An introduction to Mechanical Engineering: Study on the Competitiveness of the EU Mechanical Engineering Industry

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Final Report

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1 An introduction to Mechanical Engineering

1.1 Structure of the report and the team

The study on the competitiveness of the EU mechanical engineering was carried out by the Ifo Institute (Ifo), Cambridge Econometrics (CE) and the Danish Technological Institute (DTI). The project lead was carried out by Ifo. The Ifo institute executed the fieldwork, the majority part of the literature review and the quantitative and qualitative assessment of the competitiveness. Ifo takes full responsibility of the design of the conclusions and recommendations.

CE created the database for mechanical engineering that has provided deep insight in the evolution of the EU Mechanical Engineering sector and its most important competitors. With the help of long-term time series, a profound analysis in the performance of the EU Mechanical Engineering sector could be undertaken. The evaluation of the price competitiveness and the performance in international markets have revealed divergent results. A loss in price competitiveness on the one hand contrasts to noteworthy success in major sales markets on the other hand.

DTI wrote the subchapter on labour force and skills that provides insight in strengths and weaknesses of labour supply. Qualified labour is of outstanding importance for mechanical engineering and contributes much to the competitiveness in international markets. Recommendations have been derived to counter expected bottlenecks caused by demographic developments and the changed interest of young people in professional careers.

Chapter 1 provides an overview on mechanical engineering and highlights specifics necessary to understand the industry and its driving factors.

Chapter 2 provides a comprehensive insight in the EU Mechanical Engineering sector, differentiated by member states and major subsectors. It contains detailed information that has been collected by desktop and fieldwork research. The analysis and aggregation of this information has been done for the evaluation of the EU ME's strengths and weaknesses, and the design of recommendations that is carried out in the following chapters.

Chapter 3 presents an evaluation of the EU Mechanical Engineering sector against its most important competing economies and an investigation in its performance in major sales markets.

Chapter 4 provides a comprehensive assessment of the EU Mechanical Engineering sector's competitiveness. A quantitative evaluation of the price competitiveness and of the performance in international markets is carried out. Moreover, companies' behaviour, the organisation of value chains and structural changes are taken into account for a qualitative evaluation of the EU ME's performance.

Chapter 5 investigates the framework conditions of relevance for the EU Mechanical Engineering sector. It is dedicated to identify beneficial and obstructive factors for the long-term development of the EU Mechanical Engineering sector.

Chapter 6 provides a long-term outlook for the EU Mechanical Engineering sector. It takes into account aspects that can become drivers in the future. Among them are the strengthening of services as supplements or even new business areas for ME. The chapter concludes with a set of policy recommendations.

1.2 Understanding the project and its objectives

The request for services, dated 30th September 2010, in the context of the framework contract on Sectoral Competitiveness Studies (ENTR/06/054), was signed between our consortium, led by ECORYS NL, and DG Enterprise and Industry. The Study on the Competitiveness of the EU Mechanical Engineering Industry (ME) is led by the Munich based Ifo Institute. Cambridge Econometrics and the Dansk Technological Institute are members of the team responsible for the execution of this project.

Mechanical engineering (henceforth ME) is one of the most competitive European manufacturing industries. Over the past decade, it has performed well in international markets and has greatly benefited from the momentum of high global growth. The industrialisation of emerging economies has been the most important driver for demand for machinery and equipment. However, the high risk propensity of investors and relaxed financing conditions have also contributed to the industry's bright development. As a consequence, ME has suffered a major setback due to the crisis in the financial markets, and output of the European ME plummeted by a high double-digit rate in 2009. Demand has bounced back since then, and production has recovered, but it will take until at least 2012 for former levels to be regained.

The crisis has changed the weighting of the economies. In particular in manufacturing, the industrialized countries have lost shares in global output relative to emerging economies. This has not only had an impact on opportunities to exploit economies-of-scale but also on the strengths of industrial clusters. Moreover, the aftermath of the financial crisis has not yet been overcome. The high public debt burden and international macro-economic inequalities raise some questions as to the prospects for growth. Funding has become more difficult for enterprises, in particular SMEs, and the increasing volatility in exchange rates has augmented companies' exposure to risk.

Following the global crisis, it is a challenge to assess the competitiveness of ME and identify the changes, as well as the new challenges, that have emerged. The industry is not only one of the largest of the manufacturing sector; it is also one of the most heterogeneous, with more than 20 subsectors that face quite different market environments. As a consequence, selected market segments with specific framework conditions must be investigated.

The EnginEurope report is the most recent study on ME commissioned by the European Commission. However, the report was concluded just before the financial crisis shattered the global economy. The report highlights the importance of ME. It is not only one of the largest manufacturing industries but also an enabling industry of outstanding importance for advanced manufacturing processes and high productivity. European ME – a global leader in production technologies – provides advantages to other industries and is a vital player in a much wider value chain. The regional proximity of suppliers and users of machinery and equipment is an advantage even in the era of globalization, since the introduction of cutting-edge technologies and the optimization of processes is much easier.

The Terms of Reference (ToR) call for a new study to assess changes in the competitiveness of ME. The study comprises an investigation of the strengths and weaknesses of the industry and an investigation of framework conditions to identify opportunities and threats.

The study on ME is aimed at contributing to the initiatives of the European Commission to strengthen the competitiveness of the EU. The ToR mention the Communication of 3rd March 2010 on objectives to be reached by 2020 as a guideline for policy options.[1] Additionally the "Communication on a New Industrial Policy" - published in October 2010 - provides further information on policy measures that will be implemented to reach the Europe 2020 goals. Policy recommendations are designed to be in line with the initiatives put forward in both Communications and build on related schemes.

Much emphasis is put on changes induced by the global crisis and the identification of further existing threats as a foundation for the assessment of ME's competitiveness. The investigation lays foundations for policy recommendations for the EU, the Member States and stakeholders of the sector. The EnginEurope Report, produced by a European high-level group, proposed a comprehensive set of policy recommendations in 2007. It provides a useful starting point for the design of recommendations that take into account changes induced by the global crisis, the current economic recovery and new insights in strengths and weaknesses of the industry, opportunities and threats in its environment.

The scope of the study is ME – as the 2-digit group 28 NACE Revison 2. The ToR define 10 subsectors that are to be analysed in more detail. The selection comprises subsectors in different market and technology environments, subsectors supplying intermediary goods and final goods, subsectors providing equipment for manufacturing industries, agriculture, construction industry and mining and subsectors supplying key components to plant-engineering projects. These subsectors provide a good cross-section of the heterogeneous ME industry and it was agreed that they would be investigated during the Kick-off Meeting.

[11] European Commission, Europe 2020 – A European strategy for smart, sustainable and inclusive growth, Brussels, 3 March 2010.

Determining the decisive factors for the competitiveness of European ME is a prerequisite for the formulation of recommendations for companies and policymakers. One aspect is to highlight the comparative advantages in international competition. This point is investigated and the supply of qualified labour on all levels of importance for the industry are analysed as ME is one of the sectors in the manufacturing industry with the highest requirements on staff qualifications. The value chain, clusters and the intra-sectoral division of labour, all pre-requisites for the manufacture of high-performance machinery and equipment, are also taken into account.

1.3 Specifics of Mechanical Engineering

Since the late 1970s, ME has evolved into a leading industry in the development and application of high tech, ranging from optoelectronics to new materials and alike. Many products of the industry combine mechanical technologies – often denigrated as old technologies – with advanced technologies. The engineering ingenuity to create innovative products that combine different technologies is one of the prominent strengths of European ME. Although ME is understood as a supplier of hardware, machinery and equipment, it has evolved in the direction of a service industry. Services such as the installation of manufacturing systems, training of operators, maintenance and repair, and even the supply of finance, have become more important. These services contribute not only to higher productivity but simultaneously reduce the exposure to low-cost competition.

As a consequence, the assessment of ME's competitiveness will put a degree of emphasis on upstream and downstream linkages. The supplier industries' state of technology and their pace of innovation are of importance for the performance of ME in the global technological competition. Likewise, vibrant client industries' "demand pull" stimulates innovation in ME. The growing weight of the emerging countries in manufacturing has even accelerated in the course of the global crisis – and this has become an important topic for the assessment of the opportunities and threats to ME.

ME is characterized by smaller companies. These are not only enterprises with less than 250 employees – as SMEs are defined by the European Commission[2] - but also bigger family-owned firms with up to between 1,000 and 2,000 employees that are small compared to their global competitors. These companies are strongly dependent on business favourable EU framework conditions, functioning markets and infrastructure. Additionally, the industry is characterized by a sophisticated division of labour between companies and complex value chains. ME in the EU can build on a strong industrial clusters with a broad range of specialized companies supplying high performance parts, components and final products. A pan-European network of ME clusters has emerged, and the new Member States[3] (accession 2004 and 2007) contribute to the strengths of the industry.

As a consequence, the study pays special attention to the evolution of the value chain in ME. This concerns regional aspects such as the intra-EU division of labour, strategies in

[2] http://ec.europa.eu/enterprise/policies/sme/files/sme_definition/sme_user_guide_en.pdf
[3] Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania.

globalisation and the integration of external regions in the value chain, namely Asia, but also neighbouring countries in Eastern Europe, North Africa and Turkey. Organizational changes, above all induced by procurement strategies of big original equipment manufacturers (OEMs), impose new requirements on SMEs. High administrative requirements, system integration, funding and risk sharing are challenges that SMEs face in a globalized world.

The objective of this subchapter is to provide an overview of ME in the EU. It starts with a description of the basic characteristics of the industry, which reveals that there is a relationship between the size and behaviour of companies and the nature of their supply. Generally speaking, ME is a medium-sized industry. However, it is a very heterogeneous industry, a characteristic stemming from market environments that impose fundamentally different requirements on companies' abilities and their strategic orientation. In some market segments, the market environment imposes requirements on suppliers that small firms struggle to meet. Examples are volume markets with serial products[4] and the building of turn-key plants. Moreover, the industry is characterized by a strong intra-sectoral division of labour. Final product manufacturers of machinery, manufacturing systems and plants rely on suppliers of high-tech components that are of crucial importance for the quality and the performance of final goods delivered by ME.

Secondly, upstream and downstream linkages are highlighted that are of major importance for the competitiveness of the industry. The innovation of upstream industries is an indispensable prerequisite in maintaining pace in the international technological competition. Downstream linkages are just as important. A demand push contributes to innovation in ME. This does not only affect the pay-back period of research expenditure but also provide opportunities for the optimization of customized solutions that contribute to the European firms leading technological position.

Thirdly, general developments in global markets are identified. They provide insight into the dependency of ME on business cycles that are strongly dependent on the global investment propensity. Another aspect concerns long-term trends in demand that have been caused by the emerging economies' industrialization and soaring demand for raw materials.

Fourthly, the innovation system of ME – an industry that has been marked as a high to medium tech industry – is highlighted. This assessment deals with the fact that R&D expenditure is only roughly the average of total manufacturing. It is revealed that ME is strong in engineering and innovation activity that has never been included in the R&D surveys.

1.3.1 Basic characteristics of the sector

In 2008, ME in the EU-27 attained a production value of € 598 billion. This output was achieved by 3.2 million people employed in approximately 91,800 enterprises. For the period from 1995 to 2000, manufacturing as well as ME enjoyed comfortable growth rates. During the following lustrum a sluggish development imposed a constraint on

4 Standardized products, variations of these products are defined by the manufacturer only and not by the customer.

companies. At the end of this period demand soared and a strong upswing - last seen at the end of the 1980s – supported the EU ME to attain record heights on an unforeseen scale, prior to climaxing in 2008. The breakdown caused by the global financial and economic crisis hit the industry in 2009 and production fell by more than one fifth, on average, for all EU member states. ME benefitted from an early recovery and high growth momentum in 2010. However, former levels have not yet been reached. On average, for the entire study period, ME grew at around the same pace as total manufacturing, but was far more cyclical in nature.

Generally speaking, growth has not been sufficient to stabilize employment levels. For total manufacturing and ME it declined moderately at a similar pace. Only during the short period between 2005 and 2008 - where growth rates were well above the long-term trend - the number of employees increased. The net effect on the number of workplaces for ME between 1995 and 2010 for total manufacturing and ME was negative (Table 1.1).

Table 1.1: Key figures for EU-27 in Mechanical Engineering

Sector	Indicator	2010		Annual average growth rate in %			
				1995–00	2000–05	2005–08	2008–10
Manufacturing	Production, in current prices	€ bn	5,885	5.3	2.1	6.7	-5.2
ME[1)]			502	4.0	2.3	10.4	-8.4
Manufacturing	Gross value added, at 2010 prices	€ bn	1,504.0	2.1	0.0	1.5	-5.2
ME[1)]			157.5	2.4	0.3	6.0	-9.3
Manufacturing	Employees	1,000	30,063	-0.6	-1.3	-0.3	-4.8
ME[1)]			2,9001	-1.6	-2.2	1.8	-4.8
Manufacturing	Productivity[2)]	€ 1,000	50.0	2.7	1.3	1.8	-0.4
ME[1)]			54.3	4.0	2.6	4.1	-4.7

1) ME = mechanical engineering; - 2) Value added per capita and annum at 2010 prices.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The key data show that ME is one of the major branches of industry in the EU-27 with a share of around 9.1% of all manufacturing industries, as measured by production. Compared to other industries, ME firms are characterized by relatively high manufacturing depth. This means that in-house production plays a more important role than in most other branches, such as the chemical or motor vehicle industries. This characteristic is the result of the fact that outsourcing is more difficult. This is mainly explained by three factors: predominant small-batch and single-item production, high qualification requirements in manufacturing departments and a close communication between manufacturing, engineering and design departments. As a consequence, the share of ME's value added of total manufacturing is higher than that of production, reaching around 11.5%. The higher share of value added is also reflected in employment that also comes up to a similar share of total manufacturing.

The average number of employees per company in ME amounts to staff numbers of 34.9, whereas for total manufacturing this indicator only comes up to 18.1. These figures are extremely low and have been caused by numerous small companies each of which employing less than 10 people. Moreover, the relation between all of manufacturing and ME seems to contradict the conventional wisdom that ME is an industry with a majority of smaller firms as compared to other industries. In fact, there are only few large corporations, which support the assumption, but there is also a broad range of companies within the size category of 500 to 2000 employees. The bulk of these companies is responsible for the higher average number of employees per firm. This result is also explained by two other factors: firstly, the higher manufacturing depth linked to in-house production and comprehensive engineering activities and, secondly, the fact that Germany - with its larger firms - accounts for around one third of the EU-27 ME output. [5]

This size structure of ME is not accidental in nature, but results from production requirements. Only in exceptional cases are ME products suitable for large-scale manufacturing. This reduces the need for large production sites that are fully automated which are capable of achieving noteworthy economies-of-scale.[6] The structure of the ME industry, as well its value chain, is notably different from its automotive and aerospace counterparts in the sense that OEMs do not benefit from the same level of purchasing power there within. Larger firms can be found throughout the value chain and there are numerous suppliers to final product manufacturers that possess a strong position in the market, based upon their technical expertise and ability to manufacture components with unique characteristics.

A more detailed analysis by companies' size structure cannot be conducted for the total EU 27, but only for selected Member States. Table 1.2 depicts that there are larger companies as compared with other industries. However, the average number of employees for companies with a staff of 250 and more is only 790 for ME, whereas the average for all of manufacturing is 895.[7] This confirms conventional wisdom. ME is an industry of predominantly medium-sized enterprises, but with regard to the broad range of activities needed to finalise the product, e.g. engineering, R&D, a growing supply of services and an above average manufacturing depth of a particular size is characteristic.

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5 The EnginEurope Report does not specify the structure of the industry and speaks of the dominance of SMEs only. However, it is of importance to understand that - caused by the complexity of products and the importance of engineering - the internationally competitive backbone of the EU ME with regard to innovation and access to the global markets is strongly dependent on companies of a certain size irrespective of the fact that large groups are not decisive for the competitiveness of ME. See: European Commission, DG Enterprise and Industry (2007a), The EnginEurope Report, Brussels 2007, p 23.

6 The EnginEurope Report badges the highly-standardized, mass production typical for many manufacturing industries as commoditization. See: European Commission, DG Enterprise and Industry (2007a), The EnginEurope Report, Brussels 2007, p 22.

7 A more detailed analysis would require additional size categories to differentiate between groups of larger companies, but Eurostat does not provide these categories.

Table 1.2: Distribution of enterprises by size category and average employment

Size category	Total manufacturing[1]		Mechanical engineering[1]	
	Shares	Average[2]	Shares	Average[2]
Between 0 and 9 empl.	79,4%	2,6	59,8%	3,4
Between 10 and 19 empl.	10,5%	13,1	17,6%	13,4
Between 20 and 49 empl.	5,8%	31,6	11,8%	31,8
Between 50 and 249 empl.	3,5%	109,2	8,8%	111,6
250 or more empl.	0,7%	894,5	1,9%	790,2
Total	**100,0%**	**15,8**	**100,0%**	**33,3**

[1] Based on CZ, DE, ES, FR, IT, SK, PL, UK; [2] Number of employees per enterprise.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Nearly all of the small enterprises below 50 employees in total manufacturing and ME are handicraft companies. They do not possess the typical industrial manufacturing processes that are optimized and controlled by a planning department. Although these companies are subsumed under "Total Manufacturing" and ME their structures and their market environment is different. However their weight is limited as depicted in Table 1.3. More than three quarters of total ME' workforce is employed in companies with more than 50 employees.

Table 1.3: Distribution of employment by size category

Size category	Total manufacturing[1]		Mechanical engineering[1]	
	Employees[2]	Share[3]	Employees[2]	Share[3]
Between 0 and 9 empl.	3273	13,3%	156	6,1%
Between 10 and 19 empl.	2148	8,7%	180	7,1%
Between 20 and 49 empl.	2835	11,5%	287	11,3%
Between 50 and 249 empl.	5980	24,3%	747	29,5%
250 or more empl.	10397	42,2%	1165	46,0%
Total	**24633**	**100%**	**2535**	**100%**

[1] Based on CZ, DE, ES, FR, IT, SK, PL, UK; 2) in thsd.; [3] of total employment.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The regional distribution of ME within the EU reveals that three quarters of the output originates from the bigger five member states. Much of this predominance has been caused by the size of these economies. A closer look at the countries' economies shows that Germany and Italy concentrate on ME, whereas for France and, in particular, for the United Kingdom the share of ME in their economies' output is well below the EU average (Table 1.4).

The three new member states included in Table 1.4 contribute a markedly higher share to EU-27 employment than to value added. This is explained above all by labour cost differences enabling them to compete in low cost areas and that induced an intra-EU division of labour. A similar pattern can be observed for most of the other new member states that accessed the EU since 2004. Already before their accession to the EU these countries had become members of the European value chain in ME. Foreign direct investment (FDI) and relocation of production stimulated growth. Their share of the EU-27 has been growing for all variables illustrated in the table and this trend is still ongoing.

Table 1.4: Regional distribution of Mechanical Engineering in the EU 2008

Member state	Production	Value added	Employment
	Share of EU-27		
Germany	38.0%	41.5%	34.1%
Italy	19.1%	15.6%	15.1%
United Kingdom	6.3%	7.1%	6.6%
France	7.9%	7.9%	8.6%
Spain	3.9%	3.9%	4.1%
Poland	1.9%	2.3%	4.8%
Czech Republic	2.0%	1.9%	4.5%
Slovakia	0.5%	0.4%	1.3%

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

An examination of the intra-EU value-chains shows a concentration of the new member states[8] on metal working and the manufacture of parts and components. There are comparative advantages in these areas that have been a leftover of the former communist regimes. Linked with a cheap labour supply, this has propelled the revival of ME in the region. The prospects for the intra-EU division of labour and the exploitation of regional strengths are discussed in Chapter 4.6.

1.3.2 Interrelation with other sectors of the economy

Traditionally, strong ME upstream linkages exist in the steel and iron industries. There is a trend towards customized deliveries of parts that reduce the workload for ME firms. Castings and welded parts are procured from metal-working industries. There are ME firms that are stakeholders of upstream industries. Upstream industries are energy intensive and face certain challenges from EU environmental provisions on energy efficiency and emissions.[9] This must be taken into account in the assessment of the sustainability of ME as one of the most important industries.

The electrical engineering industry has always been an important supplier for ME. In power stations the contribution of ME and electrical engineering is around one half for both generators and turbines. In other subsectors electrical engineering provides an important input, for instance with electric drives for plants, printing machines and

8 Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania.
9 Some problems have been reported from the foundry industry in recent years. There is no sufficient supply of coking coal within the EU and it has become extremely difficult to procure metallurgical grade coal in the global market during phases of strong growth.

machine tools. Progress in controls for electric drives has contributed much to more efficient ME products and a reduction of the number of moving parts, such as gears. Inter-industrial relations have deepened in production and common engineering.

The dissemination of micro-electronics during the 1980s led to innovation. On the leading edge of these technologies was the machine tool subsector. However, the Japanese were the first to apply advanced controls and gained shares in global markets propelled by their lead. Since then Europe has caught up and ME competes at eye level with Japan.[10] A detailed assessment of the technological position in this area and other fields of relevance for ME, such as nanotechnology, optics, new materials and composites, is performed in Chapter 0.

Roughly one third of ME output is intermediary products that are delivered to other companies, such as bearings, gears, taps, valves, fluidics and engines. Many of these deliveries are intra-sectoral and are made for other ME firms. Other industries that procure intermediary products from ME are electrical engineering, the automotive industry and medical equipment, precision instruments and others.

There are a few large groups in ME that have been specializing in the automotive industry and deliver key components that are crucial for the performance of transport equipment. The market segment is characterized by large contracts, volume production and tough price competition.

The majority of output consists of capital goods dedicated for investment in a broad range of industries. There are subsectors of ME that provide capital goods for specific client industries such as the textile, commercial paper, pulp and paper, construction and mining and agricultural industry. They are strongly dependent on clients' investment behaviour. Some industries, such as textiles, pulp and paper show global investment cycles of extreme amplitudes that are challenging for the manufacturers. Other capital goods manufacturers provide products for several industries and the threat of heavy slumps is less focused, for example the manufacturers of handling equipment, such as cranes, conveyers and robots. Even machine tools have a broader range of applications, although numerous companies have specialized in the supply of machines and production systems for the automotive industry.

The outstanding importance of ME as a supplier of capital goods for a broad range of industries is mentioned in the EnginEurope Report.[11] In fact, for many industries ME supplies more than 50% of their total investment in machinery and equipment. The investment matrices calculated by Ifo, based on official statistics from the Federal Statistics Bureau and other sources, provide a clear picture of the most important suppliers of machinery and equipment. The share of ME in total investment in machinery and equipment is well above 50%. In manufacturing, the industries' refined petroleum, printing, metal products and other transport equipment are lower with around 30%. Outside of manufacturing, ME is of lesser importance. In energy water supply, recycling

10 Japan has remained on the leading edge in the development and manufacture of high-tech components for the electronics industry and holds – in certain segments – the majority of global capacities.

11 European Commission, Enterprise and Industry Directorate-General (2007a). The EnginEurope Report, Brussels, p.21, p.25.

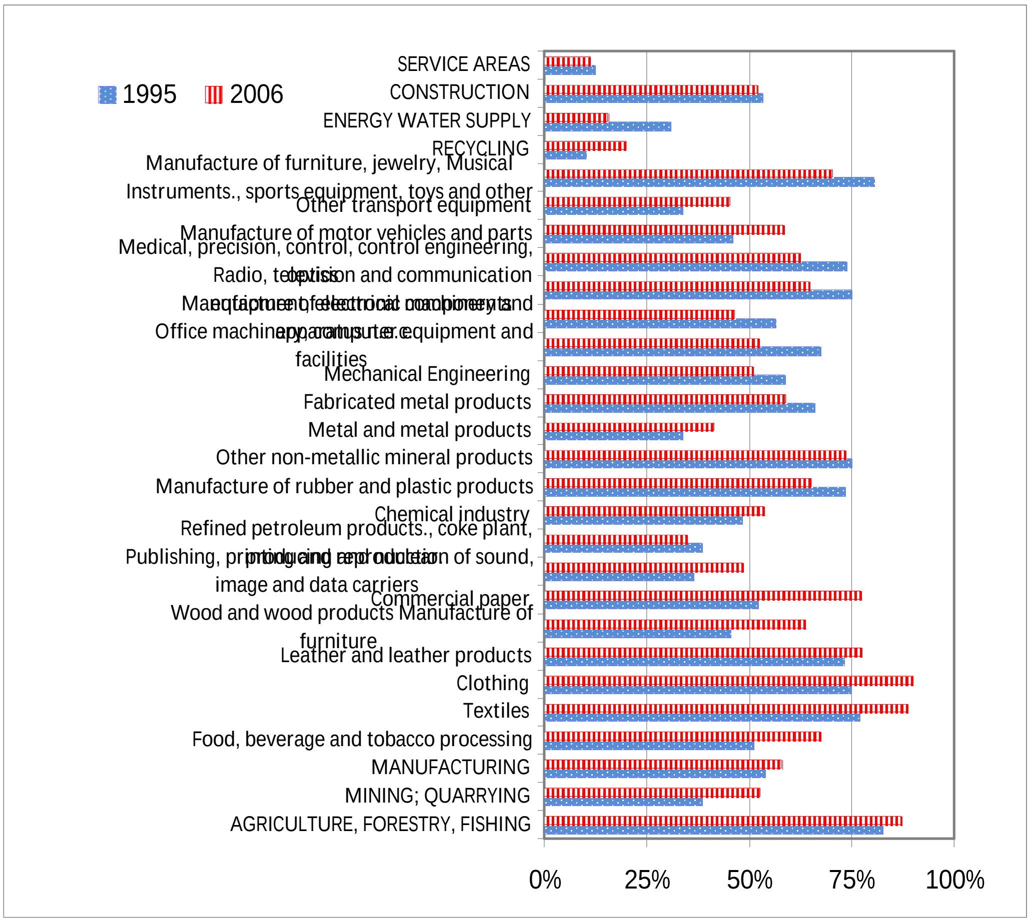
and the service sectors, the share in total investment in machinery and investment is, on average, below 20%. Although these results are for Germany only, it may be assumed that in other countries the pattern does not differ too much[12]. The structure of capital endowment within a particular industry is more dependent on production and process technologies than on national specifics (Figure 1.1).

One the most noteworthy characteristics of ME is the industry's close links with both high-tech upstream industries and a broad range of client industries. It provides the explanation of why ME is coined as an enabler. It is of crucial importance for the transmission of basic inventions and innovations.

Another approach is to assess the importance of industries as clients for final ME goods. Total output of machinery, equipment and plants that is delivered to clients in Germany is procured above all by the manufacturing sector, on average over the years more than 60%, with the automotive, chemical industry and ME itself in the lead as investors in this kind of fixed assets[13]. This consideration illustrates that the service sector is an important client for ME. This is due to the size of the sector with roughly double the contribution to German GDP (Figure 1.2).

12 For other member states comparable statistics are not available.
13 For other member states comparable statistics are not available.

Figure 1.1: Investment in Mechanical Engineering products by industry - Share of total investment in machinery and equipment

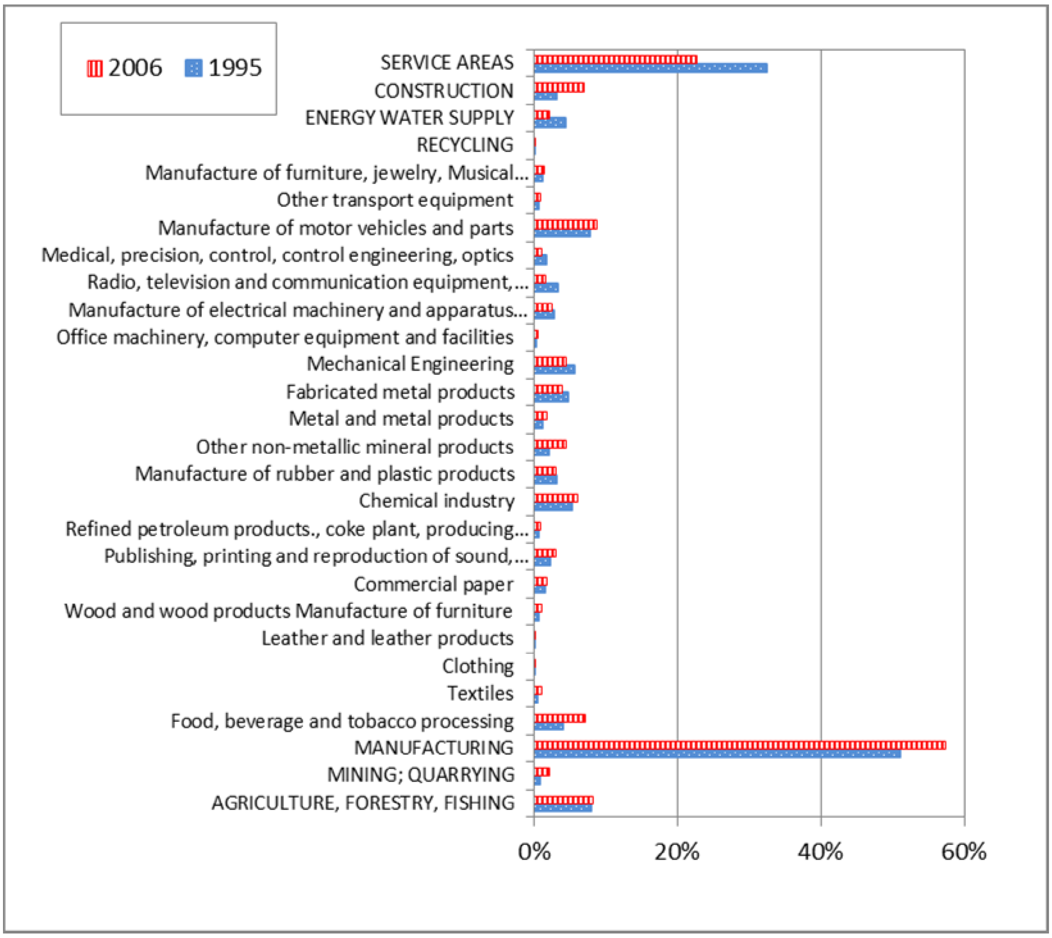


Source: Ifo Investment Matrices.

The distribution of deliveries varies between member states due to differences in economic structures. For Germany, the share of manufacturing as a client for ME is much higher than for countries with a manufacturing sector which is less important, such as the UK. However, in Italy, the new member states and, to a certain extent in Spain, the relative size of manufacturing is quite similar to that of Germany. In spite of these discrepancies between economies, one can conclude from this analysis that ME is a most important supplier of capital goods for many industries. However, the industry is strongly dependent on the manufacturing sector that is widely considered to be the driver to create business cycles, due to the fact that business cycles are characterised by a more volatile nature in this sector than in others.

The supply of ME is anything else but self-explanatory. Beyond customization one of the industry's tasks is to develop advanced solutions for client industries' production processes, be it knitting or weaving for the textile industry or services to any other industry. This shows that a close contact between ME and its clients is a prerequisite for efficient problem-solving procedures and the pace of process innovation in client industries. As a consequence a vital manufacturing sector within the EU contributes to ME's potential to stay at the leading edge of competitiveness. A typical pattern is given by the development of new processes in coordination with clients located nearby. This provides domestic clients with a competitive advantage over those based overseas. From this standpoint, client industries must be taken into account when assessing the competitiveness of an ME cluster.

Figure 1.2: Procurement of Mechanical Engineering's final products by client industries for investment purposes - Share of total procurement in Germany



Source: Ifo Investment Matrices.

Closely linked to this fact is the structure of supply in ME. Although the focus is on tangible goods, in particular machinery and equipment, the industry provides a broad range of services linked to the hardware supplied to clients. They range from pre-sales services, such as technical counselling, sales services, for example installation, the set-up of machines and systems, the training of operators and after-sales services, such as maintenance and repair.[14] In interviews with stakeholders of the industry, the share of services has been determined to lie between 15% and 30%. A small number of ME firms even offers financial services to clients. This is particularly important in the market segment for power plant engineering where funding abilities and access have become important factors in winning orders.

[14] One driving factor for the growing importance of services lies in the increasingly complex design of machinery, that asks for highly-qualified and better trained operators, maintenance and repair becomes know-how intensive. See: European Commission, Enterprise and Industry Directorate-General (2007),The EnginEurope Report, Brussels 2007, p. 26. Beyond that driver changing clients' competence and interest in outsourcing services contribute to this development.

A final point to be stressed concerns the organisation of value-chains. The large OEMs of the automotive and aircraft industries are about to restructure the organisation and try to introduce risk-sharing models. This means they are shifting responsibilities to their subcontractors. In particular, smaller companies face major challenges to manage this kind of re-organisation, with difficulties in bearing the risk. This aspect is tackled in Chapter 4.4.

1.3.3 Business cycles and long-term trends

Increasingly, the ME industry is required to cope with more severe market fluctuations than most other branches of industry. As on of the prime supplying industries of capital goods, it is highly dependent on the investment activity of the purchasing companies, which are highly sensitive to developments in the economy as a whole. This applies above all to industry's investments in equipment and machinery, into which most ME products flow either directly or indirectly. A chain of action exists here which has been incorporated into the analytical framework as the "acceleration principle".

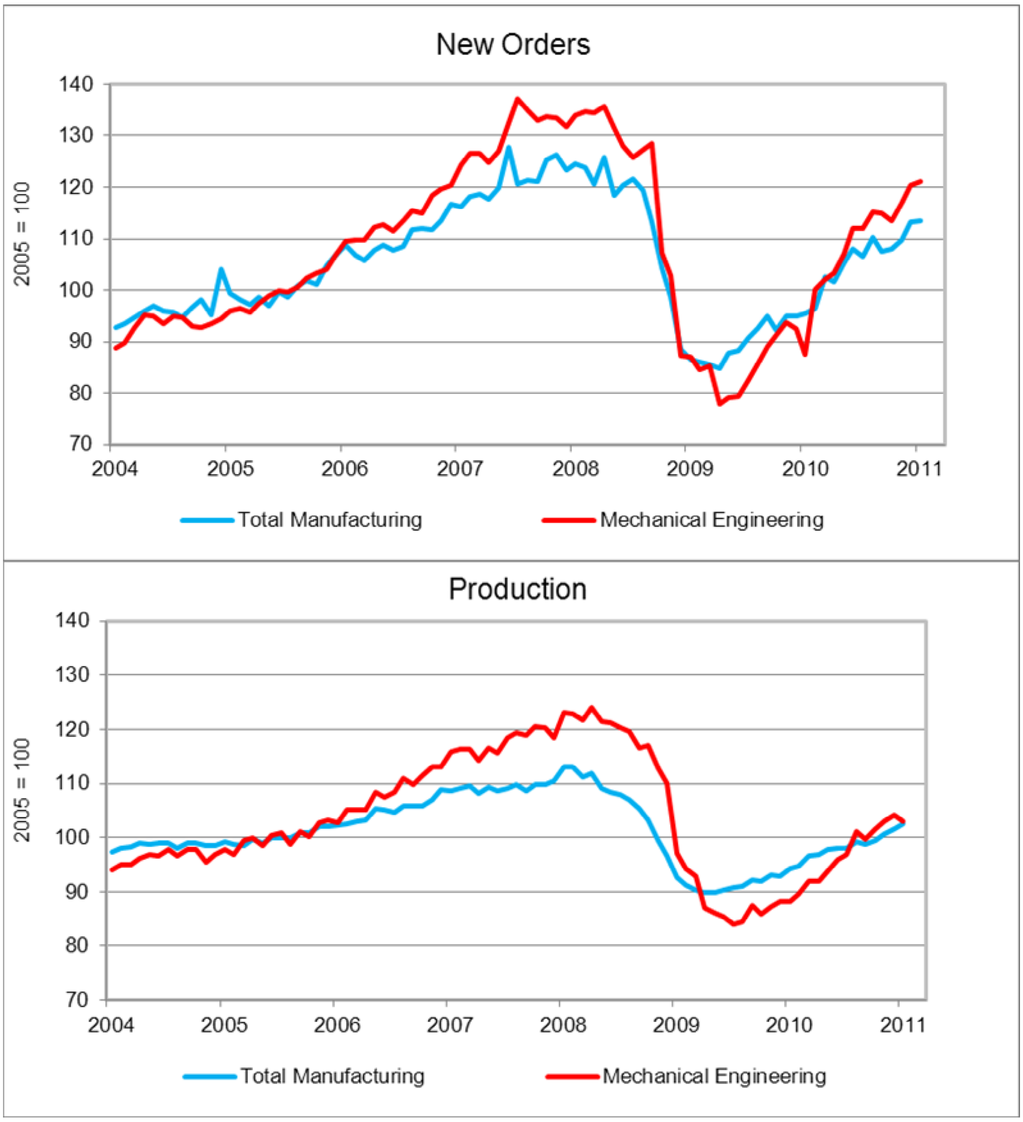
The one-sided dependency on investment activity repeatedly subjects the ME industry to pronounced cyclic fluctuations in demand. The client companies' investment decisions are a response to actual or expected changes in capacity utilisation, earnings, financing costs or general market conditions. These aspects develop in parallel for large areas of the economy, leading to cumulative processes. The resultant fluctuations in investment activity, which are more pronounced for equipment than for other business activities, have a decisive effect on the cyclical up-, and downturns of the economy as a whole. Consequently, the ME industry is almost inevitably at the core confronted by the boom and recession periods.

Figure 1.3 provides insight into the latest cyclical downswing. A slump of similar magnitude was suffered by ME during the early 1990s. The analysis of past developments reveals that major breaks in trend growth happened at intervals of between 8 to 12 years. The pattern as compared to total manufacturing is typical: a steep decline at the beginning of the downswing and a delayed but strong recovery. The breakdown is less pronounced in production because order backlogs and longer delivery times than those seen in other manufacturing industries cushion the development. In spite of the strong recovery, the level reached most recently is well below the former peak. It will take at least another year of strong growth until it is regained.

The latest downswing in ME was induced by the bursting of the real estate bubble in the US and the subsequent global crisis in the financial markets. External drivers, such as oil price shocks, have often triggered slumps in ME. The major difference to past slumps lies in the fact that the risks have not yet faded out and global disequilibria are sustainable, creating a slightly gloomy outlook on the industry, which will be further discussed in Chapter 1.

The long-term outlook for ME in the EU-27 is closely related to regional trends, above all to the degree of industrialization of the emerging economies. These countries constitute both threats and opportunities for EU manufacturers. Since the early 1990s deliveries to non-EU countries have grown much stronger than the domestic market, with the emerging economies becoming more and more important. The exports to China are of similar size than that to the US. However, exports from emerging economies are gaining shares in the global market. Some of them are about to catch up with the European leaders in technology and quality. It is of note that Korea – one of the former Asian tigers – these days competes at arm's-length with European firms in plant engineering, a market segment challenged not only by technology and engineering abilities, but also in a broad range of disciplines, reputation and funding. There are only a few firms worldwide with these abilities.

Figure 1.3: Mechanical Engineering's latest business cycle in the EU-27



Source: DG ECFIN; calculations by Ifo Institute.

The long-term prospects for ME in the EU-27 will be strongly dependent on future global growth and the ongoing industrialization of the emerging economies. The demand for physical goods, as a consequence of growing wealth and increasingly scarce natural resources, are drivers for all industries where ME has a noteworthy stake as a supplier of capital goods.

Only a decade ago, information and communication technologies (ICT) were drivers of growth. ME was regarded as a high- to medium-tech industry and considered to be lagging behind. This has changed markedly in the era of globalization. In contrast to ICT, which since its early days has been strong in the exploitation of advantages from global production networks, ME has turned out to be a less mobile industry. The relocation of manufacturing production has been less pronounced and has contributed to a better track record in workplaces in developed countries. There are comparative advantages for the EU due to its qualified workforce and a strong industrial base. If these factors can be exploited, ME will benefit from further globalization.

One of the major threats for EU ME firms in competition with emerging economies lies in human resources. Demography and shrinking interest in natural sciences and engineering among high-qualified young people and graduates is the primary barrier to overcome, as pointed out in the interviews. This has already been mentioned as a topic of special interest and is dealt with under framework conditions in Chapter 1.

1.3.4 Safeguarding the future

In ME it is hard to distinguish between expenditure on research and development and the costs incurred for the current output. The reason is that in a process with a high share of made-to-measure products, some research and a lot of development may be undertaken in connection with special orders. That is especially the case for small and medium-sized firms. Thus it is true that the available figures for research and development in ME do not reflect all the efforts taken by firms to find new technical solutions and to optimize products as well as clients' processes. However, all of these activities have to be taken into account when evaluating the pace of technological progress and the performance of the EU ME's technological position in international competition.

A rough assessment of the importance of engineering activities that are not covered by R&D expenditure, as collected by the OECD, can be derived from Figure 6.1. Among the services supplied to clients there are two groups: technical counselling and the development of software. These tasks are not classified as R&D. However, they contribute to product innovation and comprise activities in the case of counselling necessary to initiate engineering based on the final specifications of a client's procurement contract. The development of software comprises minor adjustments of programmes to clients' permanently changing needs as part of after-sales services but also activities of major importance for the development of new machines, production systems and the operation of plants. Both of these activities account for around 2.3% of total output of the capital goods manufacturing sector. Although this figure cannot be fully added to R&D efforts, it reveals that hidden engineering activities are of a remarkable magnitude.

The OECD statistics on R&D expenditure are frequently cited. They provide some sectoral information based on ISIC Rev. 3, a nomenclature that matches NACE Rev. 1. This is different from the NACE Rev. 2 that is applied throughout this study. However, the differences with regard to technology are not of a magnitude that could lead to misinterpretations. A comparison of R&D expenditure within the Triad provides an initial impression of innovation efforts in the three most highly developed economies.

The OECD statistics do not cover all of the EU-27 as only 10 have published the relevant figures. In particular, the United Kingdom is missing. However, it can be assumed that the general picture would not be much different if figures for the missing member states were available. Obviously, the EU-27 lagged behind the US and Japan in R&D expenditure towards the end of the 1990s. In the meantime major changes in the rankings have taken place.[15] EU companies have steadily increased their efforts and have caught up with Japan and the US. In contrast, Japanese ME's R&D expenditure has stagnated and is no longer far beyond the EU level. For the US, the time series are volatile and do not show any trend. Therefore, it cannot be concluded that the latest high level of R&D expenditure is sustainable or can be maintained into the future (Table 1.5). A detailed investigation of the most important competing nations' technological performance is carried out in Chapter 1 on major competitors.

Table 1.5: Research efforts measured by business expenditure on R&D in mechanical engineering (ISIC Rev.2) in € million

Year	EU[1)]	USA	Japan
1999	5,027	5,901	7,800
2006	7,098	7,843	7,704

[1)]Austria, Czech Republic, Denmark, Germany, Hungary, Italy, the Netherlands, Poland, Slovak Republic, Spain.

Source: OECD; calculations by Ifo Institute.

A second source for private sector expenditure on R&D is the "EU Industrial R&D Investment Scoreboard", which has been conducted by the Institute for Prospective Technological Studies (IPTS) that is part of the Joint Research Centre of the European Commission. The annual Scoreboard presents information on the world's top 1400 companies ranked by their investments in R&D. It contains data drawn from companies' accounts, most recently for the fiscal year 2009.[16]

R&D indicators, such as R&D intensity, vary in line with the business cycle. Therefore annual averages have been taken to highlight the performance of ME in the EU. It is of note that the "industrial engineering" sector shows a higher level in research intensity than the average of all sectors under consideration. The sector is broadly characterised as ME, however, the other industries merged under this category are likewise high-to-medium tech industries that do not feature above average research intensities (Table 1.6).

ME is a leading industry at the level of patent filings.[17]

This result is surprising at a first glance. It may be caused by the fact that the EU Industrial R&D Investment Scoreboard does not cover the bulk of smaller companies, which constitute the majority of the ME industry. Beside large groups the backbone of

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15 The latest available figures are for 2006, therefore more recent developments cannot be discussed.

16 Eurpean Commission (2010d). Monitoring industrial research: The 2010 EU Industrial R&D SCOREBOARD, Luxembourg, http://iri.jrc.ec.europa.eu/research/scoreboard_2010.htm

17 European Commission, Enterprise and Industry Directorate-General (2007). The EnginEurope Report, Brussels, p.21.

ME, medium-sized, family-owned firms are surveyed. In any case, it shows that larger EU industrial engineering firms are more active in R&D than their most important competitors from Japan and the US. Moreover, the EU industrial engineering firms are much more active, on average, than all other companies in EU sectors covered by the survey. It also exceeds the Lisbon target of minimum 3% of the Gross National Product (GNP) attained by private R&D.[18,19] In addition to equipping EU industrial engineering with a strong backing in global competition, it also underscores a comparative advantage over other domestic industries with lower R&D intensities. Moreover, the widespread assumption that ME is a high-to medium tech industry – with only on average R&D efforts - has not turned out to be true, as demonstrated by the Investment Scoreboard Survey, at least for large companies of the EU ME. This is subject to further investigations in Chapter 4.7.

Table 1.6: Research efforts measured by R&D intensity 2007 - 2009

Sector	EU	USA	Japan	Global average
	Average share of total sales in %			
All industries	2.7	4.6	3.5	2.7
Industrial engineering[1)]	3.3	2.7	2.8	2.9
[1)]Incl. commercial vehicles and ships				

Source: EU Industrial R&D Investment Scoreboard 2010/2009/2008

18 European Commission, Enterprise and Industry Directorate-General (2007). The EnginEurope Report, Brussels, p.34.

19 It is of note that the 3% objective is calculated by R&D expenditure as a percentage of GNP. The GNP is equivalent to the value added of an industry or a company. However, the research intensity as calculated by the IPTS is related to net sales. It can be assumed that the research intensity of the companies participating in the IPTS survey is roughly speaking double as high.

2 EU Mechanical Engineering

Chapter 2 contains a detailed analysis of ME in the EU-27. Time series are based on NACE Rev. 2, 28 ME. The content of this chapter is derived from official statistics, literature analysis and expert interviews.

