreciated by stakeholders of the industry. It has the potential to overcome deficiencies of market surveillance. The PSMP is currently under inter-institutional discussion.

CEN, CENELEC and ETSI are private organisations founded by the industry. They are 95 % funded by industry to provide technical services. These European Standardisation Organisations (ESOs) develop standards in response to market needs. When they receive a mandate from the European Commission, they streamline standards development to meet EU policy objectives. The outcome is European standards that harmonize requirements across the EU and support companies' measures to meet requirements laid down in EU directives.

Safety and security provisions must no longer be national issues. For a further improvement of the free movement of goods it is important to deal with these issues on European level in order to achieve a maximum safety for EU citizens.

Clusters and competitiveness

The investigation in the EEI has underscored the importance of clusters for the EU's competitiveness. The EU EEI is strong in areas where Europe can build on clusters. This is an important factor for the explanation of EE1's outstanding performance in global competition. EE1 is part of a network comprising upstream electronics, like power electronics and embedded systems, and downstream capital goods industries and transport equipment. In contrast, the losses of EU EE2 production capacities for mass-market consumer electronics and communications terminals is, at least to a certain extent, blamed on an insufficient cluster, compared to Asia. Medical equipment is an outlier within EE2. In this sub-sector the EU is on eye level with the US, while Japan is trailing behind. Throughout the past decade EE3 has been focusing more and more on supplies to international competitive EU downstream industries and reduced deliveries to third countries' markets from European production locations. This is an indication for a more cluster focussed strategy by EE3 companies.

The European semiconductor industry commands a strong global position in the development of advanced process technologies and products. There are three clusters, the interlinked triangle Nijmegen-Eindhoven-Leuven, Grenoble and Dresden. Together these regions represent the vital nucleus of the EU semiconductor industry. However, with regard to the deployment of the latest production techniques the EU has turned out to be challenged by framework conditions, not well-suited for mass-production, which would be necessary to fully utilise the capacities of a 450 mm Fab. **Three alternatives have been discussed in Chapter 4.7 to provide the industry and policymakers with basic arguments to decide on the most promising alternative. Decision making in this area is so important that it is suggested to investigate the alternatives in detail.**

Photovoltaic, a specific semiconductor product, enjoys – in principle - favourable framework conditions, due to the strong commitment of the EU and Member States to shift power generation from fossil to renewable energy sources. However, after strong growth during the early years, demand has slumped, caused by a reduction of public funds in the era of tight public budgets and simultaneously growing Chinese supply. The EU supply side for the production of solar cells underwent a major consolidation. Capacities have been dismantled. In a review of the industry's structure, the head of the Fraunhofer Institute for Solar Energy Systems disclosed a weakness that – among others – originates from the size of EU plants. They are relative small with capacities of 100 MW and 500 MW. An international competitive PV industry had to build on plants with 10 times the current available capacities.[365] For solar cells, as for other mass-produced goods, the size of plants matters and is of crucial importance for a viable deployment. This example highlights the importance of industrial policies dedicated to not only take into account R&D but the deployment of technology. This requires a comprehensive approach, the sales market environment and strategic requirements. The EU provides, with its policies focusing on a transformation to a sustainable economy, appropriate demand side conditions for PV. However, internationally competitive plants have to be large enough to exploit scale effects.

The example of PV reveals that in some markets large players are of key importance for an industry's competitiveness. In the area of large batch manufactured standardized products

[365] Werner Schulz, Photovoltaik: Großproduktion soll Standort Europa retten, in VDI Nachrichten, 1 November 2013; http://www.vdi-nachrichten.com/Technik-Wirtschaft/Photovoltaik-Grossproduktion-Standort-Europa-retten-Nr-44.

throat-cut price competition tends to eliminate smaller manufacturers. In this respect EU industrial policies should pursue a comprehensive approach on the deployment of advanced technologies, taking into account long-term global supply side equilibria.

A quite different cluster approach is pursued with the Lombardy Energy Cluster that links together not only manufacturers of equipment for the production, distribution of power, but utilities and municipalities. This cluster mixes supply side and demand side economics. This approach takes into account the complexity of advanced smart systems that have to bring together all involved parties to strive for the most advanced and energy efficient solution.[366] Here the European strengths in interdisciplinary cooperation and system engineering could turn out as very successful to develop trend setting innovations.

Access to third countries (Chapter 5.1)
The most recent multilateral trade talks in Malaysia have led to a global agreement by 160 countries. A revival of the Doha Round will contribute more to the growth perspectives of the EU EEI in global markets than bilateral FTAs. In spite of the recent success, there is not much hope that the multilateral talks will gain momentum in coming years. The EU will have to pursue bilateral trade agreements to reduce market access barriers. FTAs have become a strategic tool for governments to give their businesses an edge in global competition through eased market access. Beyond tariffs, non-tariff barriers like technical codes are in the scope of negotiations.

There might be public interest to conclude as many FTAs as possible to demonstrate measurable success. But the quality of FTAs will be more important for the dismantling of barriers to trade than the number of agreements.

Of general importance for EEI's exports to the **US** is the National Electrical Code (NEC), a federal directive that is transposed in state law. But in contrast to the EU, there is no harmonization process and provisions differ from state to state. Beyond, there are tough requirements that take into account that many buildings in the US are made of wood. The approval of installations is carried out by local authorities ("Fire Marshalls") whose decision making lacks transparency.

The recently launched free trade talks with the US should include technical provisions in the negotiations, to strive for a mutually adjusted regulatory system of technical provisions.

Although **China** committed itself to the World Intellectual Property Organization (WIPO) in WTO 2001, the governmental enforcement activities regarding IPR are neither sufficient nor transparent. JVs in combination with the deficiencies in the protection of IPR raise risks that foreign investors will lose control over know-how. **It has to be pointed out that China – as member of the WTO – has to guarantee IPR in line with WIPO. This requires satisfactory surveillance and enforcement. (Chapter 5.1.5)**

In case of obligatory third-party testing, Chinese authorities do not accept European certificates. This is a concern for the manufacturers of radio and telecommunication equipment as well as medical equipment. Market access is impeded by a deficient and non-transparent Chinese regulatory system. A body notified by Chinese authorities has to carry out the task. The Chinese notified bodies' quality is not satisfactorily guaranteed by the Chinese accreditation system. The Chinese Compulsory Certification (CCC) procedure is expensive and time consuming. Chinese experts have to travel to Europe if certification of production processes is required. Certification by

[366] ORGALIME; Electra II - The Smart World, Brussels, April 2012; p. 40; http://www.orgalime.org/page/electra

Chinese experts raises the risk of economic espionage and piracy**. In EU-Chinese trade talks much emphasis should be put on an improvement of CCC procedures.**

India is one of the more difficult markets with numerous access barriers. But taking into account the size and the long-term growth perspectives of India, it is extremely important to convince the Indian government to open up markets for the long-term welfare of the people. Furthermore, it is important to support Indian authorities in their efforts to develop a more stringent, harmonized set of regulations in line with international standards and norms. **Priority should be given to negotiations on an FTA. The importance of India as a market is underscored by US initiatives for a rapprochement of the Indian regulatory system to the US.** (Chapter 5.1.6)

The EU summit in Vilnius on 28 – 29 November 2013 brought some progress in the rapprochement of Eastern European economies to the EU. The EU-Republic of Moldova and EU-Georgia Association Agreements including DCFTAs have been signed. Some progress has been made in negotiations with Armenia, Azerbaijan and Belarus. However, the Ukrainian government decided to temporarily suspend the process of preparation for signature of the Association Agreement and DCFTA between the EU and the Ukraine.

The strengthening of East European countries' economic ties with the EU will contribute much to societal and political changes. The importance of the region is underscored by the fact that it is one of the two regions where the EU EEI enjoys a trade surplus, although competition from Chinese competitors has increased in the recent past.

For trade liberalization with Middle East and North Africa (**MENA)** – the second region where the EU EEI enjoys a trade surplus – it is of importance that beyond bilateral agreements of the EU and countries of the region, intra-regional trade is liberalized. This will be one of the indispensable prerequisites to stimulate economic development and an urgently needed process of cooperation. A first step has been taken with the Agadir Agreement, where concerned governments committed to liberalize internal trade. The Greater Arab Free Trade Area (GAFTA) has been understood as a starting point. Tariffs on Arab products have been removed, but a noteworthy number of products have been excluded from liberalization, and non-tariff barriers have not been abolished. Intra-region trade has not intensified.

Argentine, Brazil, Paraguay and Uruguay have been negotiating for the creation of a Single Market, the **MERCOSUR**, for some time, but not much progress has been made. Given its members history of unsettled internal differences, it is questionable whether MERCOSUR is an adequate counterpart for the EU in trade negotiations. Moreover, conflicting interests in agricultural policies hamper transatlantic negotiations.

Labour market and qualification

The European labour market is characterized by high unemployment, in particular amongst youngsters. Simultaneously the economy lacks a sufficient supply of adequately qualified personnel. This development has been caused, among other reasons, by a shrinking social esteem of disciplines such as natural sciences, technology, engineering and mathematics (STEM). In fact, within the EU, the number of graduates has been only stable or even shrinking over time, whereas the situation is reversed in some competing economies – as far as figures are available (see: Chapter 4.4, **Figure 4.12** and **Figure 4.13**).

Initiatives should be launched to increase the attractiveness of science and technology for youngsters. This is a task that has to be taken by Member States. Initiatives as suggested by

the industry to launch inter-school math and science competitions could do much; not only to raise qualifications, but interest in these disciplines.

Beyond initiatives taken to attract pupils and students it is important to provide opportunities to unemployed youngsters in crisis-stricken countries. Their occupational integration is urgently needed and should focus on STEM disciplines to improve their opportunities in the labour market.

EEI – like other manufacturing industries – depends on a broad range and different levels of qualifications. In this respect the low prestige of vocational training and education (VET) is an impediment that cannot easily be overcome. Here again, initiatives by the industry to improve public perception can help. **One important measure should be to bridge the curricula between VET and higher education (HE). This would provide better professional perspectives to applicants and make VET more attractive. Moreover, the brightest will help to fill the gap in the supply of STEM qualifications.**

Beyond these initiatives dedicated to generally improve the supply of labour, further initiatives are necessary to strengthen qualifications in the most high-tech disciplines, so as to keep pace with technological progress. **In this respect consultants support the request of the High Level Experts group on Key Enabling technologies to promote individual excellence in technology focused engineering research**.[367]

6.2.2 Demand side economics for EEI

The European Commission highlights in the “Communication of the European Commission on a competitive and sustainable electrical engineering industry in the European Union” that the EU EEI is not only one of the large industries of major importance for the EU’s international competitiveness, but that this industry is also pivotal for the achievement of the EU’s policy targets. Improving energy efficiency is one of the key targets. It asks for a comprehensive approach that encompasses the whole chain from power generation and distribution to consumption.[368] The Communication emphasizes the enormous losses in generation and distribution. The aged capital stock should be replaced by advanced technologies; however, replacement is cost-prohibitive. Member States are called upon to ease approval procedures for the erection of new plants and the upgrade of power lines, especially cross-border.