2.1 Profile of the EU Mechanical Engineering

2.1.1 Description of the sector

Size structure and performance

ME is an industry of medium-sized companies. However, the average company's size hides a large variation, ranging from SMEs to companies that employ several thousand people. However, extremely large corporations, such as those in the chemical and automotive industries, are the exception. The key performance figures – differentiated by group sizes – disclose a typical pattern. Smaller firms pay lower wages than larger companies and labour productivity is lower. This contrasts the Gross-Operating Rate (GOR) that is higher for smaller firms (Table 2.1). The GOR denotes the share of output that is dedicated for capital services, taxes and entrepreneurs' income.[20]

A comparison of ME with manufacturing discloses structural discrepancies that are typical. Wages and productivity are higher than for the average of all of manufacturing. This can be attributed to the need for a highly qualified labour force. For example, engineers are needed for the design of complex products and manufacturing processes that, due to the predominance of single and small batch production, qualified machine operators and workers are equally required. Manufacturing depth, as measured by the share of value added of total production, is higher for ME. Despite growing globalization and the extension of international production networks a higher share of in-house production as compared with most other industries has remained a specific pattern for ME that is above all due to complex products and processes (Table 2.1).

This 2008 snapshot is based on Eurostat statistics grouped by NACE (Rev. 2). The pattern depicted in the table below has turned out as stable. The relationship between all of manufacturing and ME has not changed much over the past two decades, although noteworthy structural changes have taken place. However, these general trends have affected all manufacturing industries in a similar manner. For instance, outsourcing and the growing international division of labour has induced a reduction of manufacturing

[20] For small firms the entrepreneurs' income explains the higher GOR.

depth. In the mid-1900s, it was measured by the quotient of value added and production, 34% for manufacturing and 42% for ME.[21]

Table 2.1: Key indicators on the performance of total manufacturing and Mechanical Engineering by the size of enterprises 2008

Employees per enterprise	Per employee and annum[1)] thsds. EUR				%		%	
	Wages		Gross value added		Gross operating rate[2)]		Manufacturing depth[3)]	
	Manu[4)]	ME[5)]	Manu[4)]	ME[5)]	Manu[4)]	ME[5)]	Manu[4)]	ME[5)]
1 to 9	12.90	18.82	30.55	43.47	19.1%	19.9%	33.1%	35.0%
10 to 19	20.34	25.20	38.59	48.10	15.8%	16.6%	33.3%	34.9%
20 to 49	23.06	27.84	44.00	51.87	14.3%	15.5%	30.0%	33.5%
50 to 249	25.78	30.79	48.71	56.83	12.5%	14.8%	26.7%	32.3%
250 or more	34.15	38.48	65.28	67.00	11.1%	13.0%	23.3%	30.6%
Total	26.81	32.86	51.87	59.50	12.4%	14.2%	25.7%	31.7%

[1)] Average for 8 member states (CZ, DE, ES, FR, IT, PL, SK, UK); [2)] (Value added-wages)/production) per employee; [3)] Value added / production; [4)] Total manufacturing; [5)]Mechanical engineering.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

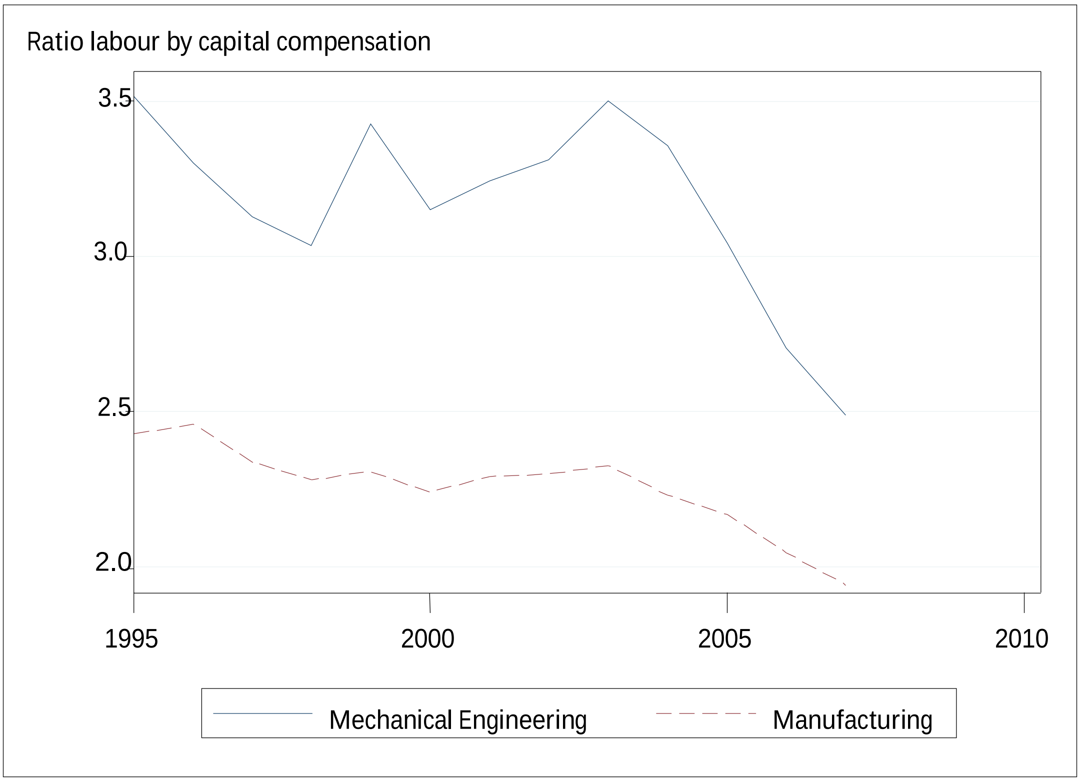
Productivity has always been a major concern in international comparisons of EU industries with their competitors in the US and Japan. ME is not an exception to the rule that labour productivity is lower than that of the competing Japanese and American industries. According to a European Working Paper[22] the EU ME only reached a labour productivity of € 59,500 in 2006, the same value that was reached in 2008, as depicted in Table 2.1. This is roughly half the productivity of the US which had reached a staggering value of € 115,200 in 2006 as highlighted in the above mentioned Working Paper. For Japanese ME this Working Paper mentions a value of € 95,700 for labour productivity, exceeding the EU's level by more than 50%. The EU's shortfall in this sector, in comparison to the success of its most important competitors from developed economies, has been acknowledged as the EU's Achilles heel in terms of competitiveness. However, EU ME companies have performed well in the global market, in particular much better than the US, outperformers in productivity.[23]

The absolute discrepancies in labour productivity within the Triad have been observed over a long period of time. There is some evidence that they have been primarily caused by stable structural differences. More important than these absolute differences are changes in productivity over time that affect the relative position of an industry in international competition.[24]

21 Kriegbaum, H. et al. (1997) "The EU Mechanical Engineering Industry – Monitoring the evolution in the competitiveness", in: ifo Studien zur Industriewirtschaft Vol. 54, Munich, p.16.
22 Commission of the European Comunities (2009). European Industry in a Changing World – Updated Sectoral Overview 2009, Commission Staff Working Document, Brussels, p.124.
23 European Commission, DG Enterprise and Industry (2007a), The EnginEurope Report, Brussels 2007, p. 22.
24 Kriegbaum, H. et al. (1997) "The EU Mechanical Engineering Industry – Monitoring the evolution in the competitiveness", in: ifo Studien zur Industriewirtschaft Vol. 54, Munich, pp.201, pp.264.

A final point must be made related to the structural idiosyncracies of the ME and their characterization. The industry is less capital intensive than most other manufacturing industries. Although factory automation has always been an important topic, the opportunities are limited even for flexible automation. Single-unit and small-batch production as well as the high share of engineering and customization narrow the economic advantage of engaging in full-blown automation. For ME, compensation of labour is around 3 to 3.5 times higher than compensation of capital. On average, for manufacturing this indicator only comes up to between 2 and 2.5.[25] (Figure 2.1)

Figure 2.1: Compensation of input factors labour and capital



Source: Eurostat; KLEMS; Ifo Institute.

Regional distribution

ME is an important industry within European manufacturing and contributes to around 9% of total output. Its regional area of gravity lies in central Europe, comprising Germany, Austria, the non-EU country Switzerland, northern Italy, the Netherlands, France, the Czech Republic, Slovakia and Poland. With regard to cross-border linkages, by trade and FDI it becomes clear that the industry is pan-European. A smaller but likewise strong cluster of ME is found in Spain, namely in the Basque region.

The contributions of the Member States differ strongly between countries. As a matter of course, the larger Member States command the more substantial shares of EU-27 output, with Germany in the lead followed by Italy in this ranking. Moreover, for both of these

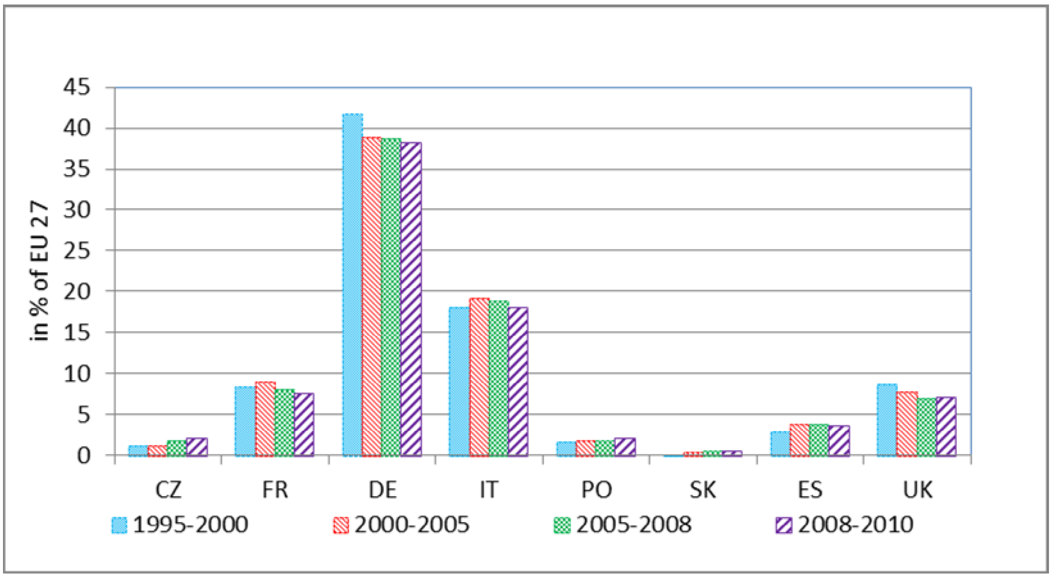
25 The decline in the most recent years is owed to the dependency of capital and labour services from business cycles: Appleton, J. and Wallis, G. (2011) "Volume of capital services: new annual and quarterly estimates for 1950 to 2009", in: Economic & Labour Market Review, pp.46.

countries ME is of above average importance and their shares respectively constitute approximately 40% and 20% of total EU production. A long-term analysis unveils that all larger Member States – with the exception of Spain – have lost some of their importance as compared with 1995. In particular, Germany experienced a long phase of consolidation in ME between 1995and 2005, resulting in a decrease in the country's share of the EU-27 output.

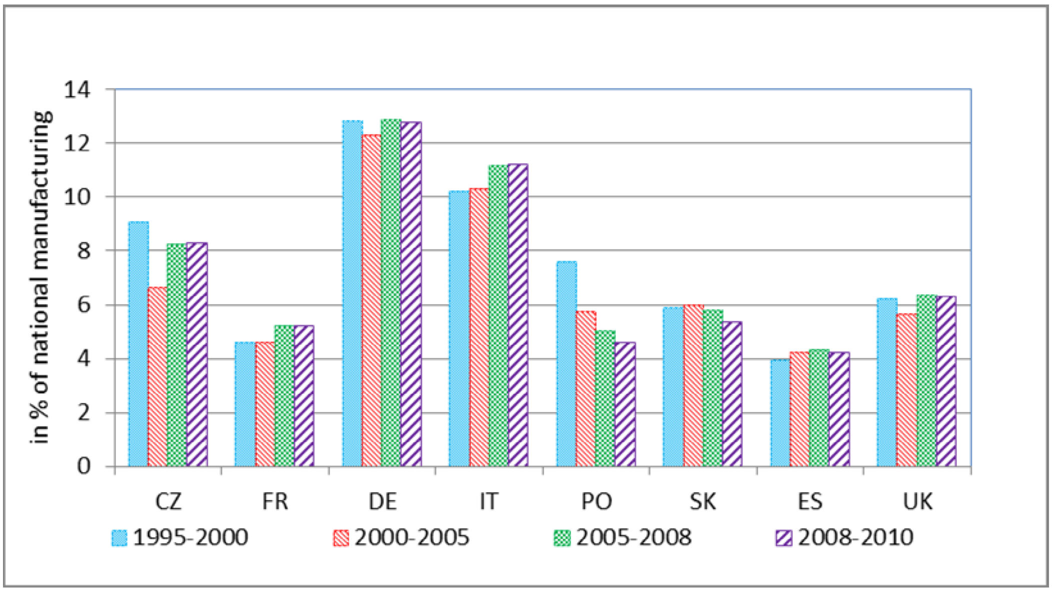
The Member States that have acceded to the EU since 2004 have grown at above average rates and gained shares in the EU-27's total output. In spite of this, a comparison of the development of ME across the whole of the EU with the progress experienced in individual new Member States[26] shows a below average growth. ME has lost shares of total manufacturing output, particularly in Poland, the Czech Republic and Slovakia, although to a lesser degree in the latter (Figure 2.2).

Noteworthy structural changes are underway in the Italian manufacturing industry. For more than a decade the competitiveness of the Italian economy in terms of pricing has worsened. In particular, consumer goods industries, such as textile and leather, have suffered from growing competition originating from low-wage countries. This has dampened the growth of manufacturing. The Italian ME with its competitive and internationally active companies was better prepared for this increasing competitive pressure and has grown somewhat stronger as a result.

Figure 2.2: Regional distribution of Mechanical Engineering production in the EU-27



[26] Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Slovakia, Slovenia, Poland, Romania.

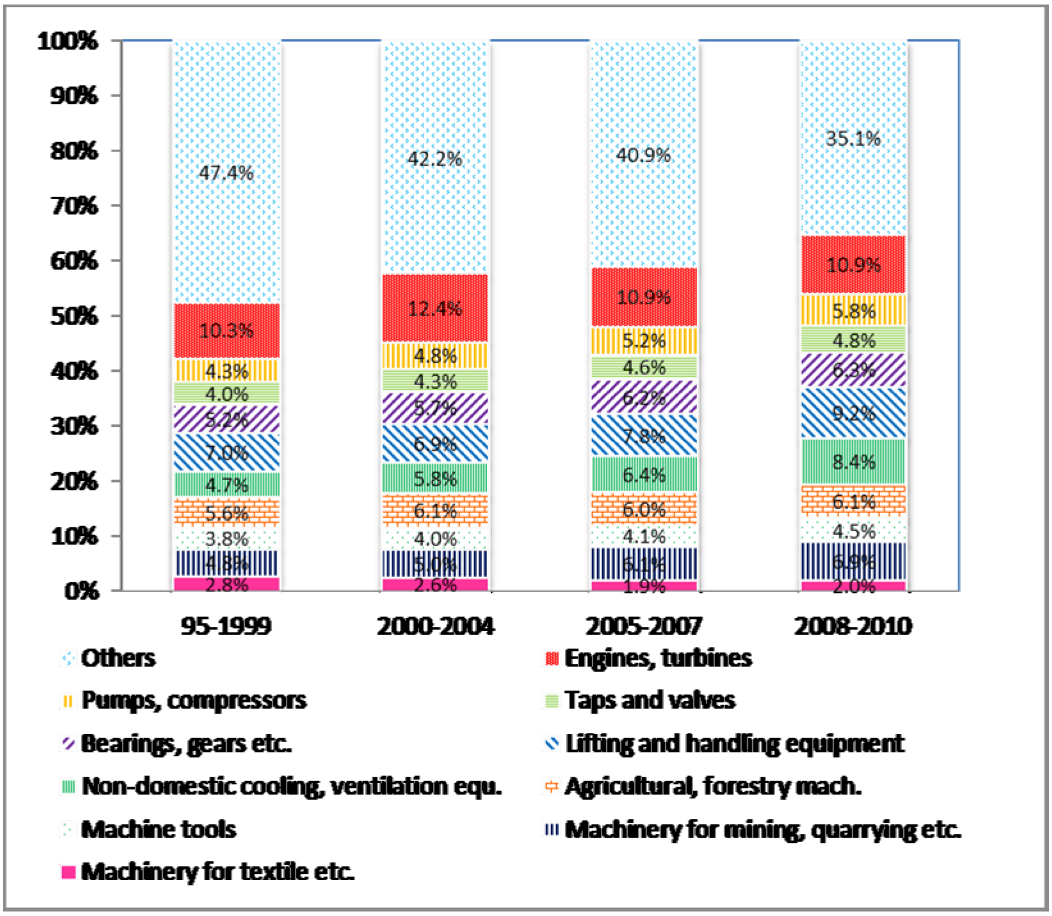


Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Subsectors

ME is a diversified industry with numerous subsectors, out of which 10 are analysed in detail as part of this study. During the late 1990s they contributed around 52% of the European industry's total production. On average they grew stronger than the EU ME and in 2008 - 2010 have commanded two thirds of total production. Only the subsector for textile machinery has performed worse than on average. Its contribution to total output shrank by nearly 1 percentage point in recent years, decreasing to only 2%. This subsector has been the most hit by globalization. The majority of textile and clothing production has been shifted to emerging economies. European machine manufacturers followed their clients and relocated production facilities. Turkey and China have become important locations for clothing and textile manufacturing and provide – simultaneously good framework conditions for the production of machinery. These countries have become important destinations for relocations. The subsector for engines and turbines has developed in tandem with the average growth of ME, although there is a strong and growing global demand for these products. However, there is some volatility in important market segments, such as power stations, and an increase in growth can be expected. All of the three component manufacturing subsectors - pumps and compressors, taps and valves, bearings, gears etc. - have enjoyed strong growth over the period under consideration. The manufacturers of pumps and compressors, taps and valves, bearings, and gears count for more than one fifth of total output. The subsector for "non-domestic cooling" leapfrogged from around 5% at the end of the 1990s up to more than 8% in recent years (Figure 2.3).

Figure 2.3: Distribution of output by major subsectors of Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Safeguarding the future

ME has been classified as a high-to-medium tech industry. This assessment is based on the fact that R&D expenditure as a share of total output is only 2% and has remained stable over the last ten years. As compared to other innovative industries, such as ICT and pharmaceuticals, the R&D expenditure of ME is comparably low. Moreover, technologies applied by ME have been assessed as mature.[27]

This view does not take into account that ME is an enabling industry. This means that this industry is crucial for the dissemination of advanced equipment, machinery and process technologies in most sectors of the economy. Most of the key technologies such as bio-, and nanotechnology, advanced materials, photonics, micro- and nano-electronics - that are perceived as key to Europe's competitiveness - are dependent on innovation within ME.[28] Two different aspects have to be taken into account:

- Innovative products are manufactured using machinery and equipment provided by ME, necessitating close communication between machine manufacturers and client

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27 Commission of the European Comunities (2009). European Industry in a Changing World – Updated Sectoral Overview 2009, Commission Staff Working Document, Brussels, pp.124.

28 European Commission (2010a). An Integrated Industrial Policy for the Globalization Era Putting Competitiveness and Sustainability at Centre Stage, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels COM (2010) 614, p.13.

industries. New processes have to be developed by companies that have developed products based on key-enabling technologies as mentioned above, together with manufacturers of machinery and suppliers of materials. From this standpoint ME is an upstream industry providing production know-how to client industries downstream.

- Here, the above mentioned key enabling technologies are developed by upstream industries. However, their widespread application in the economy needs ME enterprises that are developing specific solutions for certain industries or customized solutions for individual companies. Once more, close communication of suppliers and clients are prerequisites for best-practice solutions.

Upstream and downstream linkages contribute to ME's innovativeness. However, most of the technological progress is based on the industry's own R&D capabilities and its broad knowledge of process technologies. One of the outstanding examples in this respect has been the so-called Compact Strip Production (CSP). Developed by a European firm at the end of the 1980s, this technology enables steel works to invest in a capital and energy saving process. It has been based upon the integration of steps that have been carried out separately in former times. This process has been permanently improved and is applied around the world. Europe is the leading supplier of this leading edge technology.

One of the outstanding challenges for the European economy is sustainable production. Substantial developments are required in order to reduce Green House Gas (GHG) emissions. Although ME is not an energy intensive sector, it plays a major role in attaining political objectives.[29] Its engineering solutions are indispensable for a cleaner, healthier, safer and sustainable world. ME renders new energy sources accessible, enhances the cleanliness of existing forms of power generation and increases the efficiency of current and emerging technologies.[30]

A recent study has disclosed that among the measures designed to reduce waste generation, limit energy consumption and save both natural and material resources, the introduction of new production processes is key to fulfilling these objectives. The companies surveyed for the purposes of this research have confirmed that this need takes precedence over the introduction of new technologies or plants and is considerably more important than green-IT. Only supply chain management and R&D efforts may rival the introduction of new production processes in terms of their significance.[31]

A detailed analysis on German energy efficiency has been commissioned by the industry's association VDMA. For manufacturing industries, the sector for which ME is of crucial importance as a supplier of manufacturing technologies, a strong increase in energy efficiency has been identified through a top-down-analysis. Effects of structural

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29 Key challenges for mechanical engineering: competitiveness, climate change and energy security, See: European Commission, Enterprise and Industry Directorate-General (2007). The EnginEurope Report, Brussels, Foreword.

30 ASME. (2009). "Energy Grand Challenge Roadmap - Executive Summary", American Society of Mechanical Engineering, Washington

31 ECORYS (2011). Study on the Competitiveness of European Companies and Resource Efficiency - Draft final report, Rotterdam, p.107.http://www.google.de/url?sa=t&source=web&cd=1&ved=0CBkQFjAA&url=http%3A%2F%2Fec.europa.eu%2Fenterprise%2Fpolicies%2Fsustainable-business%2Fsustainable-industry%2Fsustainable-industry-forum%2Ffiles%2Fresource-efficiency-and-competitiveness-draft-final-report_en.doc&ei=qnrbTZLWF4jvsgb2ltjRDg&usg=AFQjCNGHMhE91ycUMAFn_qEwhH5Fn8650w

changes in the manufacturing industries have been taken into account as well as effects of business cycles that have an impact on energy efficiency by volatile capacity utilization and weather conditions to identify energy savings. The analysis disclosed an annual growth in energy efficiency of around 2% for the period between 1995 and 2005. These "technological" improvements result from investments in new machinery and equipment, so-called supplier effects, and from optimization of production processes, so-called user effects. The overall technological improvements in manufacturing have led to an energy saving of around 500 PJ (Peta Joule) in 2005 as compared to 1995.[32]

Another study, conducted via a bottom-up approach, was performed in order to gain a clearer understanding of the role of ME in energy savings. 42% of energy savings can be attributed to investment in new machinery and equipment. ME's share of manufacturing industries' total investment expenditure lies between 50% and 60% (see Figure 1.2). 58% of energy savings are attributed to users' activities to optimize production processes.[33] Even the users' activities on energy savings are strongly dependent on the opportunities provided by machinery and equipment.

It becomes obvious that ME is crucial for climate change policies. This is due to its outstanding importance as a supplier of machinery and equipment for most sectors of the economy. Beyond manufacturing, utilities are of importance for the reduction of CO_2 emissions. In power generation alone energy savings had reached a level of 120 PJ in 2005 as compared to 1995[34] (see Table 2.2).

32 Prognos AG (2009) „Energieeffizienz in der Industrie - Eine makroskopische Analyse der Effizienzentwicklung unter besonderer Berücksichtigung der Rolle des Maschinen- und Anlagenbaus", p.42.http://www.prognos.com/fileadmin/pdf/publikationsdatenbank/Prognos_Energieeffizienz_in_der_Industrie.pdf.

33 Roland Berger Strategy Consultants (2009). Der Beitrag des Maschinen- und Anlagenbaus zur Energieeffizienz – Ergebnisse einer Studie vom Oktober 2009, http://www.rolandberger.com/expertise/publications/2009-12-03-rbsc-pub-Energieeffizienz_im_Maschinen_und_Anlagenbau_de.html

34 VDMA (2009). The contribution of the mechanical engineering industry to energy efficiency Summary of two studies by Roland Berger Strategy Consultants and Prognos AG, Frankfurt am Main, p.5, http://www.vdma.org/wps/portal/Home/de/Datenbanken/Publikationen?initsearch=Summary%20VDMA%20energy%20efficiency%20studies

Table 2.2: Energy savings – ex-post and expected – in Germany induced by ME

			Final energy saving [PJ]		Energy costs [billions EUR]		Equiv. Electr. Demand of priv. h/holds [millions]		CO2 emssions reductions [millions t]	
			Today *	In 10 years	Today *	In 10 years	Today *	In 10 years	Today *	In 10 years
Prognos	Manf. Industry	Mach. constr.**	275	366	-	-	21	29	30	48
		Overall***	500	665	-	-	38	53	53.5	88
Roland Berger	Manf. Industry	Supplier	141	171	1.9	2.3	10.8	13.1	15	18
		User	116	154	1.5	2.1	8.9	11.8	12	16
		Total	257	325	3.4	4.4	19.7	24.9	27	34
	Traffic	Supplier	56	243	0.4	1.9	4.3	18.6	5	20
		User	152	191	1.2	1.5	11.6	14.6	13	16
		Total	208	434	1.6	3.4	15.9	33.2	18	36
	Logistics/trade	Supplier	15	42	0.2	0.6	1.1	3.2	1.8	5
		User	23	28	0.3	0.4	1.8	2.2	2.5	3
		Total	38	70	0.5	1	2.9	5.4	4.3	8
	Building constr.	Supplier	3	4	0.1	0.1	0.2	0.3	0.4	0.5
		User	2	3	0	0	0.2	0.2	0.2	0.3
		Total	5	7	0.1	0.1	0.4	0.5	0.6	0.8
	Industry	Supplier	215	460	2.6	4.9	16.4	35.2	22.2	43.5
		User	293	376	3.0	4	22.5	28.8	27.7	35.3
		Total	508	836	5.6	8.9	38.9	64	49.9	78.8
	Power generation		121	333	1.1	3.6	9.3	26	21	119
	Total		629	1169	6.7	12.5	48	90	71	198

* Compared with 10 years ago

** Suppliers and users

*** Technology-based savings overall

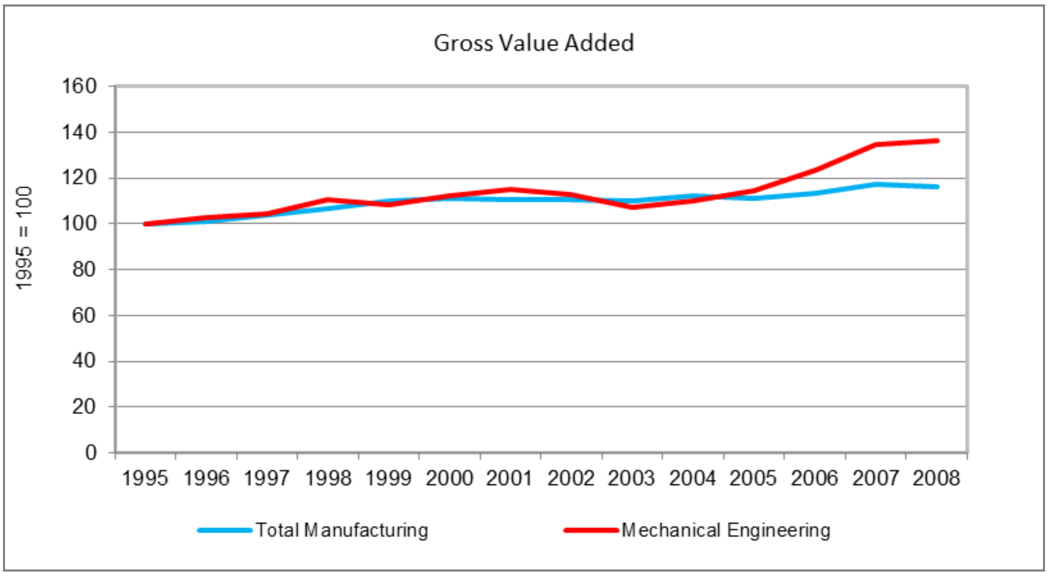
Source: VDMA (2009).

2.1.2 Mechanical Engineering compared to total manufacturing

Some key indicators for ME and total manufacturing have already been compared above. This section adopts a dynamic approach in performing this analysis and aims to compare how gross value added, labour productivity, employment, wages, and unit labour costs of ME and total manufacturing have evolved over time.

Gross value added (GVA) is considered as a first performance measure. Figure 2.4 plots the relative development of real GVA over a period from 1995 to 2008. There has been a close co-development until 2004, with ME achieving higher growth rates thereafter. The development of ME is more volatile than the development of total manufacturing. This effect primarily stems from the inherently higher cyclicality of ME.

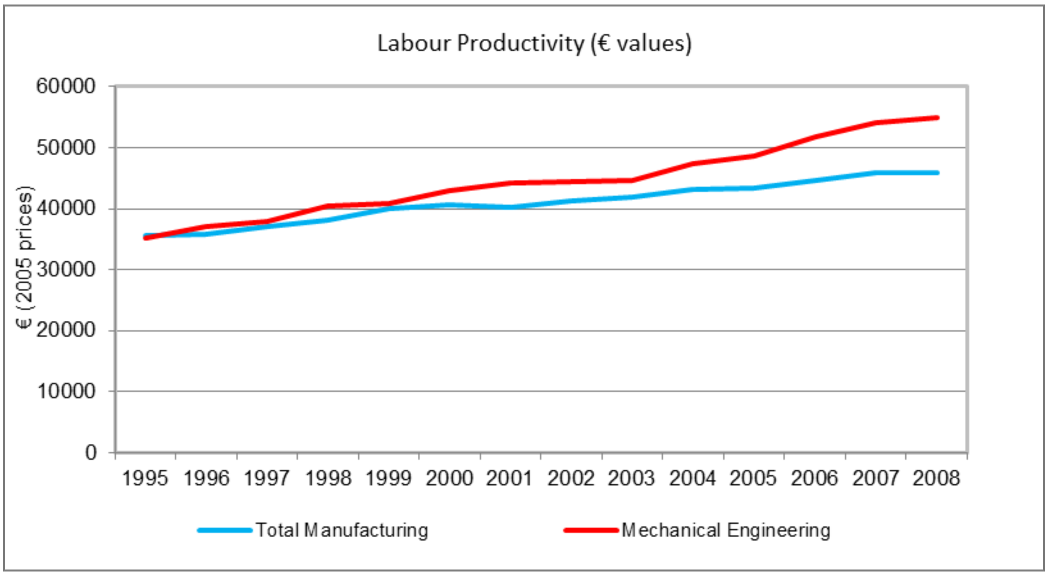
Figure 2.4: Gross value added of total manufacturing and Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Labour productivity can be used to improve understanding of the relative development of total manufacturing versus ME. Figure 2.5 plots the development of labour productivity, which is measured as real GVA divided by the number of employees. Initially, both ME and total manufacturing had very similar levels of labour productivity. Labour productivity increased almost in linear terms over the observation period from 1995 to 2008, but ME has been able to achieve higher growth rates.

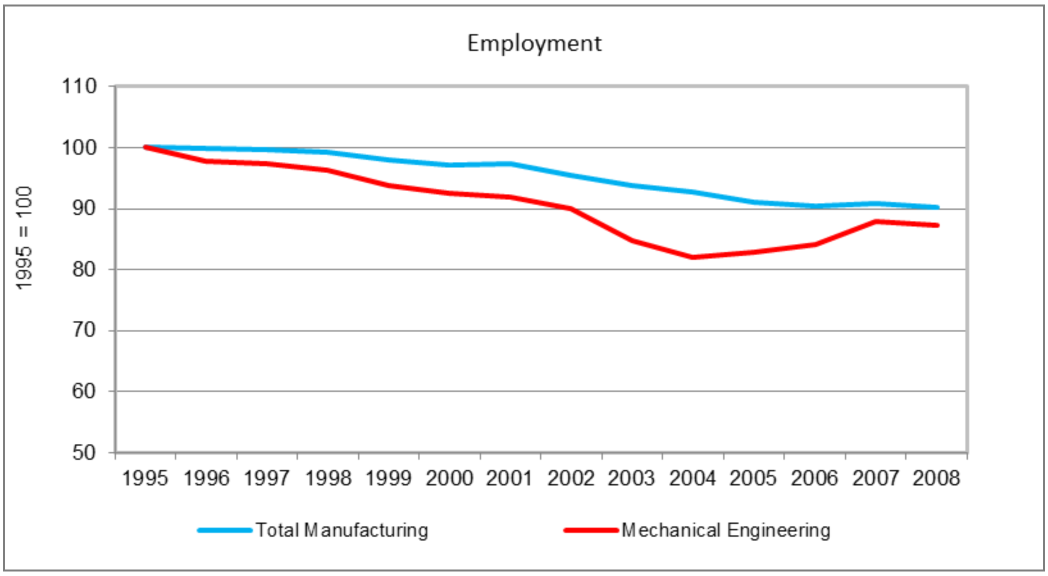
Figure 2.5: Labour productivity of total manufacturing and Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The development of labour productivity can be misleading because two effects jointly shape this measure. First, labour productivity increases if firms are able to realize real productivity gains. Second, average labour productivity also increases if unproductive firms leave the market. One has to consider the development of employment to understand how far productivity gains are driven by real productivity upgrading or only by selection effects. Relative development of employment in total manufacturing and in ME is depicted in Figure 2.6. There has been a general downward trend in employment, both in total manufacturing and in ME. However, while total manufacturing experienced a nearly constant decline in employment over the whole observation period, ME initially experienced stronger rates of decline followed by a recovery of employment since 2004. This indicates that ME's increased productivity in recent years has not been driven by selection effects but by real productivity upgrading. To a certain extent this has been caused by cyclical effects, such as the strong growth in output between 2005 and 2008.

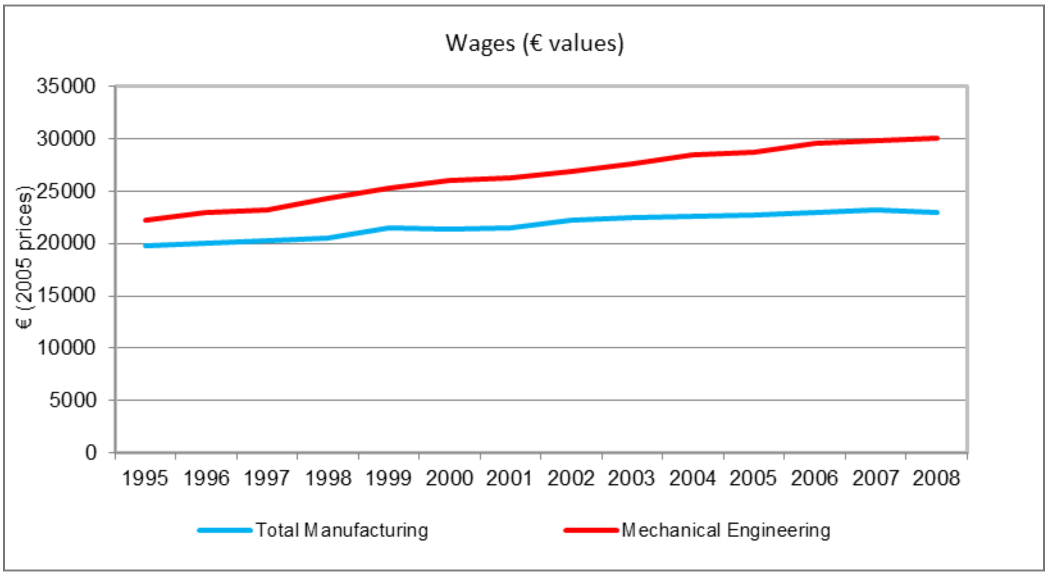
Figure 2.6: Employment of total manufacturing and Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Increases in labour productivity are only able to improve competitiveness if these productivity gains are not outweighed by higher increases in wages. Figure 2.7 depicts relative and absolute development of wages per employee in constant prices from 1995 to 2008. Both total manufacturing and ME experienced nearly constant growth rates of wages. Although ME started with structurally higher wages in 1995, the wage-gap between ME and total manufacturing became wider, both in absolute and in relative terms.

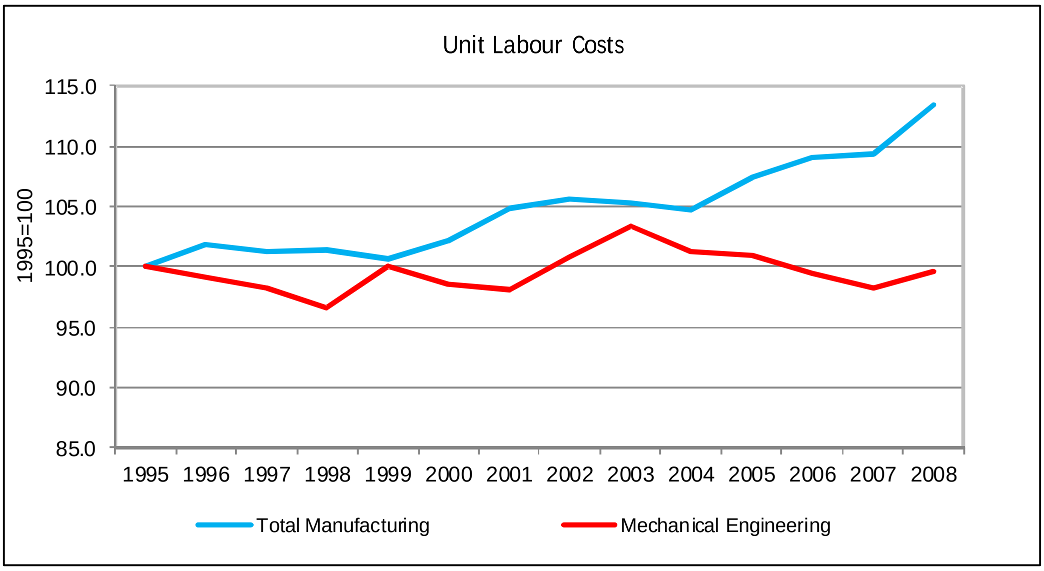
Figure 2.7: Wages of total manufacturing and Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Finally, unit labour costs are used to assess whether wage increases have overcompensated increases in productivity. Figure 2.8 plots unit labour costs, which are measured as the ratio of nominal wages to real GVA. While unit labour costs of total manufacturing have increased significantly (by 13%) over the observation period, unit labour costs in ME stayed fairly stable, fluctuating only within a window of around +/-3% compared to 1995 values. This development indicates a comparative improvement of ME's price competitiveness.

Figure 2.8: Unit labour costs of total manufacturing and Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

2.2 Mechanical engineering in selected Member States

2.2.1 France

France is the second largest European economy. However, it only accounts for approximately 8% of the overall EU-27 ME production. After Germany and Italy, with 39% and 19% respectively, France is third in this ranking. As compared with the EU average, French ME is less important: the ME's share of the EU-27 manufacturing output is around 9% and the ME's share of France's manufacturing constitutes only 5%. The regional areas of significance for French ME are the Île de France and the Rhône-Alpes. Further clusters of ME are in Alsace, Lorraine and in the regions surrounding Nantes and Toulouse. Over the long term, the growth of the French ME was, on average, in line with that of the EU as a whole. Although France is one of the mature industrialized Member States, employee wages in ME are nevertheless low, normally constituting approximately €27,000 per capita per year. This is not only below the average wage paid for employees of the EU-27 ME, but is also lower than the average of all of the French manufacturing industries. Such a relationship is not typical for ME and has not been detected for any other member state under investigation. Likewise productivity of the French ME is lower than that on average of all manufacturing industries.35 The economic performance as measured by the unit-labour costs and the GOR does not deviate significantly from the evolution of the EU average. Intra-EU competitiveness has not worsened (Table 2.3).

[35] There is no strict causal relation between productivity and wages. However, in most manufacturing industries more than half of value added per capita is paid for labour compensation.

Table 2.3: Key-figures for French Mechanical Engineering

Region	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
France	Production, in current prices	€ bn.	47	6.5	-0.3	9.6	-13.4
EU-27			598	4.0	2.3	10.4	-8.4
France	Production, in 2005 prices	€ bn	45	5.2	-1.5	7.7	-13.5
EU-27			561	3.4	1.3	8.0	-9.3
France	Gross value added, in constant prices	€ bn	14	4.1	-1.2	7.9	-13.5
EU-27			176	2.4	0.3	6.0	-9.3
France	Employees	1,000	276	2.4	-3.0	3.3	-4.8
EU-27			3201	-1.6	-2.2	1.8	-4.8
France	Gross operating rate[1)]	%	15.2	-0.2	0.2	3.7	-17.0
EU-27			14.2	0.2	-0.2	1.5	-7.6
France	Productivity[2)]	€ thsd	50	1.7	1.8	4.4	-9.2
EU-27			55	4.0	2.6	4.1	-4.7
France	Wages per employee	€ thsd	27	2.2	3.1	3.0	3.7
EU-27			32	3.7	3.1	3.7	1.9
France	Unit labour costs[3)]	€ / €	0.538	0.5	1.3	-1.3	14.1
EU-27			0.582	-0.3	0.5	-0.5	6.9

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per 1 € value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The investigation in the structure of output has disclosed some particularities for the French ME. France has always been focusing more than most of the other Member States on the ten subsectors. On average, they contribute around 65% to total production for all of the period under consideration. For the EU-27, the situation was quite different. During the early phase of investigation these subsectors only contributed 52% to the overall ME production. However, this has changed and in the recent past these subsectors now contribute around 65% to EU-27 ME production (see: Figure 2.3). This trend has been driven above all by Germany and the new Member States[36].

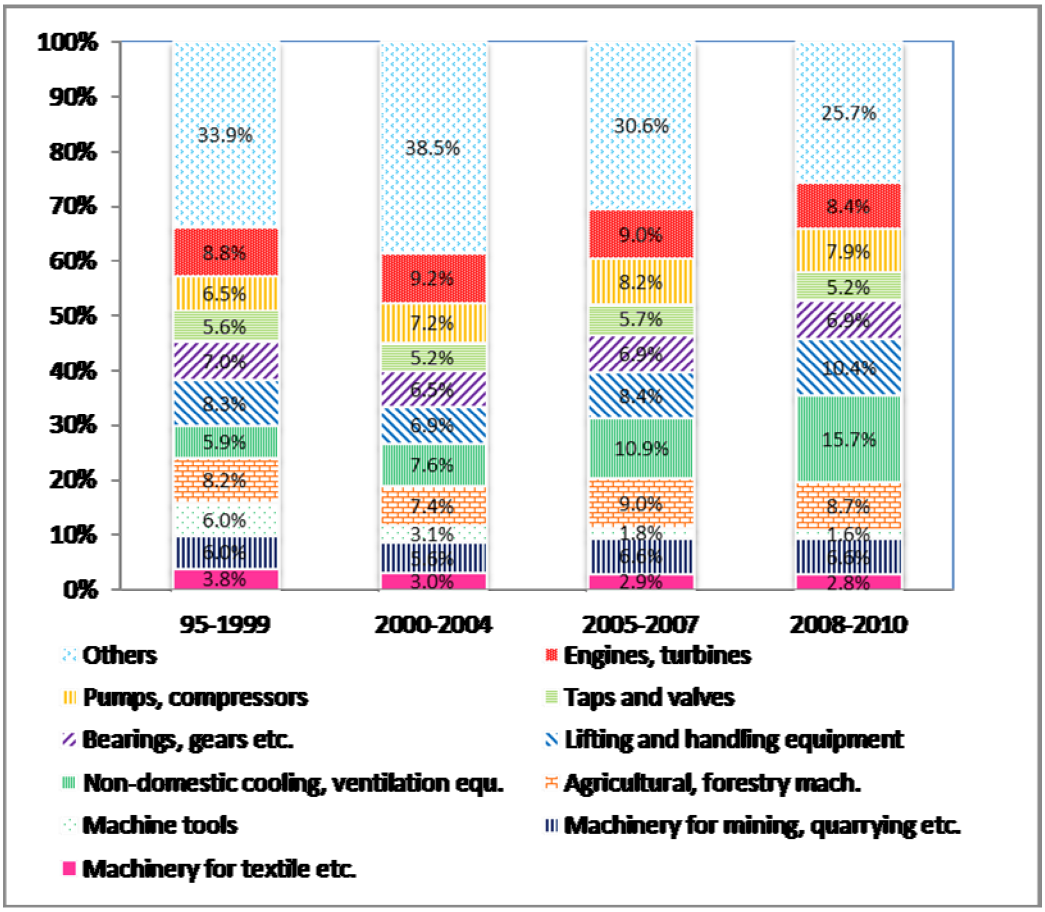
For some of the subsectors under consideration noteworthy changes have taken place over the past three quinquennia. The production of agricultural machinery grew well above average, with its share increasing from 6% during the late 1990s up to 9% during the recent past. To a greater extent, the production of non-domestic cooling and refrigeration equipment also increased. Its contribution to total ME production increased from around 6% to 11%. Both of these positive developments can be attributed – at least to a certain extent – to the demand side. Agriculture is of outstanding importance for France as compared with other mature member states. In particular, it has been reported

36 Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania.

that in the southern region of France a strong and growing interest in air conditioning (AC) is driving demand.

Traditionally the 'machine tools' subsector was of importance by size and technology. Together with the automotive industry it had created a strong industrial cluster. This has changed over the past decade. Its share of total French ME fell from 6.0% - a percentage that was well above the EU average - down to below 2% in recent years, only half of the EU-27 average for the subsector (Figure 2.9).

Figure 2.9: Structure of the French Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

It has been reported by French experts that co-operation between small and large firms in France is much less pronounced than, for instance, in Germany. This has an impact on smaller French companies' propensity to follow larger clients into foreign markets. Moreover, within the value chain of large French companies, there is strong competition between domestic and non-domestic suppliers. As a consequence, in the era of globalisation in which larger firms expand their regional range of procurement, smaller enterprises face a tough challenge from low cost countries and identify few strategic options that are realistic.

Family owned companies face some difficulties in the event of business succession. The taxation of successors is high. There is no scheme available as generous as in Germany. German legislation supports private ownership through a tax credit if a company will not be sold or dissolved within a certain period of time. The tax burden of the successor is thus moderate.

France traditionally has close ties with the Arabian Peninsula and the Mediterranean countries in North Africa. More than 10% of French exports are dedicated to these countries. Their importance for French ME exports is much higher than deliveries into the large markets of NAFTA or China. Asian markets, as well as the US, need foreign direct investment. Exports can only satisfy sporadic demand. Only a few companies have carried out the necessary strategic investment.

The regional distribution of the French ME differs strongly from Germany. The new Members are not of outstanding importance. However, the southern countries of Romania and Bulgaria have been linked into the French value chain. Turkish companies have been integrated into the value chain of French manufacturers, establishing themselves as important suppliers of intermediary metal products. Relocation of business to Turkish subcontractors and own subsidiaries are driving this development.