Energy consumption by industries, transports and buildings are areas complementary to the above mentioned supply side measures. They are, likewise, in the focus of policymakers to reach the EU targets. With regard to growth rates of power demand ICT is paramount. The Commission’s Communication refers to the following areas: industrial applications, transports and buildings. There is a close relationship between increasing energy efficiency on the demand side and societal needs, as stressed in Electra II “The Smart World”. Of the twelve “Smart ……” initiatives suggested Smart Cities, Smart Grids, Smart Buildings, Smart Lighting, and Smart Mobility have a strong focus on energy efficiency, to get more from the energy consumed and simultaneously increase the overall welfare.[369]

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[367] Further information on the stakeholders view on labour market an qualification, see: ORGALIME; Electra II - The Smart World, Brussels, April 2012; p. 42; http://www.orgalime.org/page/electra

[368] COM(2009) 594 final; ELECTRA – For a competitive and sustainable electrical engineering industry in the European Union, pp. 6; http://ec.europa.eu/enterprise/sectors/electrical/documents/electra_comm/electra_comm_2009_0594_en.pdf.

[369] ELECTRA II (2009), The Smart World – Making Europe smarter and more competitive. http://electra2020.eu/.

The 2030 framework on climate and energy policies will be built upon the EU 20-20-20 targets, the evolution of existing policies in accordance with previous experience, and changes that have taken place in the recent past. Most challenging are:

- The difficulties experienced in internationally binding agreements on climate mitigation. The most recent Warsaw Climate Conference has again highlighted the difficulties, although it was agreed upon to further advance the Durban Platform. The EU expects an international agreement by the end of 2015. If this does not happen EU businesses will face greater competitive pressure in international markets.
- Developments on EU and global energy markets, including the relation to renewables, unconventional gas and oil, as well as nuclear. In particular, declining US energy prices driven by its shale gas revolution increases the urgency to fight the malfunctioning of the EU energy markets to contain price rises.
- Budgetary problems for Member States and businesses caused by the state debt and banking crisis. Mobilising funds for long-term investments, particularly in power generation and distribution, has become more difficult. It has become more important to select projects by economic criteria: generate maximum energy saving per euro spent.

It will be necessary to provide public support to renew power generation and distribution to reach the EU policy targets and to contain energy costs, which are already higher and growing faster than in other competing economies (**Figure 5.1**). This development has been caused by some countries' massive investments in renewables and market interventions, designed to push the national sustainability policy. As the Commission states, an important deficiency and threat for a successful policy lies in the malfunctioning of EU energy markets. **The opening up of power markets will be key to simultaneously reaching the EU policy targets and maintaining or even improving the EU economies' international competitiveness.** (Chapter 5.4)

As a variety of renewable energy sources is coming online, the European electricity infrastructure needs to be substantially modernised and aligned to the purpose of being able to integrate all the energy streams from renewable and traditional sources throughout Europe. Therefore the provision of **smart grids** is highly recommended. Especially as this technology enables the efficient implementation of incentive-based demand schemes to promote the demand of new energy sources, it is highly suited to meet the "20-20-20" targets.

Based on the provision of a modernised energy infrastructure, the development of **smart cities and communities** constitutes a further possibility to improve demand side conditions. This approach ensures the implementation of the most appropriate technology as cities and communities are offered the opportunity to bring in their interests and concerns in the development of appropriate infrastructures (see chapter 5.4). Since many urban infrastructures are already at their limits, especially regarding secure energy supply or transportation, undertaking actions in this direction is recommended.

The EU Commission's attempt to implement incentive-based demand schemes for consumers opens up a variety of technological solutions to cope with the increasing energy demand in the future. This may become especially important in the area of **smart buildings**. This may also have side effects on other technologies like electro mobility, when consumers start increasing their demand for electric cars and thus require charging stations at home that efficiently provide them with energy. Also, since much existing infrastructure currently does not offer the flexibility to adapt to real-time coordination of energy supply and demand, the implementation of **smart metering systems** is an important application to meet the "20-20-20" targets.

Along with the emergence of new technologies in ICT, another important market is in appropriate systems in the field of e-health applications. **E-health** applications enhance the information exchange between different actors in the health care sector, such as doctors, therapists, pharmacists and patients to ensure comprehensive medical care and to increase service quality. Moreover, it enables an efficient allocation of resources, which is of particularly important facing a continuously aging society, increasing health expenditures and an impending congestion in medical coverage in rural areas within Europe.

7 Section IIAnnexes

Annex I.1
List of abbreviations

ABB	Asea Brown Boveri
ABS	Anti-lock braking system
AC	Alternating current
AHWR	Advance heavy water reactor
AMI	Advanced Metering Infrastructure
AMOLED	Active Matrix Organic Light Emitting Diode
APAC	Asia Pacific
APRA-E	Advanced Research Projects Agency – Energy
ARTEMIS	Advanced R&D on Embedded Intelligent Systems
ASIC	Application-Specific Integrated Circuits
ASSP	Application-Specific Standard Products
ATM	Automatic Teller Machine
ATIC	Advanced Technology Investment Company
ATVMI	Advanced Technology Vehicle Manufacturing Incentives Program
BERD	Business enterprise expenditures on R&D
BR	Brazil
CAD	Computer Aided Design
CASE	Case Construction Equipment
CCRA	Common Criteria Recognition Agreement
CdTE	Cadmium telluride
CE	Cambridge Econometrics, project partner
CE	Consumer Electronics
CEE	Central Eastern European
CEF	Connecting Europe Facility
CEM	Contract Electronics Manufacturers
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CENELEC	Comité Européen de Normalisation Électrotechnique (European Committee for Electrotechnical Standardisation)
CIP	Competitiveness and Innovation Framework Programme
CIS	Community Innovation Survey
CNC	Computer Numerical Control
COSME	Programme for the Competitiveness of enterprises and SMEs

CPSR	Consumer Product Safety Regulation
CRM	Cardiac Rhythm Management
CRT	Cathode Ray Tube
CRU	Commodities Research Unit
CSF	Common Strategic Framework
CSIL	Centre for Industrial Studies
DC	direct-current
DCS	Distributed Control System
DEC	DECISION
DKK	Danish Krones
DOE	Department of Energy
DRAM	Dynamic Random Access Memory
DSC	Digital Still Cameras
DTI	Danish Technology Institute, project partner
EBIT	earnings before interest and taxes
EBITDA	earnings before interest, taxes, depreciation and amortization
ECG	Electrocardiography
ECHA	European Chemicals Agency
ECORYS	Project partner
ECP	Excellent Performance Certification
ECSIP	European Competitiveness and Sustainable Industrial Policy
EDA	Electronic Design Automation
EEE	Electrical and Electronic Equipment
EEI	Electrical and Electronic Engineering industries
EEG	Electro Encephalogram
EEGI	European Electricity Grid Initiative
EGCI	European Green Cars Initiative
EIP	Entrepreneurship and Innovation Programme
EISA	Energy Independence and Security Act
EIT	European Institute of Innovation and Technology
EL	Greece
EMC	Electro-Magnetic Compatibility Directive
EMS	Electronic Manufacturing Services
ENIAC	European Nanoelectronics Initiative Advisory Council
EPIA	European Photovoltaic Industry Association

EPO	European Patent Office
EPoSS	Smart Systems Integration
ERDF	European Regional Development Fund
ERP	Enterprise Resource Planning
ES	Spain
ESDM	Electronic System Design and Manufacturing
ESO	European Standardization Organization
ESP	Electronic Stability Program
ETP	European Technology Platform
ETSI	European Telecommunications Standards Institute
EUROP	European Robotics Platform
EURYDICE	Network providing information on European education systems and policies
EV	electric vehicles
EVI	Electric Vehicles Initiative
FACTS	Flexible AC transmission system
FAQ	Frequently Asked Questions
FDI	Foreign Direct Investment
FEANI	European Federation of National Engineering Associations
FiT	Feed-in Tariff
FMLAA	Foreign Management Legal Accounting Act
FP7	7^{th} Framework Programme
FTA	Free Trade Agreement
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GE	General Electric
GIA	Global Industry Analyse
GOR	Gross Operating Rate
GS	Good Software
GW	Giga Watt
GWp	Gigawatt Peak
HE	Higher education
HID	High Intensity Discharge
HP	Hewlett-Packard
HVDC	High Voltage Direct Current
IC	integrated circuit

ICT	Information and Communication Technologies
ICT-PSP	Information Communication Technologies Policy Support Programme
IDC	Implantable Cardioverter Defibrillator
IDEA	Project partner
IDM	Integrated Device Manufacturers
IE	Ireland
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEE	Intelligent Energy Europe Programme
IET	Institute for Energy and Transport
IPC	Industrial PC
IPR	Intellectual Property Rights
IP-TV	Internet Protocol Television
ISC	International Standard Classification
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISI	Integral Satcom Initiative
ISIC	International Standard Industrial Classification of All Economic Activities
IN	India
IT	Italy
JCI	Johnson Controls Incorporated
JP	Japan
JTI	Joint Technology Initiatives
JRC	Joint Research Centre
KET	Key Enabling Technologies
KR	South Korea
LIB	Lithium-ion batteries
LED	light-emitting diode
LFL	Linear Fluorescent Lamp
LFS	Large File Support
LS	Leading Solution
LVD	Low Voltage Directive
MCIT	Ministry of Communications and Information Technology
MCO	Multi-functional semiconductors
MEErP	Methodology for the Ecodesign of Energy-related Products

MENA	Middle East and North Africa
MES	Manufacturing Execution System
MEST	Ministry of Education, Science and Technology
MII	Ministry of Information Industry
MKE	Ministry of Knowledge and Economy
MOCVD	Metal-Organic Chemical Vapour Deposition
MRI	Magnetic resonance Imaging
MSPR	Market Surveillance for Products Regulation
MW	Megawatt
NACE	Statistical Classification of Economic Activities in the European Community
NAND	Not-and
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEP	New Excellent Product
NET	New Excellent Technology
NKT	Nordiske Kabel og Traadfabriker
NoBo	Notified Bodies
NOR	Not-or
NT	New Taiwan Dollar
ODM	Original Design Manufacturers
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OJEU	Official Journal of the European Union
OLED	Organic Light-Emitting Diodes
ORGALIME	European Engineering Industries Association
OS	Operating Systems
OSCCA	Office of the State Commercial Cryptography Administration
PCB	Printed Circuit Board
PCI	Projects of Common Interest
P/L	profit/loss
PLC	Power Line Communications
PLED	Polymer Light Emitting Diodes
PHEV	plug-in hybrid electric vehicles
PHOTONICS21	Photonics
PMU	phasor measurement units

PLC	Private Limited Cooperation/Company
PLM	Product Lifecycle Management
POS	Point-of-Sale
PR	Progress Report
PSMSP	Product Safety and Market Surveillance Package
PT	Portugal
PV	Photovoltaic
R&D	Research & Development
RAPEX	Rapid Information Exchange System
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
REC	Renewable Energy Corporation
RF	radio frequency
RfS	Request for Services
RMB	Renminbi
RoEU	Rest of EU27
ROSF	Return On Shareholders' Funds
RoW	Rest of the World
RTD	research and technological development
S&T	Science & Technology
SCADA	Supervisory Control and Data Acquisitions
SCP	Sustainable Consumption and Production Policy
SDoC	Suppliers Declaration of Conformity
SDRC	State Development and Reform Commission
SIP	Sustainable Industry Policy
SME	Small and Medium Enterprise
SMIC	Semiconductor Manufacturing International Corporation
SOC	System-on-Chip
SOE	State-owned enterprises
SSL	Solid-State lighting
STB	Set Top Box
STEM	Science, Technology, Engineering and Mathematics
TBT	Technical Barriers to Trade
TBT	Technical Barriers to Trade Agreement
TEN-E	Trans-European energy infrastructure
TFEU	Treaty on the Functioning of the European Union

TFT	Thin Film Transistor
TLC	TVs and other Consumer Electronics
TM	Total Manufacturing
TSMC	Taiwan Semiconductor Manufacturing Conpany
TW	Taiwan
ULC	Unit labour costs
UMC	United Microelectronics Corporation
UPS	Uninterruptible power supplies
US	United States of America
USPTO	US Patent and Trademark Office
VAT	Value added Tax
VDE	Association for Electrical, Electronic and Information Technologies e.V.
VET	Vocational Education and Training
VFD	variable-frequency drive
VSD	variable-speed drive
WIIW	Vienna Institute for International Economic Studies
WTO	World Trade Organization
ZVEI	German Electrical and Electronics Industry Association

Annex I.2
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Annex II.1
Firm level analyses: Technical notes

Applied indicators

The indicators that we have used for the analyses with firm level data are summarized and described in Table 7.1. The choice for these indicators was made on the basis of two factors:

- The *data availability* in the Amadeus database
- The *relevance of the indicator* for the analyses, where we have focused on profitability and structure ratios.
  1. We have included three **profitability ratios**:
     - (a) the return on shareholders' funds,
     - (b) the EBIT margin and
     - (c) the operational profit margin.

  2. With regard to the **structure of the balance sheet**, we investigate:
     - (a) the current ratio, which focuses on a company's ability to meet its short term debt obligations,
     - (b) the solvency ratio, which focuses on a company's ability to meet its long-term obligations;
     - (c) the gearing ratio, which compares owner's equity to borrowed funds;
     - (d) the degree of debt and equity finance, which assesses the composition of the total shareholders' funds and liabilities.

We have calculated these indicators for the sample of companies for the EU-27 as a whole, for electrical and electronic engineering (EEI) and its sectors: electrical engineering (EE1), electronic engineering (EE2) and electrical components & semiconductors (EE3). We have done this for the period 2004 – 2011. For each ratio, we have computed the average and median values for the sample. The deviation of the median from average indicates the performance of smaller companies as compared to the big players of the industry.

Annual values of indicators and ratios based on the Amadeus data are calculated using the filled-in variables for the set of companies for that specific year. If for one year the variable is not filled in for a particular company, that company will not be included in the calculation of the ratio or indicator for that year. However the ratio or indicator will be calculated for the next year if the value is filled in for the next year. The consequence is that the calculation of a time series of an indicator or ratio might be based on a different set of companies for each year (within the same sample). Especially if samples are small the resulting time series are interpreted with caution.

This also implies that strictly speaking conclusions can only be drawn for the sample of companies in our dataset and not for the entire population of the EEI industry and its three sectors as a whole. However, the underlying hypothesis is that the samples are representative. The efforts and methods that we apply to increase the quality of the sample in terms of representativeness are documented in part 0 (Sample selection) of this chapter.

Table 7.1: Profitability and financial indicators for firm-level data in Amadeus

Indicator	Definition	Description
Profitability ratios		
Return on shareholders' funds	(profit/loss before tax / shareholders' funds)*100 *With "profit/loss before tax" = operating profit/loss + financial profit/loss*	The Return On Shareholders' Funds (ROSF) ratio has historically been used by industry investors as a measure of the profit for the period which is available to the owner's stake in a business. The Return On Shareholders' Funds ratio is therefore a measure of profitability from the standpoint of the shareholder. It indicates whether or not a company is generating adequate profits in relation to the resources invested in it by shareholders.
EBIT margin	(EBIT / operating revenue) *100 *With "EBIT"* *= operating profit or loss* *= all operating revenues – all operating expenses*	EBIT margin is a profitability measure that is useful when comparing multiple companies, especially within a given industry, and also helps evaluate how a company has grown over time. The EBIT margin is another measure investors can use to assess a company's financial health. The EBIT margin shows you the percentage of each euro of sales revenue that is left after all expenses have been removed, excluding net interest and income tax expenses.
Profit margin	(profit/loss before tax / operating revenue) *100 *With "profit/loss before tax" = operating profit/loss + financial profit/loss*	The profit margin relates the operational profit to the total of operating revenues, which equals net sales + other operating revenues + stock variations.
Structure and financial ratios		
Current ratio	current assets/current liabilities	Current ratio or working capital ratio measures whether or not a firm has enough resources to pay its debts over the next 12 months (short-term obligations). It compares a firm's current assets to its current liabilities. Low values for the current or quick ratios (values less than 1) indicate that a firm may have difficulty meeting current obligations; values between 1.5 and 2 are considered as being in healthy conditions.
Solvency ratio	(shareholders' funds / (non-current liabilities + current liabilities)) *100	The solvency ratio assesses a company's ability to meet its long-term obligations and thereby remain solvent and avoid bankruptcy. It provides a measurement of how likely a company will be to continue meeting its debt obligations. Acceptable solvency ratios will vary from industry to industry, but as a general rule of thumb, a solvency ratio of greater than 20% is considered financially healthy. Generally speaking, the lower a company's solvency ratio, the greater the probability that the company will default on its debt obligations.
Gearing ratio	((non-current liabilities + loans) / shareholders' funds) * 100	A general term describing a financial ratio that compares some form of owner's equity (or capital) to borrowed funds. Gearing is a measure of financial leverage, demonstrating the degree to which a firm's activities are funded by owner's funds versus creditor's funds. The higher a company's degree of leverage, the more the company is considered risky. A company with high gearing (high leverage) is more vulnerable to downturns in the business cycle because the company must continue to service its debt regardless of how bad sales are. A greater proportion of equity provides a cushion and is seen as a measure of financial strength.
Degree of equity finance	Shareholders' funds / total shareholders' funds and liabilities	These two indicators will be visualized via a breakdown of the shareholders funds and liabilities, into each of its three components: shareholder funds, non-current liabilities and current liabilities.
Degree of debt finance	(non-current liabilities + current liabilities) / total shareholders' funds and liabilities	

Source: IDEA Consult, Bureau Van Dijk (2013)

Location of main EU EEU players and clusters in Europe

The location data in Amadeus is available on NUTS-3 level. Once we selected our final sample of companies (see below) for each of the EEI sectors, we plotted the top 5000 companies in each of the EEI sectors on a EU-27 map using Mapinfo, whereby each company is represented by a dot on the map. This gives visual insight into the major concentrations in the EU. We have not visualized the turnover of the EEI companies on the map, as turnover data are not available for all companies in our sample, also depending on national requirements whether turnover has to be published or not. Moreover, plotting the turnover on a map based on annual account data could give a biased view.

Sample selection

For our analyses depicted above we have used two types of samples: one based on unconsolidated accounts and one based on consolidated accounts. The analyses focussed on the EU-27 are based on unconsolidated accounts, while the non-EU analyses are based on consolidated company data. The following table provides a schematic overview.

Using unconsolidated accounts minimizes the headquarter effects in location analysis, which is especially important for the assessment of the EU-27 located companies. Additionally the results from subsidiaries from EU-based companies in other parts of the world are excluded, which provides a clearer picture in terms of the EU located EEI. However, for non-EU players primarily consolidated instead of unconsolidated accounts are available, therefore the comparison has been carried out as depicted in **Table 7.2**.

Table 7.2: Sample structure of the micro-level analyses

	Samples		Properties of the samples
Geographical location	EU-27	EU producers – 3 sectors	Unconsolidated accounts, top-down and bottom-up approach, sample enriched with experts' input
	EU-27	EU producers – 3 sectors	Consolidated accounts, top-down approach
	RoW	Non-EU producers – 3 sectors	Consolidated accounts, top-down approach

Source IDEA Consult

In the Amadeus database there are almost 100.000 companies in EU-27 which have activity codes that correspond to the NACE EEI industry classification. We obtained the samples for the 3 EEI sectors based on