Historically close political and economic ties with North African countries have been reflected in international trade. Exports to the Mediterranean region play a bigger role than for other member states. This is also true for the French ME. However, this is not reflected in the low share of imports of ME products. Experts explained the fact by an insufficient level of industrialization.[37]

French ME's procurement from Asia comprises above all of electronics, controls, sensors and hydraulics. Most of these intermediary products stem from Japan and China. Many of these deliveries are procured by Asian manufacturers with production locations in France. They import parts and components from their global production networks.

Public support for ME, intended to strengthen technological progress, is provided above all through tax credits for R&D personnel. A substantial share of these funds is spent on standardization activities and not on innovation.

France does not run the semi-public research bodies that are available in some European Member States. The industry's common research body, the Centre technique des industries mécanique (CETIM), is funded primarily by the member companies. Beyond these basic financial means, additional income is generated by conducting third-party research for clients.

[37] This explanation seems to contrast to the aerospace industry that runs production locations in this region (see: Vieweg, H.-G. et al. (2009b) "FWC Sector Competitiveness Studies – Competitiveness of the EU Aerospace Industry", Munich, pp.126.http://www.sectorcompetitiveness.com/index.php/sector-competitiveness-studies). However, the exploitation of the region's potential requires heavy FDI and the industrial infrastructure is limited and to a lesser extent suited for ME.

2.2.2 Germany

Germany is the biggest European economy and commands a large share of EU-27 ME. Although the country has accounted for approximately 39% of EU-27 production in recent years, Germany no longer contributes 42% of overall production, as was the case in the latter half of the 1990s. ME is concentrated in North-Rhine-Westphalia, where there is a traditional on heavy industries and large machines, and in Baden-Württemberg and Bavaria, where there are numerous smaller enterprises as well as large specialized manufacturers of engines, turbines, printing machines and the like. Since German unification, Saxony another powerhouse of ME, has joined the sector.

ME is one of the industries that occupies a role of pivotal importance in the German economy, contributing between 12% to 13% of all the manufacturing output. These figures are well above the 9% average for the EU-27 ME. During the latter half of the 1990s, German ME experienced a phase of slow growth, after having benefitted from several years of accelerated globalization. The consolidation of the German economy is also reflected in the ME industry. Although the employment record was better than the EU average, the economic performance –measured by unit-labour costs and GOR – improved significantly. Over fifteen years, wage moderation provided competitive advantages. The average differential in trend growth for wages between Germany and all of the EU-27 reached around 2.5% p.a. This provides an advantage of circa 40% to the German ME as compared with 1995, during which it suffered from extremely high wages. In spite of this positive development, wages of € 43,000 per capita have remained one third higher than the EU average. It is of note that wage moderation, and not progress in labour productivity, contributed to this improved economic performance (Table 2.4).

Table 2.4: Key-figures for the German Mechanical Engineering

Region	Indicator	2008		Annual average growth rate in % 1995 - 00	2000 - 05	2005-08	2008 - 10
Germany	Production, in current prices	€ bn.	227	1.2	2.6	9.5	-8.2
EU-27			598	4.0	2.3	10.4	-8.4
Germany	Production, in 2005 prices	€ bn	214	0.1	1.4	7.4	-9.4
EU-27			561	3.4	1.3	8.0	-9.3
Germany	Gross value added, in constant prices	€ bn	73	-0.9	0.2	5.1	-9.4
EU-27			176	2.4	0.3	6.0	-9.3
Germany	Employees	1,000	1092	-0.6	-1.3	2.3	-2.0
EU-27			3201	-1.6	-2.2	1.8	-4.8
Germany	Gross operating rate[1)]	%	13.2	0.7	0.7	3.0	-17.7
EU-27			14.2	0.2	-0.2	1.5	-7.6
Germany	Productivity[2)]	€ thsd	67	-0.3	1.5	2.8	-7.5
EU-27			55	4.0	2.6	4.1	-4.7
Germany	Wages per employee	€ thsd	43	0.0	1.9	1.9	2.9
EU-27			32	3.7	3.1	3.7	1.9
Germany	Unit labour costs[3)]	€ / €	0.648	0.4	0.3	-0.9	11.3
EU-27			0.582	-0.3	0.5	-0.5	6.9

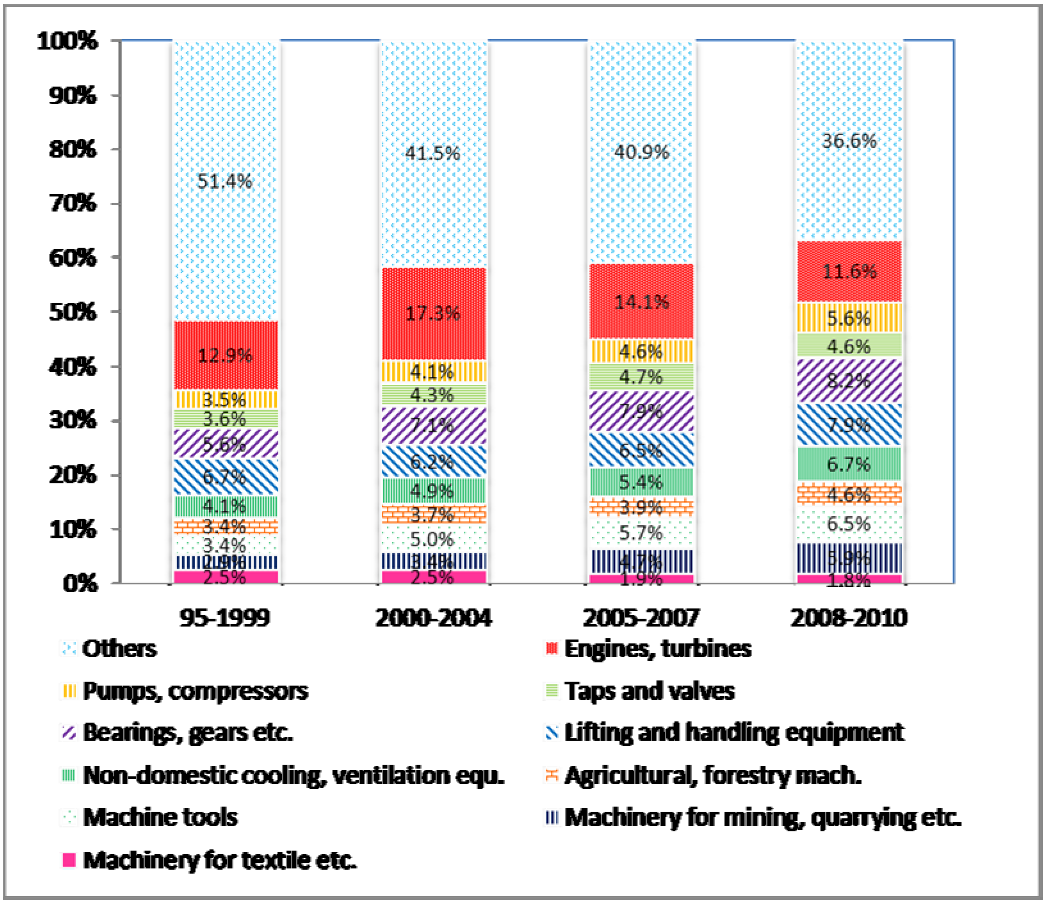
1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The German ME is well-known for its diversified supply. Over the past one and half decades a certain specialization has taken place. This is depicted by the share in terms of total production of the ten subsectors selected to be investigated in more detail. The overall share increased from 48% in 1995 to 63% in recent years. Above all, the ‘machine tools’ subsector gained importance. Its contribution to the German ME output began at 3.4% in 2005 and has reached 6% in recent years. In a similar vein, the ‘bearings, drives and gears’ substance grew at an above average rate and the subsector’s share increased from 5.6% to around 8%. Both of these subsectors show downstream linkages to all capital goods industries. Of particular importance are the relationships with the automotive industry, which constitute part of a strong European industrial cluster and have become more focused. The shares of both of these subsectors in German ME production are well above the EU average with around 4% for ‘machine tools’ and 6.3% for ‘bearings, drives and gears’.

Another sector of the German ME which is of above average importance is ‘engines and turbines’. Its share of total ME production is extremely volatile and shows no clear trend over the period under investigation. This is explained by contracts for large turbines applied in power stations, a market segment where Germany, with large manufacturers like Siemens, commands a noteworthy stake in the global market (Figure 2.10).

Figure 2.10: Structure of German Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Germany offers companies excellent conditions for research and development and the production of key technical components. This infrastructure has been mentioned by experts of ME as 'best practice'. However, German companies have been faced with the challenge of structural change and high wages. Traditionally, there was an emphasis on production within Germany and in-house manufacturing. It is only since the early 1990s that these particularities have been reduced. Many firms have become global players with production sites in the most important overseas markets. This may be caused and be rendered possible by the fact that German companies – although frequently medium-sized and family owned – are large by European standards.

Family-owned firms in Germany enjoy favourable schemes for successors that inherit a company. They are moderately taxed if the firm is maintained.

The lengthy phase of consolidation in the German economy was accompanied by increasing M&A activities. This has led to the dissolution of some of the large groups. Mannesmann was taken over by the British mobile telecom company 'Orange'. Affiliated firms, such as Mannesmann Rexroth, a manufacturer of hydraulics, and Demag Cranes were sold. It took some time until sustainable solutions were created. For an interim period both of these companies were held by Siemens. Later on Rexroth was taken over by Bosch whereas Demag Cranes went public.[38]

Since the early 1990s financial investors have invested in German ME, contributing to the process of consolidation. Smaller firms have been affiliated to groups with complementary product programmes in order to provide comprehensive solutions for client industries, such as MAG Powertrain and the Schleifring Group.

Another feature of the German manufacturing industries, and in particular ME, is their close ties along the value chain. These are not only based upon long-standing and trustful co-operation but also shared technology and the quality of deliveries. This has contributed to stable relationships, even in the era of globalization. Large clients demonstrate strong interest in supporting their domestic suppliers.

Since the fall of the Iron Curtain, the Central and Eastern European Economies (CEE) have become part of the value chains of German companies. German companies invested heavily in the region and have intensified the procurement of parts and components from independent manufacturers. Beyond these Central European value chains, overseas procurement and creation of production sites have become more important. Two aspects of these global linkages must be considered. Firstly, the procurement of parts and components driven above all by wage differentials dedicated to the production of final products in Germany and elsewhere. Secondly, the production and assembly of final products in important sales markets dedicated to improve market access.

2.2.3 Italy

As with Germany, Italy is a country with an important ME industry, concentrated in northern Italy and in the provinces of Lombardia and Emilia-Romagna. Its share of total EU-27 ME production had grown from 18% at the end of the 1990s to 19% in recent years. The success of the Italian ME is also reflected as compared to all of the Italian manufacturing. Its share had grown from 10% up to between 11% and 12% in recent years. The employment record of the Italian ME is better than the EU average. However, the economic performance has worsened throughout the period under investigation. Growth of productivity was below average, while wages were above. As a consequence unit-labour costs and GOR worsened noteworthy. This has not yet had an impact on the Italian ME's employment (Table 2.5).

[38] The Terex Industrial Holding AG, a company of Terex Corporation, US has recently submitted a hostile take-over bid.

Table 2.5: Key-figures for Italian Mechanical Engineering

Region	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Italy	Production, in current prices	€ bn	114	6.8	2.2	11.3	-12.0
EU-27			598	4.0	2.3	10.4	-8.4
Italy	Production, in 2005 prices	€ bn	106	5.5	1.1	8.6	-11.7
EU-27			561	3.4	1.3	8.0	-9.3
Italy	Gross value added, in constant prices	€ bn	27	4.7	0.0	6.3	-11.7
EU-27			176	2.4	0.3	6.0	-9.3
Italy	Employees	1,000	484	1.9	-0.8	4.0	-4.8
EU-27			3201	-1.6	-2.2	1.8	-4.8
Italy	Gross operating rate[1)]	%	13.8	-1.5	-2.7	-1.1	-10.3
EU-27			14.2	0.2	-0.2	1.5	-7.6
Italy	Productivity[2)]	€ thsd	57	2.8	0.8	2.3	-10.7
EU-27			55	4.0	2.6	4.1	-4.7
Italy	Wages per employee	€ thsd	29	5.0	3.9	3.7	-1.6
EU-27			32	3.7	3.1	3.7	1.9
Italy	Unit labour costs[3)]	€ / €	0.505	2.2	3.1	1.4	10.2
EU-27			0.582	-0.3	0.5	-0.5	6.9

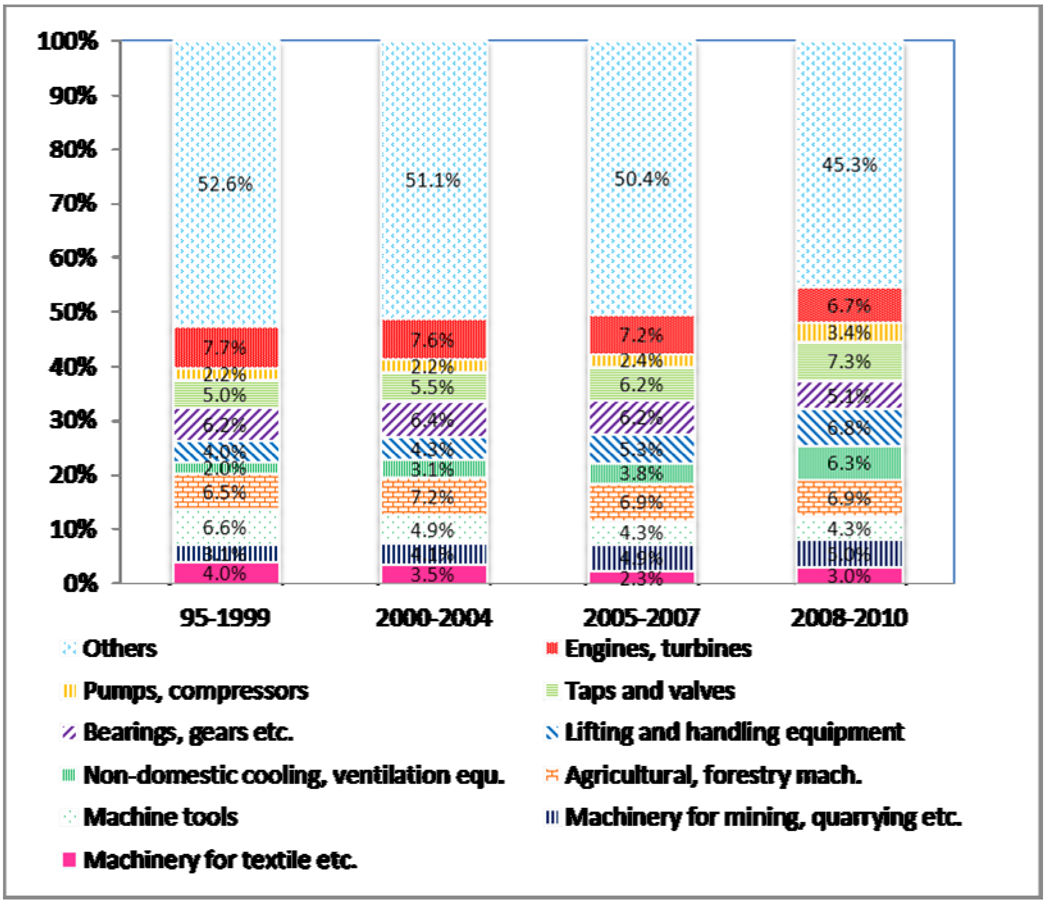
1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The Italian ME is a diversified industry. Only around half of the output comprises products of the ten subsectors under detailed investigation. In contrast to Germany, a specialization has not taken place over the past one and half decades.

Traditionally the ‘machine tools’ subsector is of importance for Italy. However, it lost some of its former weight on the Italian ME production. It declined from 6.6% in 1995 down to 4.3%, a share that is only on the EU-27 average. This development may be caused in part by the weakness of the Italian automotive industry, above all the restructuring of Fiat.

Figure 2.11: Structure of the Italian Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The Italian textile machinery is part of a strong European cluster with important manufacturers in Germany and Switzerland. Since the fall of the Iron Curtain the Czech Republic has been integrated. Downstream linkages to the clothing and fashion industry have been important drivers. The Italian textile machinery industry has lost some of its former importance. Globalization and the relocation of clients' manufacturing facilities have aggravated the situation, causing certain losses. The share of the 'textile machinery' subsector of the Italian ME's output shrank from 4% to less than 3% in recent years. One of the largest groups is ITEMA which has acquired enterprises in Italy, Germany and Switzerland to become a full-hand supplier in the core production process for the textile industry.

As in many other Member States, the 'taps and valves' subsector grew above average. The 'non-domestic cooling and ventilation' subsector enjoyed the highest growth rates within the Italian ME. Similarly to France, this expansion can be attributed to the growing demand for AC in the southern member states. The subsector has reached a share of more than 6% of total Italian ME production. Although there are internationally strong Italian players in the subsectors 'lifting and handling equipment' and 'construction machinery' they were not able to detach themselves from the overall poor framework conditions, but they performed better then most other subsectors.

2.2.4 Spain

Spain's accession to the EU in 1986 stimulated the modernisation of the Spanish economy, an inflow of foreign direct investment particularly in manufacturing, and provided strong growth for more than a decade. It is regionally concentrated in Catalonia, Asturias and the Basque country, with Valencia, Madrid and Aragon also playing a role. A particularity of Spain is the existence of large groups, such as Mondragón Corporación Cooperatica (MCC), in the legal form of a cooperative that comprises several business units as there are Fagor Automation, Fagor Arrasate and Danobat. They are among the largest companies with stakes in many subsectors of ME. Danobat is an important and large machine tool manufacturer. The Spanish ME benefitted from this development and innovative, state-of-the-art technology has subsequently been introduced. Such effort recognizes the importance of this European industry and its global competitiveness.

The ENSA Group is one of the few, not yet privatised ME companies.[39] It has been created as a manufacturer of key components for nuclear power stations, vessels, steam generators etc. ENSA is part of the global value chain for the manufacture of power plants with important stakes in the NAFTA and China. The long-term prospects are bright above all in emerging markets, but also the Czech Republic, the Netherlands and the United Kingdom provide opportunities for nuclear power plants. The most important competitors are from Korea (Doosan), Italy (Mangiarotti), France (AREVA) and Russia (ROSATOM).

Together with the US power plant manufacturer Westinghouse ENSA has set-up a joint venture for maintenance services of power plants, mechanical and communication systems, ENWESA.

ENSA representatives view relationships in the value chain as stable and reliable. This might be explained by quality and certification requirements that aggravate changes in supply chains. However, since the financial crisis delays of clients' payments have become more frequent and growing quality needs are challenging.

MTorres Group is an example for the technological and entrepreneurial potential of the Spanish ME. Founded only in 1975, it has entered promising business areas, provides production technologies for the automotive, aerospace and paper industry. It also manufactures wind turbines and has even become a wind farm promoter. One of the growing company's business areas is engineering and other technical services.

Until the middle of the last decade growth was above the EU average. However, ME has not attained the same importance in Spain as it has in other Member States. As measured by production, ME has a share of 4.5% of total manufacturing output, well below 9% for the EU average. The contribution of the Spanish ME to the EU-27 output had grown over the period under investigation but has not yet exceeded the 4% level. In contrast to the average of the EU-27 ME the number of workplaces grew steadily until the financial crisis. Simultaneously, the increase of labour productivity was below the EU trend throughout the whole period, during which wages rose strongly. Similar to Italy, the

[39] Public holding: Sociedad Estatal de Participaciones Industriales (SEPI)

country's economic performance worsened, as indicated by the strong growth in unit-labour costs and a shrinking GOR (Table 2.6).

The financial crisis hit ME during the second half of 2008 causing new orders to dramatically fall. However, production was secured by strong growth during the first half of the year and order backlogs. On average output grew over the year. ME suffered a slump in production in 2009. Manufacturers of off-road machinery were affected above all. This was caused by the breakdown of the boom in construction and civil engineering that even dampens the prospects of this particular subsector.

Already by the second half of 2009, order bookings indicated an early recovery. Since then, the upswing has been driven by foreign orders. The domestic market has remained in the doldrums. Although public projects backed demand for machinery in 2010, the overall situation has worsened in 2011. The expectations from the perspective of private enterprises are mixed. Over the course of several years, the Spanish ME industry has enjoyed soaring investment in oil refineries, but this has recently come to an end. Some suspension has been provided by growing investment in chemical plants.

Table 2.6: Key-figures for Spanish Mechanical Engineering

Region	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Spain	Production, in current prices	€ bn	23	10.3	5.3	10.2	-15.3
EU-27			598	4.0	2.3	10.4	-8.4
Spain	Production, in 2005 prices	€ bn	21	9.0	4.1	7.1	-16.2
EU-27			561	3.4	1.3	8.0	-9.3
Spain	Gross value added, in constant prices	€ bn	7	7.9	4.2	4.4	-16.2
EU-27			176	2.4	0.3	6.0	-9.3
Spain	Employees	1,000	131	5.1	1.3	1.1	-5.3
EU-27			3201	-1.6	-2.2	1.8	-4.8
Spain	Gross operating rate1)	%	15.4	0.6	-0.2	-0.5	-15.6
EU-27			14.2	0.2	-0.2	1.5	-7.6
Spain	Productivity2)	€ thsd	52	2.6	2.9	3.3	-11.5
EU-27			55	4.0	2.6	4.1	-4.7
Spain	Wages per employee	€ thsd	30	2.5	4.2	4.4	0.5
EU-27			32	3.7	3.1	3.7	1.9
Spain	Unit labour costs3)	€ / €	0.568	-0.1	1.3	1.1	13.5
EU-27			0.582	-0.3	0.5	-0.5	6.9

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Spanish ME's production has always focused on the ten subsectors under detailed investigation. They command 65% and more of the country's ME production. The 'lifting and handling equipment' subsector is by far the most important, with its share of total production rising from 18.7% during the late 1990s to 22% according to the most recent data. This is double the weight of the subsector as compared with the overall average of the EU-27 ME. This strength is explained by a strong position in industrial trucks, elevators and conveyors.

Two other subsectors have become of noteworthy importance. The 'non-domestic cooling and ventilation equipment' subsector has increased its weight from 5.1% to 8.4%. This development has been partly driven by the boom in construction and the growing attractiveness of AC installations for private households. The second subsector is 'machine tools', which has shown an even more striking development by rising from a share of only 1.6% of total output during the late 1990s up to 6.3%. This does not only show a growing specialization but indicates the availability of technological know-how within an industry that is valued as one of the core suppliers of machinery for capital goods manufacturers. To a certain extent, this growth can be attributed to the success of large manufacturing companies.

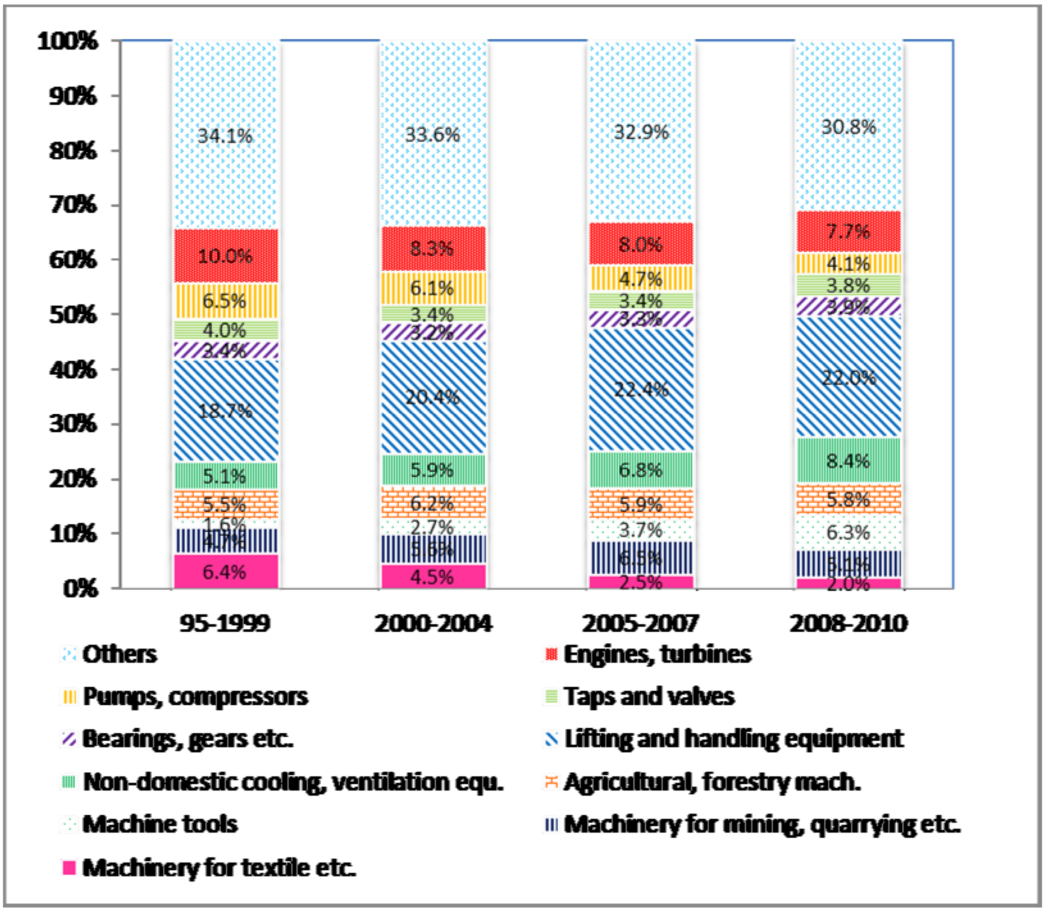
The subsectors 'pumps and compressors' and 'taps and pumps' have lost some of their importance, despite normally increasing in weight in relation to the EU average on contributions to total output. Their contribution to the output of the Spanish ME declined from 6.5% to 4.1% and from 4.0% to 3.8% between 1995 and 2010. Only approximately half of the output comprises products of the ten subsectors under detailed investigation.

During the late 1990s, the Spanish textile machinery industry commanded a relatively high share of 6.4% of overall ME production. This industry could not decouple from trends in globalization and the relocation of production to overseas countries with lower wage levels. Consequently, its share dropped to only 2% of the Spanish ME. Manufacturers have addressed the challenge and evolved towards new business areas, such as system integration and real time supervision of flexible manufacturing systems, but this was not sufficient for a compensation of losses in other areas (Figure 2.12).

Spain has been busy investing in alternative energies, in particular solar and wind power. Public support has been reduced and investment projects have become scarce. There are only a few opportunities for on-shore wind power. As it currently stands, approval has not been gained for any off-shore projects. Similar demand side problems have been emerged in other member states of the EU.

Companies of the competitive wind power industry are on the verge of acquiring projects abroad, in particular in the United Kingdom. Large companies of the industry are about to vertically integrate downstream. For instance Gamesa has opened-up a new business area and become a developer of wind farms.

Figure 2.12: Structure of Spanish Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Foreign direct investment has been of importance after Spain's accession to the EU. Foreign companies have set-up production sites but frequently key functions such R&D, sales and marketing have not been relocated. A positive example is given by the Spanish affiliate of ThyssenKrupp the ThyssenKrupp Elevator Manufacturing firm, a global leader in airport handling systems. However, in the era of globalisation this kind of division of labour has become a challenge to numerous Spanish companies.

Companies are experiencing growing competition in the domestic market. The pressure has increased in low-end products, with pumps and valves having been mentioned. Many of these products have been manufactured in China. To a noteworthy extent, these products are imported by European players that own production sites in China or sell trading goods via their distribution channels.

Most of the smaller firms are subcontractors to larger enterprises of ME. They do not have the financial and human resources to access foreign markets. As a result, they suffer from relying upon the weaker domestic market. This situation has been aggravated by large clients that reduce outsourcing and strive for improved utilization of their own capacities.

Cluster initiatives in Spain have been launched to strengthen regional specialization and to improve framework conditions for smaller companies. In spite of some positive effects most initiatives have not much contributed to structural changes on the supply side to better meet the challenges of globalization. This would require the evolution of larger, but regionally anchored firms that can allocate the necessary resources for R&D on the leading edge as well as the financial and human resources to access overseas markets. They are the cristal nuclei necessary to integrate smaller firms in stable value chains and international businesses.

2.2.5 United Kingdom

The United Kingdom led global industrialization throughout the 19th century and constituted the world market at that time. Since then it has lost its leading position in this domain. The traditional industrialized regions have remained the heartlands of ME production in the country, with the most important areas being the South East, the West Midlands, Yorkshire and Humberside and the North West.

Table 2.7: Key-figures for British Mechanical Engineering

Region	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
UK	Production, in current prices	€ bn	38	6.3	-0.9	3.9	0.3
EU-27			598	4.0	2.3	10.4	-8.4
UK	Production, in 2005 prices	€ bn	34	5.5	-2.2	0.3	-2.7
EU-27			561	3.4	1.3	8.0	-9.3
UK	Gross value added, in constant prices	€ bn	13	4.9	-3.0	0.0	-2.7
EU-27			176	2.4	0.3	6.0	-9.3
UK	Employees	1,000	213	-2.3	-4.1	-1.9	2.9
EU-27			3201	-1.6	-2.2	1.8	-4.8
UK	Gross operating rate[1)]	%	18.3	-1.9	1.0	2.4	-0.6
EU-27			14.2	0.2	-0.2	1.5	-7.6
UK	Productivity[2)]	€ thsd	59	7.5	1.1	2.0	-5.5
EU-27			55	4.0	2.6	4.1	-4.7
UK	Wages per employee	€ thsd	33	9.3	1.0	3.1	-1.9
EU-27			32	3.7	3.1	3.7	1.9
UK	Unit labour costs[3)]	€ / €	0.562	1.7	-0.1	1.1	3.7
EU-27			0.582	-0.3	0.5	-0.5	6.9

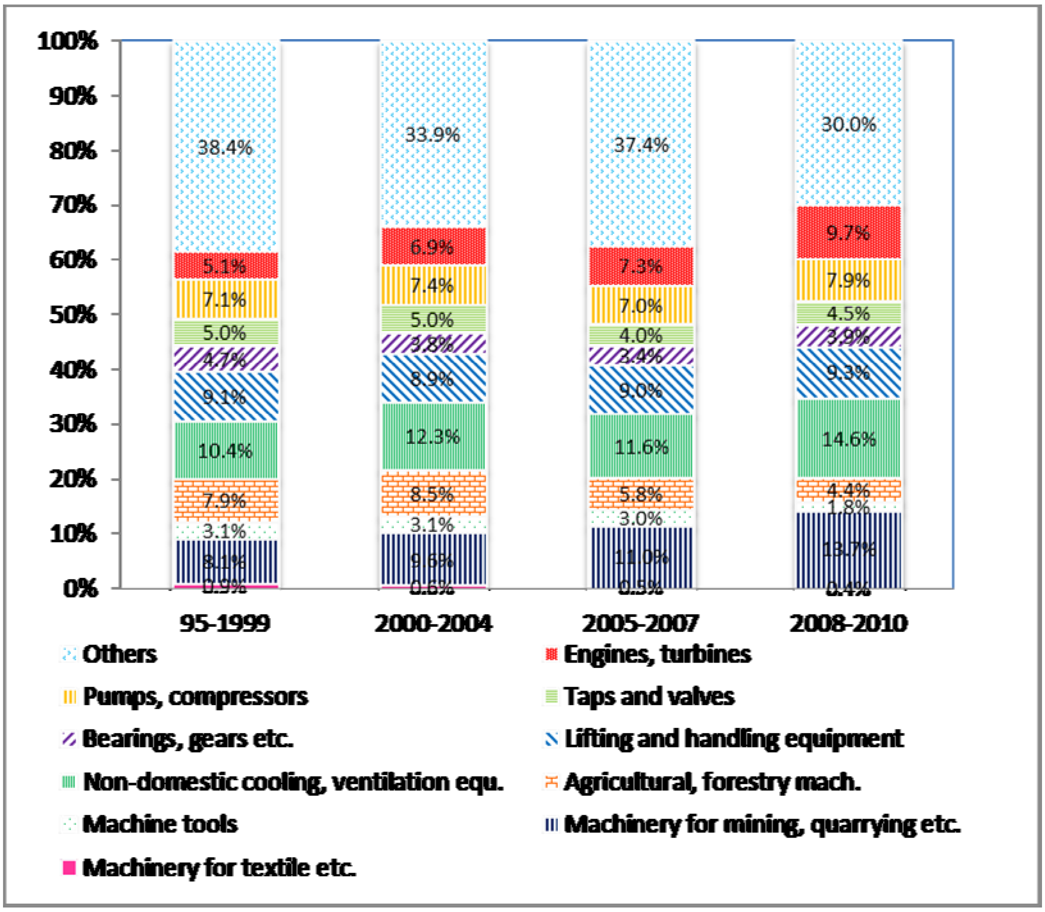
1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

British ME showed a less cyclical pattern over the period under investigation than most other Member States and did not suffer significantly from the financial crisis. However, trend growth was muted over the past decade after a dynamic expansion during the latter half of the 1990s. British ME lost shares of overall EU-27 production. It fell from 8.6% during the second half of the 1990s to 7% in the most recent past. The growth momentum of the British ME was roughly in line with domestic manufacturing. Its share of national manufacturing output remained stable over the period under investigation, at a level of approximately 6%. The British ME industry shed off staff and, in comparison to the mid-1990s, the number of workplaces declined by around one third. Wage levels in British ME industry are in line with the EU average and the increase in labour costs has been below the European mean since 2000. In spite of this development, the economic performance of British ME worsened because of a poor growth in productivity that led to an increase of unit-labour cost and a shrinking GOR (Table 2.7).

British ME production has always focused on the ten subsectors under detailed investigation, commanding more than 60% of ME's output. The 'construction and mining machinery' and 'non-domestic cooling and ventilation' subsectors are two lines of the British ME industry that are of outstanding importance, with both having increased their weight since the second half of the 1990s. They are currently responsible for approximately 14% and 15% of ME output, respectively. Most of the other subsectors' weight did not change much, with the exception of 'agricultural and forestry machinery' and 'machine tools'. In recent years they only accounted for 4.4% and 1.8% of British ME output, respectively (Figure 2.13).

Figure 2.13: Structure of the British Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The cooling and ventilation business is more dependent on regional particularities and client proximity. Ryan-Jayberg Limited is a typical medium-sized company with close linkages to retail chains in the UK and a uniquely national focus. Only few of European groups are in the market, such as the Austrian AHT, which has a subsidiary in the UK and also in the US, Turkey and China. Many of the companies are in between industrial manufacturers and handicraft enterprises that assemble complex components manufactured by large groups.

2.2.6 Poland

Following the fall of the iron curtain, Poland's emergence as a market driven economy lasted for more than a decade. The Polish ME was hit harder than other industries. Its share of total manufacturing production fell from around 8% in 1995 to its current standing of 5%. Polish ME was also hit harder than ME industries in other transition economies. Employment fell to around 50% of its former level during the mid-1990s. Since 2005 a stabilisation has been observed. The comparison of the Polish with the EU-27 ME also supports the assumption of a stabilisation. Between 2005 and 2008 the number of workplaces has been growing by 2.1% p.a., somewhat stronger than the EU average. During this phase, growth of labour productivity continued at double digit rates, exceeding wage increases and increasingly improving unit-labour costs. Structural peculiarities have been disclosed for the Polish ME: wages are higher than the average in

Polish manufacturing, with an increase of around 20%. As compared to the EU-27 average the wage level of Polish ME is around one third lower, giving Polish manufacturers an edge over Western Europe (Table 2.8).

Table 2.8: Key-figures for Polish Mechanical Engineering

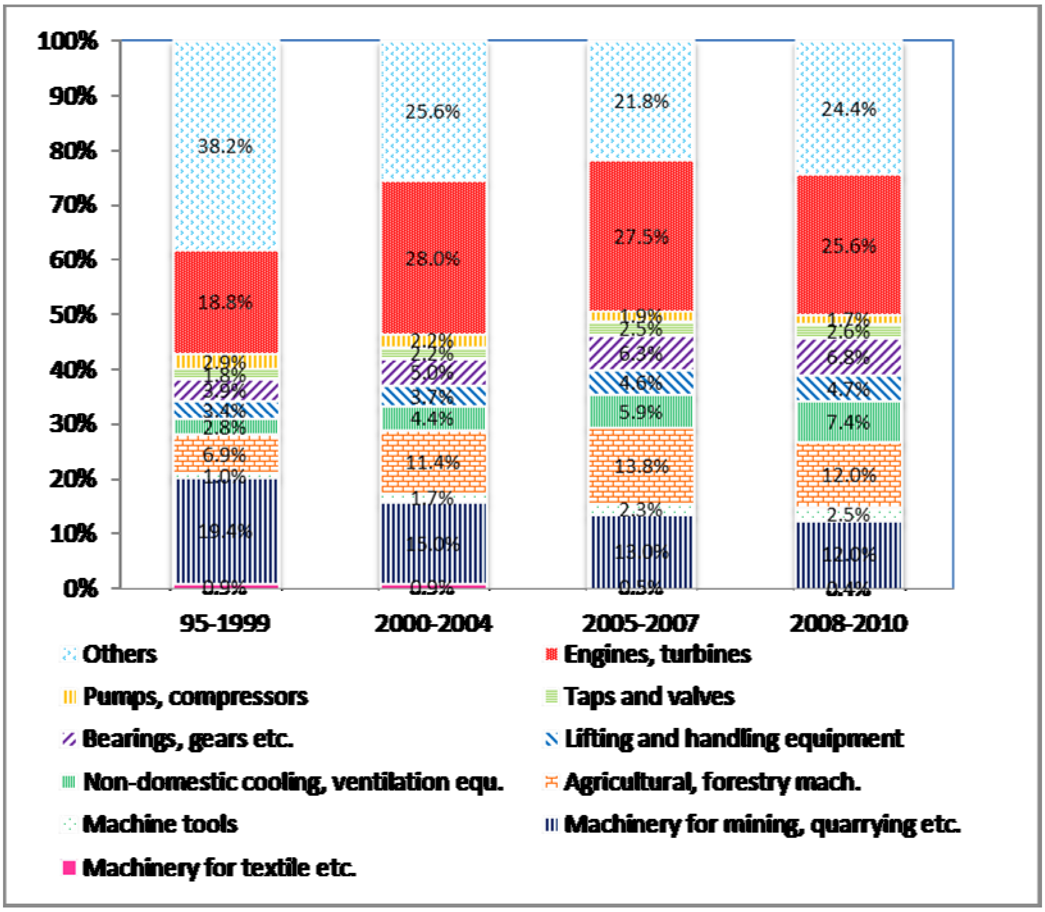
Region	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Poland	Production, in current prices	€ bn	11	6.2	2.7	15.1	-4.3
EU-27			598	4.0	2.3	10.4	-8.4
Poland	Production, in 2005 prices	€ bn	12	-0.4	2.6	18.2	-4.1
EU-27			561	3.4	1.3	8.0	-9.3
Poland	Gross value added, in constant prices	€ bn	4	0.0	-0.8	15.5	-4.1
EU-27			176	2.4	0.3	6.0	-9.3
Poland	Employees	1,000	154	-3.5	-10.5	2.1	-3.3
EU-27			3201	-1.6	-2.2	1.8	-4.8
Poland	Gross operating rate[1)]	%	18.3	-3.7	13.9	-2.5	-2.4
EU-27			14.2	0.2	-0.2	1.5	-7.6
Poland	Productivity[2)]	€ thsd	26	3.7	10.9	13.2	-0.7
EU-27			55	4.0	2.6	4.1	-4.7
Poland	Wages per employee	€ thsd	11	12.3	-0.1	10.6	1.9
EU-27			32	3.7	3.1	3.7	1.9
Poland	Unit labour costs[3)]	€ / €	0.415	8.3	-9.9	-2.3	2.6
EU-27			0.582	-0.3	0.5	-0.5	6.9

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

During the phase of transition, the Polish ME industry underwent a major structural change that is reflected in the sector's output. A specialization occurred in certain sectors which resulted in a growing share of the ten subsectors under detailed investigation. Their share on the Polish ME's production reached around 80% in recent years. This development has been driven above all by the 'engines and turbines' subsector that currently contributes more than a quarter to the country's total output. Downstream linkage to soaring production of off-road machinery explains this development (Figure 2.14).

Figure 2.14: Structure of the Polish Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The growth of the subsector 'agricultural and forestry machines' was even more dynamic, increasing its weight from approximately 7% during the latter half of the 1990s to almost 14% in recent years. In light of the important role of agriculture in Poland, there is considerable domestic demand which contributes to the attractiveness of the country as a location for the manufacture of tractors and dairy machinery. There is one independent manufacturer of tractors, Ursus S.A., owned by a Polish investment group. This company has been successful in international markets with its own distribution channels. A takeover of Ursus by another Polish industrial group is currently envisaged. Many companies from the old Member States have invested in the Polish industry for agricultural machinery. From the Nordic countries such investments have been made by Delaval, a manufacturer of dairy machinery, and the Danish Kongskilde Industries A/S, a manufacturer of soil preparation machinery that also commands a stake in material handling for plastics, paper and packaging industries. The Italian Same-Deutz-Fahr group had invested in the manufacture of components for tractors in Poland. In 2007 it spun-off the production facilities, which were subsequently taken over by another Italian company, the CBM Group.

The subsector ‘machinery for mining, quarrying and construction’ has lost some of its former weight, but has nevertheless remained important. The mining industry has a long-standing tradition in Poland. However, since the fall of the iron curtain and the advent of globalization, this client sector has lost much of its importance. Despite this, the Polish

ME builds on profound know-how for mining equipment. For example, Boart Longyear, a US group, specialising in mining equipment has heavily invested in Poland. The enterprise supplies drilling services globally and runs production sites in numerous countries. Bucyrus, another US group and manufacturer of mining equipment, has acquired a stake in the Polish ME via the takeover of the German DBT.

In a similar vein, several of the smaller subsectors, such as ‘non-domestic cooling’ and ‘machine tools’, grew at an above average rate. They reached shares of 5.6% and 2.3% respectively. The German manufacturer Gildemeister has heavily invested in Poland.

The investment of Gildemeister in Poland is typical for the involvement of many manufacturing companies in the new Member States (see Annex). The manufacturing facilities of Famot Pleszow S.A. were taken over in 1999. Since then the production program of the traditional Polish manufacturer has been redesigned to meet international standards and capacities have been markedly expanded. Beside the manufacture of final products Famot Pleszow S.A. has become an important supplier in the value chain of Gildemeister. It provides at around 40% of all castings needed for the production of the groups’ machine tools and has become an important manufacturer of components.

The component manufacturing subsectors ‘pumps and compressors’ and ‘taps and pumps’ which provide, in comparison to the EU average, an increasing contribution to the total ME output, are of only minor importance and have not performed above average for the period under investigation.

2.2.7 Czech Republic

The Czech Republic experienced a breakdown of ME during the transition phase, but it was less pronounced than for Poland. Between 1995 and 2005 the number of employees fell by one third, down to around 115,000. Until 2008, approximately 20% additional workplaces were created, but nearly all of them were lost during the financial crisis. ME is an important industry for Czech Republic. It share of total manufacturing output has been around 9% in recent years. Labour productivity is around 45% of the EU-27 ME’s average and unit-labour costs come up to only one third. These relations are quite similar to that of Poland. Since 2000, double digit growth of labour productivity exceeded wage increase and unit-labour costs shrank. This gives Czech companies an edge in cost competition and their share of total EU-27 production nearly doubled to around 2% (Table 2.9).

Table 2.9: Key-figures for Czech Mechanical Engineering

Region	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Czech Republic	Production, in current prices	€ bn	12	5.0	13.2	20.7	-9.1
EU-27			598	4.0	2.3	10.4	-8.4
Czech Republic	Production, in 2005 prices	€ bn	13	1.4	13.3	22.0	-9.7
EU-27			561	3.4	1.3	8.0	-9.3
Czech Republic	Gross value added, in constant prices	€ bn	3	2.7	9.3	18.6	-9.7
EU-27			176	2.4	0.3	6.0	-9.3
Czech Republic	Employees	1,000	143	-4.2	-2.1	3.0	-8.6
EU-27			3201	-1.6	-2.2	1.8	-4.8
Czech Republic	Gross operating rate[1)]	%	13.9	2.1	-2.5	0.0	-8.7
EU-27			14.2	0.2	-0.2	1.5	-7.6
Czech Republic	Productivity[2)]	€ thsd	24	7.2	11.7	15.2	-1.2
EU-27			55	4.0	2.6	4.1	-4.7
Czech Republic	Wages per employee	€ thsd	11	10.4	10.5	10.9	8.0
EU-27			32	3.7	3.1	3.7	1.9
Czech Republic	Unit labour costs[3)]	€ / €	0.468	3.0	-1.0	-3.7	9.3
EU-27			0.582	-0.3	0.5	-0.5	6.9

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

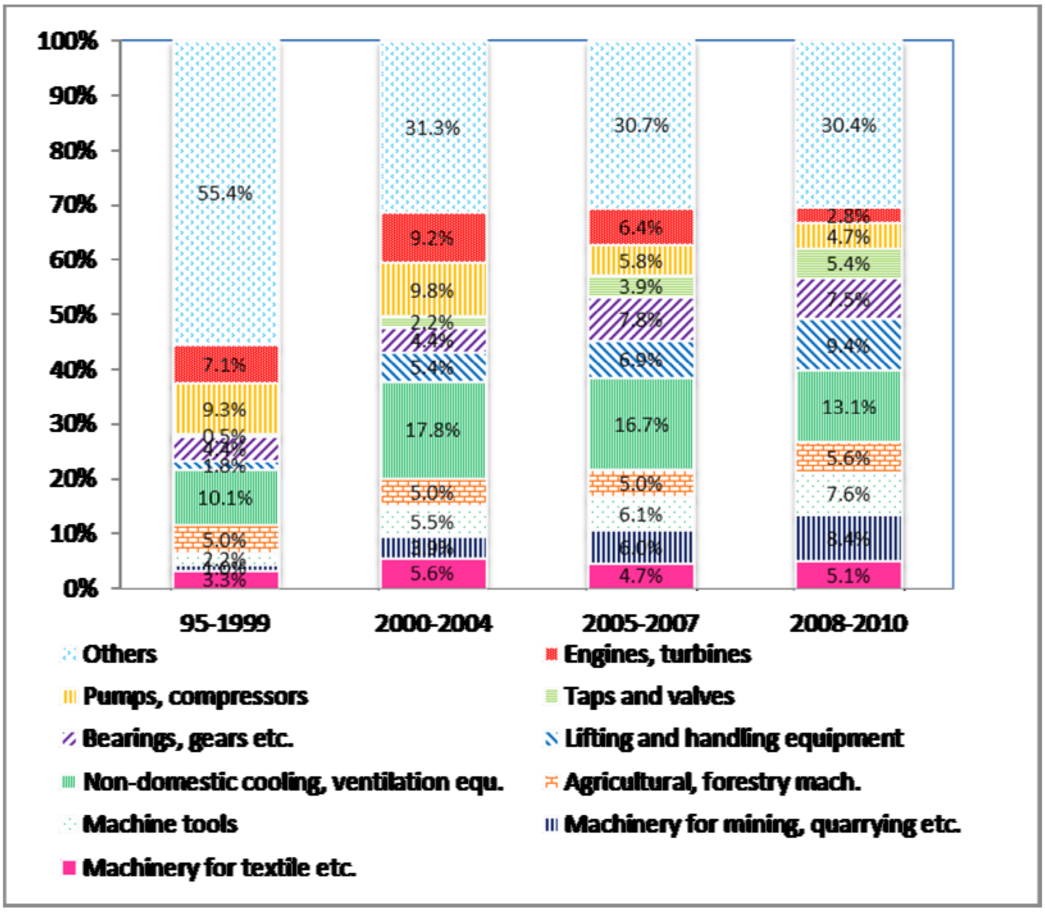
Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Czech Republic was a leading supplier of ME products and complete manufacturing systems in the socialist era. In contrast to Slovakia, which had a focus on upstream products in the metal industries and on armaments, the Czech Republic was strong in producing final products. The unbundling of the big manufacturing conglomerates and the dissolution of the centralized foreign trading organisations deprived the companies of opportunities for successful competition in international markets.