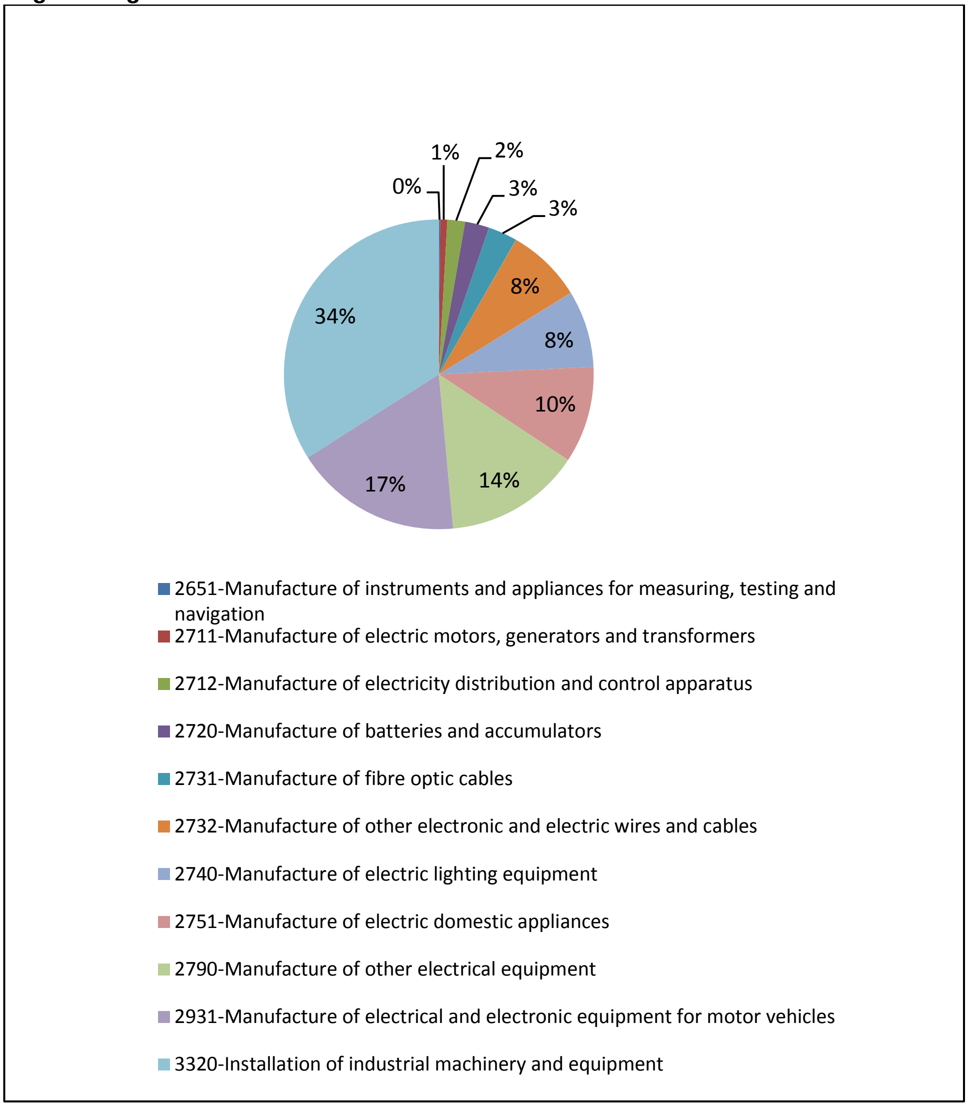
- a top-down search of the relevant NACE codes in Amadeus and
- expert and stakeholder input.

In Annex III.3, we give a complete overview of the number of companies for which we had account data available to compute the financial indicators. For each sector, year and indicator, we have displayed the number of companies for which we have the indicator account data available in our sample relative to the total number of companies for which there is account data available in Amadeus.

Annex II.2
Firm level analyses: sample characteristics

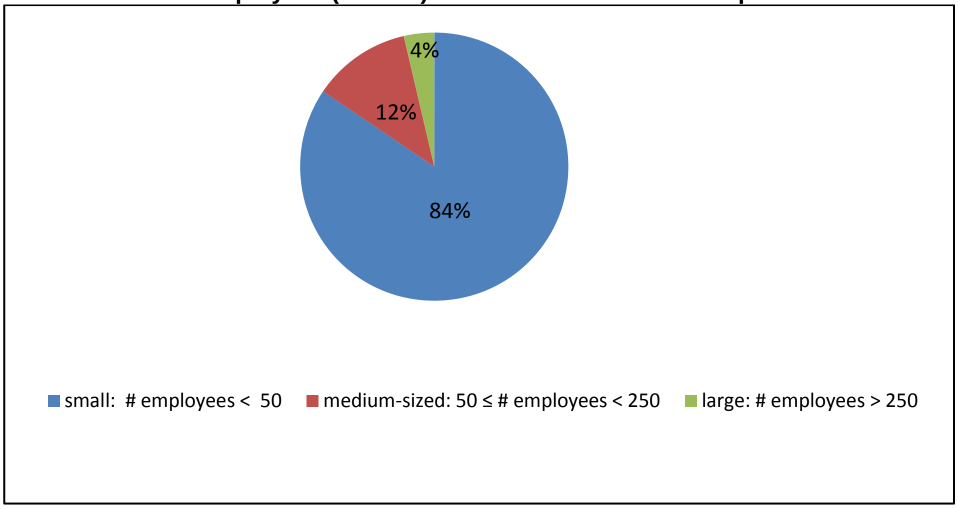
Electrical Engineering

Figure 7.1: Sectoral distribution of the number of companies in the EU-27electrical engineering sector



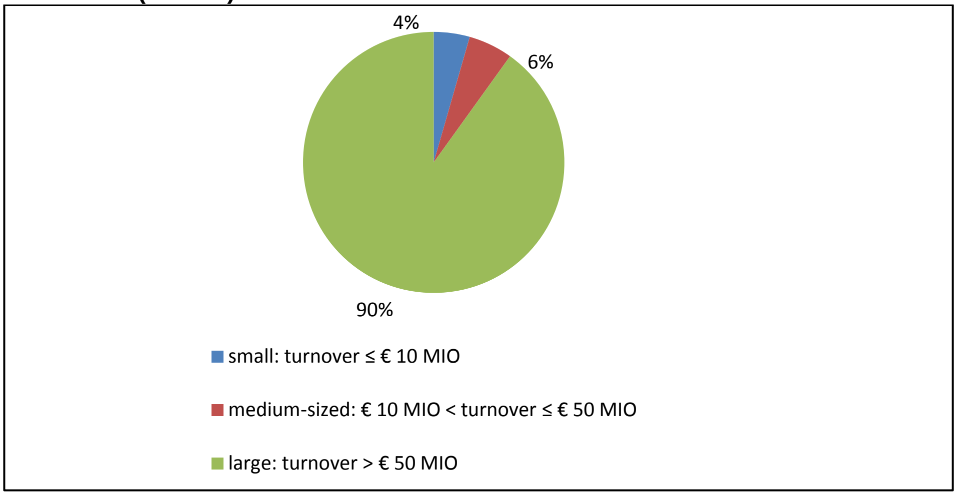
Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.2: Distribution of companies in the EU-27 electrical engineering sector according to the number of employees (in 2010) in terms of number of companies



Source: Own calculations on the basis of Amadeus/Orbis data

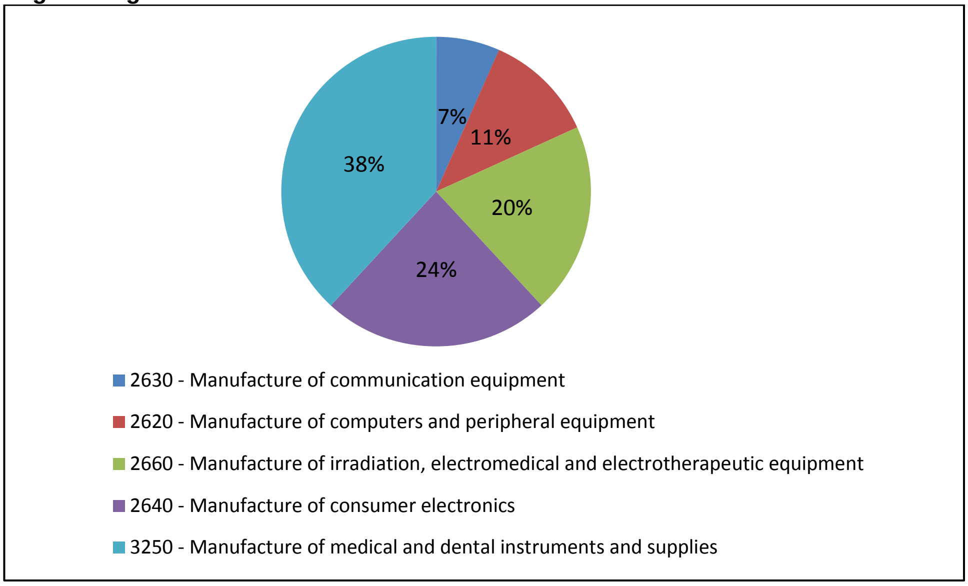
Figure 7.3: Distribution of companies in the EU-27 electrical engineering sector according to turnover (in 2010) in terms of total turnover



Source: Own calculations on the basis of Amadeus/Orbis data

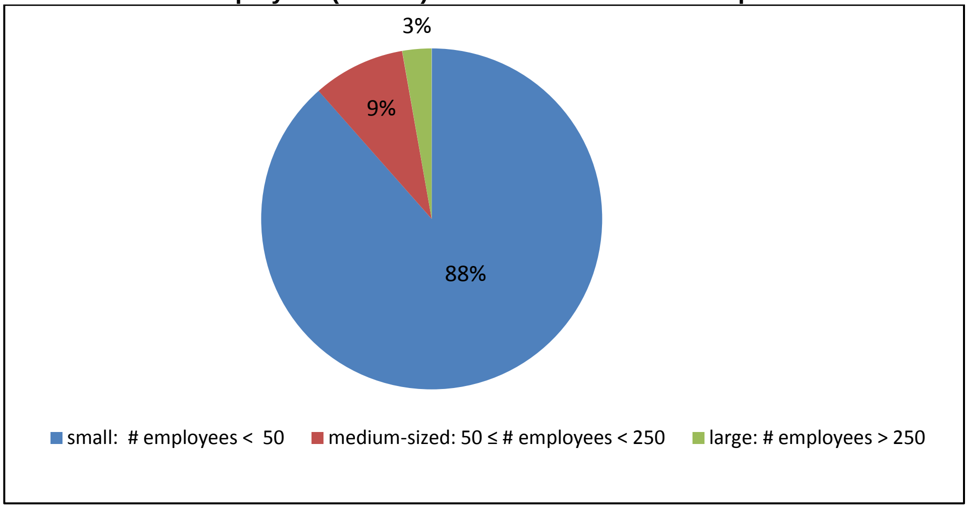
Electronic Engineering

Figure 7.4: Sectoral distribution of the number of companies in the EU-27electronic engineering sector



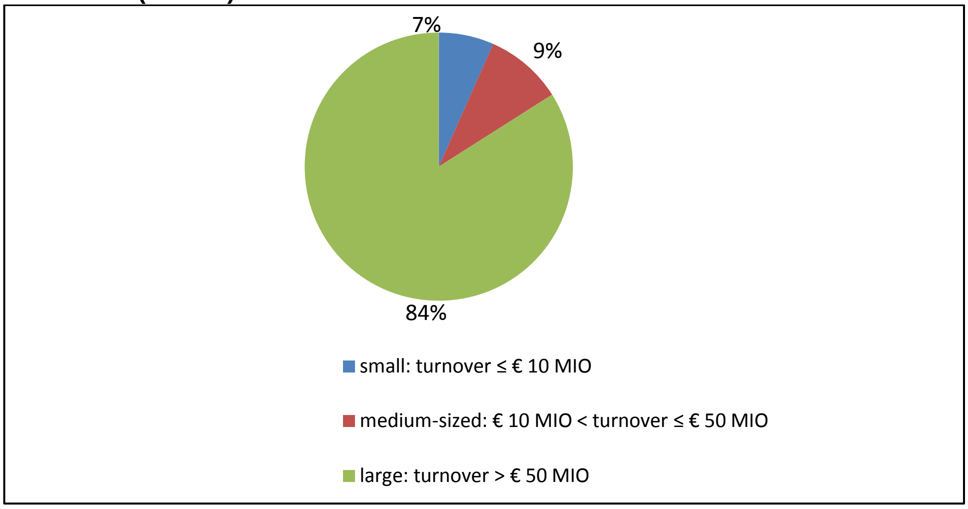
Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.5: Distribution of companies in the EU-27 electronic engineering sector according to the number of employees (in 2010) in terms of number of companies