In 2007 a major restructuring within the Czech ME took place with the creation of the • KD GROUP, a.s. that was established as the parent company of the following engineering and production companies: • KD PRAHA DIZ, a.s., • KD NOVÉ ENERGO, a.s., • KD ELEKTROTECHNIKA, a.s., POLOVODI• E, a.s. and • KD FINERGIS, a.s. Since then, the entire group of companies has been marketing itself as the • KD GROUP. The production programme comprises turbines for power generation, turn-key plants compressors, equipment for refrigeration and ventilation, components for process industries electric motors, equipment and plants for the food and beverages industries.

During the phase of transition the Czech ME became more specialized. The subsector ‘non-domestic cooling and ventilation’ increased its weight on the sector’s output from 10% to nearly 17%. The ‘lifting and handling equipment’ segment also increased from around 2% to nearly 7%. The subsector ‘bearings, gears etc.’ increased its share up to nearly 8%. The subsector's important downstream linkage to the automotive industry that had heavily invested in Czech Republic explains this development. Other component manufacturing subsectors 'pumps and compressors' and 'taps and valves' did not perform that well (Figure 2.15).

Figure 2.15: Structure of the Czech Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Czech Republic has strong know-how in the manufacturing of steam turbines for power generation and the share of total ME production depicts a degree of importance for this subsector. However, its performance was below average. One of the major problems that companies of socialist economies were confronted with concerned achieving access to the market. Technological know-how has only been a necessary prerequisite and does not constitute an independently sufficient one. This dilemma often had to be solved by affiliating with a foreign firm. The Czech supplier of turbines, Skoda a.s., has been taken over by the Korean Doosan.

The subsector 'machine tool' grew well above average and its weight increased up to 6.1%, a level that is well above the EU level and comparable to the share of this subsector in Spain. An important manufacturer of large machine tools is SKODA MACHINE TOOL a.s. During the 1990s a JV was launched together with the German Dörries-Scharman Group. Later on Skoda took over the majority. Since 2005 the company was owned by Russian investors. In 2011 it has been taken over by the Czech Alta Group, a holding with several manufacturers of metal working machinery in its portfolio. It holds close business relations with numerous EU manufacturers of capital goods and runs sales and service subsidiaries in many countries of Eastern Europe.

The Czech Republic is a significant producer of heavy machine like vertical and horizontal lathes and horizontal milling and boring machines.

It is worth mentioning the subsector ‘textile machinery’ that has a longstanding tradition in Czech Republic and can draw on qualified personnel and R&D capacities. It attracted heavy investment from Western companies after the breakdown of the iron curtain. The Czech Republic is the only Member State where the share of textile machinery in terms of total ME output has increased since the late 1990s. However the production locations in Czech Republic face tough competition from non-EU locations.

The Swiss ME company Rieter has extensive experience in Czech Republic and shifted its research facilities for textile machinery to the Czech Republic. The advantage is not only the technical competence of engineers but the existence of excellent shop floors and tool manufacturers to build new prototypes nearby. The companies Rieter CZ s.r.o. and Rieter Automotive CZ s.r.o., spun off in 2010, have been integrated into the global production network, with growing capacities in China, India, and Latin America.

2.2.8 Slovakia

During the transition phase the Slovakian ME lost around one half of its employment requirements. In line with the other new Member States under investigation, the turning point occurred in 2005 when the industry experienced a decrease of approximately 50%. The layoffs took place despite the industry experiencing much higher growth rates for production than those seen on average in the EU-27 ME industry. In the ensuing years, ME grew by around 20% until 2008, but the financial crisis subsequently wiped out these gains totally. Wages are around one third of the EU-27 average, on a similar level to those found in Poland and Czech Republic. However, labour productivity in the Slovakian ME is lower than for both of these countries at €17,000, a level which is less than one third of the EU average. Between 2005 and 2008 wage increases exceeded productivity growth and unit-labour costs increased. A deterioration in economic performance contrasts to the improvements identified in Poland and the Czech Republic. Slovakia is one of the smaller economies and contributes merely 0.5% to overall EU-27 production (Table 2.10).

Table 2.10: Key-figures for Slovakian Mechanical Engineering

Region	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Slovakia	Production, in current prices	€ bn.	3	7.9	12.6	23.1	-9.8
EU-27			598	4.0	2.3	10.4	-8.4
Slovakia	Production, in 2005 prices	€ bn	3		10.7	20.0	-9.7
EU-27			561	3.4	1.3	8.0	-9.3
Slovakia	Gross value added, in constant prices	€ bn	1		15.2	13.0	-9.7
EU-27			176	2.4	0.3	6.0	-9.3
Slovakia	Employees	1,000	42	-7.0	-4.5	4.7	-7.9
EU-27			3201	-1.6	-2.2	1.8	-4.8
Slovakia	Gross operating rate[1)]	%	12.3	-0.7	22.1	-8.4	
EU-27			14.2	0.2	-0.2	1.5	-7.6
Slovakia	Productivity[2)]	€ thsd	17		20.7	7.9	-1.9
EU-27			55	4.0	2.6	4.1	-4.7
Slovakia	Wages per employee	€ thsd	10	10.3	12.0	13.5	
EU-27			32	3.7	3.1	3.7	1.9
Slovakia	Unit labour costs[3)]	€ / €	0.565		-7.2	5.2	
EU-27			0.582	-0.3	0.5	-0.5	6.9

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

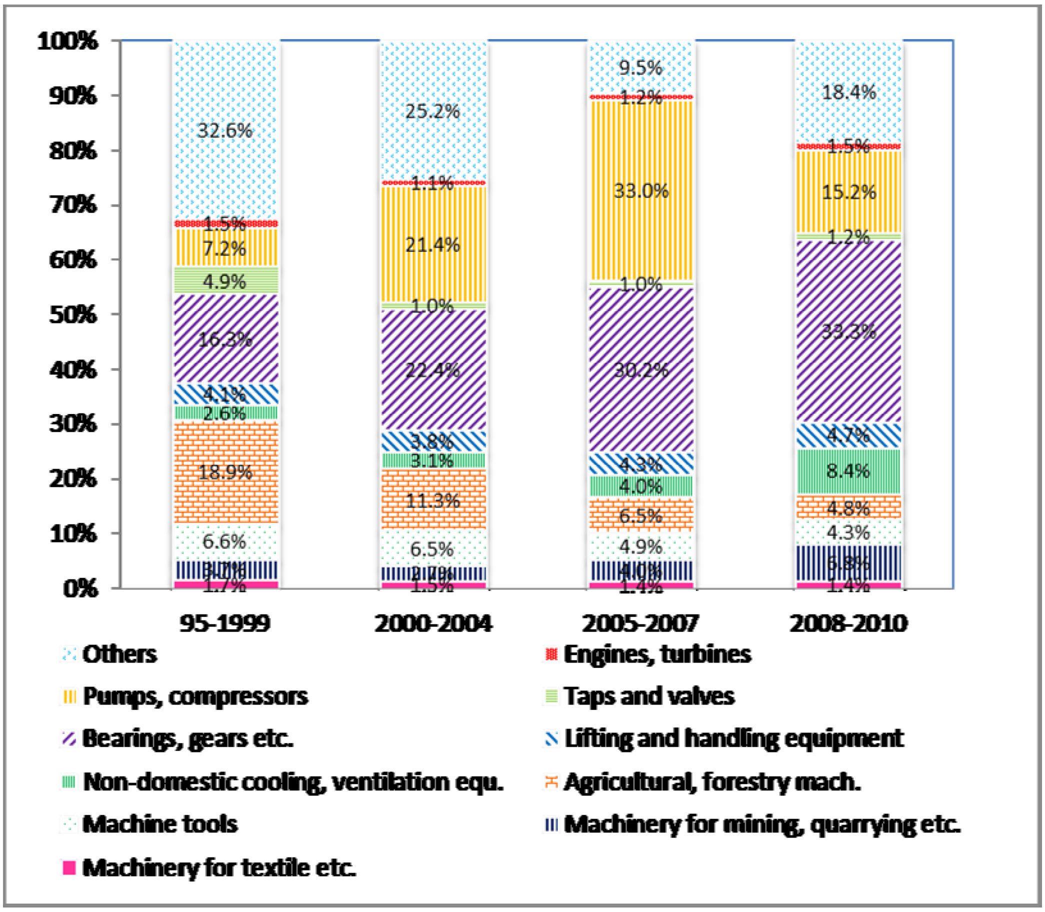
Source: Eurostat; Cambridge Econometrics; Ifo Institute.

For the duration of the Warsaw Pact, Slovakia was a centre of heavy industry. Iron ore from Russia was imported as raw material for steel works and rolling mills. Related intermediary goods were the main focus of production, whereas goods for final demand were less important. Within the former Czechoslovakia much of the downstream manufacturing was performed in the Czech region, aggravating the transition phase for Slovakia. An example is provided by the engineering group Podpolianske Strojarne (PPS) that struggled to survive and went bankrupt in 2003. After downsizing and restructuring the PPS Group a.s. was established. This company is a subcontractor to numerous manufacturers of well-known brands from different areas, responsible for lifting and handling equipment as well as construction machinery.

Of all the Member States, the Slovakian ME industry has become the most specialized. Around 90% of total output is provided by the ten subsectors under detailed investigation. One third stems from pumps and compressors. Another thirty per cent comprises bearings, gears and drives. Heavy foreign investment has been carried out by the Swedish SKF and the German Schaeffler Group.

The most dramatic slump in production was suffered by manufacturers of agricultural and forestry machinery. During the second half of the 1990s they were responsible for nearly one fifth of the overall output. In recent years this amount has shrunk to less than 7%. The subsector ‘non-domestic cooling and ventilation’ has gained some importance, but has remained well below the 5% level. Of similar size are the subsectors ‘lifting and handling equipment’, ‘machinery for mining, quarrying and construction’ and ‘machine tools’. All other sectors are close to the 1% level threshold and of minor importance.

Figure 2.16: Structure of Slovakian Mechanical Engineering production



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

2.3 Subsectors of Mechanical Engineering

2.3.1 Engines and turbines

Demand side

Machines designed to generate and utilize mechanical energy, as far as they do not serve to drive agricultural tractors, road vehicles or airplanes, are manufactured in this industry. The most important product groups in this sector are internal-combustion engines (ICE) for industry, for ships (up to 80 MW), locomotives and mobile off-road machinery (around 50 to 500 kW and even up to a maximum of 2 MW). Engines, such as steam-, gas- and water and turbines are primarily applied as prime drivers for the generation of electricity. Wind power generation is the latest product segment that has gained much importance throughout the last decade.

Turbines for industrial enterprises reach up to 100 MW and are used as stand-alone power stations. Frequently they are applied in heat-power-combinations and contribute to a reduction of waste energy. There are numerous applications for smaller turbines, e.g. pipeline compressors driven by small turbines that will gain in importance.

Large stationary ICEs are applied as permanent or emergency power generators. Their quick-start abilities are used in applications as grid stabilizers. Applications will grow in line with the extension of alternative power generation.

There is one specific market segment for small, frequently portable ICEs that are applied for forestry, such as chainsaws, agriculture and gardening. These engines, run by diesel or petrol, are in the range of 1 to 2 kW and, to a certain extent, private households are clients. They can be manufactured in large quantities. This market is characterized by large global players, but there have remained niche manufacturers who focus on special applications, for instance in quiet and environmentally friendly machinery.

Supply side

Most of the products are sold to other manufacturers of investment goods who build them into their products. This is, above all, valid for those engines which are sold to the construction, agriculture and shipbuilding industries. There are independent ICE manufacturers, e.g. Deutz (DE), Cummins (US) that are selling their engines to manufacturers of machinery. This division of labour competes with integrated manufacturing by companies that produce engines as drive units and working units, i.e. a variety of applications in-house.

Turbines are mainly used for the generation of electricity, thus they depend on the construction of power-stations. Sometimes manufacturers of these large turbines are subsystem suppliers and sometimes they are carrying out turn-key projects for their clients.

Most internal combustion engines are serial products[40] and manufactured in large quantities. Global players command large market shares. Only the very big diesel engines that are built in ships or are used to generate electricity are usually manufactured – in the same manner as turbines – as single-piece works, or in small series at best. Due to their size, the manufacturing of these engines is similar to the construction of a whole plant.

The subsector 'engines and turbines' contributes around one tenth to total EU-27 ME production. In the long run this share has remained stable. However, for the period under consideration, its evolution was less volatile. It is of note that the industry did not experience the strong upswing prior to 2008 and suffered only a slight setback in 2009. The subsector's share of ME employment reaches only 7%, although the number of employees increased between the mid-1990s and 2008. Compensation per employee exceeds the ME average and has also increased at a faster rate. To a certain extent the level and pace of wages was outbalanced by the evolution of labour productivity. Full compensation was not reached and unit-labour costs in 2008 are around one tenth higher as compared to 1995 (Table 2.11).

[40] Standardized products, variations of these products are defined by the manufacturer only and not by the customer.

Table 2.11: Key figures for the manufacture of engines and turbines – C2811

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn.	598	4.0	2.3	10.4	-8.4
C2811			60	5.7	6.1	1.4	-0.7
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2811			59	5.1	7.3	0.7	-1.7
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2811			16	3.1	6.1	6.2	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2811			230	0.5	1.4	0.8	
Total ME	Gross operating rate1)	%	14.2	0.2	-0.2	1.5	
C2811			11.0	-3.4	-1.0	2.9	
Total ME	Productivity2)	€ thsd	55	4.0	2.6	4.1	
C2811			69	2.7	4.6	5.4	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2811			42	4.6	3.4	8.1	
Total ME	Unit labour costs3)	€ / €	0.582	-0.3	0.5	-0.5	
C2811			0.603	1.9	-1.2	2.5	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Compared to other subsectors of ME the industry 'engines and turbines' is comprised of numerous large enterprises. Cost-advantages can be obtained in series production through economies-of-scale, especially in ICEs. In single or small-batch production the size of products often demands a large plant. This is project business that demands noteworthy technology and funding resources. The sector gets its most important inducements for product innovation from efforts to improve efficiency and reduce damage to the environment.

The most challenging product group by technology is large gas turbines applied for the generation of electricity. Only a small number of manufacturers from Europe and the US have the knowledge to manufacture these products. Technology is a market access barrier. For the product group of large steam turbines the situation is slightly different, although it is likewise driven by key-know-how and funding abilities. However, competitors from China and Brazil possess the necessary capabilities.[41] They are lagging

[41] The Korean manufacturer Doosan has acquired the Czech Skoda, manufacturer of steam turbines, to gain know and to tap into the European market.

behind the well-established suppliers from developed countries in terms of energy efficiency, but in many markets this lag is not that crucial.

M&A activities hint towards a growing interest in the ICE market. Caterpillar acquired in Europe MWM, a German based engine maker, specializing in certain areas of power generation from 3i, a private equity investor. It acquired in the US EMD, a manufacturer of diesel engines for locomotives. Daimler and RollsRoyce have decided to purchase Tognum, a German manufacturer of large diesel engines for ships, industrial application and power generation. The company had already been – under its former name MTU - part of the Daimler Group. In 2005 Daimler decided to sell-off all of its off-road diesel businesses in the US and Europe. MTU was taken over by the financial investor EQT.

The Italian manufacturer Lombardini, the third largest producer of serial diesel engines between 10 kW and 100 kW for the agricultural sector, was taken over by the US group Kohler, an industrial group, specializing in ICEs.

Procurement
Numerous parts and components for engines can be procured from specialized manufacturers of the metal industry. The most important intermediary products are forged rods, casted pistons and cylinder heads. Some of the manufacturers prefer in-house production and manufacturing depth is high. Others are outsourcing many parts. In particular, the automotive industry is strongly involved in outsourcing to specialized manufacturers. For the engine makers of the ME industry, make-or-buy decisions do not show a clear picture.

Business cycle
The products most affected by the financial crisis were the ICEs dedicated for off-road construction machinery. The slump in demand was strongest from countries with a breakdown in the real estate market. Demand from agriculture and from power generation was not affected to a significant extent. The latter was caused by a large order backlog and long lead times.

Long-term demand
The long-term prospects for turbine manufacturers are, on the whole, positive. The global demand for energy will be increasing strongly. The majority of investment will be in conventional power generation, nuclear fuel, coal, lignite and gas. Renewable energy production will grow at an above average rate, particularly in Europe. The demand for capacity expansion dedicated to electricity production will grow even stronger than the demand for energy, because capacity utilization of renewable power plants will never reach levels comparable to conventional power generation. Massive back up capacities have to be installed in order to meet peak demand and accommodate longer periods of lull, sometimes produced by stable anticyclones over large parts of Europe in summertime. Above average growth is also expected for back-up capacities and electric grid stabilization for large ICEs.

The market for off-road machinery and portable machinery is dependent on economic development in different areas, such as mining and quarrying, forestry, agriculture, construction, municipal services etc. With the exception of raw materials, the growth perspectives for each are strongly dependent on regional dynamics. The most prosperous opportunities are expected to lie with emerging countries.

Technology

The Strategic Energy Technology plan (SET) of the next FP (8th) will contain technologies that are of importance for centralized biomass power stations and concentrated solar power stations. One of the major challenges lies in the optimization of turbines that are operated under strongly varying modes. A focus will be on the development of gas turbines suited for these applications. A special task will be the development of gas turbines run by natural gas enriched with H_2 or pure H_2. Such turbines are necessary for buffer power stations to avoid a breakdown during peak demand times or during lulls. These power stations are not only run by natural gas but by gas generated with the help of excess electricity produced by wind power that cannot be sold at acceptable prices. This electric power will be used for electrolysis of water. The H_2 produced through this process will be burned during bottleneck times in wind-gas power stations and pressurized air power stations.

Public R&D of the US Department of Energy has been evaluated by experts of the industry as advantageous because of a different philosophy on research funding. There are no regulatory concerns from public institutions on the promotion of individual enterprises. Companies do not face the threat of losing intellectual property rights (IPR). This framework condition was mentioned by experts of the industry as an attractive incentive for European enterprises to run R&D centres in the US.

Global market developments

The market for power generation is characterized by global competition. The most important players are from Japan, the US and Korea. The Chinese have started to tap into the market. Likewise Brazil and Russia have extended their activities internationally. While competition in the market for gas turbines is limited by the need for access to technology, the market for steam turbines can be accessed by numerous players and even those from emerging economies. Political lobbying is an important topic in this market to win large contracts.

Other global markets are linked to infrastructure projects, such as the construction of pipelines. The delivery of equipment, e.g. compressor stations operated by small turbines or ICEs is put out to tender internationally.

In contrast, ICEs dedicated for industrial application and the assembly of off-road machinery constitute a regional business. Trade with these engines is predominantly intraregional. Usually the opening up of a market requires foreign direct investment. It is only in the market for small ICEs, manufactured in large quantities, that intercontinental trade is of importance. Companies such as Stihl (DE), Yanmar (JP) and Husqvarna (SE) market their products globally.

Japanese manufacturers command a strong share in the global market with serial ICEs. They had set-up production facilities in sales markets, launched their own distribution networks and co-operate with regional companies to access clients and provide solutions for specific applications.[42]

Regulation

The EU regulation of this domain has been perceived as supportive. There are no problems as regards the free circulation of goods within the Single Market. One aspect in particular has been discussed with industry experts, namely emission trading. The European Emission Trade System is often regarded as a best practice to drive innovation and reduce CO_2 emissions. However, this is only true for current investment. ETS is not a satisfactory driver for the replacement of inefficient and depreciated power plants. In 2016 a stricter regulation on emissions will be put into force. It is expected that some European power stations will be shut down. Retrofitting, in order to meet the stricter limit values, will be too expensive.

The disadvantages SMEs face by permanently increasing requirements on waste gas and noise emissions are addressed by the EU. Impact assessment of European regulation on SMEs is an important issue taken into account by the Commission. If smaller numbers of engines are manufactured, for instance below 5,000 units per year, the introduction of norms is decelerated by the Commission. In these markets smaller companies are found more frequently. The delayed procedure provides some opportunities to benefit from the experience of larger manufacturers. This is valued as a sufficiently conciliatory procedure by industry experts.

2.3.2 Pumps and compressors

Demand side

The industry 'pumps and compressors' is another typical subsector of ME that manufactures intermediary goods. There is demand for both standard and special products in all product groups for a broad range of industries. Beyond manufacturing the products are applied in power generation, waste processing and in the construction industry for heating, cooling etc.

The subsector facilitates many processes in which liquids and air are used. As a result of this, manufacturers of these products with a wide range of applications have coped relatively well with the crisis. The subsector continues to grow modestly. Energy efficiency of the products is important for the competitiveness of this subsector, for the manufacturers who integrate them in their products and for the users being the ME sector and other industry sectors. Hence the potential contribution of this subsector to the overall competitiveness of the industry is much bigger than its relative share of the ME.

A large part of the pumps and compressors are delivered as components to machine and plant builders. They are required for installation, inter alia, in chemical and petrochemical plants as well as in machines for producing, filling and sealing drinks and foods. They are

[42] This has been analysed in detail in a study on the gas appliances sector, see: Vieweg, H.-G. et al. (2009a) "The Competitiveness of the EU Gas Appliances Sector", Rotterdam, , pp. 144.http://www.sectorcompetitiveness.com/index.php/sector-competitiveness-studies

built in construction machines and in machines for building materials. Liquid pumps have a wide range of uses in plants for processing drinking, utility and sewage water. Wherever lubricants and/or cooling agents have to be dispensed of, as is the case with most mechanical operations, liquid pumps are part of the subsystems.

Pressurized air is used for a variety of different applications, for example in medical devices, and is widely utilised in the manufacturing of pneumatic tools. Compressors provide the working substance of pressurized air. Traditionally there are applications for pneumatic controls. Although they have been substituted by electronic controls to a certain extent, they have remained indispensible in some areas, such as in an explosive environment.

Supply side

The subsector ‘pumps and compressors’ is one of the smaller groups of ME. In 2008 its production reached 5.4% of total EU-27 ME. However, the industry grew much stronger than total ME. During the latter half of the 1990s its share was only 4.3%. Moreover, this industry did not suffer a breakdown comparable to other subsectors of ME during the financial crisis and has already reached former heights, at least in nominal terms. The industry’s above average development has continued. Its share of ME employment is around 5%. It shrunk over the period under investigation, although less pronounced than for all of ME. The economic performance was close to ME. Growth of productivity and wages was somewhat higher. Unit-labour costs in 2008 were around 3% higher than in 1995 (Table 2.12).

Table 2.12: Key figures for the manufacture of pumps and compressors C2813

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2813			32	5.4	4.8	11.7	0.0
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2813			29	4.2	3.6	8.4	-2.1
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2813			9	3.3	1.7	5.8	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2813			158	-1.1	-0.8	0.8	
Total ME	Gross operating rate[1)]	%	14.2	0.2	-0.2	1.5	
C2813			15.0	0.7	-1.5	2.0	
Total ME	Productivity[2)]	€ thsd	55	4.0	2.6	4.1	
C2813			60	4.5	2.5	5.0	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2813			35	4.6	3.4	4.5	
Total ME	Unit labour costs[3)]	€ / €	0.582	-0.3	0.5	-0.5	
C2813			0.587	0.2	0.9	-0.4	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

One characteristic of this sector is that in some segments of the market smaller enterprises are specializing in accommodating the needs of individual clients or specific applications. However, in some other market segments large, globally acting groups dominate the supply side. Most of these market segments are characterized by serial products[43] that are manufactured in large quantities. Global players, such as Grundfos and Danfos (both DK), run manufacturing sites globally and have strong footholds in all of the more important markets. Serial products used for a wide range of applications with a certain customization are manufactured by KSB (D) and the SIHI Group (D), a group created during the 1990s as a result of numerous acquisitions. Alstom Bergeron (F) and Weir (UK) manufacture customized equipment as well as large components for power generation, mining, oil production etc.

Smaller firms of the industry serve above all regional or even only local markets. They face challenges from globalization and regulation. Typically the products of the industry are intermediary products and companies are part of a value chain. OEM manufacturers are about to change their procurement strategies and expand their purchasing range. As a consequence, competitive pressure is growing. Competitors from EU and non-EU states

[43] Standardized products, variations of these products are defined by the manufacturer only and not by the customer.

participate in tender procedures. Smaller firms – above all from southern Member States - perceive growing competition as a threat to their existence.[44]

Certain firms active in the industry have opened up new business areas. In addition to selling machinery and equipment, they offer services to clients. They do not only design facilities for their clients, but also operate them. They are paid for the provision of faultless and sufficient services, e.g. pressurized air systems for use in industrial applications or even hospitals. These companies gain revenues beyond payments for their products and become less dependent on clients' investment behaviour.

Procurement

The majority of pumps and compressors are up to a certain size attached to a prime mover, usually an electric motor. Both of these components have to be adjusted to each other taking into account their power curves and the range of application. The electric motors have to be procured from specialized manufacturers. Manufacturers of pumps and compressors frequently produce electric motors in-house or in affiliated companies. Other serial intermediary products that have to be procured are bearings, joints and gaskets.

Other mechanical parts such as boxes, drive shafts, pistons and the like are manufactured in-house or procured from specialized manufacturers, in particular castings.

Those companies that manufacture their own electric motors procure additional parts and components. Representatives of the industry raised the issue of rare earths that are necessary for the production of metals with specific magnetic characteristics and which are important for the production of energy efficient electric motors. In recent years, bottlenecks have emerged. The dependency on deliveries from China, a country that has a monopoly on the supply of certain minerals, is perceived as posing a long-term threat to the European industry. Increasing problems are expected in coming years due to the fact that China's indigenous demand is growing strongly.

Business cycle

The industry was affected by the financial crisis. The recovery shows some differences in terms of the pace of development. Product groups dedicated for use in power generation performed better during this period. The slump was pronounced for product groups dedicated to the construction of residential and office buildings. A strong recovery of demand has taken place due to the needs of manufacturing industries. In particular, investment from the chemical industry has stimulated growth.

Long-term demand

The long-term perspectives of this industry are dependent on the final destination of the products. For instance, bright perspectives are expected for product groups applied in power generation, from the domestic market and from overseas. Likewise, waste management will show comfortable growth in particular in Europe. Other market segments related to construction will constitute a more dependent replacement, but prospects in markets such as Spain and Ireland that were hit hard by a real estate bubble

[44] The competitive pressure had prompted an industry association to launch an initiative on branding pumps country of origin to strengthen EU companies' reputation. However, the initiative was not successful.

remain subdued. Growth stimuli can be generated by trends towards the luxury refurbishment of residential buildings with sanitary facilities, increasing wealth and urbanisation in emerging economies.

Technology

The R&D efforts as measured as a share of total output have reached on average 5%. This does not include the engineering required for the development of customized solutions and applications of specific importance for certain industries.

Companies have failed to exhibit extensive interest in European schemes to further technical progress. They regard the application for funds as too complicated and they fear that know-how drain will occur in cross-border co-operative projects. Criticism has also been raised as regards the design of national schemes in France and Belgium that have been inadequately launched. The German R&D infrastructure and schemes are better suited to the needs of smaller firms. Joint initiatives of “Fraunhofer Gesellschaft” and private enterprises endowed with limited public funds push forward technology and applicable solutions.

Global market developments

Technical barriers are minor problems in international markets. Standards are developed and agreed upon by international working groups under the umbrella of the International Organization of Standardization (ISO). Consequently, the technical specifications of the industry’s products are widely accepted in third markets.

Regulation

Apart from the problems of smaller companies with technical regulations, the industry appreciates the regulatory framework. In particular, the Energy-Related Products Directive (ErP), with its specific provisions on pumps, has been perceived as a successful solution by companies.

In contrast to consumer goods, market surveillance is not sufficient in markets for industrial goods. Non-compliant imported products from third countries have remained a point of concern. Despite the introduction of Regulation 765/2008 on market surveillance and accreditation, which entered into force on 1 January 2010, little has changed. Due to the sector’s experts, the identification of non-compliant products has to be carried out at customs. However, officers are not qualified to identify problematic deliveries. As a consequence, imported CE-marked products are traded within the Single Market, although they do not comply with EU provisions. The sale of counterfeit products is another problem related to insufficient market surveillance. The disclosure of infringements against EU provisions is dependent on companies’ investigations into the sales markets. Further legal enforcement is necessary to safeguard the objectives pursued by European directives on environmental protection, health and safety in the workplace.

A specific point has been raised that concerns manufacturers own imports from third countries. They perceive that the certification of their production abroad is not always sufficient. Occasionally, EU clients do not accept deliveries from Russia or China, although the production facility in question has been certified by a notified body. These problems are caused because the quality of notified bodies differs strongly in third countries. The accreditation is no guarantee for the acceptance of a passed certification.

Smaller firms face some problems with the regulation. It is challenging to re-engineer products to meet minimum standards on energy efficiency. The directive on the restriction of hazardous substances, the RoHS Directive 2002/95/EC, requires that electrical and electronic parts do not contain banned substances. Smaller firms have to trust that suppliers comply with EU provisions. They do not own the know-how and the necessary equipment to guarantee compliance and bear the risk. A similar problem is raised by the registration, evaluation and authorisation of chemicals, as outlined in the Reach Directive 2006/121/EC. This directive is dedicated to ensure the safe use of chemicals for human health. While bigger firms employ specialized staff, such as chemical engineers, to comply with EU requirements, smaller firms have to engage costly external technical services.

2.3.3 Taps and valves

Demand side

Valves, slide valves, flaps, taps and actuators are the products allocated to this industry. The buyers of these products are utilities, suppliers of electricity, gas and water, the chemical and mineral oil processing industries, the sanitary and heating trades and private households for do-it-yourself jobs. A lot of smaller valves and fittings are sold through shops. This applies in particular to taps and valves for building technology. In the sanitary fittings area and in Heating, Ventilation and Air Conditioning (HVAC), products can often be produced in large series. Therefore, larger manufacturers are also found alongside the many small and medium-sized companies that are present in this sector.

Supply side

The subsector ‘taps and valves’ currently commands a share of 4.6% of the total EU-27 ME production. During the latter half of the 1990s, it constituted only 4.0% of overall production. The industry grew much stronger than total ME in nominal terms. As calculated in real terms, the situation changes. Between 2005 and 2008 growth of ‘taps and valves’ was below total ME output. The industry was hit by the financial crisis and the breakdown in construction, in particular in Spain and Ireland. The industry has not yet reached former record heights. The employment record was better than the total ME industry average as the number of workplaces was reduced by around 1.5% in 2008 as compared to 1995. Muted productivity growth – below the average of total ME - and wage increases above the trend, at least until 2005 caused a deterioration in economic performance. Unit-labour costs picked-up over the whole period under consideration (Table 2.13).

Table 2.13: Key figures for the manufacture of taps and valves C2814

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2814			28	5.4	4.8	10.8	-5.2
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2814			24	2.8	2.9	5.8	-6.2
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2814			8	1.3	1.6	2.8	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2814			144	-1.1	-0.8	2.6	
Total ME	Gross operating rate[1)]	%	14.2	0.2	-0.2	1.5	
C2814			16.0	-1.0	-0.5	-0.6	
Total ME	Productivity[2)]	€ thsd	55	4.0	2.6	4.1	
C2814			57	2.4	2.3	0.2	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2814			34	4.7	3.7	3.0	
Total ME	Unit labour costs[3)]	€ / €	0.582	-0.3	0.5	-0.5	
C2814			0.603	2.2	1.3	2.8	
1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.							

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

In the business area of taps and valves for sanitary applications and HVAC are large manufacturers that pursue global strategies. Two German firms, Grohe and Hansgrohe, are leaders in the global market for premium sanitary taps and valves. Both of these firms were family owned. In 2004 Grohe has been taken over by a private equity firm, TPG Partners IV, L.P, and a financial investor. The company was restructured and the global production network strengthened. These days Grohe runs facilities in Germany, Portugal, and Thailand. Its German competitor, Hansgrohe, has taken in a specialized US investor[45], but a minority stake has remained in the hands of the family. The company runs production sites in Germany, the Netherlands, France, China and the US.

In the area of HVAC, two Danish companies are global leaders, namely Grundfos and Danfos. They are full-hand suppliers for all components necessary for the assembly of heating ventilation equipment and air conditioning. Therefore they manufacture not only taps and valves, but also pumps and compressors (see: Chapter Pumps and compressors 2.3.2). Danfos runs production sites in many European countries, the US, Canada, Brazil, China, India, eastern European countries and Japan. Both companies are privately held global players with corresponding production networks.

[45] Masco Corporation, the world's largest manufacturers of brand-name products for the home improvement and new home construction markets. http://www.masco.com/corporate_information/index.html

Many of the taps and valves used for power generation and in industrial applications are larger and have to be adapted to the specific needs of industrial processes or even customized. In this business area, there are smaller suppliers that serve specific market segments and larger firms that provide a broad range of products and services, necessary for the clients' specific needs. Companies such as the German KSB and the British Weir PLC are global players in a market environment quite different from sanitary fittings and HVAC. These companies run production sites in all major markets. Close contact to clients and engineering are important features of competition. For instance KSB is involved in a JV with SEC, SEC-KSB Nuclear Pumps & Valves Co., Ltd., in China for the manufacture of components dedicated to the construction of nuclear power stations.

Globalization is a challenge for smaller enterprises in this subsector. As contractors to larger firms they are asked to:

- meet foreign competitors' product prices,
- follow suit clients' activities in foreign countries and
- relocate production to better meet stricter cost requirements.

Both of the latter requests can only be obeyed by high investment and are not suited to many of the smaller companies. They do not have adequate access to the financial markets and cannot bear the risk involved.

Procurement

Taps and valves are mechanical components with different quality and reliability requirements. High-performance parts are manufactured in-house, in particular components dedicated for use in nuclear power stations have to fulfil the highest standards and obtain specific certificates. Since the fall of the iron curtain, mechanical production has to a certain extent been relocated to new Member States. Electric components, such as step motors, and controls are procured from specialized manufacturers, sometimes from affiliated firms. Sensors and other electronic equipment frequently originate from Asia.

Procurement strategies are quite different in the industry, ranging from between 15% and 50% of total production value. Frequently, product requirements are the driving factors behind the level of in-house production performed.

Business cycle

The subsector taps and building valves was severely hit by the financial crisis. The industrial valves subsector suffered a less dramatic slump and has been developing in the same way as that of pumps and compressors. The momentum of the recovery has not been sufficient to reach the same output levels as 2008.

Long-term demand

The long-term perspectives for this industry are quite similar to that of pumps and compressors. Deliveries dedicated to power generation are expected to have a bright future. Likewise, waste management will show comfortable growth, especially in Europe. Other market segments related to construction will be more dependent on replacement.

The refurbishment of residential buildings will be better off with the upgrading of sanitary facilities and growing wealth as well as urbanisation in emerging economies.

Technology
New developments in the energy efficiency of buildings and water efficiency could give the sector a new boost in competitiveness. The high degree of automation of taps and valves with actuators assures its competitiveness for the future.

Global market developments
Trends in global markets are quite similar to 'pumps and compressors'.

Regulation
The assessment of the regulatory framework is comparable to 'pumps and compressors'.

2.3.4 Bearings, gears and drives

Demand side
The manufacturing of bearings, gears and drives is the archetype of an industry supplying intermediary products. These parts and components are needed for all kinds of movements and torque transmission, be it rotation, linear or any other kind of curve. The products are delivered to most of the other ME industries. They are assembled into all kinds of capital goods and delivered to the transport equipment industries for the manufacture of cars, ships, railways and aircraft. Bearings, gears and drives are needed for power generation, waste recycling, warehousing etc. Consumer goods industries procure bearings, gears and drives for use in certain applications, for instance domestic appliances, hard disc drives for computers, multi-media applications etc.

Supply side
In general this subsector is one of the largest suppliers of parts and components for the European and international mechanical engineering Industry. Within the EU a lot of global actors are located which provide key technology dedicated for applications of growing importance, such as e-mobility and renewable energy. Nevertheless the structure of this industry is a mixture of large groups and privately-held smaller enterprises owned SMEs. Only to provide examples, companies like Brevini, Bongfiglioli, ATA, Moventas, SNR, Schaeffler Group, SKF, SEW, Carraro, ZF, Renk, Hansen, CMD, Siemens, KTR, Stromag, Voith are globally known brands suppliers of high-tech.

The subsector 'bearings, gears and drives' commands a 6.4% share of the total EU-27 ME production. During the latter half of the 1990s, its share was only 5.2%. The industry grew much stronger in terms of total ME output from 1995 to 2005. In subsequent years, growth accelerated but no longer exceeded ME. Germany, Italy and France are the most important manufacturing nations. Germany contributes over 50% to total EU output.

The industry was hit severely by the financial crisis has not yet recovered to its former record heights. The industry's share of total ME employment was 7.2% in 2008. The number of employees has remained stable as compared to 1995. This employment record is better than for total ME. However, productivity was lagging behind overall development, in particular during the phase of high growth between 2005 and 2008. For that period, productivity only grew by 2.5% p.a. as compared to total ME which grew at a rate of 4.1%. As a consequence, economic performance worsened, unit-labour costs increased and the GOR has declined by a noteworthy extent (Table 2.14).

Table 2.14: Key figures for the manufacture of bearings, gears and drives C2815

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2815			38	6.7	4.8	10.9	-8.8
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2815			36	5.8	4.0	8.6	-10.0
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2815			13	4.3	2.1	4.5	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2815			230	-0.5	-0.7	2.0	
Total ME	Gross operating rate1)	%	14.2	0.2	-0.2	1.5	
C2815			16.4	0.0	-1.8	-3.1	
Total ME	Productivity2)	€ thsd	55	4.0	2.6	4.1	
C2815			56	4.8	2.8	2.5	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2815			32	4.4	3.6	4.0	
Total ME	Unit labour costs3)	€ / €	0.582	-0.3	0.5	-0.5	
C2815			0.571	-0.3	0.7	1.5	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Two markets with different framework conditions have to be discriminated within this industry. Most of the bearings are highly standardized products and manufactured in extremely large series. They are marketed globally in a manner similar to commodities. Big players share the world market, such as the Japanese NSK, NTN, JTEKT[46] and Minebea that all run production sites in Europe. The US Timken - that took over its US rival Torrington in 2003 - runs several production sites in Europe. The Swedish SKF and the German Schaeffler Group (INA, FAG) are large European manufacturers belonging to the most important global players in this market.

The other market segment is comprised of companies that are specializing to a certain extent. There are large manufacturers that are part of the automotive value chain, such as the German manufacturers ZF and Schaeffler.

[46] Merger of Koyo and Toyoda Machine Works Ltd. in 2005.

Germany, Switzerland and Austria create a strong cluster in drive technology. Italy, number two in Europe, has always been competitive in drive technology, but companies suffer from the Italian economy's loss of competitiveness. In particular locations in Italy have been facing growing competition from new member states, Eastern Europe and China. Although larger technology driven companies successfully withstand growing competitive pressure, it seems that there a structural changes in Italy, which could also affect other European nations.

SNR is an important supplier to the automotive, aeronautics and space industries. Moreover, it is a provider of solutions for industrial applications. SNR is one of the most prominent manufacturers of drive technology in France. SNR was affiliated with Renault - the French automaker - until 2006. In 2007 was acquired by NTN, the large Japanese manufacturer of bearings. Since the early 1960s NTN has a stake in Europe. In addition to owning a distribution network, it also runs production sites in France, Germany, Italy and Romania. NTN has two R&D centres in Germany and France and benefits from the EU infrastructure and this shows how important the European market is for companies outside Europe. This is one example for Asian manufacturers, in particular from Japan, Korea and China, are attracted by the European market, try to get access or to acquire know-how.

New Member States' companies faced noteworthy problems during the transition phase. Some disappeared from the market, others were taken over by western companies and others had to survive by serving as subcontractors to final product manufacturers in western Europe. However, there are some success stories in relation to independent manufacturers. An emerging manufacturer of gears and drives, that is strong in technology and international markets, is the Czech WIKOV group. It has diversified in a broad range of drives for power generation and process technologies. Finland is specialising in drives for ships and commands a strong position in the global market. There are some French manufacturers in drive technologies that have a focus on military applications. Belgium has also been improving its position in drive technology.

The industry's companies are suppliers of key-components to their clients on upper tiers in the value chain. Larger, service oriented manufacturers are about to become subsystem suppliers and offer after-sales services and life-cycle management. This contributes to improving their bargaining power. The interest of the enterprises in the supply of additional services contrasts to the aeronautics industry where OEMs pursue organizational changes in the value chain, asking their suppliers to become subsystem contractors and risk sharing partners. They try to relocate responsibilities on lower tiers of the value chain and smaller suppliers fear being overcharged.[47] It must be acknowledged that the aerospace industry is quite different from ME and other client industries. The organizational changes required by aeronautic companies are more far-reaching than those offered ME companies to their clients.

[47] Vieweg, H.-G. et al. (2009b) "FWC Sector Competitiveness Studies – Competitiveness of the EU Aerospace Industry", Munich, pp.293.http://www.sectorcompetitiveness.com/index.php/sector-competitiveness-studies

Procurement

Rare earths have been a topic of discussion for the past two years. However, the public debate appears to be exaggerated with regard to the breadth of application in this subsector. Rare earths are only of importance in market niches for the most energy efficient electric motors, a small market segment. They are necessary for the manufacture of permanent magnets. Although they contribute to higher energy efficiency, they are too expensive for many applications. For instance, prime drives for automobiles will not contain such permanent magnets.

The integration of mechanical, electrical and electronic technologies has had an impact on the development of the industry's companies. Some of the larger gear and drive manufacturers have acquired producers of electric prime drives or set up their own research and production facilities. Progress in controls and power electronics has contributed to an integration of these technologies. Many companies sell complete drive units that contain the primary and secondary drives, as well as the control.

Some companies own foundries and build on high manufacturing depth. This can be an advantage in the case of high rigidity and lightweight requirements that are of special importance for the automotive industry. However, this is part of a company's manufacturing philosophy and does not constitute a general necessity. Other firms sold or shut down these facilities and procure gear boxes and other components from subcontractors. Frequently they originate from the new Member States in eastern Europe, but even China is a country of origin.

Business cycle

The industry suffered from the financial crisis throughout Europe. However, the recovery shows some differences in the pace of development. While German bearings, gears and drive manufacturers have performed well, the French and Italian competitors have not yet grown at similar rates. This is explained by the strong stimulation of German client industries and has arisen, especially in the case of Italy, due to a loss of competitiveness. In line with the average for the EU-27 in 2010, output has not attained its former heights.

Long-term demand

Bearings, gears and drives are delivered to a broad range of industries. The long-term perspectives are dependent on the final destination of the products. For instance, bright perspectives are expected for the manufacturers of gears and drives, dedicated for applications in power generation, whether conventional or alternative. In contrast, the demand for applications in off-road machinery will only be moderate within the EU, whereas in emerging markets further strong growth will be achieved. Infrastructure, urbanisation and the thirst for raw materials are driving factors. Changes can be expected in drives and gears delivered to the automotive industry. Subsidies for the introduction of electric cars will affect the small car segment, currently operated with ICEs. Shift or automatic gearboxes are not needed in electric cars.

A study of the European automotive market by McKinsey has outlined that the following changes are expected to occur between now and 2020. The share of electric vehicles and plug-in-hybrids[48] in relation to the total numbers of cars sold in the market will range between 3% and 16%. The underlying assumptions for both scenarios are based on an average oil price over the period of 60 USD and 110 USD respectively. Bigger vehicles will not be significantly affected by this development. They will stick to conventional ICEs, optimized to meet the challenge of electric drive. These engines will be much smaller and lighter, but with the same performance characteristics as currently stands. Therefore, no changes are expected in relation to the biggest segment of the European automotive market - cars driven by ICEs - that will have a share of 77% and 60% respectively in 2020. Hybrids, such as the Toyota Prius, and mild-hybrids, that according to the McKinsey study will command a market share of 20% and 24% in 2020 respectively, use an electric drive to support the ICE and will require even more mechanical parts, gears and drives.[49]

Example for technological progress by co-operation and the strengths of EU manufacturers: There is a close relationship between manufacturers of machines and gears to solve machining problems. For example, Klingelnberg, a German machine tool manufacturer of machines for the production of bevel gears, developed machinery for bevel gears applied in rear axle drives of vehicles. This engineering success provided an opportunity to design light, low friction differentials that make significant contributions to fuel saving driving. While the European automotive industry is interested in the application of this innovation, US competitors are unconcerned.

The US industry is conservative and trusts in conventional solutions. Big is "beautiful" even in the design of drive components for vehicles. Resource saving has not become an issue. The US is lagging behind global progress in mechanical drive technology.

Technology

In addition to Europe, the most important drivers in technology are Japan, the US and Korea. Japan has remained secretive and information on research results can barely be assessed. An evaluation of the products in the market suggests that Japan is close to the European industry in terms of mechanical equipment, such as drives gears, spindles, cams etc. In electrical drives, related power electronics and controls, Japanese suppliers command a strong position in global competition.

The Koreans have been strong in shipbuilding and are strengthening their position in upstream industries. Hyundai Heavy Industries has taken over Kestermann, a German manufacturer of drives, know-how driven and specializing in large drive components.

Innovation in prime drives has made noteworthy progress in recent decades. Power electronics and controls have contributed to an automated and more accurate regulation of torque and revolutions per minute (rpm). This has had an impact on the drive industry. To a certain extent, mechanical parts have been replaced. Electronically controlled direct

48 Plug-in hybrides combine an electric motor with a range extender, an ICE of a fuel cell to recharge the battery or support.

49 Vieweg, H.-G. and Wanninger, C. (2010) „Perspektiven für die Gießereiindustrie – Update der Prognose Guss 2020", in: ifo Schnelldienst 1/2010, Munich, pp.12.

driven machines have been developed. In other applications the number of gears could be reduced. Generally speaking, three technological disciplines have been converging towards more integrated innovation processes: electronics, electrical and mechanical technologies. This development is reflected in the evolution of companies which have widened their expertise in electrical components and electronics, in R&D and manufacturing.

The subsector's success is based on the long-standing experience, quality and the state of technology. The most important drivers are close ties to universities, customer groups and suppliers. The EU is on the leading edge of technology and pushes the global progress.

In some areas mechanical parts have been substituted by advanced prime drives. However, this is a limited process. For example, large mechanical components for the transmission of high power, as used in power plants, ships and the like, will not be affected by this replacement.

At the moment a strong market view is on renewable energy, especially in field of wind-power onshore and offshore. Numerous EU players supply key components, only to mention some of them SKF, Schaeffler Group, SNR, Siemens, Hansen, Bosch, Eickhoff.

Developments in the wind power market and global competition:
Wind power is an old technology for power generation, but only in since the past two decades it has become more important due to progress in mechanics, electronics material technologies etc. It has grown strongly over the past decade and benefitted extensively from enormous subsidies for regenerative power generation. Typical for new technological areas is competition between different concepts. Two approaches have been mentioned:

- The wind turbine is linked to the generator by a drive. Low turbine rotary speed is transformed into high rotary speed driving a relatively small generator.
- The generator is driven directly by the wind turbine. The generator is a low-speed, large machine.

An in-between solution has been developed by Areva Wind GmbH by using a planetary gear with a mean gear ratio, dedicated to combining the advantages of both concepts. Both of these concepts have their advantages. The future will have to show which will succeed.

It is a highly competitive market. GE has developed and automated an electronic adaption system for wind power machines in order to automatically regulate the rotation speed. The electronic system and related electronic solutions have been protected by GE. GE strategically blocked the US market from competitors so as to apply electronic solutions to the problem. A European manufacturer has developed a hydraulic system for this purpose that can be applied in the US market and which will overcome the market access barrier.

Already in 1994 the European leader in direct driven wind power engines, Enercon, was the victim of US espionage supported by a US public agency.

The emergence of China as a competitor in advanced technologies has been strongly supported by industrial policy. In previous years, the market of drives for wind-power generation was fragmented. Around 10 manufacturers competed with each other. Public policies had contributed to a consolidation process. The few remaining firms are strong in needed technologies and face a market environment that allows them to grow and exploit economies-of-scale. The Boston Consulting Group's traditional market theory paradigm of "Profit Impact of Market Shares" (PIMS) has been applied – perhaps not directly from the textbook - by Chinese industrial policy to boost R&D through companies exposed to less contested, but profitable markets. Until now, Chinese wind-power generator manufacturers did not play a major role in the global market. One Chinese manufacturer, Goldwind, has launched a joint venture with the US company Timken in order to gain access to the American market which is growing strongly. This co-operation is important in order to access the market, which is strongly dependent on public funds.

Global market developments

Globalization has induced companies to develop global networks to better exploit promising foreign markets and to utilize comparative advantages in Europe and elsewhere. The utilization of comparative advantages has led to cross-border value chains for the procurement of intermediary products that are delivered from foreign subcontractors or the company's own production locations. Final products are manufactured within the EU and subsequently distributed. Another opportunity to exploit comparative advantages, that has become more important since the early 1990s, is the production of final goods overseas, whether through a company's own facilities or via foreign owned manufacturers. These products are imported by European manufacturers and sold through their distribution networks. This has raised some concerns from companies that have not yet adjusted their production networks to account for globalization. An initiative on marking products by the country of origin was not successful.

Regulation

The subsector's supply is predominantly intermediary products that are of crucial importance for the manufacturers of final goods' energy efficiency. The major challenge for the industry's companies from regulation is linked to the broad range of client industries. The directive ErP 2009/125/EC is setting requirements on energy-using products. The requirements have been specified for different product groups. Manufacturers of gears and drives typically deliver their products into many industries and have to take into account their clients' needs so as to meet the ErP' specifications for different applications. This a challenge in particular for smaller companies because they have to develop their products in compliance with different provisions.

EU standards are developed together with ISO and are accepted internationally. As a consequence technical barriers to trade are a minor problem. Some difficulties have been reported for exports to the US that gets its own way in standardization based on ASTM.

2.3.5 Lifting, handling and storage equipment

Demand side

The supply of the industry must be discriminated from lifting and handling equipment which is applied on construction sites, such as tower cranes, dumpers, etc. These products are dealt with under construction machinery, which is discussed below. The supply of the industry must also be discriminated from robotics and factory automation. This equipment is applied for the handling of work-pieces along production lines, the placement in and removal of work pieces from production machines, as well as the assemblage of products. These products are not under detailed investigation in this study.

This sector includes conveyor belts, cranes serial lifting gear (such as winches, electrical and pneumatic lifting platforms and trucks), rack-storage retrieval equipment, lifts and elevators and trucks for in-plant transport. Trucks for in-plant transport are all non-rail vehicles on wheels used for conveying, pulling, pushing or lifting loads, such as hand and pallet trucks. Beyond these products the subsector's supply comprises mobile elevating work platforms. These are self-propelled platforms, vehicle mounted platforms, trailer push-around, vertical personnel platforms, insulated aerial devices. The products of this sector are applied on production sites and in warehouses or distribution centres. Automation has been an important topic since the late 1980s. Services and system engineering have opened-up new business opportunities for manufacturing companies.

There are four quite distinct market segments. The first segment comprises materials for handling and lifting equipment in mining and quarrying, e.g. large conveyor belts for the transport of coal and other minerals. The second segment comprises lifts, escalators and conveyer belts for the in-house transportation of passengers, for instance in airports. The third segment comprises in-house transport and storing for manufacturing industries. The fourth segment comprises in-house transport and warehousing for service industries. It is quite obvious that all manufacturing industries need intralogistic services. The flow of material comprises not only transport and handling throughout the manufacturing process, but also the buffering of incoming goods in procurement storages, intermediary storages and finished goods warehouses. Even the supervision of the material flow and material stocks for clients is offered by companies of the industry, as well as the operating of intralogistic systems.

These developments are reflected in the wording "Intralogistics" that has been used to point to the fact that comprehensive solutions have been the subject of the industry's supply over the past several years. Intra-logistics is defined as follows: Complete turnkey systems focussing on automation, control and IT, and integration of several types of materials handling equipment into one system. Moreover "Intralogistics" discriminates the services of the industry from road-, rail-, ship- and air haulage that can be denoted as "Extralogistics".

The majority of important clients for the lifting and handling industry of the service sector are companies from the retail and wholesale industry. The industry equips warehouses with racks, industrial trucks and guided vehicles. Beyond the design of warehouses and the supply of hardware, the industry also provides the necessary software.

The industry's supply is indispensable in a globalized world. Regional and international hubs, harbours and airports are equipped with hardware like cranes, conveyors, industrial trucks, warehouses and the like as well as the necessary software tools based on system engineering. The industry's supply is of importance for manufacturing and service companies in order that they continue to increase efficiency in a world based on the division of labour within regions and between regions.

Supply side
The subsector 'lifting and handling equipment' has gained shares of total EU-27 ME production over the period under investigation. It increased from 7% during the late 1990s up to more than 9% in recent years. Driving factors for this above average growth were globalization, growing relocation and the expansion in division of labour in value chains. Since 1995 the industry had grown stronger than ME. After 2005 growth momentum accelerated up to more than 20% p.a. on average. However, the financial crisis hit the sector harder than any other subsector of ME under investigation in this study. It will take some years until former levels will be reached once more. Strong growth in employment, in particular during the years after 2005, has contributed to a worsening of the economic performance. In spite of strong output growth, productivity only increased slightly. Unit-labour costs and the GOR degraded. Much of the improvement in economic performance was depleted during that phase of 2010 (
Table 2.15).

As defined by NACE Rev. 2 the subsector comprises lifting and handling equipment. However the supply of the subsector goes beyond these products. It also comprises storage equipment such as containers, racks and other articles necessary for warehouses and storages. The European sectoral committee (ESC) of the subsector, FEM, publishes these figures on its Website.[50] Total EU production value in 2008 came up to € 73.0 mln. Thereof € 8.5 mln comprised repair and maintenance. The remainder of € 64.5 mln concerns containers, racks etc. that are part of the subsector's supply, but are not contained in the sector ME as defined by NACE Rev. 2.

[50] FEM. Statistics 2005-2009. European Materials Handling Federation, Brussels, http://www.fem-eur.com/data/File/FEM%20stats%202005-2009%20(final).pdf

Table 2.15: Key figures for the manufacture of lifting and handling equipment C2822

Sector	Indicator	2008		Annual average growth rate in % 1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2822			59	4.5	3.8	21.0	-16.2
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2822			55	3.2	2.6	18.4	-16.3
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2822			17	2.5	1.2	9.9	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2822			291	-1.9	0.4	7.9	
Total ME	Gross operating rate[1)]	%	14.2	0.2	-0.2	1.5	
C2822			14.8	3.3	-1.0	-7.1	
Total ME	Productivity[2)]	€ thsd	55	4.0	2.6	4.1	
C2822			57	4.5	0.7	1.8	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2822			31	2.6	1.6	3.9	
Total ME	Unit labour costs[3)]	€ / €	0.582	-0.3	0.5	-0.5	
C2822			0.540	-1.8	0.8	2.0	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The structure of the supply side is extremely heterogeneous. In some areas, such as mining and quarrying as well as harbour equipment, heavy industry products are manufactured, for example large cranes and conveyors. The Finish Kone is a global leader in these markets that benefits from the industrialization and urbanization of emerging economies. Its product programme also contains escalators, conveyors and lifts dedicated for residential buildings, office buildings and hubs for in-house passenger transport. In this area the company is competing with Otis, a daughter company of the US technology group UTC and the German Thyssen-Krupp.

In line with the improved global economy and good funding conditions, companies have been eager to improve their strategic position in the market. A growing number of biddings and takeovers have been observed. Manufacturing companies in emerging markets are being taken over in order to exploit cost advantages and increase local content in regions with high growth potential. Simultaneously, these heavy industry companies are expanding their supply of services. More and more comprehensive intralogistic systems are offered to clients, after-sales services are improved and even services linked to the operation of hubs are carried out. As a consequence of this strategic reorientation, those heavy industry companies - that are about to penetrate into service markets – are eagerly acquiring small, specialized service enterprises that have been working in relevant market niches.

Large series are manufactured in the market for industrial trucks. This market segment is dominated by big groups such as Toyota (JP) and others that exploit economies-of-scale. Over the past decades consolidation has taken place in the industry. The German technology group Linde was one of the drivers behind this development, with takeovers already occurring during the 1980s and 1990s. In 2006 the brands Linde, Still and OM merged. The new holding company, KION, was purchased by KKR and Goldman Sachs. Companies that have not had the opportunities to compete by scale effects have been specializing as system suppliers, e.g. for high rack warehouses, including stock management systems. For other serial products[51], such as travelling cranes, the market environment is quite similar. The products are manufactured in large quantities and distributed worldwide.

Manufacturers of the manifold of parts and components, such as the racks, containers and barrels needed for the construction of intralogistic systems, are suppliers in the value chain. They are specializing in certain applications or build their reputation on intelligent solutions or well-priced products. The industry regards them as an indispensable part of "Intralogistics". However, the industry, as defined by NACE Rev. 2, does not contain the output of these companies.

Procurement

The companies that manufacture handling and lifting equipment for harbours, mining and quarrying need large parts. Traditionally these parts are manufactured in-house. Over the past decade changes have been observed and production has been relocated, predominantly to locations in Asia, some of which are self-owned. By definition this is in-house production, but it is no longer in Europe.

Generally speaking, the industry needs a broad variety of different parts and components. As far as key-know how components are concerned, in-house production has remained of importance. Other parts, such as conveyer belts, bearings and engines that ask for a certain manufacturing know-how are procured from specialized suppliers. But there remain numerous parts and components for the assemblage of intralogistic systems that are price sensitive because requirements on quality and processing know-how can be met by subcontractors.

During the 1990s many of these parts were outsourced to Hungary, Poland, the Czech Republic, and the Slovak Republic. However, these countries have become more expensive. Relocation to Romania and Bulgaria has occurred. In recent years even Belarus and Ukraine have become locations for the procurement of these parts and components.

For those companies that have become suppliers of comprehensive intralogistic solutions software engineering is crucial. It is decisive for the performance of systems and contains key know-how. To a large portion these activities are carried out in-house, but the development of software modules has been relocated. There are some opportunities in Europe, above all in the Baltics and in Bulgaria. Indian companies play an important role

[51] Standardized products, variations of these products are defined by the manufacturer only and not by the customer.

as subcontractors for software development. India is also of importance as a location for the remote control of operations. For example, one company in the material handling and lifting industry, that is strongly involved in the contracting business and operates systems for its clients, uses the basic qualifications of its staff located in India to oversee the surveillance of intralogistic systems installed around the world.

Business cycle

The industry has been hit extremely hard by the financial crisis. Industrial trucks were the most affected, with a breakdown of output by 46% in the western EU member states (not accessed 2004 and beyond). Manufacturers of these products suffered early in the downswing cycle. Other handling materials were not substantially affected, but lost on average around 40%. Large scale equipment, such as cranes for harbours and conveyors for mining and quarrying did not suffer likewise.[52] This has been caused by order backlogs and long lead-times that cushioned the downswing. Due to the early recovery and strong, growing demand for minerals, mining companies have to further expand their capacities. Most of the heavy industry companies did not suffer much from the global recession.

Some of those “intralogistic” companies that have expanded their supply into services enjoyed a stabilizing effect. After-sales services, maintenance and repair are not significantly exposed to investment cycles and can count on a smoother development of demand over time. In particular, companies who are working as contractors for their clients have done pretty well during the crisis.

Long-term demand

The prospects of the industry are above the average for ME. It does not only benefit from the demand of strong emerging economies but also from globalization and the growing international division of labour. For decades, cross-border trade and passenger traffic have been growing at rates much stronger than global GDP. In line with this development, hubs have to be permanently extended and new facilities are erected around the world. The urbanisation in emerging economies is another driver for deliveries to the construction industry.

Globally, the European materials handling, lifting and storage industry is leading through its ability to manufacture highly innovative and competitive equipment to agreed high technical standards, safety at work place and regulatory requirements. Intralogistic systems have become an essential driver in the case of larger projects, by enabling efficiency gains and energy savings thanks to tailor-made engineering solutions.

Technology

Basic research is not an important topic for the lifting and handling industry’s companies. The focus is on system engineering, the solution of clients’ individual problems and the development of industry specific applications. The expenditure for these activities come up to between 3% and 4% for those companies that are strongly involved in the supply of complete intralogistic systems and which offer comprehensive services. Other companies

[52] Due to statistics of the subsectors ESC, FEM, the breakdown of repair and maintenance was more pronounced than the production of equipment indicating that clients delayed these activities during the crisis. See: http://www.fem-eur.com/data/File/FEM%20stats%202005-2009%20(final).pdf

in the industry – in particular those that manufacture serial products[53] in large quantities – are significantly less engineering intensive.

Global market developments

During the 1990s access to the US market was difficult. In publicly funded projects 'buy American' clauses hampered the access of European companies. Since then, discrimination has lost some of its former importance. Other problems for the European handling and lifting industry have emerged from clients' behaviour and preferences. Automation and high-rack warehouses were not in focus in contrast to developments in Europe. This has changed in the recent past. US companies mention demography and an insufficient supply of qualified personnel as explanations for driving investment in more sophisticated intralogistic systems.

The US lifting and handling equipment manufacturers are upbeat on their perspectives. Their perception might be overestimated by the current recovery of the US manufacturing sector that is interpreted by some experts as a reindustrialization of the economy. More tangible is the extension of the Panama Canal that can stimulate the trans-Atlantic trade that has lost some of its former importance to the trans-Pacific trade. Deliveries will be shipped directly through the channel to the US east coast. Transport costs for European products will be markedly reduced, although the capacities of east coast harbours have to be increased accordingly.

Generally speaking, Africa is less important, but demand from South Africa for handling and lifting equipment has been growing noteworthy. Initial stimulus was caused by the soccer championship. The infrastructure, such as airports, harbours and the like, had to be developed for the event. Since then South Africa has remained an important market. For the setup of subsidiaries, it is indispensable to comply with antidiscrimination provisions.

[53] Standardized products, variations of these products are defined by the manufacturer only and not by the customer.

As an indication for global developments in the market for material handling and lifting equipment, the evolution of industrial trucks by large regions is taken as an example.

The so called BRIC have become the most important market by size and growth momentum for industrial trucks today. China is by far the largest Asian market. The global sales of industrial trucks in Asia have reached 40%, whereas the Western European share was 28%. These figures are based on sold units. As calculated by market value the discrepancy is not that large. European industrial trucks are – on average more technologically advanced and have to comply with high safety and environmental standards.

The Asian growth potential is much higher than Europe's. Economies, such as India are about to follow suit China's development of industrialisation and become important markets for industrial trucks.

South America with its by far largest market Brazil is growing strongly, 2010 threefold the numbers of 2000 were sold 2010. In spite of its share of only 4% in 2010 the market is supposed to gain much importance in a couple of years.

Turkey, the emerging economy between Europe and Asia has enjoyed the highest growth rates of all nations with close trade relations to the EU. It is about to overtake Poland maybe soon, the 2nd largest Eastern European market for industrial trucks after Russia. Since Turkey has adopted EU legislation such as machinery directive, European manufacturers should be well positioned to satisfy the demand for industrial trucks.

Region	Share of global sales
Western Europe	28
Eastern Europe	5
North America	15
Central America and Caribbean	1
South America	4
Middle East	3
Asia	40
Africa	2
Oceania	2

Source: World Industrial Trucks Statistics (WITS Report 2010, European, US, Brazilian, Chinese, Korean, Japanese manufacturers).

Beyond these specific aspects of market developments, Asia will remain the powerhouse of the market for lifting and handling equipment in terms of both size and growth perspectives.

Regulation

Single Market

The European materials handling industry is affected by numerous European Directives and Regulations in the fields of internal market (Machinery Directive, Exhaust Gas Directive 2000/25/EC and Noise Directive 2000/14/EC for non-road mobile machinery

(NRMM), health, safety and environmental directives, such as WEEE, RoHS, REACH. The ESC of the industry, FEM, is involved in standardisation work, in particular by producing technical recommendations that provide guidance for the design, construction and use of safe, sustainable, energy-efficient and ergonomic materials handling equipment.

An important regulatory challenge lies in the need for coherence among different pieces of EU legislation affecting the same product. The Exhaust Emissions of NRMM Directive and the Outdoor Noise Directive provide a classic example. These Directives set limit values in stages for exhaust emissions and noise, respectively, and they affect the same product groups: industrial trucks, certain types of cranes and mobile elevating work platforms. Implementing the two sets of requirements simultaneously is source of great technical difficulties. Whereas both Directives are to be revised in 2012, some level of coordination would be necessary to avoid complications that will eventually negatively impact on companies' competitiveness.

The other regulatory challenge European materials handling companies are faced with is not related to legislation itself but to its enforcement. FEM highlights that the industry is fully committed to implement and respect European regulatory requirements and to make the necessary investment, but in return, effective and efficient market surveillance must be in place to combat the proliferation of non-compliant or counterfeit equipment. The current state of market surveillance leads to unfair competition with non-compliant suppliers. It poses serious safety threats on machine operators and environmental hazards. It hinders European companies' competitiveness by negative effects on the ability to innovate and can ultimately threatens employment. FEM has perceived similar problems with market surveillance as other ESCs and has raised the issue at European level with a view to putting more efforts into market surveillance, in particular for capital goods, which have suffered from a certain lack of focus compared to consumer products.

Access to foreign markets

There are some non-tariff barriers that will be erected by some countries that hamper free trade. ISO 3691, a standard agreed worldwide describing safety requirements for industrial trucks and which is about to be published (but already known worldwide in its current pre-version ISO FDIS 3691) will be adopted by CEN as EN standard giving presumption of conformity soon. Regardless of ISO 3691 as a standard agreed worldwide, some countries such as the US or China do not accept industrial trucks in compliance to ISO 3691 to be put on their market. China for example is requesting type test approvals by third party organisations (AQSIQ) as a precondition for placing industrial trucks on the market. Not accepting standards agreed worldwide and imposing obligatory type test approval are non-tariff trade barriers challenging the competitiveness of EU manufacturers which contributed a lot into the creation of ISO 3691 over the past years.

The EU industrial truck manufacturers benefit from a number of free trade arrangements in place between the EU and other countries. Further negotiations are ongoing with India, Singapore, Malaysia, Canada, Ukraine and the Mercosur-Countries. Some of these countries might in the future be highly significant markets for industrial trucks manufactured in Europe. But for a number of important economies, such as North

America, China and Brazil no bilateral, free trade agreements are not in place and EU manufacturers fear the threat of tariffs on industrial trucks to be introduced by these countries.

2.3.6 Non-domestic cooling and ventilation equipment

Demand side

Most of the industry's products are applied in construction, for example in residential and office buildings, as well as in manufacturing sites and wherever heating, cooling and air conditioning (AC) are needed. Traditionally, the parts and components that are manufactured in the industry are procured by construction companies and engineering firms specialized in heating, cooling and AC-systems. A third category of clients concern contractors that install and run such systems for real estate owners.

Specialized subcontractors to the automotive industry supply equipment for mobile AC-applications. The dissemination in passenger vehicles has contributed much to the acceptance of AC in residential buildings in Europe, in particular in southern countries.

A third business area exists with cleanroom equipment. It is not of importance in terms of volume but is challenging as regards the requirements on the number of particles per cubic metre of air. There are enterprises that have specialized in the design and equipment of adequate systems that are widely used in wafer and chip production, as well as in other high-tech research and production facilities.

Supply side

The subsector 'non-domestic cooling and ventilation equipment' has gained shares of total EU-27 ME production over the period under investigation. It increased from less than 5% during the late 1990s up to more than 8% in recent years. One long-term driving factor was the growing need for an improved working environment in office buildings and industrial plants. A second factor was the need for higher standards of living in residential buildings and, in particular, the demand for AC. The real estate boom in some Member States has pushed the growth of the industry, particularly between 2005 and 2008. The financial crisis and the breakdown of the real estate bubble hit the industry, but this was bolstered by a more steady demand in other Member States. Strong growth in employment over the whole period - and in particular during the years following 2005 - had undermined economic performance. Labour productivity growth was well below the average of ME. Unit-labour costs and the GOR degraded (Table 2.16).

Table 2.16: Key figures for the manufacture of non-domestic cooling and ventilation equipment C2825

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2825			50	7.7	6.9	20.8	-8.5
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2825			45	6.2	4.9	16.6	-9.1
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2825			14	3.3	5.4	8.9	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2825			258	1.9	3.0	7.4	
Total ME	Gross operating rate[1)]	%	14.2	0.2	-0.2	1.5	
C2825			14.6	-3.0	2.5	-4.2	
Total ME	Productivity[2)]	€ thsd	55	4.0	2.6	4.1	
C2825			52	1.4	2.3	1.4	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2825			30	3.0	2.8	2.7	
Total ME	Unit labour costs[3)]	€ / €	0.582	-0.3	0.5	-0.5	
C2825			0.576	1.6	0.5	1.3	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The industry's product programme comprises of, above all, serial products[54] that are procured by clients for the construction of heating, cooling and AC-systems. As a result, services to clients are primarily provided in the area of after-sales, such as maintenance, repair and the training of operators. Their share of total turnover was estimated by industry experts to be around 10%.

Mergers and acquisitions in the industry have been observed in recent years.[55] Some have resulted in a consolidation through the takeover of smaller firms by larger manufacturers. Market shares have been acquired through the exploitation of already existing distribution channels and the reputation of regionally well-known brands. Other takeovers are directed to become full-hand suppliers. These activities are understood as initial steps towards the supply of complete systems, a trend that incorporates the potential to change downstream linkages.

54 Standardized products, variations of these products are defined by the manufacturer only and not by the customer.
55 A detailed analysis of initiatives in parts of the market is available in: for gas appliances, see: Vieweg, H.-G. et al. (2009a) "The Competitiveness of the EU Gas Appliances Sector", Rotterdam, pp.50.http://www.sectorcompetitiveness.com/index.php/sector-competitiveness-studies

In the market for AC numerous firms exist in southern Member States of the EU, namely in Spain, France and Italy. They have benefitted extensively from strong regional demand. However, in general, it has been noted that smaller firms serving local southern markets are suffering from growing competition. Their advantage of having close contacts with their clients is dwindling. They are challenged by larger companies that tap into these markets. Moreover, they are challenged by European legislation that is directed towards achieving a more sustainable economy. Tough limit values on energy efficiency can only be reached by noteworthy research efforts. Smaller firms often cannot raise the needed resources.

Currently the downstream linkages to the sales markets are changing. Traditional real estate operators owned technical capacities to run heating, cooling and AC-systems. More and more operators now outsource these services to specialized companies. Simultaneously contractors that design and run such systems for their clients are reducing their technical staff and are becoming more dependent on manufacturers' after-sales services.

These demand side developments provide some leeway for a strategic redirection of manufacturers. They can offer clients additional services to fill in their widening knowledge gap. In addition to traditional after-sales services, and on top of installation and set-up, they can provide the supervision and permanent control of heating, cooling and AC-systems. Through such a development the manufacturers could reduce their dependency upon clients' investment cycles and gain a steadier cash-flow.

As compared to some companies in the pumps and compressors industry, services in this domain are far less developed and are yet to become important business areas. To what extent this is feasible has to be determined by the individual company. However, strategic mergers and acquisitions undertaken by companies in order to become full-hand suppliers could be, as highlighted in interviews, a first step towards the development of full service oriented manufacturers that exploit business model opportunities related to contracting and BOT. In the long run manufacturers could become investors themselves in the real estate sector. If this is perceived as a business model by some manufacturers, they will become contractors that supply heating, cooling and AC-services. Their service orientation will be similar to those of contractors in the compressor industry.

Procurement

The industry needs a broad range of intermediary products, such as fans, electric motors, filters, funnels, controls, taps, valves, manometers, flow control units, taps valves etc. Most of these components are procured from European firms. Frequently, metal sheet parts and steel constructions are procured from new Member States and eastern Europe. Electronic components and sensors originate from Asia. US firms command a strong position in the global market for controls specialized in heating, cooling and AC. Firms such as Honeywell and Johnsons Controls have large stakes in the European market and have their own production and research facilities in the Single Market.

Business cycle
The industry was hard hit by the financial crisis in 2008. Above all, those countries that experienced a real estate bubble were affected the most. Spain and Ireland have not yet recovered. The other European markets are in an upswing cycle. Since 2010 the industry's output has increased, but has remained well below former heights. Companies expect to achieve former levels in 2012 at least.

Long-term demand
In recent years the market for heating, cooling and AC has benefitted from investment in replacement, a development driven by the need for greater energy efficiency. More efficient gas appliances played an important role. In southern countries the demand for AC has increased markedly. As regards more recent times, developed and optimized process technologies, such as cogeneration heat pumps etc., will pull demand in the years to come. These drivers will be of importance in the long-run for market growth, whereas demography will put a brake on capital-widening investment within the EU. Additional growth can only be expected in light of consumers' interest in improving the indoor climate. In emerging economies urbanisation will be the most important driving factor.

Technology
Technological progress of the industry is strongly dependent on the combination of different disciplines and is directed towards the creation of a convenient atmospheric environment. Simultaneously firms strive for a highly efficient heating, cooling or AC-system. On the one hand efficiency means a careful use of energy for heating, cooling and AC. On the other hand efficiency means the careful use of energy within the heating, cooling and AC-system itself, that is necessary to drive electric motors, fans, taps, valves etc. The major challenge for companies is linked to the fact that a stand-alone optimization of components does not necessarily result in an energy-efficient and optimized heating, cooling or AC-system.

Global market developments
There is a market segment for small standardized AC-equipment. It is characterized by substantial competition on a global scale, led by Asian and US companies that command large shares in the European market.

Most heating, cooling and AC-systems are built in buildings, a market that is regionally fragmented and in which customized solutions are predominant. Many of the parts and components, such as funnels, are bulky and not traded over long distances. They are procured locally. Interregional trade is observed only in relation to more sophisticated components, as for is the case with pumps, taps and valves. Global trade and competition mainly occurs in the market for controls and sensors.

Regulation
Technological progress of the industry is of major importance for the success of European efforts to reduce CO_2 emissions related to heating, cooling and AC. Of major importance is the ErP which requires products to be energy efficient. The ErP simultaneously concerns each individual component of a heating, cooling and AC-system and the system as a whole. As a consequence, experts mention that problems have arisen due to conflicting specifications. Moreover, the heating, cooling and AC-systems have to be

evaluated together with their final destination in a building. The overall energy efficiency of a building has to meet the provisions of the Energy Performance and Buildings Directive (EPBD). Such an assessment can induce additional requirements on a heating, cooling and AC-system that, on a stand-alone basis, meets all of the relevant EU provisions. This can have an impact on the free circulation of products in the Single Market, a reality aggravated by the fact that Member States are allowed to introduce tougher limit values than those imposed by the Commission.[56]

2.3.7 Agricultural and forestry machinery

Demand side

The customers for these machines are to be found almost exclusively in agriculture and forestry. Sales to municipal authorities play a subordinate role and sales to do-it-yourself customers are even less important. In particular, the latter market segment comprises a lot of products manufactured outside the EU. Most of the agricultural machinery is sold to clients via specialized dealers who are performing maintenance and repair services for their clients. Only large agricultural contractors and municipalities purchase directly from manufacturers. One important subsector is the gardening, forest and turf machinery which distributes to both the professional market via dealers and the consumer market via do-it-yourself channels.

Supply side

The manufacture of agricultural and forestry machinery is one of the smaller subsectors of EU-27 ME. Its share of total production was around 6% in 2008. It has only slightly increased over the period under investigation. From 2000 onward the pace of growth was of the same magnitude as for ME. Manufacturing depth only comes up to 25% as measured by the ratio of value added and production. Over the period of investigation it shrunk by a noteworthy extent. Wages are much lower than the ME average. They fall below the average of ME by 20% and productivity is only 10% lower. However, wages grew much stronger than productivity and contributed to a worsening economic performance. Unit-labour costs grew strongly whereas the GOR declined (Table 2.17).

[56] Vieweg, H.-G. et al. (2009a) "The Competitiveness of the EU Gas Appliances Sector", Rotterdam, pp.91.http://www.sectorcompetitiveness.com/index.php/sector-competitiveness-studies

Table 2.17: Key figures for the manufacture of agricultural and forestry machinery C283

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C283			38	8.7	2.4	11.0	-12.1
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C283			35	6.2	0.1	8.0	-13.5
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C283			9	3.6	-1.4	4.1	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C283			180	-0.7	-1.0	1.7	
Total ME	Gross operating rate[1)]	%	14.2	0.2	-0.2	1.5	
C283			13.0	-2.0	-1.5	-4.0	
Total ME	Productivity[2)]	€ thsd	55	4.0	2.6	4.1	
C283			49	4.4	-0.4	2.4	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C283			26	6.2	1.9	5.6	
Total ME	Unit labour costs[3)]	€ / €	0.582	-0.3	0.5	-0.5	
C283			0.526	1.8	2.3	3.2	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The market environment within the agricultural and forestry machinery industry shows major differences. Tractors are serial products, manufactured in – as compared to most other product groups of this subsector - large quantities.[57] Manufacturers are strongly interested in the exploitation of economies-of-scale. The global market is dominated by big players that command stakes in all the important sales markets. The market for harvesters shows similar characteristics. Big players primarily shape the supply side. Strategies to gain market shares play an important role in ensuring companies gain an edge over their competitors. Cost degression favours the establishment of large companies which dominate both of these market segments.

In relation to the majority of the rest of the agricultural machinery, the market environment shows different characteristics. It comprises machines and devices for working the soil, such as seeding and drilling, for plant care, harvesting, fertilizing, milking, animal husbandry and transport of produce. Beyond the manifold tasks in the agricultural production and processing sector that require a broad range of machinery and equipment, regional particularities and traditions provide an explanation as to why the

57 The total European tractor production is between 200.000 and 250.000 units per year split on different manufacturers. There is a huge variety of models with different specifications leading to often low quantities produced per model. Accordingly tractors today are only build on demand - not on stock – in specific versions for each customer, that do not only vary in simple options like cars, but many factors.

market environment is considerably less homogenous. There are opportunities in the market for smaller, specialized companies that are closer to their clients and better placed to know their needs in comparison to the large, globally active groups.

During the past several decades important changes have taken place among the industry's global players. A good example is provided by AGCO, an industrial holding created by a management buy-out of Deutz Allis from KHD in 1990. In an initial public offering in 1992 of one-half of its stock, the company became listed on NASDAQ. Since then it has grown through acquisitions and has become one of the global leaders in agricultural machinery. It owns numerous important brands, such as Massey Ferguson (US), Valmet (brand changed to Valtra) (SF) and Fendt (DE). Fiat has always held a large stake in the sector. In 1991 it acquired New Holland B.V. from Ford Company. The merger of Case IH and New Holland under the umbrella of the Italian Fiat group has created an even larger player in the global market that is able to exploit synergies and has better access to the US market, by far the most important market worldwide. On 1 January 2011 Fiat demerged its automotive and industrial business. Since then the agricultural branch is part of Fiat Industrial and, together with construction machinery, constitutes part of the CNH business division. As underscored by the presence of the US manufacturer John Deere, who has become an important supplier to the agricultural sector since more than 50 years, with its European headquarter in Germany and production sites, research facilities in numerous European countries. The strengths of Japanese groups in the EU lie in the supply of small machinery and equipment, e.g. small tractors for agriculture, gardening and municipal applications. Large family owned companies are an exception in the market for tractors and combined harvesters. In other market segments large family-held groups are of importance with global reach, such as the German Claas KGaA, by far the largest group, and Krone, the Italian Same-Deutz-Group and Argo-Group, the French Exel-Group and Kuhn-Group and the Norwegian Kverneland.

Procurement

Many of the industry’s final products are complex systems and comprise numerous subsystems, as for instance a tractor with its engine and the drivers cab etc. In recent years more and more sophisticated electronic systems have become part of state-of-the-art agricultural machinery. Different strategies in relation to value chains are being pursued by the companies. Some focus on ensuring the comprehensive in-house production of certain key components. Some manufacturers develop and produce their own engines, whereas others procure engines from specialized companies that deliver ICEs to a broad range of industries. In any case, the procurement of parts and components is crucial to the success of companies.

Engines and drivers’ cabs are procured by specialized subsystem suppliers. Most of them are located in the old Member States. Welded parts and castings are to a large extent subcontracted, and, following the breakdown of the Iron Curtain, are procured from central European states that have become Member States of the EU since 2004. In recent years, the industry for agricultural machinery has shifted procurement further eastward to lower prices of purchased parts and components. Growing wages within the new Member States are drivers for relocation. These days Ukrainian and Russian firms have become partners in the industry’s value chains. The integration of Turkey into the value chain for the delivery of mechanical parts has to be mentioned. This country is not only a location for production but also one of the fastest growing sales markets.

Deliveries from Asia comprise mechanical parts and components, in particular from China. Japanese firms supply high-tech hydraulics and electronic equipment.

Business cycle

The demand for agricultural and forestry machinery is strongly dependent on Farms' income – which is to a large part decoupled from general business cycle. The income is strongly influenced by external variables, such as agricultural policy, weather and public policies, for instance on energy and environment. Likewise structural changes in European agriculture driven by CAP and the trend to larger farms affect income and investment behaviour in the agricultural sector. The agricultural and forestry machinery industry suffered a major breakdown in demand during the global crisis. The supply of funds for investment had dried up, although the credit worthiness of clients did not deteriorate. Of the exports markets, the demand from Russia was most affected by the crisis. This added to the worsening of the business environment in Western Europe as Russia is a market of outstanding importance for European manufacturers of agricultural machinery and equipment.

As soon as the acute crisis had faded away, access to the financial market improved and the demand for agricultural machinery soared. Output subsequently grew strongly, driven by piled-up investments, and has already reached former heights. The clients' financial situation is regarded by machine manufacturers as being as good as it was before the crisis. However, manufacturers' output has failed to already reach former heights by a considerable amount.

The subsector "Garden, forestry and turf machinery" is recovering slowly from the crisis while simultaneously competition from China has been increasing.

Long-term demand

In the past, the demand for agricultural machinery in the EU resulted almost exclusively from replacement requirements. The long service life gave farmers great latitude time-wise for investing in replacements. All the uncertainty on possible future developments in agriculture led to investment decisions being delayed for a lengthy period. The industry experienced poor growth and perspectives were subdued. In recent years this has changed for the better. Soaring global demand for food and policies directed towards climate protection have provided new opportunities for investments in the agricultural sector. The long-term growth trend has improved in recent years. The production of renewable primary products has contributed significantly to a brighter long-term outlook.

Two drivers for the long-term demand are decisive

- *Global demand for food:* need to produce more food for a growing global population and the demand for higher quality food and more meat.
- *Renewable energy production:* In regions where there is sufficient agricultural land for an efficient production the land will be applied for renewables. This is a topic mainly in developed markets especially in Europe, North- and South-America.

All in all global prospects for strong growing demand in agricultural machinery are very good – especially outside the EU.

Interest in turf care, creation of green spaces, smart irrigation and protection of ecosystems are providing new opportunities for the subsector which is continuously developing innovative products and using new power sources like lithium batteries. This activity is underpinning future opportunities of the segment “garden, forestry and turf machinery”.

Technology:

Traditionally technological development within Europe was driven mainly by demand for high-productivity solutions for comparably small Western European farms and very high requirements regarding operational safety. The past decade has led to a trend to provide sophisticated technology also for large-scale farms and the introduction of electronics into all areas of agricultural machinery. The use of the global positioning system (GPS) has enabled guidance and steering systems for more accurate field work but also a more exact monitoring of yields and by this the computer-aided more efficient use of input factors like water, fertilizer and pesticides. Also it ensures the consistent tracking of all relevant information as requested by the Common European Agricultural Policy (CAP) and food security. The combination of tractors and different attached equipment made the introduction of electronic communication between different components and machines from differing manufacturers a key challenge. Interfaces have been defined and technologies developed. The specific needs regarding an extremely fast availability of parts and services during harvest-time has led to a focus on a very efficient after-sales business and online surveillance of machinery even mobile machinery.

Environmental regulation has become an important topic for R&D. The major challenge is the reduction of engines’ exhaust gas (Directive 2000/25/EC). The noise reduction of outdoor machinery (Noise Directive 2000/14/EC) is only of importance for few product groups. It was reported by interviewees that the share of activities designated for environmental protection out of the total research expenditure in the agricultural tractor segment has reached a level of more than 50%. One company even mentioned a share of 70%. This is valued by manufacturers as a cost factor that has to be brought into account for clients, although they do not benefit in an economic sense adequately from these innovations.

Global market developments

Growth of the global market is driven by soaring demand for food and the improvement of human nutrition. This adds to new markets for renewable primary products. Regional differences in demographic developments and welfare creation are drivers of demand for machinery. Emerging economies are the most promising markets for growth by volume. Mature economies do not have similar perspectives, although a certain amount of growth will be driven by efforts to render agriculture more sustainable.

Regarding large overseas markets China and India provide promising prospects. Until today both markets are dominated by simple low-tech solutions manufactured in large quantities by local industry. The introduction of efficient European large-scale technology could contribute to a considerable increase of agricultural production, necessary to improve the level of self-sufficiency.

The large global players from Europe and the US have tapped into all of the promising markets to manufacture and sell their products, focusing above all on complex serial machinery, such as tractors, harvesters and so on. However, specifics in regional production, soil, products and traditions provide room for local suppliers who have the requisite knowledge and close relationships with their clients. For smaller European agricultural machinery manufacturers many of these remote markets are out of reach. However, eastern Europe has always been of importance and even smaller companies command noteworthy shares in this region.

Turkey, North Africa and Arabia are markets that provide growth potential for smaller companies. Due to the European Mediterranean Association Agreement (EMAA) access to North African markets has been eased. There are many local manufacturers in Turkey that also cover well the Middle-East. So there is only room for smaller EU companies with specific know-how for niche products, like potato harvesters, irrigation equipment etc.

Market access barriers

Russia is of importance for EU manufacturers, but they face some problems in market access. Imports from Europe are hampered by customs tariffs and exclusion from subsidized finance to protect national Russian manufacturers. Most of their clients have to externally finance their purchases. The usual funding is through public sources. However, these funds are only made available in case of local content. As a consequence, European manufacturers start building production facilities within Russia.

It was also reported that similar trade barriers exists in Latin America, namely in Brazil.

Regulation

The most important directive for mobile machinery and tractors is the exhaust gas Directive (Directive 2000/25/EC). The outdoor noise directive (Directive 2000/14/EC) is not relevant for most agricultural machines, except for lawn mowers and some specific machines. Both directives are – where applicable - perceived as challenging and ask for comprehensive research activities. For the safety of operators of mobile machinery has to comply with the vibration directive (Directive 2002/44/EC).

For tractors there is a sophisticated set of type-approval legislation covering safety (occupational and road) as well as environmental aspects. This system is of extremely high importance for tractor manufacturers. There is a tendency within the EU institutions to more and more copy requirements from the automotive sector to the tractor legislation, which creates a lot of technical and legal challenges, as tractors are not built for transport only and are not sold to consumers. Especially the introduction of the car distribution and maintenance requirements via the type approval procedure endangers the functioning system for tractors.

The industry requests a global harmonization of requirements and contributes to this objective via ISO standards. The industry is also involved in work on UN-ECE and OECD. The EU should recognise the efforts by applying harmonized solutions. This would also contribute to the EU manufacturers' global competitiveness.

For off-road machinery, free circulation in the Single Market is hampered by non-harmonization of road approvals within the EU, there are problems with market surveillance. For both issues see Chapter 2.3.8.

2.3.8 Machinery for mining, quarrying and construction

Demand side

The customers for these machines are to be found in three different market segments. The first market segment is construction of buildings and civil engineering. Drivers for buildings are on the one part residential buildings which are dependent mainly on the general economic climate, interest rates and – in the long-run – social and demographic trends. On the second part non-residential building activity (offices, factories and warehouses) is driven by business cycles and interest rates; in the long-run capacity utilization, growth trends and – in recent years – speculative expectations. Civil engineering is strongly dependent on public expenditure for the creation and upgrading of infrastructure. In the developed world the demand is above all dependent on replacement and refurbishment. Additional demand can be expected from waste recycling, water treatment etc. However, tight public budgets and the crises in some member states dampen prospects.

The second market segment comprises machinery and plants for the manufacture of building materials. There was a strong demand in some developed economies, such as the US, Spain and Ireland in recent years. But the development was driven above all by real estate bubbles and has come to a sudden end. In contrast, a long-term demand for building material machines and plants comes from emerging economies. The build-up and upgrading of infrastructure, as well as growing urbanisation, necessitates a permanent expansion of capacities for building materials.

The third market segment is mining and quarrying: This segment is dedicated to mineral extraction of all kinds. This is a global business that has gained much importance over the past decade. Until then many of the mineral markets had been characterized by sufficient supply and price pressure. Since then strong global growth momentum has led to bottlenecks and hefty price increases. Access to mineral deposits has become a topic of national strategic interest. In some mineral markets consolidation has taken place and few players dominate the global market. This has not yet had much impact on machine manufacturers because demand drives investment in exploration and extraction. However, during a slowdown the clients' purchasing power could have strong negative effects on machine manufacturers.

Supply side

The subsector 'mining, quarrying and construction machinery' has grown only slightly better than the EU-27 ME average. Its share of 5% during the late 1990s has increased to approximately 6% in recent years. In the long run it had benefitted from strong demand for construction and civil engineering in peripheral countries of the Community and, after 2005, the acceleration of the real estate bubble in Spain, Ireland and the UK led to soaring demand for construction machinery. In comparison to output growth, the creation of workplaces was only moderate. From 2000 onwards unit-labour costs decreased and contributed to an improved economic performance. To a certain extent the industry shows some structural similarities with the subsectors for agricultural and forestry machinery. The manufacturing depth, as measured by the ratio of value added and production, is only 26% and wages are on average lower, but around only one tenth (Table 2.18).

Table 2.18: Key figures for the manufacture of machinery for, mining, quarrying and construction C2892

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2892			44	8.4	4.4	20.1	-11.5
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2892			40	6.9	3.1	16.3	-13.3
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2892			10	2.9	1.5	12.3	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2892			182	0.2	0.1	5.2	
Total ME	Gross operating rate1)	%	14.2	0.2	-0.2	1.5	
C2892			14.3	-4.7	-0.3	-0.3	
Total ME	Productivity2)	€ thsd	55	4.0	2.6	4.1	
C2892			57	2.7	1.4	6.7	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2892			29	4.9	1.5	6.5	
Total ME	Unit labour costs3)	€ / €	0.582	-0.3	0.5	-0.5	
C2892			0.504	2.2	0.1	-0.2	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The most important groups of products applied on construction sites, quarries and mines are earth moving equipment (excavators, shovel loaders), road building equipment, concrete and mining equipment. The production of building material is carried out with machines for crushing, sorting, sifting and mixing earth, stones or ores and plants for the processing of non-metallic minerals, e.g. cement, glass and ceramics.

Serial production predominates in the manufacture of building machines and mobile off-road machines for construction sites, mining and quarrying. Up to a certain size these machines are mainly standard products. In mining machines, production in small series pre-dominates. Special excavators for open-cast mining can reach the dimensions of complete manufacturing plants and are always produced one-off.