Source: Own calculations on the basis of Amadeus/Orbis data

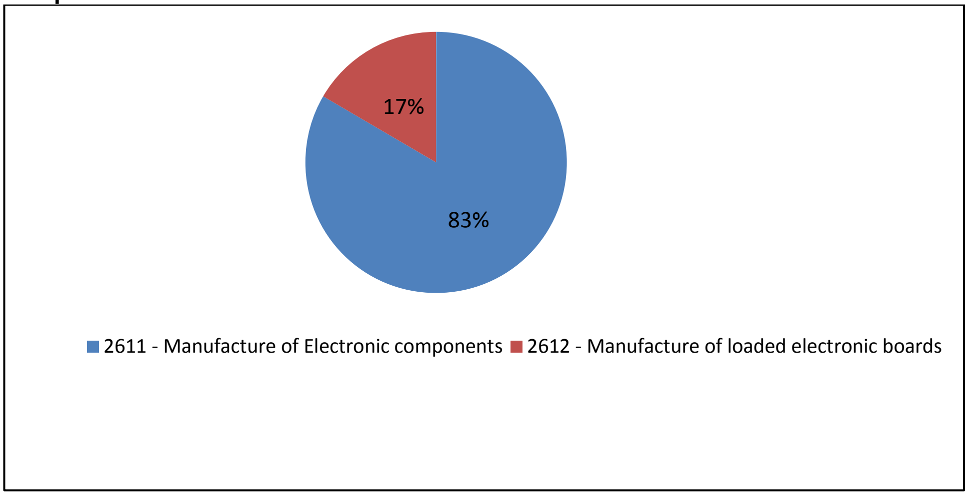
Figure 7.6: Distribution of companies in the EU-27 electronic engineering sector according to turnover (in 2010) in terms of total turnover



Source: Own calculations on the basis of Amadeus/Orbis data

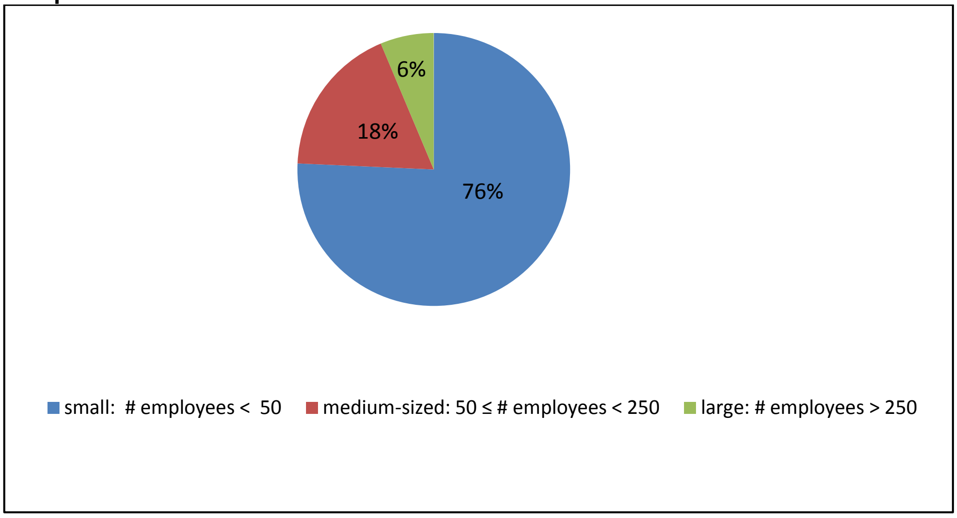
Electronic components and semiconductors

Figure 7.7: Sectoral distribution of the number of companies in the EU-27electronic components and semiconductor sector



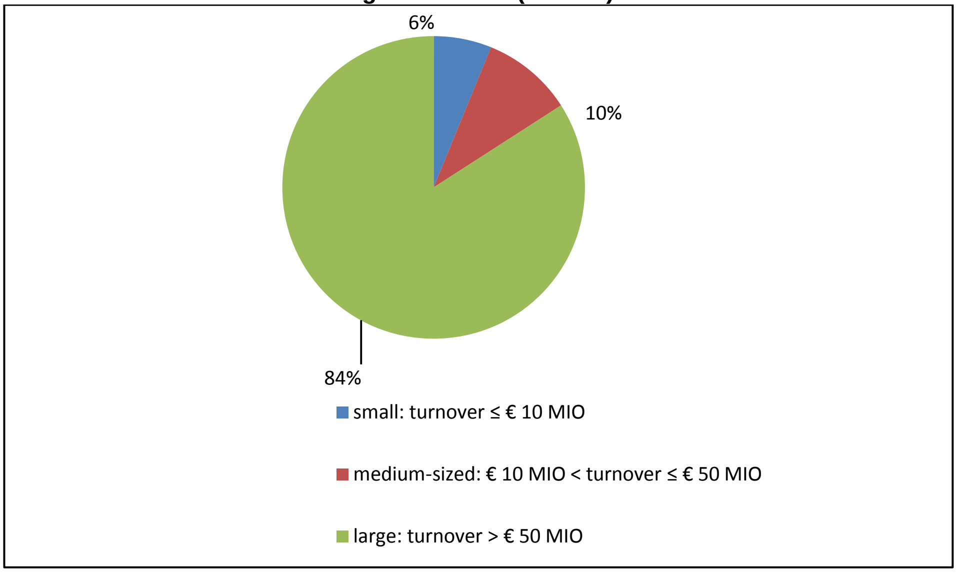
Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.8: Distribution of companies in the EU-27 electronic components and semiconductor sector according to the number of employees (in 2010) in terms of number of companies



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.9: Distribution of companies in the EU-27 electronic components and semiconductor sector according to turnover (in 2010) in terms of total turnover



Source: Own calculations on the basis of Amadeus/Orbis data

Annex II.3
Firm level analyses: Representativeness

Electrical Engineering

Table 7.3: Overview of data coverage in the Amadeus database in the Electrical Engineering sector

Year	Total # of companies in the sample for which account data is available	% of companies in the sample for which account data is available on the following indicators:					
		Return on shareholder funds	Profit margin	EBIT Margin	Current ratio	Solvency ratio	Gearing
2004	26,750	72%	80%	80%	98%	100%	84%
2005	32,674	64%	71%	71%	92%	99%	78%
2006	36,777	59%	65%	66%	92%	99%	76%
2007	41,056	57%	64%	64%	92%	99%	73%
2008	43,068	56%	64%	64%	92%	98%	73%
2009	44,887	54%	63%	64%	92%	98%	72%
2010	45,669	55%	63%	63%	93%	98%	73%
2011	32,702	65%	69%	69%	96%	99%	78%

Source: Own calculations on the basis of Amadeus/Orbis data

Electronic Engineering

Table 7.4: Overview of data coverage in the Amadeus database in the Electronic Engineering sector

Year	Total # of companies in the sample for which account data is available	% of companies in the sample for which account data is available on the following indicators:					
		Return on shareholder funds	Profit margin	EBIT Margin	Current ratio	Solvency ratio	Gearing
2002	7,717	69%	73%	73%	92%	95%	77%
2003	9,461	71%	75%	75%	92%	96%	78%
2004	12,484	72%	77%	77%	91%	95%	78%
2005	14,729	65%	69%	70%	88%	96%	74%
2006	16,083	59%	63%	63%	86%	95%	72%
2007	18,347	60%	63%	63%	86%	96%	68%
2008	19,291	59%	62%	62%	85%	94%	66%
2009	24,481	48%	51%	51%	70%	77%	54%
2010	20,420	57%	60%	61%	83%	91%	65%
2011	13,907	67%	68%	68%	87%	92%	73%

Source: Own calculations on the basis of Amadeus/Orbis data

Electronic components and semiconductors

Table 7.5: Overview of data coverage in the Amadeus database in the Electronic components & semiconductor sector

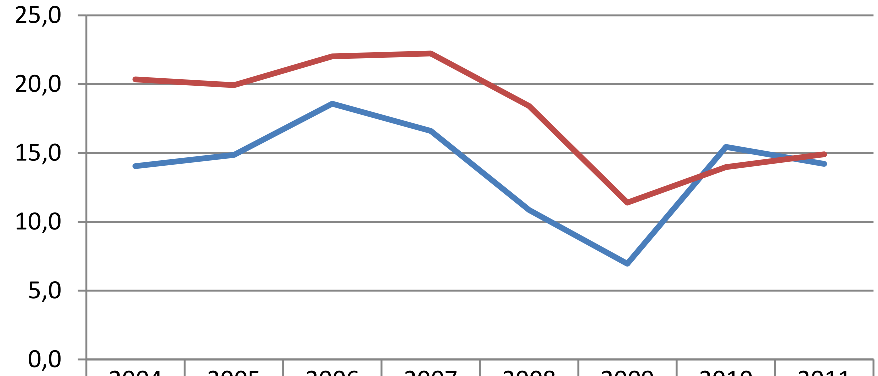
Year	Total # of companies in the sample for which account data is available	% of companies in the sample for which account data is available on the following indicators:					
		Return on shareholder funds	Profit margin	EBIT Margin	Current ratio	Solvency ratio	Gearing
2004	3,913	67%	70%	70%	92%	97%	77%
2005	4,967	57%	59%	59%	85%	97%	71%
2006	5,689	51%	52%	52%	84%	96%	70%
2007	6,365	52%	52%	52%	83%	96%	67%
2008	6,787	51%	51%	51%	82%	96%	65%
2009	7,553	46%	49%	49%	78%	90%	61%
2010	7,420	48%	50%	50%	83%	93%	65%
2011	5,241	55%	56%	56%	84%	90%	68%

Source: Own calculations on the basis of Amadeus/Orbis data

Annex II.4
EU-27 firm level analyses: EEI industry data

Profitability ratios

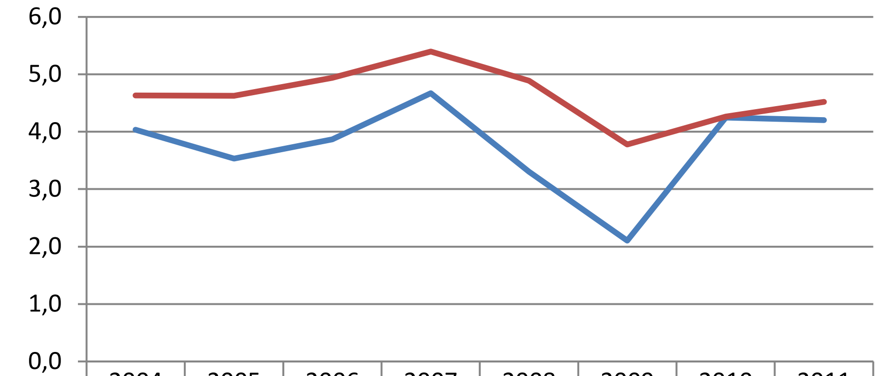
Figure 7.10: Return on shareholders' funds[370] (in %) in the EU-27 EEI sector