In building material machines, complete manufacturing plants, e.g. cement factories or brickyards, play a large role. Plant engineering is a market in which beyond the technical supply services are of major importance. Financing and different kinds of operating schemes must be offered by manufacturers in order to ensure successful tenders. Big engineering groups are suppliers in these markets.

Serial production characterizes the market of construction machinery. There is an oligopolistic competition among large players from Japan (e.g., Komatsu, Hitachi), Korea (Doosan, Hyundai), the USA (e.g., Caterpillar) and Europe (e.g., Volvo CE, Fiat Industrial with its construction branches, New Holland Construction, Case and the Fiat Kobelco joint venture). With Zoomlion, Sany and XCMGthree Chinese companies were among the ten biggest global manufacturers in 2010. They not only produce and sell in China, but export and have launched FDI projects. Zomlion acquired the Italian concrete equipment manufacturer Cifa in 2008 and purchased crane know-how from Jost Cranes in 2011. Sany builds a factory in Germany. Above all in the area of earth moving equipment, companies pursue volume market strategies and size matters. Smaller European firms which are not global players face difficulties in these market segments. They cannot utilize economies-of-scale and have to pursue niche strategies.

Volvo can be taken as exemplary for business strategies of large European players of the industry, in the market segment for serial construction machinery. The company started a joint venture with Clark in the mid-1980s to get access to the US market. Within Europe Volvo acquired smaller companies and contributed to a consolidation of the industry. In 1995 Volvo took over the shares of Clark and created Volvo CE. In subsequent years the company invested in Asia. It acquired a Korean company and a majority stake in a Chinese construction machinery company. Volvo CE has strengthened its position in the global market.

Liebherr is the largest family held company that competes on eye level with the large groups of the construction machinery industry. Traditionally the Swiss company runs production locations in Germany and Austria, but has become a global player in the market with production sites, service and sales subsidiaries in all important markets. Other large family held companies in this market segment are JCB, UK, Fayat Group, France and Krone, Germany

Procurement

Many of the industry's final products are complex systems and comprise numerous subsystems. In recent years more and more sophisticated electronic systems have become part of state-of-the-art off-road machinery. The strategies on value chains are to a certain extent the same as for agricultural machinery (see Chapter 2.3.7).

Manufacturers who do not produce own engines have to trust on suppliers. However, the supply side is marked by a limited number of manufacturers, a challenge in particular in upswing cycles and changed regulation. Delivery times can become a huge problem. This was extremely problematic when the engine emission Stage III B came into force.

An important point has been raised in interviews that relates to the procurement of gears and drives that are crucial for the performance of construction machinery, for quality and operational availability. The specialized European manufacturers have erected plants in emerging countries, namely in China, to benefit from strong growth in the region. These components are purchased by Chinese manufacturers of construction equipment to upgrade the quality of their own products. Competition from Chinese manufacturers upgrading their machines with high-tech European components is only one concern. Another, more long-term threat, lies in the relocation of suppliers' total production to Asian countries to better serve emerging economies and to exploit scale effects. In such a scenario European manufacturers of quarrying, mining and construction machinery could face disadvantages in the value chain by slackening networks of importance for R&D and innovation. Such a development could affect key-components such as gears, drives and hydraulics. If these components have to be imported in the future then the European construction machine cluster will lose some of its current strengths.

Business cycle:
The construction machinery segment suffered a major breakdown in demand during the global crisis, above all in those countries that experienced a real estate bubble. Firstly, the overall downswing led actors in the enterprise sector and private households to stop construction in an uncertain environment. Secondly, potential customers faced difficulties in external funding of purchases. Moreover, rental companies that in some EU member states are the most important clients amplified the downward trend by pro-cyclical behaviour. The building material segment that had strongly benefitted from demand in emerging economies experienced a less severe slump. Likewise, the mining and quarrying segment was less affected by the crisis. Both of the latter segments benefitted much from the recovery of global demand and the scarcity of minerals. However, these segments play only a minor role in the industry and could not compensate the weaker business environment for construction machinery.

The recovery in Europe after the crisis is quite different from country to country. Demand in Germany, Scandinavia and France is again on a satisfying level – but still below the pre-crisis years. On the other hand demand Spain is still decreasing further and also the Italian market has not really managed to recover. The current level of output for all of the industry in the EU has not yet reached former heights. This will take at least another year.

Long-term demand
Construction machinery is one of the sectors that will be strongly affected by regional discrepancies in demand. The growth in the developed world will only be moderate due to several factors, such as demography and an infrastructure that is more or less sufficient. Civil engineering – that depends much on public expenditure – will suffer from persistent tight public budget constraints. Replacement is predominant. Investment in – for instance trans-European networks and a more sustainable economy – will not lead to a noteworthy higher trend growth. The importance of the European demand in the global market will decrease further on.

Emerging economies, with the need to invest in new infrastructure and to meet demand from increasing urbanisation, will remain the growth markets. Their growth will stimulate investment in mining and quarrying to meet the soaring demand for minerals. Although the long-term prospects are bright, European manufacturers will find it challenging to remain successful in promising but remote markets, while the domestic market does not provide sufficient growth potential for EU manufacturers to better benefit from increasing scale effects.

Technology

Over the past decade electronic control, electronic monitoring and information systems have been opening up new innovation potential. The linkage of mobile machinery to the global positioning system (GPS) has led to guidance and steering systems for more accurate field work, saving time and increasing efficiency. The linkage of mobile machines to the internet has provided manufacturers with new opportunities to offer better and more comprehensive after-sales services, such as maintenance and repair. The machine can be checked on-line in operating mode. Quick response increases the availability of machinery and even the downtime of machinery can be prevented. On-line supervision of machinery that is applied in remote areas in mineral deposits has become an indispensable feature for clients. This provides clients not only with better services but also enables them to introduce efficient fleet management systems.

Global market developments

By far the largest manufacturers in the industry are Komatsu (JP) and Caterpillar (US). The other big players from Europe follow suit. In the market for excavators and other serial machinery the Japanese, EU and US manufacturers are on eye level. The market for mini-excavators is dominated by Japanese manufacturers, with Chinese manufacturers following suit. EU firms are strong in the supply of gigantic excavators for open-cast mining. They are also global leaders in special markets such as tunnelling machinery, groundwork and structural facing. US firms are leading in oil drilling and related equipment.

The international market for building material plants is dominated by European firms which are strong in engineering. Most of these manufacturing companies are small and market niche specialists. Their know-how is often indispensable for the production of high-quality building material. Together with plant engineering firms they command a technologically driven lead in the market. Japanese and more recently Korean firms are catching up. Beyond technology their strength lies in attractive financing schemes and they have become an important competitor in building materials plants.

Regulation

Specific aspects of technical regulation affect agricultural machinery as well as construction machinery, the Noise Directive 2000/14/EC and the exhaust gas Directive 2000/25/EC (see: Chapter 2.3.7). The latter is particularly challenging and asks for comprehensive research activities. For off-road machinery, free circulation within the Single Market is hampered by non-harmonization of roading approvals in the EU. Multiple approval procedures are costly and lengthen time to market by a considerable degree. Although an investigation has been conducted around a decade ago, no initiatives were taken in order to find a solution.[58]

[58] Vieweg, H.-G. and Dreesen, M. (2001) “Restrictions of the Free Circulation of Off-road Machinery in the EU – Final report”, Munich, http://www.pedz.uni-mannheim.de/daten/edz-h/gdb/01/gesam.pdf

As in other subsectors of ME market surveillance is a concern of the industry. However, costly provisions on noise and emissions that are not valued by clients make well-functioning market surveillance even more important for fair competition. The principle of subsidiarity has left market surveillance to the Member States' authorities, even after the new regulation entered into force from 1 January 2011. As a consequence, it is carried out differently by the Member States. Usually the responsibility has not been allocated to one organization. Different bodies have to oversee that products are in compliance with provisions, such as noise, safety in the workplace and exhaust gas emissions etc. Moreover, interviews unveiled that in many countries allocated resources are scarce and not sufficient to fulfil the task. Imported products from non-EU countries that have not been identified as non-compliant with European provisions at customs can circulate within the Single Market. The likelihood that these products will be uncovered as non-compliant is quite low. On-site findings can hardly be expected.[59] The importance of this problem is underscored by the fact that a high share of R&D is dedicated to abiding by European provisions and European clients are charged with this extra-expenditure via pricing. Non-compliant imports distort competition. This problem has to be solved through adequate market surveillance, best implemented at customs, to reach a level playing field in terms of competition.

2.3.9 Machine Tools for metal working[60]

Demand side

Metaphorically speaking, machine tools are described as machines that can reproduce themselves. Machine tools are „mother machines and are key to productivity and efficiency gains in customer sectors. Machine tools play a strategic role in boosting the competitiveness of the entire economy. They are the capital goods predominantly applied for the capital goods industry. Most of the clients are

- manufacturers of machinery and equipment, electrical and mechanical engineering,
- manufacturers of transport equipment, cars, ships, railways, air and spacecraft,
- manufacturers of power generation and distribution equipment, conventional fossil fuel-, nuclear power stations as well as renewable power generation, such as wind, solar, hydro and geothermal and
- the die and mould industry, med-tech industry, domestic appliances, metal goods, defence sector, jewellery, watch-making, optical industry and others.

Of major importance in terms of volume are the automotive industry and its supply chain. Its above average growth has provided growth stimuli for decades. Since the mid-1990s growth has shifted from developed economies towards emerging economies. Since the early 2000s the growth differential between emerging and developed countries has become larger. The developed countries' automotive markets have become saturated.

59 It was reported that machines manufactured in China by a big European group for the Chinese market, complying with Chinese provisions have been exported to the EU. The exports were carried out by a Chinese trader – not affiliated to and without the knowledge of the European group. These European branded machines do not comply with EU provisions and can hardly be detected.

60 The sector metalworking has been tackled in a study of DG Enterprise and Industry in 2009: http://ec.europa.eu/enterprise/sectors/mechanical/metalworking/index_en.htm

Moreover, the shift towards electro mobility will have further impact on the demand for machine tools.

A driver in technology is the aircraft industry, with high-speed processing, machining of specific materials etc. The use of machine tools is not limited to complex mechanical components, such as gears and final products. Machine tools are also applied in the basic ferrous and non-ferrous metal industries, as well as in the metal working and metal products industries.

Supply side

The subsector 'machine tools' contributes 4.8% to total EU-27 ME production. Over the period under consideration the industry had grown well above average. It is of note that the industry's gross-value added growth was below average – with the exception of the period between 2005 and 2008. The manufacturing depth shrank from around 44% at the end of the 1990s to around 33% in recent years. This development has to a certain extent been induced by an increase in outsourcing, but also by the procurement of key-components from specialized manufacturers instead of in-house production. The increase in labour division has contributed to enhancing efficiency by specialization. Labour productivity grew stronger than in most other subsectors under investigation and unit-labour cost improved from 2000 onward. However, employment record was worse than for total ME (Table 2.19).

Table 2.19: Key figures for the manufacture of machine tools C2841

Sector	Indicator	2008		Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2841			29	3.6	3.5	16.9	-14.9
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2841			27	3.0	2.3	14.7	-16.2
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2841			9	1.8	0.7	7.7	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2841			159	-3.0	-2.6	3.1	
Total ME	Gross operating rate1)	%	14.2	0.2	-0.2	1.5	
C2841			13.3	-0.7	1.6	-2.5	
Total ME	Productivity2)	€ thsd	55	4.0	2.6	4.1	
C2841			55	5.0	3.5	4.4	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2841			34	5.3	3.0	3.9	
Total ME	Unit labour costs3)	€ / €	0.582	-0.3	0.5	-0.5	
C2841			0.625	0.4	-0.4	-0.5	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The supply side comprises the products mentioned under 2841 NACE Rev. 2 with the description “Manufacture of Metal Forming Machinery”. However, the group comprises metal working machinery for cutting, such as lathes, milling machines, machines for boring drilling and grinding, and forming, such as presses and punching, slotting and bending machines. Traditionally the industry consists of medium-sized companies, specializing in certain machining areas, that are family owned and in the legal form of a limited. A particularity of Spain is the legal form of a cooperative. Danobat and Mondragon are the largest companies within the machine tool industry and organised as cooperatives. Since the early 1990s the industry has been consolidating and cross-border mergers and acquisition have changed the structure of the industry. Smaller groups have been merged to become full-hand suppliers of certain technologies able to provide complete manufacturing systems, such as the German MAG Powertrain. Such activities underscore the development towards a more engineering oriented industry. Another example is the German Schleifring Group. The large Italian group Comau has acquired companies for the production, engineering and after-sales services in Germany, France, Spain, Romania and Sweden to strengthen its European market access. The merger of Georg Fischer and AGIECharmilles has created a Swiss-French group strong in precision machining and specific processing technologies. The StarragHeckert Holding AG is a holding that has acquired a variety of specialized machine tool manufacturers in different member states.

Within the EU a specialization has been observed. Swiss and German companies are strong in high-tech precision machine tools. Many German, French and Italian machine-tool manufacturers foster close contacts with client companies that are of importance for customized solutions and system engineering. Northern countries are strong in flexible automated solutions and care for customer intimacy.

Procurement
A machine tool is a complex capital good that needs a broad range of different parts and components, be it mechanical, electrical or electronics. Beyond in-house production and assemblage, purchasing strategies are crucial. The majority of welded steel constructions and castings originate from new Member States. Specialized manufacturers of spindles, tools and handling systems are important suppliers to the machine tool industry. The quality and state of technology of the latter supply is of key importance for the performance of machine tools. European high-tech component suppliers are on the leading edge worldwide and contribute to the competitiveness of the European machine tool cluster. In the area of controls and related equipment, European machine tool manufacturers can trust on a capable domestic upstream industry that is on eye level with its Japanese competitors.

However, beside European suppliers of advanced components, there are Asian manufacturers who have tapped the European market and offer budget-priced as well as high-tech components to machine tool manufacturers. In the area of controls and high-tech equipment the European Siemens and the Japanese Fanuc are global player of major importance. Other Asian countries, in particular Taiwan and Korea, provide electronics, sensors etc. and mechanical parts.

Smaller manufacturers of machine tools face cost problems in procurement. They order only small quantities and have no bargaining power to get discounts on key components that their large competitors are able to negotiate.

Business cycle
The machine tool industry was one of the subsectors worst hit by the financial crisis. Most important was the slump in demand from the automotive industry that, in the developed countries, became dependent on public support to prevent a major breakdown. In the meantime the situation has changed and the strategic investment in the global automotive industry has been expanded strongly. However, as is typical with the machine tool industry, long lead times have delayed an early increase in production.

Long-term demand
The long-term demand for machine tools has been driven by an above average growth of some more important client industries. The aerospace industry and shipbuilding are driven by globalization and, although extremely volatile, will continue to enjoy strong growth. In addition to this, the advancement of manufacturing systems to higher levels of precision (meso, micro, nano-machining) to cater the needs of electronics, computer and biomedical industries are expected to open up new markets for machine tools, as well as the shift towards the use of more sustainable energy resources (wind, solar, geothermal etc.) and the subsequent energy infrastructure investments.

The automotive industry is at a crossroads. Its above average growth was driven by an increased need and interest in mobility. In recent years new technologies have been pushed forward by rising energy prices and the necessity to reduce anthropic gas emissions. The dissemination of electric cars will affect machine tools, by reducing the number of mechanical parts to be machined and causing some highly-sophisticated operations to lose some of their importance. However, as outlined in Chapter 2.3.4 the dissemination of electric cars over the current decade will remain limited and not change the demand of the automotive industry for machines to a large extent. Another technology that will have an impact on the industry is CFRP, a composite that is widespread in the manufacture of aircrafts; the application in the automotive industry for high-performance cars has already started. The breadth and speed of CFRP dissemination and of other plastics is unclear yet. It will affect the demand for machine tools by the structure, more moulds and dies will be needed. A strong MT is necessary to maintain and develop the know-how and control over future technologies and products, including battery cars. Machine tools are not confined to the machining of metal, but also machine tool technology will be used for other materials such as glass, ceramic and composites which are expected to have wide applications in the future.

Technology
In the area of high-tech machinery and systems, Japanese and European players are the most important and compete on eye level. The Japanese command a strong position in the global market of high-tech serial products[61]. It is supported by volume production, standardization and a budget-priced domestic supply of controls. They run production sites in many important sales markets and they exploit economies-of-scale to a large extent. The strengths of European manufacturers are more related to engineered, customized solutions and the design of specialized manufacturing systems. The European machine tool industry is strong in customizing and engineering. Beyond these activities the industry has a strong focus on research.

Korea and Taiwan have been catching up the lead and are strong in quality and the state of technology. They have become important competitors in the global market.

European machine tool companies have a strong interest European schemes, and they actively participate in FP7 (NMP, ICT) and the Factories of the Future programme. However, the administrative workload has been criticized as a burden above all for smaller firms, aggravated by the requirement of cross-border co-operations. It is agreed upon that European schemes ask for multi-national co-operations. In the long run this can lead to a better management of resources, pooling of competencies in different technologies and the exploitation of comparative advantages in the Single Market. Some criticism has been highlighted on the complexity of rules and procedures, administrative burden, long-time contracts and uncertainty about IPR management.

Many Member States value the machine tool industry as the core enabler for others and are keen to support research activities. Firms' proximity to national institutions eases access to national schemes, in particular for smaller ones.

[61] Standardized products, variations of these products are defined by the manufacturer only and not by the customer.

The European machine tool industry is at the leading edge of environmental techniques. Widely used are several solutions to increase energy efficiency. Example is regenerative feedback which allows to feed back the energy into the intermediate direct current (DC) circuit).This allows the current from regenerative operation of drives to be returned to the system. This is in particular of importance for the machining of heavy work pieces. Generated power is used in other drives or it can be fed to the mains. If there is no use for the power it is transformed to heat in resistors and disappears in the atmosphere. There is some demand for “ecofriendly machines” and a standard (ISO 14955) is under development.

The graduates from universities build on a comprehensive theoretical background, but often do not possess a satisfying functional knowledge. This aggravates their integration into the labour market and endangers success in their first employment. For engineers and other technical staff it is quite important to be proficient in basic design tools, such as Pro Engineer and Solidwork. A broad technological knowledge is needed for the integration of multi-technologies (eg. hydraulics, control etc.) that characterize advanced machine tools and manufacturing systems.

Global market developments

In 1999 40% to 50% of global machine tool demand was from Europe. At that point, Asia was responsible for approximately only a quarter of the requests. This relation has since changed dramatically. In 2010 the share of Europe has fallen to around a quarter, whereas Asian consumption of machine tools has reached two thirds of global demand. The survey disclosed that European machine tool manufacturers do not expect that their home market will regain its former weight. Above average growth potential will only occur in emerging economies, Russia, India, Brazil and other South American countries. Turkey and North Africa are valued as nearby growth regions. The sluggish demand is not perceived as a European particularity. Also the US and Japan will not provide many opportunities for expansion. The developed world will lose some of its predominance.

The Chinese machine tool industry has become large in terms of its size. However, the focus is on medium-quality and low to medium-precision machining. Above all they supply machinery to sweat shops and subcontractors on lower levels in the value chain. There are only a few exceptions, although the Chinese government shows strong interest in upgrading its domestic machine tool industry. As a consequence, public R&D has become of importance for the industry.

One of the major threats for the European manufacturers lies in their distance to emerging markets with high growth potentials. As for many other ME subsectors machine tool firms’ proximity to clients is an important factor for innovation, the development of new solutions and customized systems. As a consequence, machine tool manufacturers cannot serve these markets only through exports. Pre- and after-sales services have to be offered in important sales markets. The necessity to design to clients’ needs and supply customized solutions without much delay requires, at least to a certain, extensive local production.

Numerous European machine tool manufacturers have tapped into the Asian markets. Locations for after-sales services have been expanded, design capacities and assemblies have been set-up, as well-as the production of basic parts and components that are not only manufactured for local production but are also delivered to European locations.

It has been reported that deliveries of machine tools to China are hampered by provisions outlining that only key components that cannot be procured within the domestic market may be imported. For Chinese companies who want to invest in complete machines procured from abroad the access to funds has been aggravated. As a consequence, European exporters to China face a worse market environment than in former times when imports of advanced machinery were perceived by public authorities as a basic need for the upgrading of Chinese manufacturing industries. Difficulties have also been reported for Brazil and Argentina.

Regulation

The harmonization of the technical framework has contributed to a free circulation of goods in the Single Market. The revision of the machinery directive has been appreciated by the industry. Problems have been raised by the implementation / revision of the directives on recycling, 2002/95/EC (RoHS) and the use of hazardous substances, 2002/95/EC (WEEE). Policy changes in the process of redesigning the directives have caused unexpected effects.

Machine tools fall under the scope of the EcoDesign Directive as energy-using products. No mandatory measures for this product group are set up yet even if a study is on-going. In the meantime, CECIMO has already launched an initiative for a self-regulatory system to decrease the energy consumption of machine tools. Energy efficiency of machine tools will become an even more important issue with growing regulatory/legal requirements towards more sustainable modes of production.

Growing competition from third countries has been perceived in the EU market. In line with this development problems with non-compliant machine tools have gained importance. Market surveillance has been evaluated as ineffective and contributes to unfair competition. There are clear deficiencies in how market surveillance is carried out in Europe. There are insufficient resources and insufficient controls. In contrast to consumer goods, capital goods suffer from a lack of focus. Ex-post controls, such as market surveillance, are the most costly procedures to ensure compliance. However, lack of capacity and resources at Member State level, as well as varying degrees of enforcement in different Member States, create an uneven field. There is a strong need to increase awareness of CE marking among companies. The non-European manufacturers in particular have to improve their compliance with these provisions. There is a need to invest in on-the-border controls to improve market surveillance. It is vital that Member States step-up cooperation and build up resources dedicated to market surveillance (e.g. Italy only has a staff of 6 people for this task).

2.3.10 Machinery for textile, apparel and leather production

Demand side

The most important products are spinning machines, looms, knitting machines, textile finishing machines, sewing machines and automatic sewing machines. The buyer industries require both standard products and special machines, such as spooling, reeling, winding and twisting machines. Most of the sewing machines are applied for the manufacture of clothing and are produced in large series. Since the 1990s the textile machinery industry has evolved into new business areas. Beyond clothing and home and household textiles, so-called technical textiles have become more important. The textile industry has been involved in developing technologies for the manufacture of textiles that are used in landscaping and the automotive industry. A broad area of application is in the manufacture of composites and sandwich materials.

Technical textiles have become a growth engine for the European clients of the machinery industry, whereas the demand from conventional applications has suffered from the globalization of the textile industry. Technical textiles have become an integrated part of the EU manufacturing industries, with close ties to domestic clients. In contrast, the former strong EU cluster of textiles for clothing and home textiles has lost much of its former importance. Large parts of the production process have been relocated, an eventuality that has occurred in not just the more costly Member States. Even the competitiveness of southern EU Member States is dwindling and losing ground. Close to the EU, only Turkey and to a certain extent North Africa have remained important markets. However, even these locations are expensive as compared with the Asian power houses for the manufacture of traditional fabrics and clothing.

Supply side

The subsector 'machinery for textile, apparel and leather production' is the smallest among the groupings to be investigated in detail. In 2008 the industry had contributed only 1.9% to total EU-27 ME production. It is the only industry that had lost importance over the period under consideration. In 1995 the industry’s share rose to 2.8%. Simultaneously manufacturing depth shrank from 43% to 30%, as measured by the ratio of value added and production. The number of workplaces was reduced by 45% between 1995 and 2008. Despite this, the industry's economic performance worsened because of the dampened development of productivity (Table 2.20).

Table 2.20: Key figures for machinery for textile, apparel and leather production C2894

Sector	Indicator		2008	Annual average growth rate in %			
				1995 - 00	2000 - 05	2005-08	2008 - 10
Total ME	Production, in current prices	€ bn	598	4.0	2.3	10.4	-8.4
C2894	Production, in current prices	€ bn	11	2.3	-2.8	6.3	2.4
Total ME	Production, in 2005 prices	€ bn	561	3.4	1.3	8.0	-9.3
C2894	Production, in 2005 prices	€ bn	11	1.7	-3.4	5.5	2.2
Total ME	Gross value added, in constant prices	€ bn	176	2.4	0.3	6.0	
C2894	Gross value added, in constant prices	€ bn	3	0.8	-5.2	-3.0	
Total ME	Employees	1,000	3201	-1.6	-2.2	1.8	-4.8
C2894	Employees	1,000	74	-3.9	-5.2	-4.4	
Total ME	Gross operating rate[1)]	%	14.2	0.2	-0.2	1.5	
C2894	Gross operating rate[1)]	%	10.0	4.8	-4.4	-10.8	
Total ME	Productivity[2)]	€ thsd	55	4.0	2.6	4.1	
C2894	Productivity[2)]	€ thsd	45	4.9	-0.1	1.5	
Total ME	Wages per employee	€ thsd	32	3.7	3.1	3.7	
C2894	Wages per employee	€ thsd	31	2.2	2.1	4.0	
Total ME	Unit labour costs[3)]	€ / €	0.582	-0.3	0.5	-0.5	
C2894	Unit labour costs[3)]	€ / €	0.683	-2.6	2.2	2.5	

1) (Value added minus wages) / production in nominal terms; 2) Value added per capita and annum in 2005 prices; 3) Wage per € 1 value added in prices of 2005.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The traditional European centres of the textile machine industry have been Germany with a strong focus on spinning, Italy with a strong focus on knitting and Switzerland with a focus on weaving. Great Britain and France follow far behind. A relatively large role has been played by Belgium due to its weaving machine production, in particular for carpets. For more than two decades, a process of consolidation has been underway in the industry. The early 1990s, with its economic crisis, was marked by numerous mergers and acquisitions. Large groups took over independent companies. Production capacities have been dismantled or relocated. Noteworthy capacities have been built up, in particular in China.

After the fall of the Iron Curtain there was some hope that Europe would be better able to withstand competitive pressure from Asia. The central European countries were strong in the textile and clothing machinery industry. Beside production sites, good know-how and noteworthy capacities in R&D were available. Wages in the transition countries were much lower than in Western Europe. The large Western groups as well as medium-sized enterprises had heavily invested in this region. But it turned out that most of these locations were not offering competitive wages and were located at a far distance from client markets in Asia. Large parts of these capacities have been relocated to Asia.

The consolidation of the EU textile industry is highlighted by M&A activity. One of the leading groups, Oerlikon Textile, a business area of the Swiss technology holding, has acquired numerous European manufacturers. In 2007 Oerlikon had taken over Saurer, another Swiss group that had driven the consolidation of the industry for years. Today it comprises:

- Oerlikon Barmag, a specialist in the spinning of man-made fibres and which has been strong in the engineering of complete manufacturing facilities. The company owns large production capacities in China.
- Oerlikon Neumag, has a focus on staple fibre technology and offers solutions in non-wovens, woollen and tapestry, and
- Oerlikon Schlafhorst, a leading supplier of rotor and ring spinning machinery and systems.

All of these brands have been independent companies during the early 1990s and were themselves growing by virtue of M&A activity.

Another example of the consolidation of the Industry is given by ITEMA, an Italian group that has acquired enterprises in order to become a full-hand supplier in the core production processes for textiles. The company offers spinning, weaving and comprehensive manufacturing solutions. It has acquired:

- Sedo Treepoint, a company located in Germany specializing in advanced automation solutions for the textile industry, taken over in 2008,
- Loepfe, located in Switzerland specializing in quality control systems,
- Sulzer Textil, the weaving branch of the Swiss based Sulzer group,
- Savio, an Italian based spinning machine manufacturer

Procurement

The larger companies active in this industry run global production networks. As a consequence, cross-border intra-firm trade plays an important role. Key-components are exported to non-European production locations, other components, such as machine frames, castings etc. are also imported. While components are delivered globally, for other intermediary products long-distance haulage is not an option. They are procured from European or Turkish suppliers.

Business cycle

The manufacturers of machines and plants for the textile and clothing industry experience even stronger cycles than other subsectors of ME. They follow global investment cycles of the textile industry and are different from the cycles in other capital goods industries. The industry had suffered a slump in output of nearly 40% in 2009, but there was an early recovery of demand with an immediate restart of production. It was the only industry that had already exceeded the 2008 pre-crisis level by 2010.

Long-term demand

The long-term demand for textile machinery for conventional applications will be driven above all by emerging economies. Demography and growing prosperity will provide strong stimuli, whereas the demand from the developed world will be lagging behind. This will remain a challenge to European machine manufacturers, although they heavily invested in emerging economies. They have to work hard not to lose close contact to their clients all over the world. It is not sufficient to manufacture close to clients in Asia. Engineering activities and new manufacturing solutions have to be developed together with clients.

Technology

Many manufacturing technologies are mature and innovation is marked by stepwise progress. Process automation and quality of production securing equipment are important areas. Clients are strongly interested in a more integrated production process. The integration of two manufacturing processes saves time, working capital and labour. Some progress has been made in this area, but opportunities are limited.

Generally speaking, progress in these areas is expensive and of importance above all for production facilities that have remained in the developed world. Production locations in Asia that have lost their cost competitiveness are shut down and capacities are relocated, for instance from China to Vietnam, Indonesia or to less developed regions in China.

Technological progress is strong in technical textiles. A broad range of applications has been opened up by R&D. There are sensor fibres to control temperature as well as the lengthening of materials and applications for fibres with specific abilities in the health sector and hygiene. An important area of application is composites and compounds that comprise textile-reinforced concrete, CFRP etc. CFRP is indispensable for the manufacture of wind power blades. It is heavily applied in structures of civil aircraft and will be disseminated in the automotive industry.

Progress in these technologies is strongly dependent on interdisciplinary R&D. The manufacturers of fibres and other basic materials, such as the machinery required for laying, weaving and knitting fabrics, as well as potential clients for applications, have to come together in joint efforts to find solutions.

Currently a broad dissemination of CFRP is hampered by difficulties in the automation of processes. Process technicians and experts in robotics are co-operating to find solutions to a more industrialized manufacturing process. Although Europeans are on the leading edge of technology, competition is growing; for example Brazil has become an important supplier of wind power blades to the EU.

Global market developments

Until the mid-1990s European, Japanese and, -to a lesser extent, Korean and Taiwanese companies have dominated the global market for textile machinery. This picture has changed dramatically. New players have entered the market, in particular from China and India. Even in technologies that were perceived as high-tech and not easy to be adapted, such as spinning and weaving, enterprises from emerging countries have gained importance. However, they often have to trust in the supply of European key-components for the manufacture of high performance machines.

The business of European manufacturers with complete machinery, manufactured in the EU, has become more regional. To a large extent it is dedicated to meet the demand of textile manufacturers in Europe, including Turkey and North Africa. Exports to other regions comprise a growing share of key components necessary for the production of high performance machinery. These components are delivered to own production sites abroad, but also to non-EU textile machine manufacturers. Due to experts of the industry, the intra-industrial, cross-border trade has shifted from complete machinery to parts and components. In 1990 their share was 20% of total global trade with textile machinery. Until 2008 their share increased to 28%.

A similar development has also happened with the Japanese textile machinery. Both industries have always been driven by technology and have been on eye level in this respect. However, the companies could not withstand the growing competitive pressure in mass markets and have had to focus on high-tech components and specialities.

European manufacturers with production locations in China experienced cost disadvantages for their facilities as compared to facilities owned by Chinese companies. Several factors have been mentioned as possible explanations for these discrepancies, for example access to the labour market, funding conditions and preferential treatment by public authorities.

Barriers to trade are of lesser importance. However, the Brazilian customs system has been mentioned as an issue of concern.

Regulation

Technical standards are no topic of major importance for trade barriers, neither within the EU nor on third countries' markets. It was reported that within the Single Market competition is sometimes distorted by clients' interest to procure machinery without obligatory equipment for safety in the workplace. One case has been identified where a European manufacturer supplied textile machinery that did not comply with the machinery directive due to a customer's requirement. Such purchases are made possible by insufficient market surveillance and poor controls on health and safety in the workplace.

2.4 Specific topics for the assessment of the performance of EU ME

2.4.1 Supply side analysis of EU Mechanical Engineering

Companies' initiatives in the area of business combinations are of major importance for structural changes on the supply side. They incorporate the threat of distorting competition and – if certain thresholds are exceeded – they are subject to legal approval. The following analysis is based on different sources:

- Database on mergers, acquisitions etc., that by their size had to be authorized by the EU DG Competition and concern ME.
- Information collected through expert interviews.
- Information gained from the news and via the internet.

Financial market players

Numerous mergers and acquisitions in the ME industry are done by private equity firms and investment funds. Among them are the large and well-known players without regional or sectoral specialization. These generalists are widely known for their large and spectacular deals and have contributed to structural changes in ME. These are Alchemy

Partners, Axa Private Equity, Bank of America, Barclays Bank, Blackstone, Cerberus, Citigroup, CPPIB; Kohlberg, Kravis, Roberts (KKR) and Goldman Sachs.

Smaller funds have specialized in industries and / or regions. They strongly build on their specific know-how. The following funds are active on a global scale but only in a few industries: BC Partners (consumer goods, manufacturing and health) and First Reserve Corporation (energy industry).

Funds with a more limited focus are: CapVis (Germany, Austria, Switzerland, specializing in ME, services, and consumer goods), EQT IV & V (Northern and Eastern Europe/mid-size companies), Industri Kapital (Northern Europe/IT, manufacturing, healthcare, service, retail), Onex (aerospace/ healthcare and industrials), Sagard (France, Belgium, Switzerland/mid-size companies), Triton III Holding (Europe).

In this section, the activities of financial market players are highlighted in order to disclose structural changes in the industry and discuss the topic, based upon the conventional wisdom, that these players pursue medium-term objectives not well-suited for ME firms.

The German technology group Linde was one of the drivers of structural change with takeovers already occurring during the 1980s and early 1990s. It acquired manufacturers of industrial trucks, serial products[62] and strived for a market lead. The business area encompassing a portfolio of well-known brands was created to exploit synergies. In 2006 the brands Linde, Still and OM were merged under a newly created holding company, KION, to spin-off a business area that did not correspond well with Linde's other business areas. Kion was purchased by KKR and Goldman Sachs. A restructuring is envisaged in order to enhance economic performance by making use of scale effects without losing proximity to clients.

Wittur (Germany, a specialist in components for the lifting and handling equipment manufacturers) was first bought by a consortium led by Goldman Sachs in 2006. After consolidation the firm was sold to a consortium led by the German Triton III Holding GmbH in 2010. Triton III, a European based investment fund, is focusing on medium-sized firms and beyond Wittur has acquired further stakes in ME:

- Dunkermotoren, a manufacturer of electric drives and gears, with specialized solutions for a broad range of sectors comprising elevators, industrial automation and equipment for healthcare.
- Tyco Waterworks, a business area of Tyco International, a conglomerate located in Switzerland. Triton III reorganised a portfolio of brands, such as Erhard, Frischhut, Strate, Schmieding, Unijoint, Wafrega, Bayard, Belgicast and Atlantic Plastics under a newly created company, TALIS. The company employs around 1,500 people and runs production sites in several Member States.

This is an example of a specialized smaller private equity fund that, as is the case with most of these funds, tend to invest in medium-sized companies that have a certain sectoral knowledge. They invest in portfolios of smaller firms, supply management infrastructure,

[62] Standardized products, variations of these products are defined by the manufacturer only and not by the customer.

offer services that a single company can hardly afford and provide access to financial means.

The German firms Grohe and Hansgrohe are leaders in the global market for premium sanitary taps and valves. Both of these firms were family owned. In 2004 Grohe was taken over by a private equity firm, TPG Partners IV, L.P, and a financial investor. The company was restructured and its global production network strengthened. Grohe currently manages facilities in Germany, Portugal, and Thailand. Its German competitor Hansgrohe has taken in a specialized US investor, but a minority stake has remained in the hands of the family. The company runs production sites in Germany, the Netherlands, France, China and the US. The need for restructuring, professional management and funding of growth strategies have been important factors in determining changes in ownership.

MTU Aero Engines is a supplier to the aerospace industry but also manufactures gas turbines for industrial applications. In 1999 it acquired Vericor, a US manufacturer, an investment directed towards the development and marketing of small turbines for industrial and marine applications. In 2000 when EADS was created MTU became part of the DaimlerChrysler group. In course of restructuring Daimler sold all of its off-road activities to KKR in 2004, MTU Aeroengines and MTU Friedrichshafen, a manufacturer of ICEs for a broad range of applications. Both business areas went public in 2005 under a new company, Tognum AG. In the meantime KKR has sold all of its shares. In 2011 the company was taken over by a JV of Daimler AG and Rolls Royce.

Financial market players have taken an important role in the restructuring of ME. They ease the restructuring of large industrial groups that try to concentrate on business areas with better prospects. In such cases they work as interim owners that work hard to benefit from their investment by de-investment in a certain time span. They contribute to the consolidation of market segments through structural deficits, with numerous companies close or even below the optimal size of an enterprise.

Smaller and more specialized funds frequently show more interest in long-term engagements, in particular if they invest in portfolios that create consistent business areas. Targets are troubled companies that fit this profile accordingly. Management services and financial means are provided to brighten their prospects.

European industrial investors
Since the early 1990s the industry has been consolidating and cross-border mergers and acquisitions have changed the structure of the industry. Smaller groups have been merged to become full-hand suppliers. Sometimes private equity firms and financial investors are involved in the creation of sustainable units. These activities are not always proactive but reactive and carried out in the aftermath of an economic crisis.

The European machine tool industry suffered from a major crisis at the beginning of the 1990s. Many companies went bankrupt or had to scale down. A consolidation period started. Mergers and acquisitons took place and, in the long run, more competitive companies and groups have emerged. Strategies to become full-hand suppliers for certain technologies and applications have been taken, for instance by the German firms MAG

Powertrain and the Schleifring Group. The large Italian group Comau has acquired companies for production, engineering and after-sales services in Germany, France, Spain, Romania and Sweden in order to strengthen its access to the European market. The merger of Georg Fischer and AGIECharmilles has created a Swiss-French group strong in precision machining and specific processing technologies. The StarragHeckert Holding AG has acquired a variety of specialized machine tool manufacturers in different Member States.

The consolidation of the EU textile industry has been highlighted by merger and acquisition activities. The number of independent companies in the industry has been reduced by takeovers. Some large groups have emerged, such as Oerlikon and Rieter which have headquarters located in Switzerland. Both of the companies have their own brands and production sites in numerous Member States. These groups have globalized their production networks and run facilities in Asia, namely in China and India. Another example for the consolidation of the Industry is given by ITEMA, an Italian group that has acquired enterprises to become a full-hand supplier in the core production processes for textiles.

European players abroad
Globalization has driven European companies to access foreign markets through local production. This development does not only concern assembly or the manufacture of simple products. More often production lines have to be opened-up to manufacture complex and know-how intensive products. Frequently these activities are carried out by JVs together with local partners.

Quingdao Qiyao Wärtsilä MHI Linshan Marine Diesel Company is a joint venture (JV) by China Shipbuilding, the Japanese company Mitsubishi and the Finish Wärtsilä in 2007. It has been created to manufacture and market two-stroke, low-speed marine diesel engines. China Shipbuilding is an important manufacturer of civil and defense vessels, Wärtsilä is one of the global leaders in large diesel engines and MHI is a leading heavy industry manufacturer. Through this JV Wärtsilä strengthens its access to the rapidly growing Chinese shipyards. In another JV, together with Hyundai Heavy Industries, Wärtsila has secured access to the Korean shipbuilding and power plant industries.
KSB has set-up a JV with SEC, SEC-KSB Nuclear Pumps & Valves Co., Ltd., located in China, dedicated to the manufacture of taps and valves for use in the construction of nuclear power stations.

2.4.2 EU ME – regional distribution and division of labour

The old EU 15[63], with the last members joining in 1995, has been extended significantly by the addition of ten new Member States in 2004[64] and two more new Member States in 2007[65], forming the EU27. This section aims to compare the relative development of the ME sectors of the old EU15 Member States and the 12 new members (EU27-EU15).

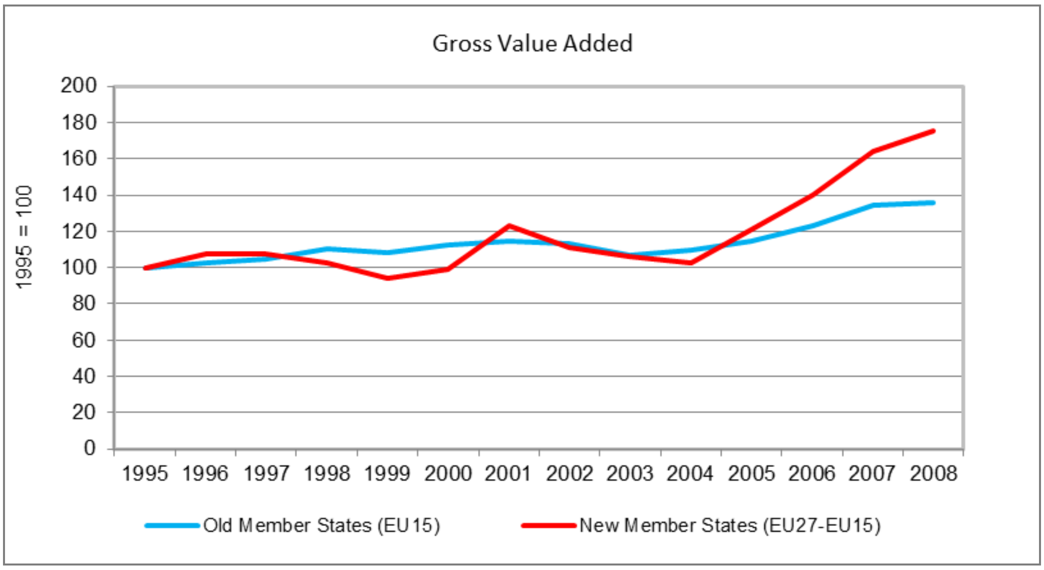
[63] EU15 member states: Belgium, France, Germany, Italy, Luxembourg, Netherlands, Denmark, Ireland, United Kingdom, Greece, Portugal, Spain, Austria, Finland, and Sweden.
[64] New member states that joined in 2004: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia.
[65] New member states that joined in 2007: Bulgaria and Romania.

Comparing different performance measures (gross value added, labour productivity, employment, wages, and unit labour costs) renders it possible to evaluate how far the new members have been able to catch up with the old Member States.

Integration of the new Member States in the EU-27 economy

Relative development of gross value added (GVA) is an appropriate high-level measure to assess if new Member States have been able to catch up with the old Member States. Figure 2.17 depicts the relative development of GVA in the ME sector at constant prices from 1995 to 2008. The development shows that the new Member States have not been able to outperform the old Member States before joining the EU in 2004. However, starting from 2004 the new Member States show significantly higher growth rates than the old Member States. In 2008, GVA in the new Member States is 75% higher than in 1995, while the old Member States have only been able to increase their GVA by 36%. Finally, GVA development in the new Member States seems to be more volatile than GVA development in the old Member States.

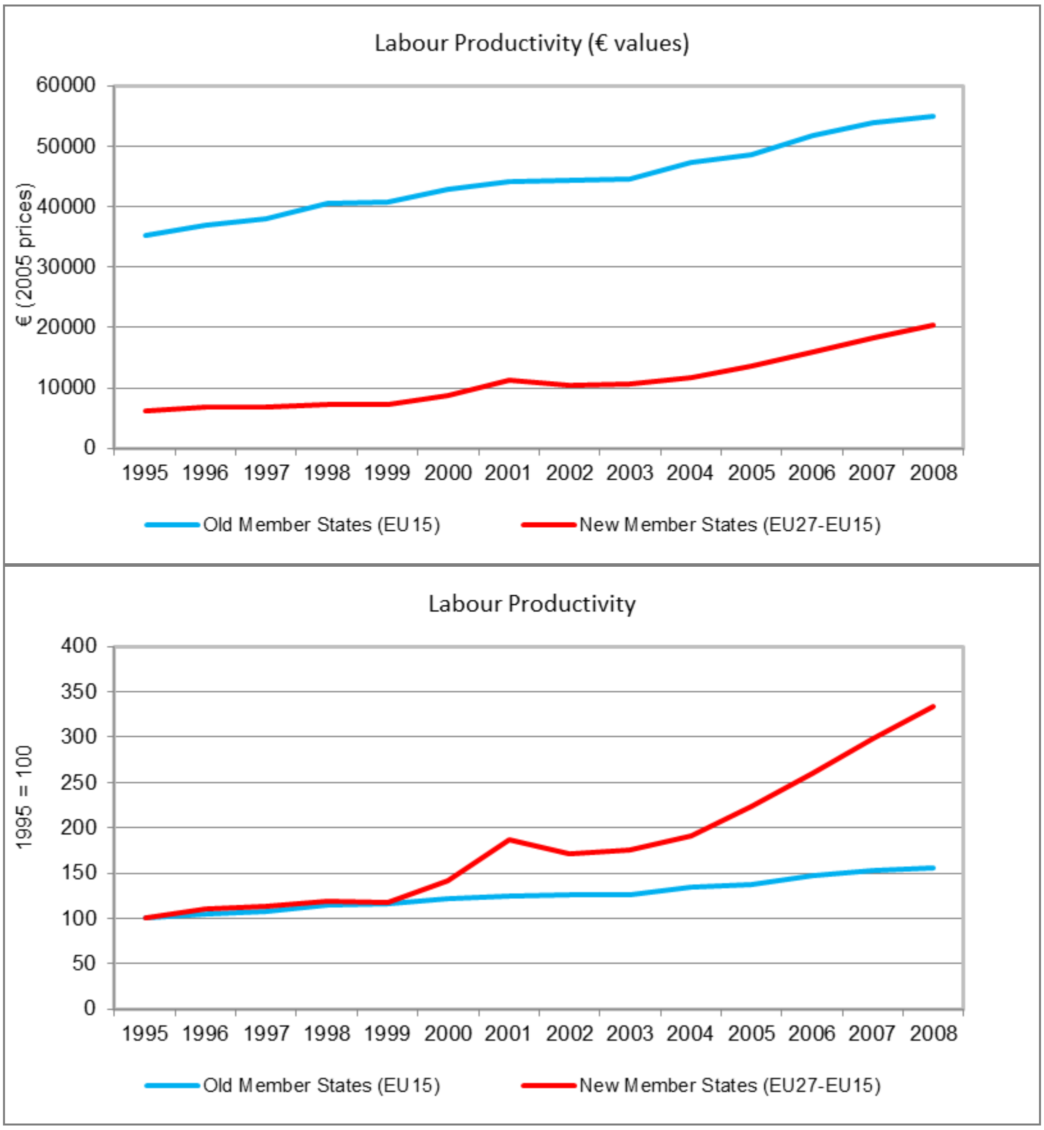
Figure 2.17: Gross value added in old and new Member States for Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

To understand the catch up process of the new Member States, development of labour productivity has to be considered. Figure 2.18 depicts the development of new and old Member States' constant-price labour productivity, both in relative and in absolute terms. Relative labour productivity in the new Member States has increased at a much greater pace than in old Member States. In 2008 GVA per person in the new Member States has more than tripled compared to 1995 values, while old Member States could increase labour productivity by only little more than 50%. However, in absolute terms, the new Member States are still lagging far behind. In 2008, new Member States generate GVA of around € 20,000 per person, while the old member states generate GVA of around € 55,000 per person. The gap between new and old Member States decreases between 1995 and 2008 from a factor of 5.8 to a factor of 2.7.

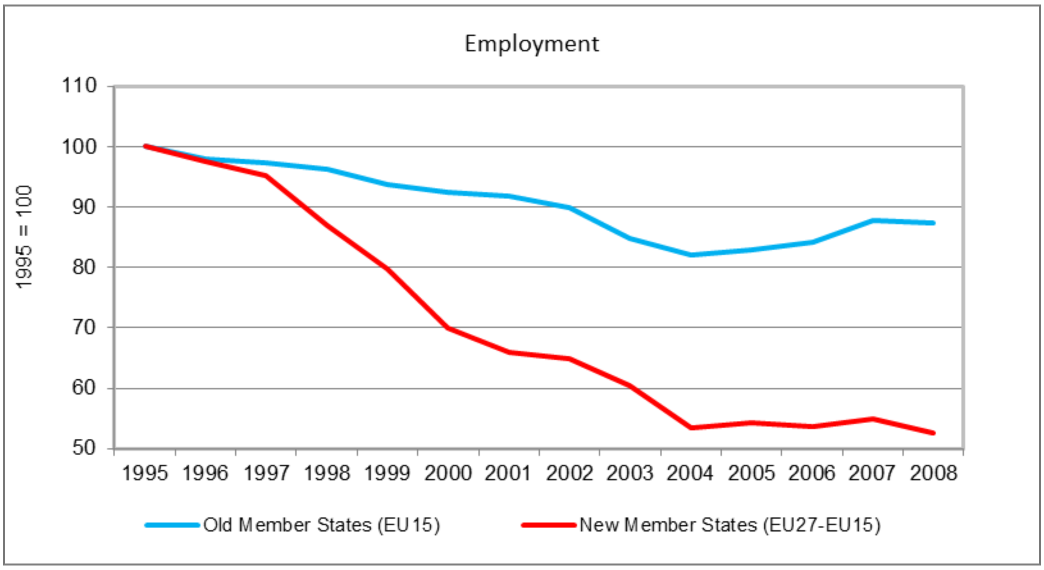
Figure 2.18: Labour productivity in old and new Member States for Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

As already mentioned in Chapter 2.1.2, the development of labour productivity can be misleading because two effects jointly shape this measure. First, labour productivity increases if firms are able to realize real productivity gains. Second, average labour productivity also increases if unproductive firms leave the market. One has to consider the development of employment to understand to what extent productivity gains are driven by real productivity upgrading or only by selection effects. Relative development of employment is depicted in Figure 2.19. Both new and old Member States experienced a decline in ME employment over the period from 1995 to 2008. The decline in the new Member States has been much stronger than in the old Member States. In 2008, employment in the old Member States was down to 87% compared to 1995 levels, while it was down to 53% in the new Member States. Even though there has been a strong decline over the whole observation period, the situation has stabilized since 2004, with new Member States losing no more employees and old Member States being able to even increase employment. The new members' strong productivity increases since 2004 do not therefore seem to be driven by selection effects but by real productivity upgrading.

Figure 2.19: Employment in old and new Member States for Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Increases in labour productivity are only able to improve competitiveness if these productivity gains are not outweighed by higher increases of wages. Figure 2.20 depicts relative and absolute development of wages in constant prices from 1995 to 2008. In relative terms, development of wages in old and new Member States has been comparable until 2004, but wages in the new Member States increased significantly faster thereafter. In absolute terms, there is still a large gap of a factor of around three between wages in new and old Member States.

The enormous wage differentials that exist between the old and the new Member States are not only caused by wage levels but also by the structure of employment. In the old Member Sates the share of white collar occupations in terms of total employment is higher than with the new entrants.66 As a consequence, we can conclude that these discrepancies will not totally fade away.

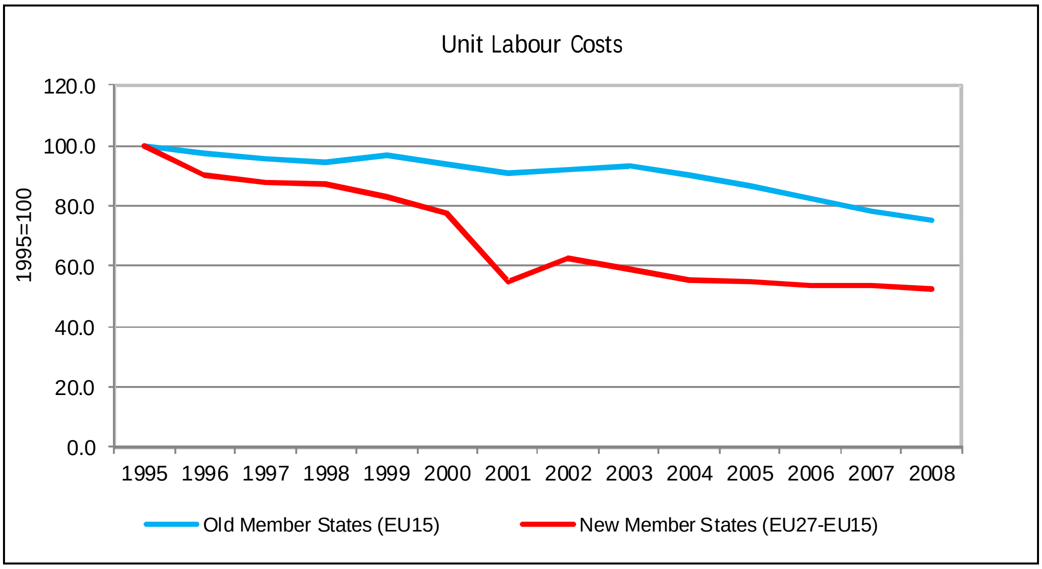
66 On average the enterprises are more focused on production and to a lesser extent on R&D, sales and marketing. A good example is provided by Famot Pleszow S.A., part of the German Gildemeister Group. This enterprise manufactures its own final products, but has become an important member in the mother company's value chain. See: Chapter 2.2.6.

Figure 2.20: Wages in old and new Member States for Mechanical Engineering

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The net effect of increases in wages and increases in productivity can be assessed by evaluating the development of unit labour costs. Unit labour costs are measured as the ratio of nominal wages to real GVA. Figure 2.21 plots the relative development of unit labour costs from 1995 to 2008. Since 2001 unit labour costs in old and new Member States seem to stay fairly stable and develop in large parts in parallel. That is, increases in real GVA have been counteracted by nominal wage increases of a similar magnitude in new as well as in old Member States.

Figure 2.21: Unit labour costs in old and new Member States for Mechanical Engineering



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

From this analysis it can be concluded that the transitional phase in most of the new Member States has ebbed away during the middle of the last decade. Currently we observe a more evolutionary process driven by comparative advantages, the endowment and quality of input factors. The yet existing wage differentials have remained high and will drive further on a regional shift in the division of labour, but this is expected to be a long-term development. Wage differentials will not disappear. They are an important feature in all large economies to stay competitive in a broad range of final products and along the value chain.

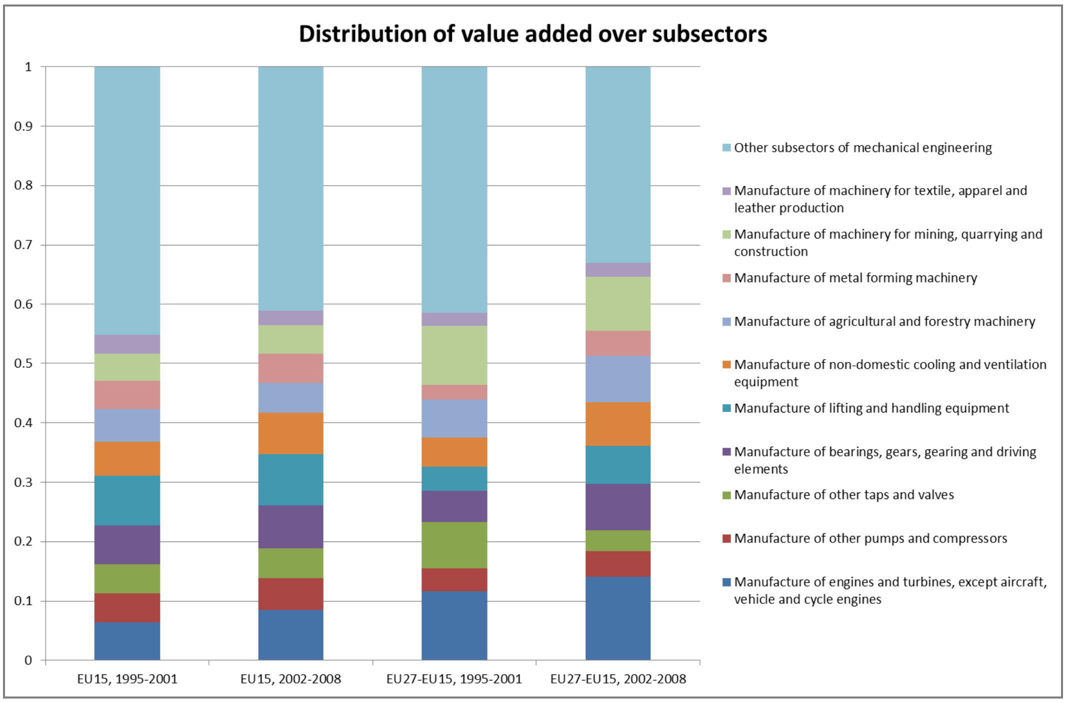
Adjustments in the division of labour in the EU-27 Mechanical Engineering

The analysis of the ME by Member State in Chapter 2.2 had unveiled changes in the structure of production, in particular of importance for the new entrants. A comparison with the output of the so-called “old” Member States confirms an underlying development. The new Member States have been specializing in the 10 subsectors under consideration. They command around two thirds of total new Member States' production.

Only one of the subsectors has suffered a shrinking share of total ME output in the new Member States, namely ‘taps and valves’. A closer look to the time series reveals that the transitional process had induced a reduction of capacities until the end of the 1990s. Since 2000 this subsector’s output has developed more or less in parallel to all of ME. Both of the off-road machinery subsectors, agricultural and construction machinery command a higher stake in the new entrants output than in the old Member States. In particular for Poland a specialization has been identified and much investment from other Member States took place. This strength is consistent with the manufacture of engines that has been already more important at the beginning of the period under investigation and has grown much stronger. The new Member States do not only have a noteworthy stake in the production of ICEs but also in turbines. The Czech manufacturer of large steam turbines, Skoda, was taken over by the Doosan Power Systems, UK, a member of the Korean Doosan Group. It is of note that the share of ‘metal forming machines’ (machine tools) has grown steadily and reached a share of total output comparable to the “old” Member

States. This subsector is valued as know-how intensive and of key importance for capital goods industries (Figure 2.22).

Figure 2.22: Sectoral division of labour in the EU-27 Mechanical Engineering



EU-15: Old Member States; EU-27 - EU-15: New Member States.

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The pattern in the subsectoral division of labour cannot be easily explained by wage differentials. In fact for some sectors, as for instance is the case with the manufacturing of agricultural and construction machinery, wages are lower than on average for the EU-27 ME, though there are other subsectors such as 'machine tools' and 'engines and turbines' with much higher wages than the sector average.

It can be assumed that the division of labour on the subsectoral level is more dependent on comparative advantages, the quantitative and qualitative endowment with factors, which have also been important for FDI in the region.

The division of labour that primarily is driven by wage differentials concerns parts and components that do not fall into the scope of ME as defined by NACE Rev. 2, but are procured from upstream industries. Among them are castings, steel structures etc. These upstream linkages that have been created after the fall of the iron curtain are, according to the experts interviewed, endangered.

2.4.3 Non-European players activities in the EU

The objectives pursued by non-EU manufacturers' investments in the Single Market are strongly dependent on the target company, ranging from the need to gain access to brand names with high client preferences via the purchase of distribution and service channels to the acquisition of technology and know-how.

In 2005 Dürkopp Adler, a traditional German manufacturer of sewing machines, was taken over by the Chinese Shanggong Group (SGSB). Dürkopp Adler runs several production sites in Europe. SGSB is a large group partly owned by a regional government. Its strategy is explicitly to become one of the largest groups in the market for sewing machines in the world. Dürkopp Adler has been acquired in order to upgrade technology, improve market access and exploit the well-known brand name.

The German Assyst/Bullmer, a manufacturer of advanced cutting machinery for the sewing industry, was taken over by a small German manufacturer of cutting technologies and the Chinese New Jack Sewing Machine. The JV has been renamed topcut-bullmer, a limited company that manufactures and distributes cutting technologies.

Elkem, a Norwegian company that is know-how driven in the area of materials, has been taken over by the Chinese Bluestar group in 2011. It is specialising in high-tech materials based on carbon and silicon. These materials are applied in upstream industries for the production of solar cells, ferrosilicon-based alloys applied in foundries, steel mills, the automotive industry and ME. The Chinese mother company is also specializing in high-tech materials based on silicon and an upstream company for the manufacture of technical textiles. Bluestar had already acquired in 2007 the silicon business area of the French firm Rhodia. This company is key for material innovations in downstream industries and fits into the scope of technology owned by Bluestar.

Kohler Co. is a family held group with headquarters in the US, founded during the 1920s. Among other business areas it has a stake in ME. The focus is on ICEs, applied as portable or stationary power generators. Further applications are in agriculture, construction, forestry and gardening. The company runs several plants in the US and in Europe. In 2005 it acquired the French, family owned manufacturer of power generators driven by ICEs, SDMO. Simultaneously it took over SOOREL, a manufacturer of control panels for power generation and BES, a company specialized in the maintenance of this equipment. In 2007 Kohler acquired the Italian Lombardini, a family held company with a traditional focus on the manufacture of small ICEs. The firm is the third largest manufacturer of serial diesel engines between 10 kW and 100 kW for the agricultural sector. The US firm expands its global representation by improving its access to the European market, using regional brands, distribution channels and production sites.

MWM, a manufacturer of large ICEs, was part of the Deutz group until 2007 when it was sold to 3i, a private equity investor. Only three years later in autumn 2010 Caterpillar, a global player in construction and mining machinery, purchased MWM. It has been integrated in the US firm's production network together with other companies that have been acquired within a short period of time. Another company acquisition was EMD, a US manufacturer of diesel engines for locomotives.

3 Major competitors and sales markets

This chapter is dedicated to the analysis of the more important competing economies and the evaluation of their performance, focussing on the evolution between 2000 and 2010. Changes in the labour productivity and labour costs are analysed to identify changes on the cost competitiveness. Moreover, an investigation in public research policies of relevance for ME is carried out for the assessment of the framework conditions on innovation in the different competing economies under consideration. Finally, an analysis of the economies global trade and bilateral trade with the EU contributes to an assessment of the comparative performance of ME in relation to other domestic industries.

A second aspect to be tackled in this chapter is an investigation in important sales market. The analysis is dedicated to disclose the EU-27's performance in the international trade with ME products. Are growth potentials in promising markets sufficiently exploited or market shares lost to other players? Following that, what will be the long-term prospects?

3.1 Major competitors

The USA, Japan and China have been mentioned in the ToR as the most important competing economies for the EU-27 ME. This chapter focuses on a presentation of the competing industries, their evolution, trends in efficiency and the trade performance.

The competing economy's evolution of output and changes in efficiency are compared to the EU ME. It is of note that the time series are converted into EUR by fixed exchange rates of 2010. Time series in constant prices are rebased to 2010, i.e. nominal values 2010 correspond to equal constant price values (volumes) 2010.

The trade performance assessment looks at the relative strengths of the competing economy's ME as compared to the competing economy's total manufacturing (comparative advantage). This analysis considers the performance on global trade as well as in bilateral trade with the EU.

3.1.1 United States

Output and evolution

The US ME had reached a total output of € 221.6 bn in 2010, as measured by turnover. This means 44% of the EU-27 output. The number of workplaces of around 1.1 million is roughly 40% of the EU ME's employment level. However, the US value added reaches a share of 65% and indicates a higher labour productivity than the EU (Table 3.1).

The US ME's growth was muted during the past decade. Even between 2000 and 2008, at times of soaring global investment in machinery and equipment, the annual average growth rate was less than 1.5%. During the global economic crisis all of the gains have been lost. The value added of the US ME in 2010 – as calculated in constant prices – is 17% below the value of 2000. Against this background, the EU ME had suffered a similar setback as its US rival during the financial crisis. However, due to a higher growth rate up to 2008 the real value added in 2010 had already regained the level of the base year 2000.

This development of the output parallels with the employment figures in the US: of the total 1.5 million employees in 2000 only 1.1 million had been retained in 2010. For the EU-27, the decline of employment rate was similar in absolute terms (400,000). The much higher number of workplaces available, however, meant that the EU ME had lost 'only' 14% of its employment, whereas the US ME had laid off roughly one quarter of the workforce.

Efficiency

International comparisons of labour productivity highlight astonishing high levels for the US, both in terms of macroeconomic and sectoral investigations. These results coincide with the findings of this study: compared to the EU-27, the US ME's labour productivity is around 70% higher. The result is even more striking if one compares the development over the period under consideration. Labour productivity in 2010 is 8.4% higher than in 2000 whereas labour costs per employee had increased only by 6.0%. The wage development for the US ME shows a moderated growth in 2005 and the years to follow, albeit with a major breakdown happening on the outbreak of the financial crisis.

Over the same period the EU had enjoyed a much better growth of labour productivity. Despite a fall in labour productivity induced by the crisis in 2010, productivity exceeded the 2000 base level by 16.4%. Against this background, wage increases accelerated after 2005 and did not even shrink between 2008 and 2010. This development had worsened the economic performance of EU enterprises. In contrast to the US, the EU-27 unit-labour costs (ULC) soared after 2008, due to low capacity utilization, and the gross operating rate (GOR) fell strongly. The negative economic impact of the crisis on the US ME was much less pronounced than for the EU. This might have been caused by different occupation models, wage contracts and a more rigid European labour market.

Table 3.1: Output and efficiency of the US mechanical engineering

Sector	Indicator	2010[1]		Annual average change rate in %		
				2000– 05	2005–08	2008– 10
USA						
Output[2]	Current prices Constant prices	€ bn	221.6	0.9 1.0	3.1 1.5	-8.0 -9.5
Value added Employees	Constant prices Numbers	€ bn 1000	103.0 1130	0.1 -5.1	2.2 1.9	-12.0 -2.9
Labour productivity	Value added per capita[3]	€	91125	5.5	0.3	-9.3
Labour costs	Per employee	€	39815	3.7	1.8	-8.5
Gross operating rate[4]	Share of value added	%	56.3%	1.4	0.1	0.6
Unit-labour costs[5]	Labour costs per output unit	€/€	0.44	-1.7	1.5	0.9
EU-27						
Output[2]	Current prices Constant prices	€ bn	502.1	2.3 1.3	10.4 8.0	-8.4 -9.3
Value added Employees	Constant prices Numbers	€ bn 1000	157.5 2900.5	0.3 -2.2	6.0 1.8	-9.3 -4.8
Labour productivity	Value added per capita[3]	€	54290	2.6	4.1	-4.7
Labour costs	Per employee	€	33243	3.1	3.7	1.9
Gross operating rate[4]	Share of value added	%	38.8%	-0.6	0.5	-8.6
Unit-labour costs[5]	Labour costs per output unit	€/€	0.61	0.5	-0.5	6.9

[1] 2010 prices and exchange rates; [2] US output = turnover, EU output = production; [3] At constant prices; [4] (Value added - wages)/value added); [5] value added at constant prices per € 1 labour costs.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Trade performance

The US ME currently delivers 58% of its output to domestic clients. This demand had shrunk all over the study period. With a decrease of 33% between 2000 and 2010, US manufacturers lost shares in their domestic market. Despite this difficult market environment, foreign suppliers were able to stabilize their sales of machinery in the US. US machinery imports from the EU performed even better and gained shares of total ME imports. In the shrinking US market the EU ME gained, up to 13% in 2010. In 2005 the EU ME had only reached roughly 5%. (Table 3.2)

The US machinery exports to the EU grew at a higher rate than than the US imports. However, the traditional trade deficit with the EU remained nearly unchanged. This stabilization was caused by different trade levels. The growing US ME exports are above all explained by the expansionary development of the EU machinery market. As a drawback, the US manufacturers lost shares in the Single Market of 5% in 2010.

The US ME **global trade balance** shows a surplus that has improved between 2000 and 2010. Of major importance are deliveries to NAFTA countries, Canada and Mexico. The US traditionally commands high shares in Latin America. In the meantime, Asia and particularly China have become important markets, too. The trade with non-EU regions more than compensated for the trade deficit with the EU. The global trade balance grew by roughly € 5 bn up to € 13.8 bn in 2010.

A comparison with **global trade of total manufactured goods** unveils a much better performance for the US ME compared to the average of all other industries Traditionally, the US trade balance is negative. Over the study period, the gap increased by € 70 bn, up to a trade deficit of € 566 bn in 2010. The comparative advantage of the US ME is confirmed by both trade indicators: the so-called Balassa Index (BI) is positive and has grown over the period under investigation. This means that for the US, the ME share of total exports of manufactured goods is higher than compared to total global trade in ME. Likewise, the Revealed Comparative Advantage (RCA) discloses an advantageous position of the US ME trade balance compared to the US trade balance for all manufactured goods.

In terms of **transatlantic trade**, the picture looks slightly different, though. The positive and growing BI indicates a stronger and even growing concentration of US ME exports to the EU. This development is mirrored – among others – also for global trade. In terms of the global RCA for US trade with ME products, the RCA value for transatlantic trade of US and the EU is negative. The magnitude of trade had been reduced between 2000 and 2010, indicating a reduction of the trade deficit. This development is attributed above all to the growing EU demand for ME products.

Table 3.2: Trade performance of the US mechanical engineering

Sector	Indicator	2010		Annual average growth rate in % 2000 - 05	2005-08	2008 - 10
USA	Domestic demand[1] Mech. engineering	€ bn	207.8	-3.7	-4.6	-4.7
EU-27			374.2	1.4	9.7	-11.0
US global trade Total manufacturing	Imports	€ bn	1429.8	0.6	1.9	0.3
	Exports	€ bn	863.4	-2.9	6.6	1.1
US - EU trade Total manufacturing	Imports	€ bn	240.3	1.6	-0.3	-1.6
	Exports	€ bn	168.2	-4.0	4.6	-4.7
US global trade Mechanical engineering	Imports	€ bn	80.0	1.7	-0.4	-2.0
	Exports	€ bn	93.7	-2.6	6.2	1.4
US - EU trade Mechanical engineering	Imports	€ bn	27.3	4.3	3.2	-7.1
	Exports	€ bn	17.7	1.8	8.6	-5.6
				2000	2008	2010
Trade balances Manufacturing	Global[2]	€ bn		-494.1	-577.1	-566.4
	EU[2]			-32.2	-63.0	-72.1
Trade balances Mechanical engineering	Global[2]	bn. €		9.0	7.8	13.8
	EU[2]			-9.2	-11.8	-9.6
BI Mechanical engineering[3]	Global[2]	0=neutral >0=advantage <0=disadvant.		18.2	19.9	25.0
	EU[2]			-22.2	19.6	22.0
RCA Mechanical engineering[4]	Global[2]			58.6	61.0	66.3
	EU[2]			-35.0	-17.2	-7.6

1) Production plus imports minus exports; 2) Exports minus imports; 3) Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); 4) Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i / j: Mechanical engineering / USA; t / r: Total manufacturing / all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

R&D Policies

Challenges

The US manufacturing sector accounts for 20% of the total value of global output. US manufacturers perform half of all research and development (R&D) activities within the US, by employing 17% of the national scientists and engineers. Being exposed to increasing international competition, US manufacturers have been losing ground.[67] One of the most troubling indicators for the National Institute of Standards and Technology (NIST) is the US trade deficit in advanced technology products: an indicator is the fact that in 2008, for the first time, more than half of US patents were awarded to companies outside the United States. Equally worrying is the below-average export performance of the national manufacturing sector as a whole. In terms of the value of merchandise

67 http://www.nist.gov/public_affairs/factsheet/comp_manuf2012.cfm

exports as a percentage of all domestically made goods, the US proportion is less than half of the average for the world's 16 largest economies, placing it at the very bottom of the scale. Given the facts, that 95% of all potential consumers live outside the United States, that emerging and developing countries are the fastest-growing and that domestic demand continues to suffer from the economic crises probably for a long time to come, increases in US exports can be considered as the primary path to sustainable rates of future economic growth.[68]

In an attempt to tackle these issues, the US administration is committed to facilitating the building of domestic manufacturing capacity to advance new product creation, fuel new emerging industries and create jobs for the future. Different departments and government agencies traditionally support the industry by promoting basic research, industrial R&D, innovation, SMEs[69] and start-ups. The Department of Energy's Advanced Research Projects Agency (ARPA-E) fosters R&D in the field of new energy sources.[70] The Department of Defense and its Defense Advanced Research Projects Agency (DARPA) finances R&D in a wide range of technologies.[71]

Chief Manufacturing Officer

An important organization for many manufacturing industries is the National Institute of Standards and Technology (NIST), which is an agency of the Department of Commerce (DOC). The agency has a unique mission to work closely with industry. In view of the dissatisfactory situation of the US manufacturing industry the NIST announced the appointment of the agency's first-ever Chief Manufacturing Officer in July 2011.[72] By creating this new position, the US aim at leveraging NIST's strong relationship with industry to accelerate innovation that should create manufacturing jobs and enhance global competiveness. As part of this effort, the position will support the broader "Advanced Manufacturing Partnership" (AMP) launched by President Obama in June 2011.

Advanced Manufacturing Partnership (AMP)

The AMP is being developed based on the recommendation of the President's Council of Advisors on Science and Technology (PCAST) which released a report entitled "Ensuring Leadership in Advanced Manufacturing".[73] It calls for a partnership between government, industry, and academia to identify challenges and opportunities to improve the performance across multiple manufacturing, such as ICT, bio-, and nanotechnology. The plan will leverage existing programs and proposals and will amount to more than $ 500 mln.[74] A number of key steps have already been announced, such as

- Projects including small high-powered batteries, advanced composites, metal fabrication, bio-manufacturing, and alternative energy,
- Time reductions to develop and deploy advanced materials,
- Investments in next-generation robotics,
- Development of innovative energy-efficient manufacturing processes and materials to cut the costs of manufacturing, while using less energy,

68 http://www.nist.gov/public_affairs/factsheet/comp_manuf2012.cfm
69 http://www.sbir.gov/
70 http://energy.gov/sites/prod/files/edg/news/documents/DOE_StrategicPlan.pdf
71 http://www.darpa.mil/
72 http://www.nist.gov/director/molnar-070111.cfm
73 http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf
74 http://www.whitehouse.gov/the-press-office/2011/06/24/president-obama-launches-advanced-manufacturing-partnership

- DARPA explorations of new approaches that have potential to dramatically reduce – by a factor of max. 5 – the time required to design, build and test manufactured goods while enabling entrepreneurs to meet the US Department of Defense needs,
- The Department of Energy launch of an initiative with the Ford Motor Company and the National Association of Manufacturers to make use of the Department‘s National Training and Education Resource to educate and train a new generation of manufacturers.

The 2012 budget of President Obama includes six initiatives focused entirely or in part on helping to drive continuous innovation in the manufacturing sector, and to enable major advances in production processes and capabilities. Activities carried out under the six proposed initiatives are supposed to enable NIST to bolster and diversify research efforts that will strengthen the US manufacturing competiveness in high-value-added product markets:

- Innovations for 21st century manufacturing: faster, smarter, and cleaner products,
- Advanced materials for industry,
- measurements to support the production of nanotechnology-based products,
- measurements of science and standards to support biomanufacturing
- the advanced manufacturing technology (AMTech) Consortia Program
- strengthening measurement services in support of industry needs.

Hollings Manufacturing Extension Partnership (MEP)

Besides the initiatives already mentioned above, the US administration intends to request a budget increase for the “Hollings Manufacturing Extension Partnership (MEP)”. The MEP is a nationwide network of about 1,550 manufacturing experts that provide technology and business assistance to small and medium-sized manufacturers. Overall, more than 34,000 businesses were served by MEP in 2010.

Technology Innovation Program (TIP) of the NIST

Established in 2007, the NIST Technology Innovation Program assists US businesses and institutions of higher education or other organizations, e.g. national laboratories and nonprofit research institutions, to support and promote innovation through high-risk, high-reward research in areas of “critical national need”. In 2009, manufacturing and biomanufacturing i.e., advances in materials and critical manufacturing processes, were identified as areas of critical national need by the TIP. To reach out to manufacturers and to select further areas of critical national need, TIP has asked interested parties to submit white papers describing an area of critical national need and how those needs might be addressed through potential technological developments, fitting the category of high-risk, high-rewarding R&D.[75] These white papers encouraged submitters to provide their input on critical national needs and asked them to select one or more of the following: civil infrastructure, complex networks and systems, energy, ensuring future water supply, healthcare, manufacturing, nanomaterials/nanotechnology, and sustainability. The topics of “energy” and “manufacturing”, with the latter including materials and sustainable manufacturing, were amongst the most frequently selected ones.

[75] http://www.nist.gov/tip/factsheets/upload/white_paper_fact_sheet.pdf

In April 2011, US President Obama signed into law, the final Continuing Resolution for the remainder of the Fiscal Year 2011. Under this bill, TIP was allocated $ 44.8 million for the continued funding of ongoing TIP and ATP[76] projects.[77] The President's FY 2012 budget request was submitted to Congress. Under this plan, the President recommends $75 million for TIP in FY 2012. Pending approval of the FY 2012 budget, TIP expects to hold finding competitions in one or more of the following research areas:

- Advanced Robotics and Intelligent Automation
- Civil Infrastructure
- Energy
- Healthcare
- Manufacturing
- Water

TIP has been updating its programmatic plan to reflect changing priorities with an expectation to revise its program. As such, it continues to solicit comments from the public on TIP-drafted white papers and invites the public to submit white papers that elaborate on the research topics above or that propose new areas of research for consideration in future competitions. It is expected that these white papers will determine the program priorities for TIP.

Conclusions

Performance of mechanical engineering

Despite the prevalent position of the US in R&D, the US manufacturing industry has been rather underperforming in terms of industrial production and workplaces. Within that trend, the ME can not be considered an exception albeit at a first glance, the indicators for the economic performance of the US ME suggest a high competitiveness. Labour productivity is nearly 70% higher than for the EU and increase in labour costs could be more than compensated by productivity gains. However, the number of workplaces was reduced by 23%. This pattern supports the assumption that productivity has not increased by efficiency gains but by losses of marginal workplaces and the closure of non-productive production facilities.

Large US manufacturers have gained price competitiveness by relocating production to low-wage locations. The growing share of imports can not only be attributed to foreign manufacturers success in the US market, but also to own imports of US companies. Since more than a decade this development has been discussed under the slogan “hollowing out”.

In spite of this gloomy development of the US ME, the trade analysis for ME displays a better performance than for most other manufacturing industries. The BI index on export specialization shows a considerable growing concentration of US exports on ME products. Moreover ME is one of few industries where the US trade balance is positive. This is an amazing result if one takes into account that the US is understood as a country leading in advanced technologies, whereas its position in mature mechanical technologies is less pronounced. An explanation is provided by the fact that ME is an industry that is

[76] The Advanced Technology Program (ATP) was the predecessor program of TIP.
[77] http://www.nist.gov/tip/index.cfm

“less mobile” than many other industries, even high-tech industries. The industrial infrastructure, required long-term relationships in the value chain, context-specific know-how and the predominance of small- to medium batch production quantities are factors that explain why ME is less prone to the relocation of production. In this respect, mature industrialized countries, such as the US own comparative advantages that can be exploited by ME enterprises.

R&D activities

The strong position of the US in the global R&D landscape contrasts to the low performance of the US manufacturing sector. Several factors may explain the reasons behind: while the US research key strength lies in the ICT sector, the sector characteristics render it easy for companies to relocate their ICT production to low-wage locations. This has lead to many of the manufacturing facilities already shifted to Asia. Furthermore, many R&D resources are dedicated to the defense industry. Despite their triggering effect they are overall less relevant for market oriented innovations.[78]

Numerous public initiatives have been launched to primarily foster the US position in technologies with growth perspectives. The areas of technologies are the same that are in the focus of the other competing countries’ public policies under consideration, ICT, bio technology, production technology, green technologies and health. There are noteworthy efforts to give a hand to smaller companies. However, no information has been made available on noteworthy effects.

The Obama administration has been busily expanded activities and launched new programmes to overcome the weak performance of the US manufacturing. However, budget constraints limit the possibilities and 2012 budgets have not been finally agreed upon. Some initiatives, such as the Technology Innovation Programme (TIP) are in an early stage. However, the multitude of public initiatives does not provide the impression of a stringent approach. The tenor of the papers analysed does not support optimism that a turnaround is reachable.

3.1.2 Japan

Output and evolution

The Japanese ME had reached a total output of € 151.9 bn in 2010, as measured by turnover, equalling to 30% of the EU-27 output. The number of workplaces of around 0.68 million is roughly 24% of the EU ME’s employment level. However, the Japanese value added reaches a share of 42% and indicates a much higher labour productivity than the EU (Table 3.3).

78 During the early 1990s it was expected that – induced by the end of the Cold War – the US could become a more important competitor in manufacturing. However, the transition of R&D efforts from defence to more market relevant areas of activities has not taken place. See: Kriegbaum, H. et al. (1997) “The EU Mechanical Engineering Industry – Monitoring the evolution in the competitiveness”, in: ifo Studien zur Industriewirtschaft Vol. 54, Munich, p.201.

The Japanese ME's growth was steady between 2000 and 2005. Between 2005 and 2008, when EU output accelerated, the Japanese growth lost momentum. The financial crisis induced a more severe breakdown than for any other of the large economies under consideration here. The value added of the Japanese ME in 2010 – as calculated in constant prices – is around 30% below the value of 2000, whereas the EU ME had already regained the level of the year 2000 in 2010.

The employment record of the Japanese ME was weak for the period under investigation. The number of workplaces was reduced by 27%: of the 935,000 employees in 2000 only 685,000 had been retained in 2010. In contrast to that, the EU ME accounts for losses of 'only' 14% of its employment.

Efficiency

The Japanese ME's labour productivity is the highest among the economies under consideration. It exceeds the EU by 78%. Up to 2008 labour productivity grew only slightly and lost nearly all of the efficiency gains during the financial crisis. In 2010 labour productivity is only 0.8% higher than in 2000. However, wages declined from 2005 onwards and contributed much to the price competitiveness. Wage levels in 2010 are 10% lower than in 2000.

In the same period, the EU had enjoyed a much better growth of labour productivity. Despite the decline caused by the crisis in 2010, productivity exceeded the 2000 level by 16.4%. However, wage increases accelerated after 2005 and wages did not decrease between 2008 and 2010. This development had worsened the economic performance of EU enterprises. Despite progress in labour productivity the EU ME's ULC had increased of around 15% between 2000 and 2010. Contrasting that, the Japanese ULC decreased by around 10% over the period under investigation and the GOR increased by 3.5%, up to 66.5%. The EU ME's GOR fell from 47% in 2000 down to 38.8% in 2010. For both of the indicators, Japan is in the lead, its ME shows the lowest ULC and the highest GOR.

Table 3.3: Output and efficiency of the Japanese mechanical engineering

Sector	Indicator	2010[1)]		Annual average change rate in % 2000– 05	2005–08	2008– 10
Japan						
Output[2)]	Current prices Constant prices	€ bn	151.9	1.3 2.4	1.7 1.5	-22.1 -22.0
Value added	Constant prices	€ bn	66.2	1.4	0.1	-17.2
Employees	Numbers	1000	684.6	-0.2	-1.5	-12.0
Labour productivity	Value added per capita[3)]	€	96700	1.7	1.6	-6.0
Labour costs	Per employee	€	32.4	0.5	-2.4	-3.0
Gross operating rate[4)]	Share of value added	%	66.5%	0.1	2.1	-1.5
Unit-labour costs[5)]	Labour costs per output unit	€/€	0.34	-1.2	-3.9	3.1
EU-27						
Output[2)]	Current prices Constant prices	€ bn	502.1	2.3 1.3	10.4 8.0	-8.4 -9.3
Value added	Constant prices	€ bn	157.5	0.3	6.0	-9.3
Employees	Numbers	1000	2900.5	-2.2	1.8	-4.8
Labour productivity	Value added per capita[3)]	€	54290	2.6	4.1	-4.7
Labour costs	Per employee	€	33243	3.1	3.7	1.9
Gross operating rate[4)]	Share of value added	%	38.8%	-0.6	0.5	-8.6
Unit-labour costs[5)]	Labour costs per output unit	€/€	0.61	0.5	-0.5	6.9

[1)] 2010 prices and exchange rates; [2)] Production/turnover; [3)] At constant prices; [4)] (Value added-wages)/value added); [5)] value added at constant prices per € 1 labour costs.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Trade performance

The Japanese ME delivers 45% of its output to domestic clients and suffered strongly from the decline of its home market. In 2010, the market value was less than half of 2000. This was by far the deepest fall among the economies under investigation. Over the whole period machinery imports grew at an annual average rate of 2% and gained a market share of 22% in 2010, as calculated by the import ratio. This ratio has come close the EU-27 import ratio of 23%. However, it must be taken into account that to a large extent these imports originate from own production sites abroad and to a lesser extent from foreign owned companies. Traditionally, foreign firms do not command large shares in Japanese markets. This is caused primarily by cultural barriers and to a lesser extent by tariff or non-tariff barriers. Relocation is on top of the agenda for the Japanese manufacturing, with China having become an important location for outward investment. Considering the difficult market environment, the EU manufacturers performed well in Japan. Their exports to Japan, i.e. imports for the Japanese trade balance, grew at an annual average rate of 2.6%, even stronger than total Japanese machinery imports. However, their share in the Japanese ME market remained at a low level of only 4% (Table 3.4).

The Japanese machinery exports to the EU grew strongly until 2008, followed by collapsing exports of up to 20% in the years after. This is partly due to the financial crisis and an overvalued Yen. The Japanese share of the EU domestic demand by exports is below the EU share of the Japanese ME markets. However, the Japanese ME has a long-standing tradition in global production networks. They shift production to more cost competitive countries hence more easily circumventing exchange rate volatilities. Moreover, Japanese enterprises own numerous production sites in the EU.

The Japanese ME global trade balance shows a surplus that has improved between 2000 and 2010. Despite the overvalued Yen it has reached € 65.1 bn in 2010. Japan benefits strongly from demand in the region, in particular from China. To a certain extent, this development is driven by the relocation of production sites by client industries. The Japanese **trade balance with the EU** showed no clear trend between 2000 and 2010. In 2010, it rose up to € 9.9 bn and accounted for nearly half of the Japanese trade surplus with the EU in manufactured goods.

The development of the Japanese **global trade balance** with manufactured goods discloses an increasing focus on ME products. The surplus declined to € 33.2 bn in 2010, while the surplus for ME had reached € 65.1 bn during the same period. Without ME the Japanese trade balance would have been negative. The comparative advantage of the Japanese ME in relation to other domestic industries is confirmed by both trade indicators, for global trade as well as for bilateral trade with the EU. The Balassa Index's (BI) increase indicates the cumulative specialization, particularly pronounced for bilateral trade with the EU-27. Likewise the Revealed Comparative Advantage (RCA) discloses the growing importance of ME for the Japanese trade surplus.

Table 3.4: Trade performance of the Japanese mechanical engineering

Sector	Indicator	2010		Annual average growth rate in % 2000 - 05	2005-08	2008 - 10
Japan	Domestic demand[1] Mech. engineering	€ bn.	86.8	-6.0	-4.0	-19.1
EU-27	Domestic demand[1] Mech. engineering	€ bn.	374.2	1.4	9.7	-11.0
Japanese global trade Total manufacturing	Imports	€ bn.	512.5	0.1	7.8	0.3
	Exports	€ bn.	545.6	-1.8	3.3	4.2
Japan - EU trade Total manufacturing	Imports	€ bn.	43.8	-0.5	-1.1	1.8
	Exports	€ bn.	64.9	-4.1	0.5	-7.0
Japanese global trade Mech. engineering	Imports	€ bn.	18.9	2.3	3.8	-1.4
	Exports	€ bn.	84.0	-0.6	3.6	4.0
Japan - EU trade Mechanical engineering	Imports	€ bn.	4.2	5.0	6.1	-7.9
	Exports	€ bn.	14.1	5.9	6.6	-11.9
				2000	2008	2010
Trade balances Manufacturing	Global[2]	€ bn.		95.9	-6.7	33.2
	EU[2]			46.5	32.8	21.2
Trade balances Mechanical engineering	Global[2]	€ bn.		56.6	58.3	65.1
	EU[2]			8.0	13.2	9.9
BI Mechanical engineering[3]	Global	0=neutral >0=advantage <0=disadvant.		48.0	55.9	60.0
	EU			32.2	100.6	94.2
RCA Mechanical engineering[4]	Global			132.4	139.8	142.8
	EU			53.8	73.3	82.5

1) Production plus imports minus exports; 2) Exports minus imports; 3) Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); 4) Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i / j: Mechanical engineering / Japan; t / r: Total manufacturing / all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Research and development

Challenge

Japan belongs to the technologically most advanced countries within the OECD: its gross expenditure on R&D (GERD) edged higher to 3.3% of GDP in 2009 ranking third highest in the OECD after Finland and Sweden. Over 66% of GERD were financed by industry, only 17.7% by government. This share of public contribution is the lowest of all OECD countries. With regard to its patent activities Japan ranked second in OECD after the United States. Its science and innovation profile demonstrates top performance in numerous areas, such as consumer electronics, ICT and automotive. Moreover, the Japanese ME traditionally belongs to the sectors which are highly competitive worldwide by its products and its advanced state of technology.

Yet, the Japanese economy has continued to stagnate for about 20 years since the collapse of the bubble economy at the beginning of the 1990s. Therefore in 2010, the Japanese government has concluded the "New Growth Strategy" which should lift Japan out of the economic deadlock. The new approach is demand-driven by aiming at developing a problem-solving country as a way to create new demand and improve people's lives.[79] According to the strengths of Japan in the fields of science and technology, the new economic strategy is based to a large extent on technological and educational innovation.

New Growth Strategy

Innovation policy in Japan continues to be set at the highest level of government by the Council for Science and Technology Policy (CSTP)[80]. The council is responsible for drafting the "Science and Technology Basic Plan" (STBP). In its latest version, the 4th STBP sets out the time period 2011 to 2016. According to the CSTP, past policy directions were implemented mainly to promote S&T rather independently and less often aligned with with other pertinent policies and ministries. Now there was increasing need in Japan for the government to make an all-out effort to strongly and strategically promote S&T policies by integrating innovation policies, and tying S&T policies closely to other key policy areas, such as industry, economy, education, diplomacy etc., based on the New Growth Strategy.[81]

On the basis of the New Growth Strategy the 4th STBP describes two major innovation fields as pillars of growth:

- Green Innovation
- Life Innovation.

The government will promote Green Innovation with the aim to solve the climate change issues menacing Japan and rest of the world. Besides, it aims at bringing about the world's most advanced low-carbon society by identifying trends in non-fossile fuels that many countries are developing competitively as a key to future growth. Such promotion is expected to facilitate further innovation of environmental and energy technologies, building on Japan's existing strengths.

Japan is facing the most rapidly ageing society in the world. Hence, solutions to assure adequate medical and nursing care, are expected to become key in the future, while showing respect for personal views of life and death.

To support these growth areas the government wants "to reinforce Japan's superiority in science and technology that has been developed over a long period of time in line with a strategy for making Japan a superpower in science and technology, as well as information and communications technology".

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79 Ueki, K. (2011) "Demand-side innovation policies in Japan", in: OECD (Ed.), Demand-side innovation policies, Paris.

80 OECD (2010). Science, technology and industry outlook 2010. Organization for Economic Co-operation and Development, Paris.

81 CSTP (2010). Japan's Science and Technology Basic Policy Report. Council for Science and Technology Policy, Tokyo, www8.cao.go.jp/cstp/english/basic/4th-BasicPolicy.pdf

Within the New Growth Strategy, altogether 21 measures, identified as National Strategic Projects, are expected to impact economic growth. One of them relates to the utilization of information and communications technology which should be further promoted. Although Japan is among the leading countries in IT innovations, it is lagging behind many other countries in its application. Another Strategic Project is enhancing research and development (R&D) investment. The government aims to increase public- and private-sector R&D investment to over 4% of GDP by the fiscal year 2020. To achieve this, the Japanese government aims at implementing a two-fold approach: enhancing government-involved R&D according to the 4th Science and Technology Basic Plan and implementing various measures to promote R&D, such as carrying out regulatory reforms, for instance. It is envisaged to review the system of public support to increase the effectiveness of public R&D promotion. Public-private partnerships are recognized as an efficient tool for common efforts. Private Finance Initiatives (PFI) for R&D shall receive tax incentives.

The new demand- and problem-oriented S&T policy approach seems to be clearly different from the former technology and industry promotion schemes. Still in the 3rd STBP (2006-2010) the conventional promotion patterns prevailed with eight areas being supported[82]:

- Life Science
- ICT
- Environment
- Nanotech/Materials
- Energy
- Manufacturing technology
- Social infrastructure
- Frontier (Technologies for deep sea and space exploration).

From the technological point of view, the new R&D policy is obviously more focused. It remains to be seen whether the new approach will lead to a higher innovation level and to more economic effectiveness. It is also unsure if a significant shift of resources to concerned industries will happen. Although areas such as life science and renewable energies will benefit from the new S&T policy, many other sectors and industries are likely to continue benefitting from support for public and private R&D activities. Regarding private R&D one has to keep in mind that in Japan more than 98% of business enterprise expenditure on R&D is financed by the industry itself.