	2004	2005	2006	2007	2008	2009	2010	2011
average	14,0	14,9	18,6	16,6	10,8	7,0	15,4	14,2
median	20,3	19,9	22,0	22,2	18,4	11,4	14,0	14,9

Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.11: EBIT Margin[371] (in %) in the EU-27 EEI sector



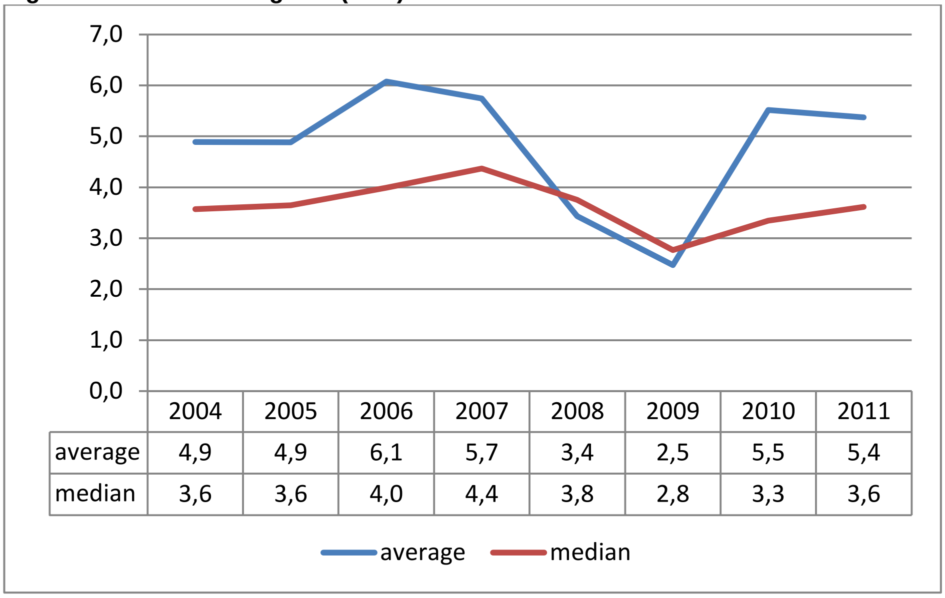
	2004	2005	2006	2007	2008	2009	2010	2011
average	4,0	3,5	3,9	4,7	3,3	2,1	4,2	4,2
median	4,6	4,6	4,9	5,4	4,9	3,8	4,3	4,5

Source: Own calculations on the basis of Amadeus/Orbis data

[370] Formula = (profit/loss before tax / shareholders' funds)*100

[371] Formula = (EBIT / operating revenue) *100 with "EBIT" = operating profit or loss = all operating revenues – all operating expenses

Figure 7.12: Profit margin[372] (in %) in the EU-27 EEI sector

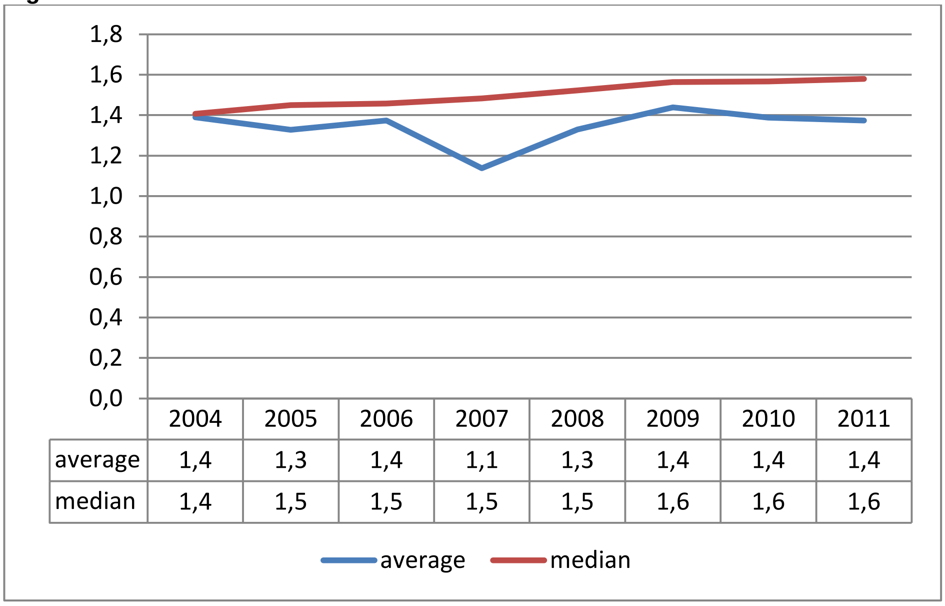


	2004	2005	2006	2007	2008	2009	2010	2011
average	4,9	4,9	6,1	5,7	3,4	2,5	5,5	5,4
median	3,6	3,6	4,0	4,4	3,8	2,8	3,3	3,6

Source: Own calculations on the basis of Amadeus/Orbis data

Structure ratios

Figure 7.13: Current ratio[373] in the EU-27 EEI sector



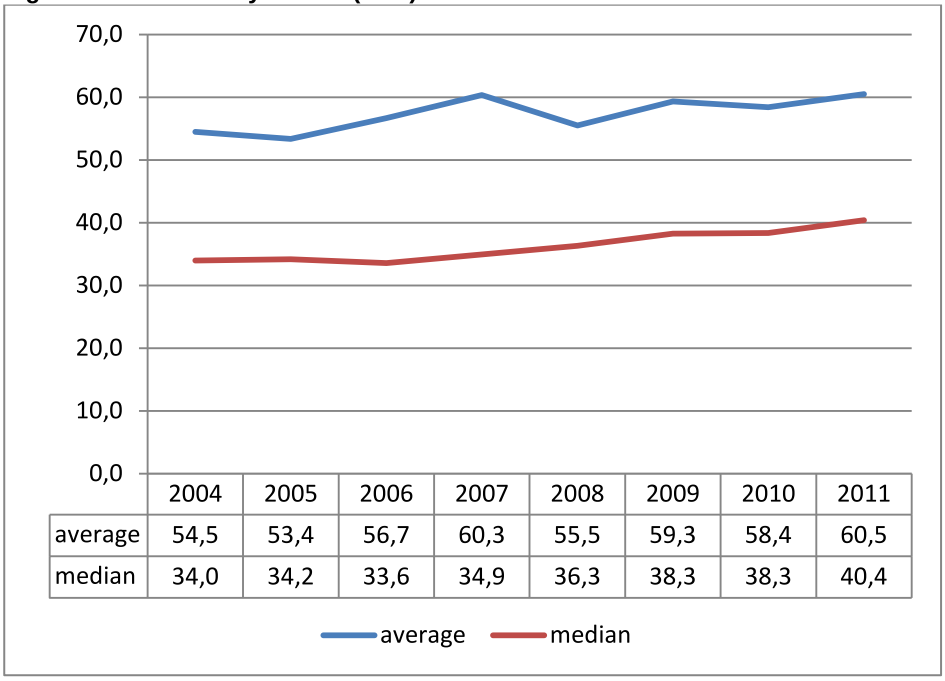
	2004	2005	2006	2007	2008	2009	2010	2011
average	1,4	1,3	1,4	1,1	1,3	1,4	1,4	1,4
median	1,4	1,5	1,5	1,5	1,5	1,6	1,6	1,6

Source: Own calculations on the basis of Amadeus/Orbis data

[372] Formula = (profit/loss before tax / operating revenue) *100 with “profit/loss before tax” = operating profit/loss + financial profit/loss

[373] Formula = current assets/current liabilities

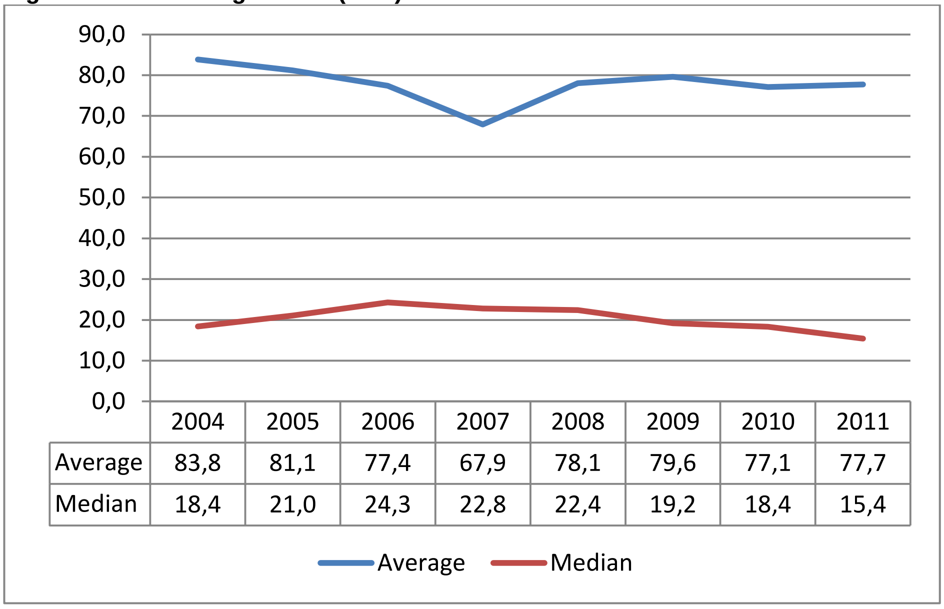
Figure 7.14: Solvency ratio[374] (in %) in the EU-27 EEI sector



	2004	2005	2006	2007	2008	2009	2010	2011
average	54,5	53,4	56,7	60,3	55,5	59,3	58,4	60,5
median	34,0	34,2	33,6	34,9	36,3	38,3	38,3	40,4

Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.15: Gearing ratio[375] (in %) in the EU-27 EEI sector



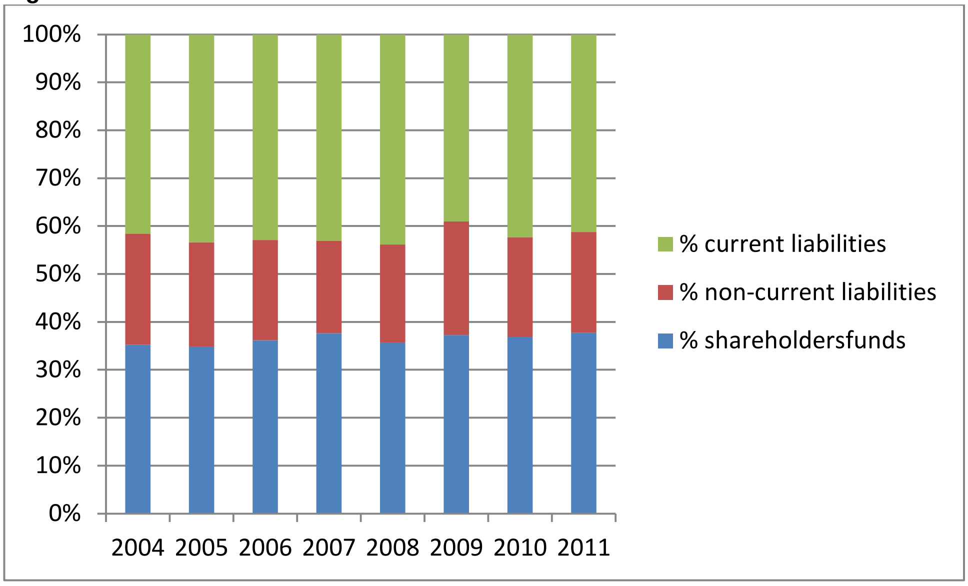
	2004	2005	2006	2007	2008	2009	2010	2011
Average	83,8	81,1	77,4	67,9	78,1	79,6	77,1	77,7
Median	18,4	21,0	24,3	22,8	22,4	19,2	18,4	15,4

Source: Own calculations on the basis of Amadeus/Orbis data

[374] Formula = (shareholders' funds / (non-current liabilities + current liabilities)) *100

[375] Formula = ((non-current liabilities + loans) / shareholders' funds) * 100

Figure 7.16: Structure of shareholders' funds and liabilities in the EU-27 EEI sector



Source: Own calculations on the basis of Amadeus/Orbis data

Overview table

Table 7.6: The micro-economic performance of EEI industry (a) (b)

	EEI			
	MEDIAN		WEIGHTED AVERAGE	
	Average (2004-2011)	Change rate (2004-2006) versus (2010-2011) in percent	Average (2004-2011)	Change rate (2004-2006) versus (2010-2011) in percent
Return on shareholder funds (in %)	17.9	-30.5%	13.9	-6.3%
Ebit margin (in %)	4.6	-7.2%	3.7	10.8%
Profit margin (in %)	3.6	-6.8%	4.8	3.1%
Current ratio	1.5	9.4%	1.3	1.2%
Solvency ratio (in %)	36.2	16.1%	57.3	8.4%
Gearing ratio (in %)	20.2	-20.4%	77.8	-4.2%

Source: Own calculations on the basis of Amadeus/Orbis data

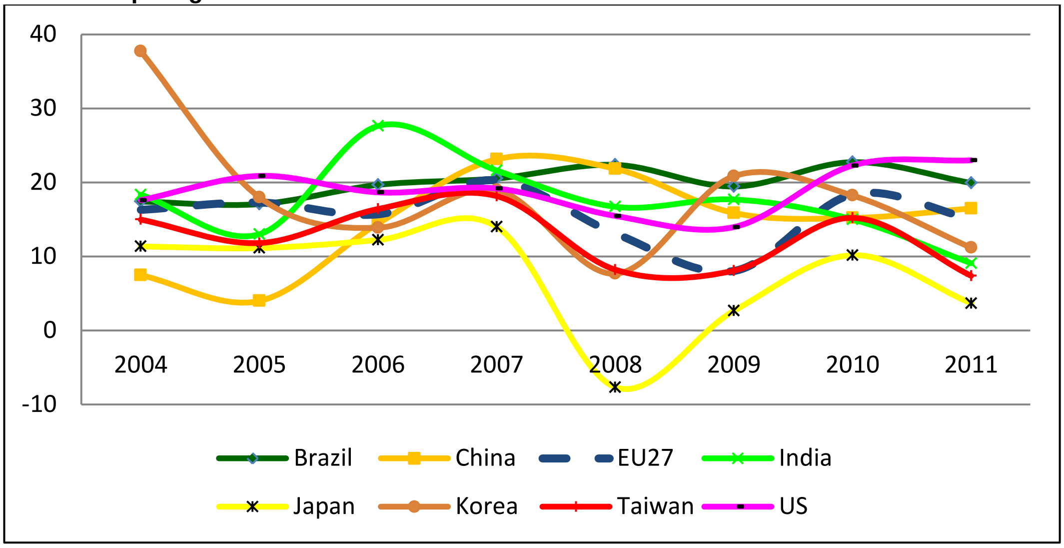
(a) Computations in the table are based on the median values and the weighted averages of the ratios.

(b) Gearing ratio: a high gearing ratio means that the company is financially more vulnerable. Therefore we would like to note that an increase in the gearing ratio (a positive change rate) means a deterioration and a decrease in the gearing ratio (a negative change rate) means an improvement in the gearing ratio.

Annex II.5
Competing countries firm level analyses: EEI industry data

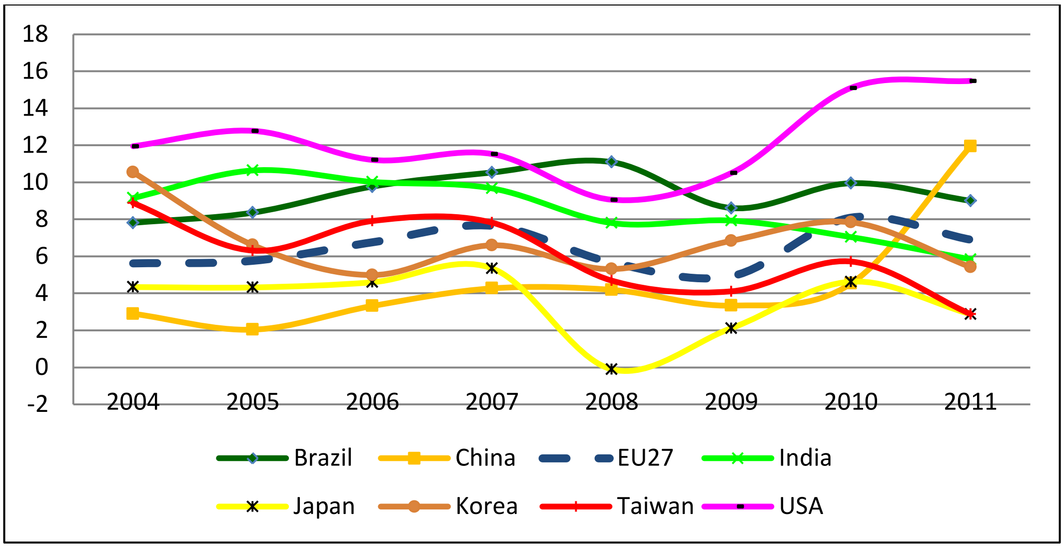
Profitability ratios

Figure 7.17: Average return on shareholders' funds[376] (in %) in the EEI sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.18: Average EBIT margin[377] (in %) in the EEI sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

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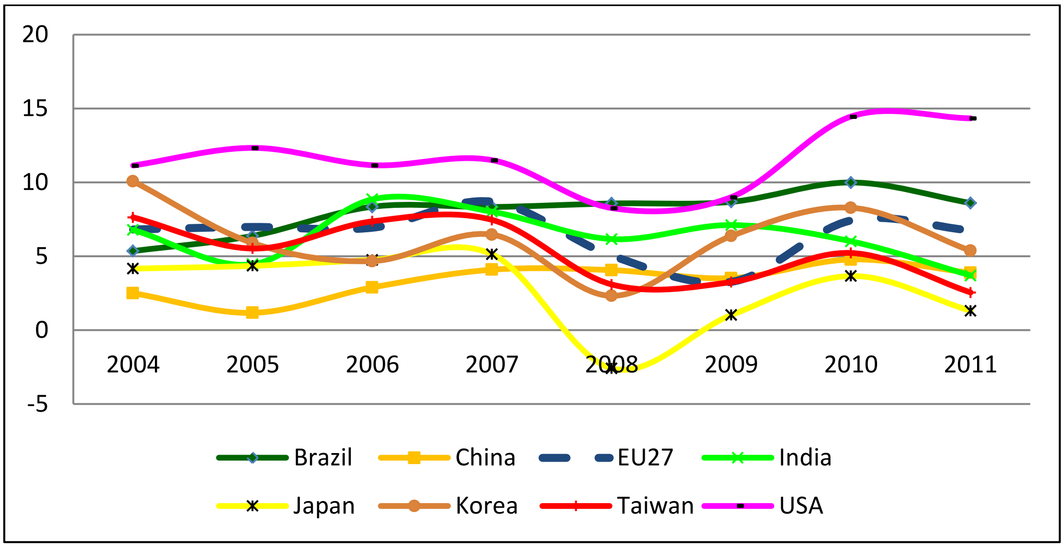
376 Formula = (profit/loss before tax / shareholders' funds)*100

377 Formula = (EBIT / operating revenue) *100 with "EBIT" = operating profit or loss = all operating revenues – all operating expenses

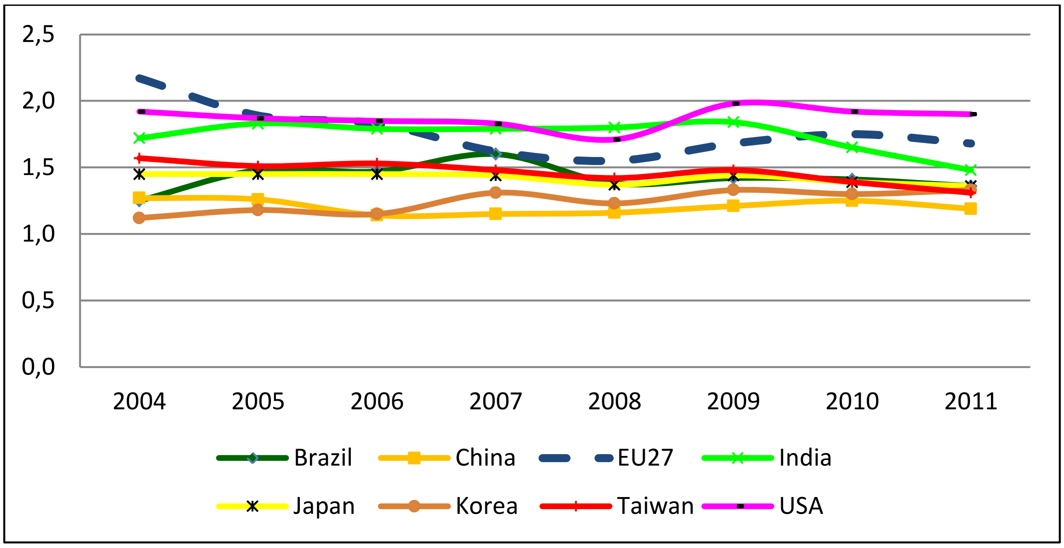
Figure 7.19: Average profit margin[378] (in %) in the EEI sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Structure ratios

Figure 7.20: Average current ratio[379] (in %) in the EEI sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

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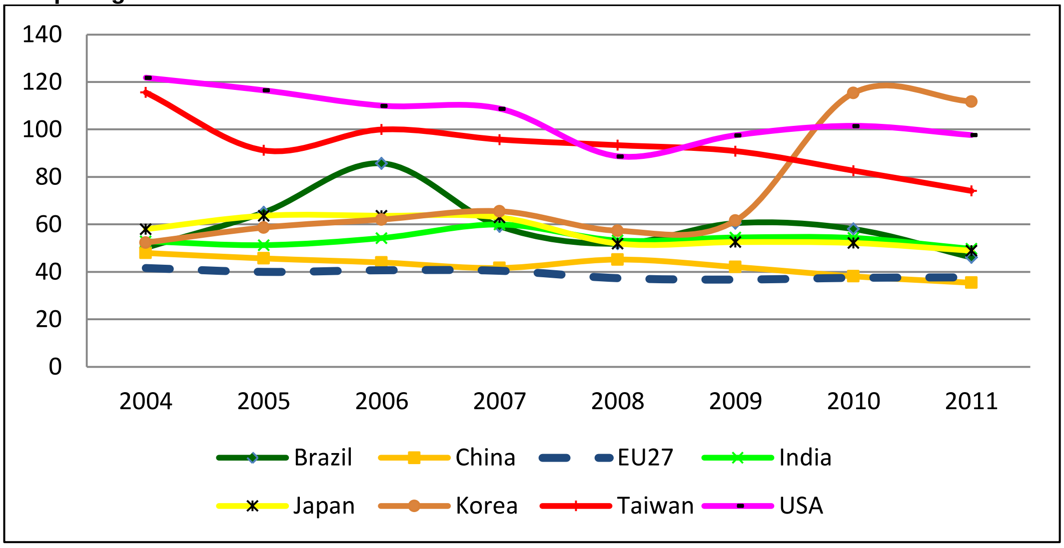
[378] Formula = (profit/loss before tax / operating revenue) *100 with “profit/loss before tax” = operating profit/loss + financial profit/loss

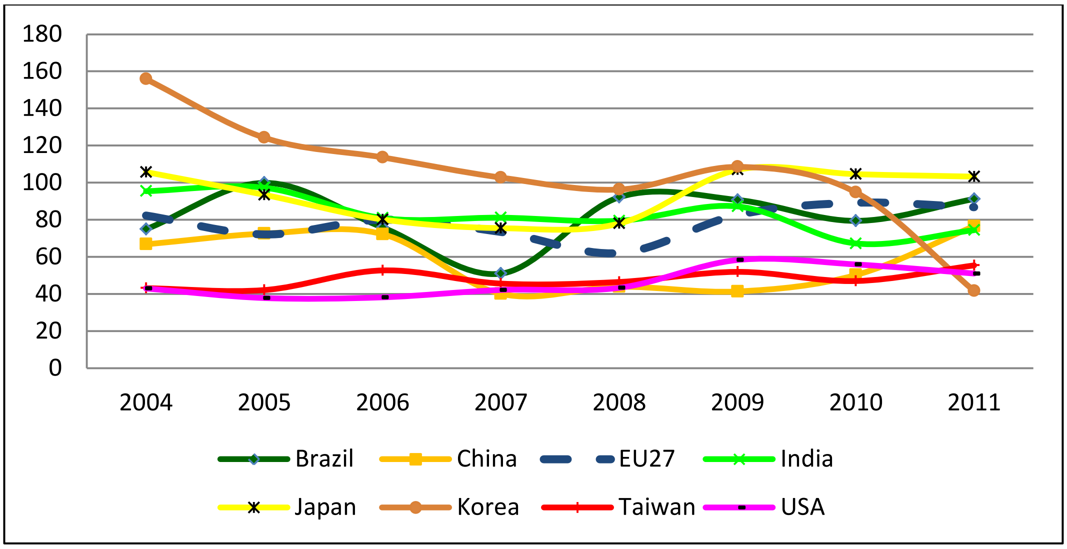
[379] Formula = current assets/current liabilities

Figure 7.21: Average solvency ratio[380] (in %) in the EEI sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

Figure 7.22: Average gearing ratio[381] (in %) in the EEI sector in the EU-27 and in competing countries



Source: Own calculations on the basis of Amadeus/Orbis data

[380] Formula = (shareholders' funds / (non-current liabilities + current liabilities)) *100

[381] Formula = ((non-current liabilities + loans) / shareholders' funds) * 100

Overview Table

Table 7.7: Overview table EEI [a] [b] [c] [d]

	Return on shareholder funds (in %)		EBIT margin (in %)		Profit margin (in %)		Current ratio		Solvency ratio (in %)		Gearing ratio (in %)	
	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004 -2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004-2011)	Change rate (2010-2011) versus (2004-2006) in percent	Average (2004-2011)	Change rate (2010-2011) versus (2004-2006) in percent
Brazil	19.9 *(1)*	18.2% *(3)*	9.4 *(2)*	9.6%	8.0 *(2)*	38.9% *(2)*	1.4	-1.1%	59.6	-22.3%	81.9	2.1%
China	14.8	83.4% *(1)*	4.6	199.3% *(1)*	3.4	98.0% *(1)*	1.2	-0.3% *(3)*	42.5	-19.8%	58.0 *(3)*	-10.1% *(3)*
EU-27	15.5	1.9%	6.4	24.0% *(3)*	6.5 *(3)*	2.6%	1.8 *(1)*	-12.6%	39.0	-7.8% *(3)*	78.6	12.6%
India	17.4	-38.7%	8.5 *(3)*	-35.2%	6.4	-27.5%	1.7 *(3)*	-12.1%	53.8	-1.5% *(2)*	82.9	-22.4% *(2)*
Japan	7.2	-40.2%	3.5	-15.0%	2.7	-43.8%	1.4	-5.2%	56.7	-18.2%	93.5	11.6%
Korea	18.3 *(3)*	-36.6%	6.8	-10.2%	6.2	-0.8%	1.2	14.3% *(1)*	73.1 *(3)*	96.8% *(1)*	104.7	-48.0% *(1)*
Taiwan	12.5	-21.5%	6.0	-44.2%	5.3	-43.2%	1.5	-12.1%	92.9 *(2)*	-23.3%	48.1 *(2)*	11.3%
USA	18.9 *(2)*	18.9% *(2)*	12.2 *(1)*	27.6% *(2)*	11.5 *(1)*	24.7% *(3)*	1.9 *(1)*	1.6% *(2)*	105.3 *(1)*	-14.2%	46.3 *(1)*	34.8%

Source: Own calculations on the basis of Amadeus/Orbis data

(a) Per ratio, we have indicated the ranking of the best 3 performing countries (in terms of averages over the period 2004 - 2011) between brackets and in italics.

(b) Per ratio, we have indicated the ranking of the best 3 performing countries, in terms of the change rates 2010 - 2011 versus 2004 - 2006, between brackets and in italics.

(c) The computations of the averages were based on the averages in the graphs above.

(d) Gearing ratio: a high gearing ratio means that the company is financially more vulnerable. Therefore we would like to note that an increase in the gearing ratio (a positive change rate) means a deterioration and a decrease in the gearing ratio (a negative change rate) means an improvement in the gearing ratio.

Annex III
List of interviewees

	Last Name	Name	Company	Country	Type of Interview
1	Abma	Hendrik	EECA/ESIA/Sectoral Committee	Belgium	telephone
2	Amann	Guillermo	Ormazabal	Spain	telephone
3	Blank	Oliver	ZVEI European Liason Bureau	Belgium	telephone
4	Dauvin	Jean-Philippe	Independent Semiconductor expert & former Chief Economist at STMicroelectronics	France	face-to-face and written answer
5	Denjoy	Nicole	Secretary General of COCIR (European Radiological, Electromedical and Healthcare IT Industry association)	Belgium	face-to-face
6	Dulitz	Sonja	ZVEI/Deutscher Industrieverband	Germany	telephone
7	Escher	Francois	Freescale	Switzerland	telephone
8	Eric	Jourde	Délégué Général of FIEEC (Fédération des Industries Electriques, Electroniques et de Communication)	France	face-to-face and written answer
9	Focchi	Michela	Association of European Automotive and Industrial Battery Manufacturers/Sectoral Committee	Italy	written answer
10	Gontermann	Andreas	ZVEI	Belgium	face-to-face
11	Guillaume	Adam	chargé de Mission Europe at FIEEC	France	face-to-face and written answer
12	Hoffmann	Alfred	Infineon	Germany	telephone

13	Konecki	Wojciech	CECED Poland	Poland	telephone
14	Matheron	Gérard	Director of STMicroelectronics' plant of Crolles	France	telephone and written answer
15	Meli	Luigi	CECED/Sectoral Committee Domestic Appliances	Italy	telephone
16	Mittelbach	Klaus	ZVEI	Belgium	face-to-face
17	Monizza	Guiliano	T&D Europe European Sectoral Committee	Italy	telephone
18	Pazin	Zeliko	EFFRA & Orgalime	Belgium	face-to-face
19	Pflug	Volkmar	Siemens	Germany	telephone
20	Porter	Howard	BEAMA/National Association	UK	telephone
21	Pradas Poveda	José Ignacio	Sercobe	ES	telephone
22	Raguin	Paul	CEO of Eolane	France	telephone and written answer
23	Renko	Janez	Eletronic and Electrical Engineering Association National Association Slovenia	Slovenia	telephone
24	Riedemann	Christoph	Orgalime	Austria	face-to-face
25	Rizzo	Gilles	Interconnection component expert at GIXEL (Groupement Français des Industries de Composants et de Système Electroniques)	France	face-to-face and written answer
26	Schellekens	Evelyne	Installation AIE	Belgium	telephone
27	Schlenk	Manfred	Mineba	Germany	telephone

28	Sommerer	Harald	Manufacturers/Zumtobel AG Lightning	Austria	telephone
29	Sturm	Jürgen	Lighting Europe/Sectoral Committee	Belgium	telephone
30	Vandale	Freddy	BEAMA/National Association	UK	telephone
31	Wendt	Volker	Europacable/European Sectoral Committee	Belgium	telephone
32	Westgeest	Alfons	Association of European Automotive and Industrial Battery Manufacturers/ Sectoral Committee	Belgium	telephone

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