Conclusions

Performance of mechanical engineering

Until the early 1990s the Japanese manufacturing has been extremely successful in the global economy and conquered large shares in the most important markets. The companies did not only pursue export strategies, but heavily invested in sales markets as well as in low-wage production locations. This has led to a reduction of the dependency from domestic demand, domestic framework conditions, as well as exchange rate

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82 Baba, T. (2010) "Japan's R&D Strategy of Nanomaterials", www.nseresearch.org/2010/presentations/Day1_Toshio_Baba_JapanNanotech_201012.pdf

variations. This has helped the companies to master the Japanese economy's problems of stagnation and an overvalued currency.

The economic performance of the Japanese ME is highlighted by labour productivity of € 96,700 per capita and annum, equal to 78% above the EU level. To a certain extent, this level might be attributed to an overvalued Yen in 2010, but this will by no means explain all of the difference. The US and the Japanese labour productivity are of comparable magnitude. The Japanese labour productivity had not increased between 2000 and 2010, but declining wages have contributed to an improved economic performance. Although former output levels had not been reached in 2010 the ULC are around one tenth below the 2000 level and the GOR increased. The number of workplaces was reduced by 27%. The pace of reduction was the same as for the contraction of the Japanese ME's value added.

Similar to the US, the slogan "Hollowing out" has been a topic in the Japanese public. Relocation of production sites has a long-standing tradition. The growing share of imports of total domestic demand has not only been caused by foreign manufacturers' success in the Japanese market, but by own imports of Japan's firms.

Japan's success in global markets has been strongly linked to ICT and the automotive industry. Having this in mind Japan's trade balance provides interesting results: already in 2000 nearly half of the global trade surplus with manufactured goods stemmed from trade with ME products. Already in 2010 without ME, the Japanese balance of trade with manufactured goods would have been negative. For Japan as well as for the US ME had gained importance in their trade balances. Admittedly, the growing surpluses have been caused to a certain extent by the shrinkage of the domestic market whereas global demand for machinery has been booming. But the growing specialization of exports on ME supports the assumption of advantages for the production of ME products in developed economies that do not exist in a similar extent for most other industries.

R&D activities

Public initiatives have played an outstanding role for the ascent of the Japanese economy. The former Ministry of International Trade and Industry (MITI) was the mastermind of the Japanese companies' success in global markets. Its successor, the Ministry of Economy, Trade and Industry – created 2001 – has never reached this reputation. In spite of publicly co-ordinated efforts for the triumphant advance of Japanese companies, public funding of R&D has not been of similar importance as for other OECD economies. Regarding private R&D expenditure, Japanese companies have been on the leading edge in world markets.

Japanese R&D policies have always been directed on S&T for innovations with promising prospects in sales markets. In contrast to other economies public initiatives, they had not been co-ordinated with pertinent ministries and societal interest groups. This has changed only recently with the 4th STBP that envisages a broad anchorage and ownership of its initiatives. Further on, the focus of policies on only two subjects, green and life innovation, primarily dedicated to meet domestic needs signifies a turning point in Japanese public policies.

This recently defined New Growth Strategy for Japan with its reorientation of R&D policies is a paradigm shift. It will be quite interesting to see if schemes under the new STBP are sufficiently attractive for companies that primarily trust in self-financing of research projects.

3.1.3 China

Up to the end of the last century, most Chinese machinery companies were state-owned enterprises lagging behind in technological development and with inappropriate governance structures. There were many areas where the Chinese did not have much IP and domestic demand was primarily generating more imports. In the past decades, however, the main strategy of Chinese government then was importing high-end machinery to upgrade own production, starting joint ventures with foreign firms and with minority foreign shares to become familiar with advanced management methods.

In the first decade of the new century, with the spill-overs of foreign investment, talent pools were created and firm's internal management practice was improved. Along with the long-term boom in economy, Chinese firms hence began operating under better financial conditions, which allowed them to catch up with their foreign competitors. The government then promoted technology transfer within the booming market: instead of importing machines, the government had shifted its target to importing capital. In an attempt to capture this opportunity, many foreign firms acquired majority shares of Chinese firms. However, the plan of "market in exchange for technology" was often not successful, since it created a resurging nationalistic and independent approach and resistance to acquisitions by foreign investments. Initiatives to upgrade the domestic machinery industry have been taken and measures have been launched to limit imports of machinery to protect domestic manufacturers.

Size and growth of the Chinese market have provided good framework conditions for the development of large companies that – by their size – are capable of exploiting higher economies-of-scale than their Western competitors. In producing harbour cranes the Shanghai Zhenhua Heavy Industry has become world market leader and outperformed the German Competitor Demag Cranes and the Finnish company Kone – albeit by numbers, not by technology.

Corporate strategies and business models

FDI activities of Chinese companies abroad have raised concerns on growing competition in global markets. In the media, large investments in access to natural resources are attracting primordial attention. M&A and the investment in key know-how dedicated to strengthening technological competence are less visible but are likewise alarming, although investment volumes are much smaller. This is a more recent development that started during the latter half of the 1990s and is expected to accelerate in the years to come. A survey carried out by the China Council for the Promotion of International Trade (CCPIT) has disclosed that within manufacturing industries the subsectors "Textiles and textile products" and "Machinery and equipment n.e.c." are of major importance among Chinese enterprises' outward investment with around 14% and 17% respectively, directed towards developed countries. The share of "Machinery and equipment n.e.c." related to Chinese FDI in developing countries even exceeds 20%. The FDI objectives between developing and developed countries show different patterns. Most pronounced are discrepancies in “technical introduction”, being of notable importance for investments in developed countries and “resource exploitation” which is important for developing countries. For both of the target regions, market access is important.[83]

Table 3.5 juxtaposes affiliations between European and Chinese enterprises. Both of the Danish companies listed (NKT cables and Danfoss District Energy) have invested in Chinese production sites. NKT cable has invested to better serve the Chinese market and expand the current product programme from low to medium voltage cables up to high-voltage cables. The investment of Danfoss in Chinese production is dedicated to support the global activities of the company. Beyond production R&D is carried out. The tripartite JV provides Wärtsilä with a better downstream access. The area of gravity for shipbuilding has shifted to Asia and European manufacturer may have to follow to stay competitive. This development is equally valid in market segments with a limited number of competitors, such as large diesel engines for vessels. The KSB JV, mentioned in the table below, will strongly benefit from the nearly insatiable Chinese demand for Energy. Other Chinese activities of KSB – not mentioned below - are linked to the company’s global value chain and a division of labour between different company locations. The Chinese investment in the manufacture of machinery for the clothing and apparel industry concerns an industry that has been under consolidation for more than two decades. The availability of technology but also of well-known brand names and distribution channels might have driven the acquisitions.

The last two examples do not concern mechanical engineering, but are of importance as upstream suppliers. FACC is strong in CFRP and is involved in the value chain of the most prominent aircraft manufacturers. The application of CFRP is not yet widespread in ME, but there is potential with dissemination expected to accelerate once automation of production processes for CFRP will progress further. The Norwegian ELKEM is a manufacturer of substance based on silicone, carbon etc. and as such a supplier to the electronics, the iron and non-iron industries for the production of high-performance materials.

The current European Chinese business exchanges do not provide ground for the assertion of an asymmetric threat imposed by China to the EU-27 countries. Within both trade blocks, companies exploit opportunities and contribute to an international division of labour that has the potential to serve both. In the long run, however, the “go global policy” of the Chinese government provides competitive framework conditions that may threat EU companies. In particular if Chinese domestic growth will slow down FDI, will become more attractive for Chinese firms.

A survey on “push factors” for Chinese companies to invest in the EU gives clear indication: of prime importance for enterprises is the Chinese authorities’ interest of “going global”. The availability of funds only ranks second. However, the factor

83 CCPIT (2010). Survey on Current Conditions and Intention of Outbound Investment by Chinese Enterprises, China Council for the Promotion of International Trade, Brussels, pp. 11, http://trade.ec.europa.eu/doclib/docs/2010/may/tradoc_146193.pdf

"stagnant domestic demand" is on a much lower rank.[84] The 12th Chinese Five-Year Plan (FYP) highlights the need to shift from foreign led to domestic led growth. This will contribute not only to higher welfare and wealth creation, but induce also higher wages. The reduction of income inequalities is another important theme for the planning period 2011 to 2015. This will equally induce wage increases and force China's enterprises to move further up the value chain towards a more know-how driven production. As a consequence, the policy shift will not reduce competitive pressure for developed countries companies, since Chinese firms will endeavour to leave the low-wage manufacturing position and move towards high-value added products.[85]

Table 3.5: Selected Chinese European affiliations

Target/Joint venture, country		Products	Activity	Year	Acquirer/Country	
High-voltage Cable Factory	CN	High-voltage cables	Takeover	2009	NKT Cables	DK
Tau Energy Products	CN	Heat exchanger	Takeover	2010	Danfoss District Energy	DK
Qingdao Qiyao Wärtsilä MHI Linshan Marine Diesel Co. Ltd.	CN	2-stroke diesel engines for vessels	Joint venture	2006	Mitsubishi	JP
					China Shipbuilding Industry Corporation (CSIC)	CN
					Wärtsilä	FI
SEC-KSB Nuclear Pumps & Valves Co., Ltd.	CN	Pumps, valves	Joint venture	2009	KSB	DE
					SEC	CN
Dürkopp-Adler	DE	Clothing machinery	Takeover	2005	ShangGong Group (SGSB)	CN
Topcut-bullmer	DE	Clothing machinery	Takeover	2009	New Jack Sewing Machine	CN
					Assyst / Bullmer	DE
FACC AG	AT	CFRP	Takeover	2009	Xi'an Aircraft Industry (XAC)	CN
ELKEM	NO	High-tech materials	Takeover	2011	Bluestar Group	CN

Source: DG Competition, http://ec.europa.eu/competition/elojade/isef/index.cfm?clear=1&policy_area_id=3 (selected cases) and different sources.

[84] CCPIT (2010). Survey on Current Conditions and Intention of Outbound Investment by Chinese Enterprises, China Council for the Promotion of International Trade, Brussels, pp. 14, http://trade.ec.europa.eu/doclib/docs/2010/may/tradoc_146193.pdf

[85] Consonery, N., Feigenbaum, E., Ma, D., Meidan, M. and Hoyle, H. (Euroasia Group), (2011) "China's Great Rebalancing Act", New York-Washington-London, pp. 25,www.eurasiagroup.net

Output and evolution

The Chinese ME had enjoyed a breath taking growth over the past decade. In 2010 total output had reached € 480.6 bn, i.e. 96% of total EU-27 output. In terms of value added, the Chinese ME even exceeded the EU ME. In constant prices, the annual average growth rate nearly scored 20% between 2000 and 2010. The number of workplaces increased by an average growth rate of around 6% up to 6.1 million in 2010, more than double the employment of the EU-27 ME. This development contrasts to the losses in jobs in the US, Japan and the EU-27. The global financial crisis did not affect the Chinese ME at least growth did not lose momentum (Table 3.6).

Efficiency

The Chinese ME's labour productivity is well below levels of the developed world, although it had grown strongly. In 2010 it reached € 26399, this is around half the EU average. In 2000 it was only € 8089. The annual average growth rate was 12.6%. However labour costs per worker increased at an annual rate of 15.6% and exceeded by far the relative gains in efficiency. In 2010 labour costs per annum and employee accounted for € 3700, at around 11% of the EU average. As a consequence of strong growth of labour costs, the Chinese ME's economic performance had worsened throughout the period under investigation. Compared to the other economies in the study, however, and due to low wages, - the worsened economic indicators show a much better situation for the Chinese ME than for the ME of the other economies under consideration. The Chinese GOR discloses that 86.0 % of value added is available to serve profits and other input factors than labour. In 2010 the Chinese ULC were at € 0.14 per € 1 value added. The respective figure for the EU-27 accounted for € 0.61.

Table 3.6: Output and efficiency of the Chinese mechanical engineering

Sector	Indicator	2010[1)]		Annual average change rate in %		
				2000– 05	2000–08	2008– 10
China						
Output[2)]	Current prices Constant prices	€ bn.	480.6	25.3 21.4	25.7 18.1	24.8 29.0
Value added	Constant prices	€ bn.	161.4	15.7	25.4	18.4
Employees	Numbers	1000	6113	5.0	5.4	8.5
Labour productivity	Value added per capita[3)]	€	26399	10.2	19.0	9.2
Labour costs	Per employee	€	3700	16.1	17.6	11.6
Gross operating rate[4)]	Share of value added	%	86.0%	-0.7	0.2	-0.4
Unit-labour costs[5)]	Labour costs per output unit	€/€	0.14	5.3	-1.2	2.3
EU-27						
Output[2)]	Current prices Constant prices	€ bn.	502.1	2.3 1.3	10.4 8.0	-8.4 -9.3
Value added	Constant prices	€ bn.	157.5	0.3	6.0	-9.3
Employees	Numbers	1000	2900.5	-2.2	1.8	-4.8
Labour productivity	Value added per capita[3)]	€	54290	2.6	4.1	-4.7
Labour costs	Per employee	€	33243	3.1	3.7	1.9
Gross operating rate[4)]	Share of value added	%	38.8%	-0.6	0.5	-8.6
Unit-labour costs[5)]	Labour costs per output unit	€/€	0.61	0.5	-0.5	6.9

[1)] 2010 prices and exchange rates; [2)] China = turnover, EU-27 production; [3)] At constant prices; [4)] (Value added-wages)/value added); [5)] value added at constant prices per € 1 labour costs.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Trade performance

At present, Chinese ME is strongly focused on its large domestic market that absorbed 85% of its output in 2010. In 2000 the absorption rate had been lower and only amounted to 80%. Although exports grew at around 20% on average per annum, the domestic demand grew even stronger. The global financial crisis did not affect the development in the home market, in contrast to foreign markets with exports dropping in 2009 by 20%, but entirely recovering in 2010 already.

Foreign machine manufacturers command a share of 15% of the Chinese market by exports. The share is below the penetration of foreign manufacturers in Japan and the EU of around one fifth of the market value and much lower than for the US foreign penetration rate of 38%. Over the period under assessment, this rate had strongly declined. In the year 2000 foreign manufacturers achieved a market share of 36% in China by imports. Important to bear in mind is that FDI had become an important topic for the manufacture of machinery in China and during the past decade. Production capacities have been extended by foreign players to get better access to the largest machinery market in the world (Table 3.7).

The Chinese **global trade balance for all manufactured goods** shows a surplus. It grew up to €.149.8 bn in 2010 from € 27.1 bn in 2000. The broadening gap was caused by the initial surplus. The annual average growth rates for imports and exports for all of the period under investigation scored 16% each.

Total Chinese machinery exports grew at a much higher rate than imports between 2000 and 2010, i.e. at annual average rates of 22% and 12% respectively, causing a decline of **global Chinese trade deficit with ME products**. In 2010, the deficit of just € 5.2 bn – as compared to a total export value of € 70.1 bn - is considered to be marginal. This deficit was caused only by trade with non-EU trading partners. In 2000, this trade showed a deficit and it turned into a large surplus in 2010. The **bilateral machinery trade with the EU** shows a different pattern: Chinese imports grew at a similar pace as exports, i.e. on annual average of 14,6% and 14,2% respectively. The Chinese trade deficit increased to € 9.1 bn.

An emerging comparative advantage for Chinese ME products in relation to other domestic industries is confirmed by both trade indicators, at least for global trade. The global Balassa Index (BI) shows that machinery gained importance in Chinese exports, although ME products' weight has remained lower than in world trade. When it comes to the European Union, the situation is different since the machinery share of Chinese exports to the EU had been reduced over the past decade. It reduced from 54% in 2000 to 27% in 2010. The RCA calculates the position of an industry – measured by the trade balance – in relation to other national industries. A negative sign indicates a higher dependency of domestic demand from foreign deliveries. The Chinese RCA for machinery discloses an above average dependency from foreign supply of ME products. This is owed to strong domestic investment in machinery and equipment that cannot be met by domestic production. It is of note that the Chinese RCA for the bilateral machinery trade with the EU is even more pronounced negative. This suggests the assumption that China is more dependent on machinery supply from the EU-27 countries than from other supplying countries and continents. The share of EU ME deliveries on total Chinese machinery imports had been growing from 31.2% in 2000 to 37.2% in 2010.

Table 3.7: Trade performance of the Chinese mechanical engineering

Sector	Indicator	2010		Annual average growth rate in % 2000 - 05	2005-08	2008 - 10
China	Domestic demand[1] Mech. engineering	€ bn.	485.8	21.8	20.9	27.1
EU-27			374.2	1.4	9.7	-11.0
Chinese global trade Total manufacturing	Imports	€ bn.	1038.9	16.9	13.2	16.4
	Exports	€ bn.	1188.7	17.8	16.7	10.6
China - EU trade Total manufacturing	Imports	€ bn.	113.1	15.1	14.8	20.1
	Exports	€ bn.	282.3	16.6	15.6	6.7
Chinese global trade Mech. engineering	Imports	€ bn.	75.3	14.0	7.5	17.2
	Exports	€ bn.	70.1	24.7	28.5	5.6
China - EU trade Mechanical engineering	Imports	€ bn.	28.0	13.4	15.2	16.8
	Exports	€ bn.	18.9	15.8	21.2	0.9
				2000	2008	2010
Trade balances Manufacturing	Global[2]	€ bn.		27.1	204.3	149.8
	EU[2]			48.7	169.5	169.3
Trade balances Mechanical engineering	Global[2]	€ bn.		-13.1	8.1	-5.2
	EU[2]			-2.1	-1.9	-9.1
BI Mechanical engineering[3]	Global[2]	0=neutral >0=advantage <0=disadvant.		-89.4	-31.1	-36.0
	EU[2]			-28.1	-16.4	-23.1
RCA Mechanical engineering[4]	Global[2]			-95.5	-9.8	-20.6
	EU[2]			-141.9	-125.0	-130.6

1) Production plus imports minus exports; 2) Exports minus imports; 3) Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); 4) Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i / j: Mechanical engineering / China; t / r: Total manufacturing / all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Research and development

Long-Term National Science and Technology (S&T) Development Programme

In the guidelines for the Chinese „Medium- and Long-Term National Science and Technology (S&T) Development Programme (2006-2020)" the main pillars of the future Chinese S&T policy have been outlined:

- Innovate independently,
- Achieve development in selected areas by leaps and bounds,
- Support development and
- Guide the future.[86]

[86] Xinhua on 2 February 2006, citing PRC State Council

The S&T Development Programme declares the manufacturing industry as the main pillar of the national economy and outspokenly states: "while China is a world manufacturing power, it is not a manufacturing powerhouse. It has a weak technological basis and poor innovative capabilities and primarily produces low-end products using manufacturing processes that entail heavy consumption of resources and energy and cause serious pollution." The 11th Five-Year Plan (2006-2010), which outlines and implements the economic and technological priorities in a shorter view also stressed the relevance of independent innovation and emphasized the focal role of firms in the innovation process. In part due to their huge home market, Chinese manufacturers are capable of acquiring technological expertise. Besides, the technological and vocational qualification of Chinese ME companies has been steadily improving. In some areas they even perform at eye level with European or Japanese firms. They are successful not only in imitating already existing products but also in developing further new machinery. For instance in producing harbour cranes the Shanghai Zhenhua Heavy Industry has become world market leader and outstripped the German Competitor Demag Cranes and the Finnish company Kone by numbers.

With stronger competiveness, the government is no longer willing to "sacrifice" domestic markets in exchange for technology, but instead, prefers to encourage "independent innovations". The telecommunications industry was the first manufacturing industry to pursue that strategy. With technologies upgraded and talents assembled, also the Chinese ME firms are now aiming at markets beyond its shores. Nowadays, Chinese firms are more ambitious not only in acquiring technological knowledge and protecting their home markets but also in expanding to international markets. As a result, they are acquiring foreign firms, establishing their own technological standards, and are heading to achieve "leapfrog" developments. In 2009 Chinese companies acquired over 50 firms in industrial countries, after 38 in 2008, 33 in 2007 and 20 in 2006.[87]

Foreign investors are still welcome in China but face a more restrictive environment regarding the acquisition of second tier companies by majority shares. In this respect, the Chinese government keeps on encouraging the transfer of technology, rather than machines or capital. Yet, important manufacturing sectors, such as the automotive industry and civil aviation are booming. In the latter, China makes considerable efforts to place a 190-seated self-developed aircraft on the market. This means that the country will be dependent on the import of high-tech components, machine tools and special purpose machinery for some time. The Chinese government is aware of the future demand for mid- and high-end imports. In 2010, the government abolished import tariffs for some machinery products such as turbines, boilers, compressors, metal working machines, construction machinery and agricultural machines. Moreover, environmental technology has a high priority.[88]

[87] Wanner, C. (2010) "Stille Riesen", in: KPMG, Manufacturing Now, Stuttgart.

[88] GTAI (2010). Branche kompakt, VR China, Maschinen und Anlagenbau. Germany Trade and Invest, Köln.

12th Five-Year Plan (2011-2015)

In March 2011, the National People's Congress passed the 12th Five-Year Plan (2011-2015).[89] The ambition of this new Five-Year Plan is to create a new economic development model. The plan is based on a more qualitative assessment model of growth, and sets key targets to improve the living conditions of the Chinese citizens. It calls for a shift from reliance on fixed-asset investments to technological advancement, innovation and consumption as the main drivers of growth. Further to that, sustainable growth is expected through energy savings and the further promotion of environmentally friendly technologies. One further key objective is a more inclusive distribution of wealth amongst the population.

For ME, the following sustainability and ecologic targets are particularly likely to have relevance also for foreign investors and firms:

- Decrease of the GDP energy consumption per unit by 16%
- Decrease CO_2 emissions by 17%
- Increase the share of non-fossil fuels in primary energy consumption from 8.3% to 11.4%.
- Reduce the total discharge of major pollutants by 8% to total of 10%.
- Reduce the amount of water usage per average unit of increased industrial production by 30%.

Focus on Strategic Emerging Industries

Along and besides these targets China has sketched seven strategic emerging industries (SEI) as focal aspects of capital investments and policies. The following industries will account for 8% of GDP by 2015:

- Biotechnology
- New Energy
- High-end equipment manufacturing
- Energy conservation, environmental protection
- Clean-energy vehicles
- New materials
- Next generation IT

According to the Minister of Science and Technology, Wan Gang, the concept for developing SEIs is to enable Chinese enterprises to compete in high-end, value-added industries at a global level. Of the seven sectors listed above, three are expected to promote sustainable growth targets. The target is to develop complete industrial chains from basic development to commercial applications. In April 2011, the Ministry of Industry and Information Technology launched a RMB 100 bn investment plan for renewable energy vehicles. Other blueprints expected from the Ministry will cover high-end equipment manufacturing, new materials and future internet and ICT. Analysts say that the high-speed rail network is a core element in the high-end equipment manufacturing sector. In the energy sector, a difference from the 11th Five-year Plan is that the renewable energy industry has expanded from the development of new resources like wind, solar, bio and nuclear to now encompassing resource usage technologies like clean coal technology, smart grids and non-conventional gas resources like coalbed

89 Economist Corporate Network (2011). The 12th Five-Year Plan: China's Economic transition, Shanghai.

methane and natural gas hydrocarbons. Also carbon capture, utilization and Storage (CCUS) technology development has been supported. Totally $ 1.5 trillion are to be spent over ten years to promote the seven SEIs.[90]

Innovation is closely related to the development of SEIs. China has been focused on the concept of independent or indigenous innovation. According to this concept, indigenous innovation is to boost the level of R&D on the part of local companies, thereby helping them to upgrade their capabilities and global competiveness. Some of the specific targets for the 12th Five-Year plan are that National expenditure on R&D to account for 2.2% of GDP (achievement in 2007: 1.7%) and a score of 3.3 patents filed per 10,000 people.

Although the SEIs policy has gained much media attention , it is actually a resumption of former approaches to identify strategic industrial sectors, as has been done in other industrialised countries, as well. The intensified ambition and centralised character of Chinese industrial policy will shift from a "Made in China" label for manufacturing to a "Designed in China" label, thereby moving up the global value chain. To achieve that target, China has laid out specific industrial guidelines, also valid for ME[91]:

- Phase out excessive capacity that is technologically inferior or polluting
- Move up the value chain by encouraging indigenous innovation
- Optimise industrial structure so as to have full benefit throughout the value chain
- Encourage industrial consolidation, mergers and acquisitions (in such sectors as the automotive and pharmaceutical industry) to foster global champions.

China's ambition of upgrading its manufacturing sector is also clearly demonstrated in the goals set for export industries in the 12th Five-Year Plan. The guidelines advocate for an upgrade of labour-intensive production and a further promotion of higher-value exports such as machinery and high-tech products.

National High-Tech R&D (863) Program

In line with the economic Five-Year Plans, the Chinese authorities launch the National High-Tech R&D (863) Program. The main objectives of the 863 Program are to fund technological research and innovation in areas of strategic importance to the nation's economic and social development as they are appointed in the Five-Year Plans and in the S&T development program. In recent years, the strategic priorities for 863 have also included advanced manufacturing technologies. The program has strongly supported energy research due to its strategic importance in meeting other targets such as national security, environmental sustainability and attracting significant offshore investment capital.

Back in 2001, the government initiated a focus on renewable energy and storage technology as a critical step towards energy independence and industrial growth. It started to direct public funding to research, product development, and application of technologies in the renewable energy sector.[92] The program has contributed to rapid technological development and notable expansion in the wind, solar and hydroelectric industries. In

[90] PwC (2011). The Business of China's 12th Five Year Plan, in: global trends. PricewaterhouseCoopers.
[91] Economist Corporate Network (2011). The 12th Five-Year Plan: China's Economic transition, Shanghai.
[92] Thornley, B., Wood, D. et al. (2011) "Impact investing, Pacific Community Ventures".

conjunction with China's aggressive emissions reduction targets, it has fuelled major investments in domestic infrastructure and deployment. Public expenditure for the 863 program increased more than 1200 % between 1996 and 2005.

Most observers assume that the 863 Program has played a key role in China's recent technological and industrial ascent, although it is difficult to measure the direct return on high-tech R&D spending in terms of increased and competitive production capacity. China's key strength in high-tech R&D has been its ability to absorb and improve on existing technologies, leveraging quick-response manufacturing capabilities to develop commercial applications and bring products to market. Often lower production costs ensure an additional competitive momentum.

There have been a number of notable commercial successes in the renewables sector at least partially attributable to the 863 Program. For instance, China has become the leading manufacturer of wind turbines for domestic use, and has recently begun to expand its export capacity; it is also the world leading producer and consumer of solar-powered water heaters. A prime example is the Xinjiang Goldwind Science & Technology Company is the largest wind turbine manufacturer in China. It started its R&D operation through public support in 1998, taking on the program's goal of developing China's first 600 kW-generating set. Goldwind subsequently received three National Science and Technology Projects and has enjoyed tax incentives and infrastructure investments from local government. Ever since, it has acquired independent R&D capacity and patented a 1.5 MW turbine model, which has been licensed for use on German wind farms. Goldwind was first listed on the Shenzhen stock exchange in 2007. Despite the country's recent focus on innovation, traditional "cooperation" patterns which require foreign companies to cooperate with Chinese firms in exchange for market access are still prevalent.

National Key Technologies R&D Programme

Another R&D promotion scheme is the "*National Key Technologies R&D Programme*". It focuses more directly on industrial needs than the 863 Programme, promotes technical upgrading and restructuring of industries, and tackles major S&T issues in national economic construction and social development.[93] Although its English title remains unchanged, its Chinese name changed in 2006 to *National Key Technologies R&D supporting Programme*, implying a stronger role for institutes and enterprises in generating initiatives. In the 11th Five-year Plan, the programme was targeted at research in:

- Key technologies and products for sustainable agricultural development
- Common key technologies for basic and pillar industries
- Technical support to the informatization of the national economy
- Key technologies for environmental protection and rational utilization of resources
- Modernization of traditional Chinese medicine (TCM)
- Major public welfare technologies and technical standardization.

93 http://www.access4.eu/_img/article/MoST_3_-_National_Key_Technologies_RD_Programme.pdf

Approximately € 3 bn. of public funding was budgeted for the 11th Five Year Plan period with private enterprises being the major beneficiaries. Interested foreign organizations have the opportunity of consulting their Chinese partners about the possibility of applying for a fund.

Conclusions

Performance of mechanical engineering

The Chinese ME has strongly grown over the past decade and is at arm's length with the EU by the size of its output with € 480.6 bn. The domestic market absorbs 85% of production with only the remaining 15% of production for export. Domestic and foreign demands have been drivers for the breath taking growth with rates of similar magnitude, i.e. 20% p.a. and more.

Likewise, the Chinese ME's labour productivity has grown at an average rate of more than 10% per annum. However, in 2010 – with € 26399 - it had reached only half of the EU-27's level. Notwithstanding this, however, some EU member states record similar labour productivity, e.g. Poland and the Czech Republic. The Slovakian ME' labour productivity is even lower.

In 2010 Chinese labour costs amounted to € 3700 in 2010, a low figure as compared to the size of labour productivity. As a consequence the economic performance – although it had worsened over the years between 2000 and 2010 – measured by ULC and GOR are advantageous in competition with developed countries. For instance, ME companies of the EU member states Poland, the Czech Republic and Slovakia face much higher per-capita labour costs of around € 11000 per annum.

China has become a global powerhouse for manufacturing industries. It commands a large trade surplus of around € 150 bn. In terms of rade with machinery the situation is different, since traditionally, the Chinese' trade balance is negative. Due to joint efforts, however, the gap has been narrowed down from € 13 bn in 2000 to € 5.2 bn in 2010. This value is small compared to total Chinese machinery exports of € 70.1 bn.

The relation of Chinese trade with the EU and with non-EU shows noteworthy differences. The Chinese trade deficit with the EU has widened caused by machinery imports growing stronger than exports. It had grown from € 2 bn in 2000 up to around € 9 bn in 2010. Simultaneously, the Chinese machinery trade with non-EU countries had changed from deficit to surplus.

The investigation in the Chinese ME unveiled certain strengths that go beyond mere labour costs. The upgrading of the industry by quality and the state of technology has made much progress. On the one hand, it seems as if this development has been caused by a proactive industrial policy dedicated to provide incentives to invest in promising markets by stimulating R&D and set-up production capacities.

On the other hand, it has also been driven by regulatory measures to control access of foreign industrial investors. This strict regulation of market access contrasts the transparent and generally applicable competition law and investment conditions faced by foreign, and in particular Chinese investors, when investing in the EU.

Chinese authorities explicitly support their companies' foreign initiatives. Financial means for acquisitions will be made available by banks if public initiatives suit to the objectives of Chinese policies.

The 12th FYP advocates a more domestically driven economic development and a steady rise in wages. This will push Chinese enterprises to increase productivity and manufacture more advanced and sophisticated products and services. This suggests that the Chinese policy directed to stimulating domestic demand will not reduce competitive pressure from Chinese companies but instead increase it in market segments where European ME enterprises see their traditional strengths.[94]

China suffers from deficiencies in many markets. This led to a misallocation of resources and loss-making companies. Permanent governmental intervention is needed to control the development. However, successful Chinese companies may find themselves in a disadvantageous competitive position over foreign firms through the lose funding mechanisms available and the limited surveillance and enforcement of safety and environmental regulations.

China, joining the WTO in 2001, the market environment has not yet made the progress necessary to provide fair conditions for competition. One of the outstanding problems highlighted in the literature and by the experts of the industry is related to IPR. It is perceived as a major threat to foreign investors and hampers the potential for cooperation between Chinese and EU companies, also in different views over counterfeiting qualifying as a misconduct. In so far, the legal enforcement and the surveillance of the IPR law is of outstanding importance for China.

R&D activities

Chinese R&D policies are strongly linked to industrial policies that are not only dedicated to catching up with developed countries' lead in technologies and advanced products. Apart from that, the policies also focus on the creation of an internationally competitive supply side, consisting of larger companies in the position to exploit scale effects and with the capacity of allocating sufficient resources to fund big R&D projects. The government supports the emergence of big corporate players and national champions, e.g. in the wind power industry. Only those companies and industries that are meet the criteria obtain easy access to financial resources.

The Chinese long-term research programme is dedicated primarily to the catching up of developed countries' lead and to reduce the dependency from foreign design and the delivery of key components. Foreign companies are welcomed for the upgrading of the Chinese economy, through JVs as the preferred model.

[94] If this objective can be realized is not definitive. The trade-off between wages and productivity on the one side and the level of employment on the other side is a tough challenge for local governments and could induce them not to pursue such a strategy. For a discussion see: Consonery, N., Feigenbaum, E., Ma, D., Meidan, M. and Hoyle, H. (Euroasia Group), (2011) "China's Great Rebalancing Act", New York-Washington-London, p.8. www.eurasiagroup.net

The latest five-Year-Plan has shifted public objectives more on domestic demand. In this respect it is similar to changes in Japanese public R&D. Much emphasis has been put on the economic development of peripheral regions and equally so on tackling environmental consequences. It has been acknowledged that the upgrading of the Chinese economy by tangible investment is insufficient. Investment in intangible assets, such as education and know-how for instance, has to be strengthened to enhance and sustain the catching-up process.

Seven strategic emerging industries have been identified as promising for the futre development of China, among which are biotechnology, new materials, new energy sources, high-end manufacturing equipment, energy conservation and protection of the environment, clean energy vehicles and next generation ICT. These areas of technology are considered as being crucial in the global race for competitiveness.

3.2 Major sales markets

3.2.1 Russia

Russia's global manufacturing exports amounted to € 281.4 bn in 2010 while imports only reached € 160.8 bn, giving Russia a global trade surplus of € 120.6 bn for manufactured goods. In 2008, the surplus was even higher at € 145.7 bn. Imports as well as exports strongly grew between 2000 to 2010 at an average annual growth rate of 17.3% and 9.7% respectively, although trade plummeted in 2009 at around one third (Table 3.8).

Table 3.8: Russian trade with mechanical engineering products

Sector	Indicator	2010		Annual average growth rate in % 2000–05	2005–08	2008–10
Russian global trade Total manufacturing	Imports	€ bn.	160.8	18.0	32.4	-3.4
	Exports	€ bn	281.4	11.7	17.9	-6.0
Russia - EU trade Total manufacturing	Imports	€ bn	86.3	20.2	22.8	-9.3
	Exports	€ bn	158.6	12.8	16.5	-5.6
Russian global trade Mech. engineering	Imports	€ bn	15.2	24.1	25.1	-22.4
	Exports	€ bn	1.8	1.3	9.3	-13.0
Russia - EU trade Mech. engineering	Imports	€ bn	14.1	17.9	26.3	-15.4
	Exports	€ bn	0.3	5.0	15.9	-18.2
				2000	2008	2010
Trade balances Manufacturing	Global[2]	€ bn		79.1	145.7	120.6
	EU[2]			39.1	73.1	72.2
Trade balances Mechanical engineering	Global[2]	€ bn		-2.7	-22.9	-13.4
	EU[2]			-4.0	-19.2	-13.8
BI Mechanical engineering[3]	Global[2]	0 = neutral > 0 = advantage < 0 = disadvant.		-177.5	-248.1	-259.3
	EU[2]			-311.1	-347.3	-371.5
RCA Mechanical engineering[4]	Global[2]			-218.5	-298.4	-270.3
	EU[2]			-386.1	-422.4	-437.2

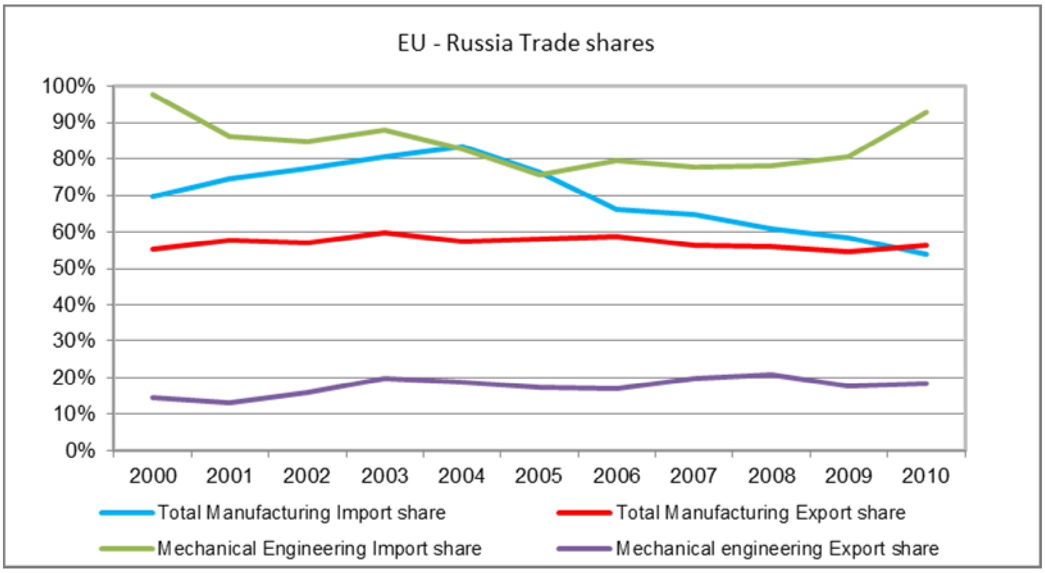
[1] Production plus imports minus exports; [2] Exports minus imports; [3] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/Russia; t/r: Total manufacturing /all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Russia is also a net exporter of **total manufactured** goods in bilateral trade with the EU. A surplus of € 72.2 bn in 2010 was obtained by exports worth € 158.6 bn and imported goods worth € 86.3 bn. Bilateral Russian imports grew at higher rates between 2000 and 2008 than exports did – the import surplus nearly doubled within a decade. Russia's imports from the EU accounted for a rise of 83% in global imports in 2004, followed by a steady declined to 61% in 2008 and 54% in 2010. The EU share of total manufactured Russian exports stayed nearly constant between 2000 and 2010, amounting to 60% in 2003 and 54% in 2009.

Russia is a net importer of **ME goods**, globally as well as in bilateral trade with the EU. Global machinery imports amounted to € 15.2 bn in 2010 while exports were only at € 1.8 bn. Like in bilateral trade for manufactured goods, Russia's machinery imports grew stronger between 2000 and 2008 than exports. Russian machinery imports peaked in 2008 at € 25.2 bn, plummeted to € 14.6 bn in 2009 and recovered slightly in 2010. Likewise, the exports peaked in 2008 at € 2.4 bn and fell back to € 1.8 bn in 2009 and recovered slightly in 2010 at € 1.9 bn. Trade with the EU shows a growing deficit for the period under consideration. In contrast, Russian trade with EU trade and the non EU trade balance for machinery was slightly positive between 2000 and 2004, turned into a deficit the following years and again was positive at € 0.35 bn in 2010. The EU's share on Russian ME imports declined from 98% in 2000 to 76% in 2005. After 2005 it steadily increased to 93 % in 2010. Machinery exports to the EU amount only to around 20% of global Russian ME exports (Figure 3.1).

Figure 3.1: Evolution of Russian trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Conclusions

Trade specialization is indicated by the BI. The growing negative indicator discloses that Russia is not specializing in machinery. This strategic choice is primarily manifested in trade with the EU, since the EU is the dominant foreign supplier of machinery for Russia. Machinery from other countries of origin only account for up to 7%. In contrast, machinery exports to the EU are only marginal. The EU takes advantage of a strong comparative advantage in trade with Russia. Moreover, Russia was and has been strongly dependent on machinery imports in particular from the EU. It is even more dependent on imports of other manufactured goods to meet its domestic demand. This is indicated by the strongly negative RCA index that is more pronounced for the bilateral trade with the EU in machinery than in global Russian machinery trade.

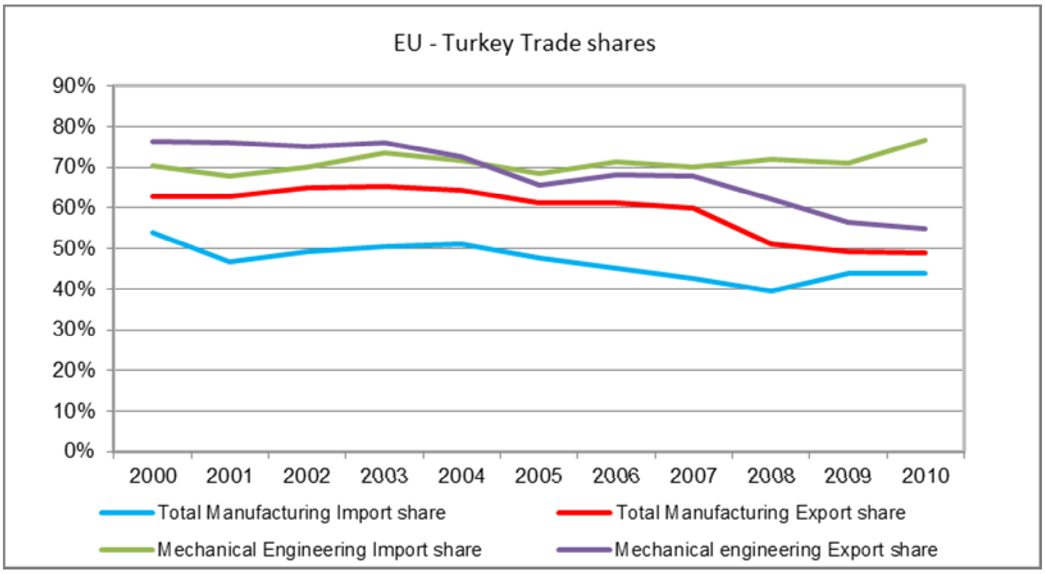
3.2.2 Turkey

Turkey was a net importer for manufactured and machinery goods in 2010. The value of global imports of manufactured goods amounted to € 139.4 bn in 2010, that of exports to € 86.0 bn. On average, positive growth rates for imports and exports could be observed between 2000 and 2008. Exports, however, were growing at a higher rate, growing on average by 14.7% and 15.0% per annum between 2000-2005 and 2005-2008, respectively. Imports were recording growth rates of 9.9% between 2000 and 2005 and growth rates on average of 13.5% between 2005 and 2008. They declined by around a quarter from € 137.0 bn in 2008 to € 100.7 bn in 2009 and fully recovered to a value of € 139.4 bn in 2010. Exports were faced with a similar development between 2008 and

2010, but did not manage to recover fully. They amounted to € 89.7 bn in 2008, € 73.2 bn in 2009 and € 86.0 bn in 2010. Furthermore, the decline in exports from 2008 to 2009 was not as sharp as the decline in imports. The result was a decrease in the trade deficit from € 47.3 bn in 2008 to € 27.4 bn in 2009. The deficit decrease was not sustained and reached a value of € 53.4 bn which is the highest in the period under consideration.

In **ME the trade deficit with non-EU countries narrowed** in recent years. This development was caused by growing exports, indicating a slight change in the Turkish position in the international ME market. The country is about to become a machinery supplier for other countries. The trade balance with the EU does not yet show noteworthy changes (Figure 3.2).

Figure 3.2: Evolution of Turkish trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

In bilateral trade with the EU, a similar pattern can be observed. The trade balance is negative. Export growth rates are higher than that of imports. Exports grew on average by 14.1% in the early years of the decade and kept on growing at a slower pace in the years between 2005 and 2008. Imports grew on average at rates of 7.2% in the period 2000-2005 and by 6.7% between 2005 and 2008. Like in global trade, there was also a sharp decline in imports and exports from 2008 to 2009, with exports declining less sharply, which led to a reduction of the bilateral trade balance deficit for manufactured goods of € 8.1 bn in 2008 to € 8.0 bn in 2009. Again, this was not sustained, because the trade balance not only reached the highest deficit in global trade in 2010 but also in bilateral trade. The trade deficit in bilateral trade more than doubled from € 8.1 bn in 2008 to € 19.0 bn in 2010. Both the import and export shares of the EU on Turkey's global trade for manufactured goods declined between 2000 and 2010. The EU's share on Turkish imports declined from 54% in 2000 to 40% in 2008 and again increased to 44% in 2009 and 2010. EU's share on Turkish exports declined from 63% in 2000 to 60% in 2007, 51% in 2008 and 49% in 2009 and 2010 (Figure 3.2).

Table 3.9: Trade performance of the Turkish mechanical engineering

Sector	Indicator	2010		Annual average growth rate in % 2000–05	2005–08	2008–10
Turkish global trade Total manufacturing	Imports	bn. €	139.4	9.9	13.5	0.9
	Exports	bn. €	86.0	14.7	15.0	-2.1
Turkey - EU trade Total manufacturing	Imports	bn. €	61.1	7.2	6.7	6.3
	Exports	bn. €	42.1	14.1	8.5	-4.4
Turkish global trade Mech. engineering	Imports	bn. €	10.6	10.2	4.9	1.7
	Exports	bn. €	4.2	21.8	19.5	-3.0
Turkey - EU trade Mech. engineering	Imports	bn. €	8.1	9.6	6.5	5.0
	Exports	bn. €	2.3	18.2	17.4	-8.8
				2000	2008	2010
Trade balances Manufacturing	Global[2]	bn. €		-28.7	-47.3	-53.4
	EU[2]			-12.9	-8.1	-19.0
Trade balances Mechanical engineering	Global[2]	bn. €		-4.5	-5.8	-6.4
	EU[2]			-3.1	-4.6	-5.8
BI Mechanical engineering[3]	Global[2]	0 = neutral > 0 = advantage < 0 = disadvant.		-100.7	-57.9	-55.3
	EU[2]			-81.0	-38.6	-43.7
RCA Mechanical engineering[4]	Global[2]			-105.8	-41.5	-45.0
	EU[2]			-112.6	-82.1	-89.1

[1] Production plus imports minus exports; [2] Exports minus imports; [3] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/Turkey; t/r: Total manufacturing/all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Turkey's ME exports came up to € 4.2 bn in 2010 and imports reached € 10.6 bn. Thereof, the bilateral ME trade with the EU accounted for 55% of total exports and 77% of total imports. The EU's share of Turkish ME imports had increased from 2005 on. The EU share of total Turkish machinery exports had declined from 2003 on. While bilateral Turkish exports grew on average by 18.2% between 2000 and 2005, bilateral imports grew on average at only 9.6%. The bilateral trade deficit for ME was at € 3.1 bn in 2000, € 4.6 bn in 2008 and € 5.8 bn in 2010. On the other hand, the global trade deficit for machinery stood at € 4.5 bn in 2000, € 5.8 bn in 2008 and € 6.4 bn in 2010. The increase in the global trade balance deficit can be attributed to the increased trade activities with the EU, as the trade balance deficit with non EU countries is falling since 2007. It was at € -2.1 bn in 2007 and declined by more than 60% to -0.6 bn € in 2010. This development is underlined by a decreasing comparative disadvantage as shown by the BI.

Conclusions

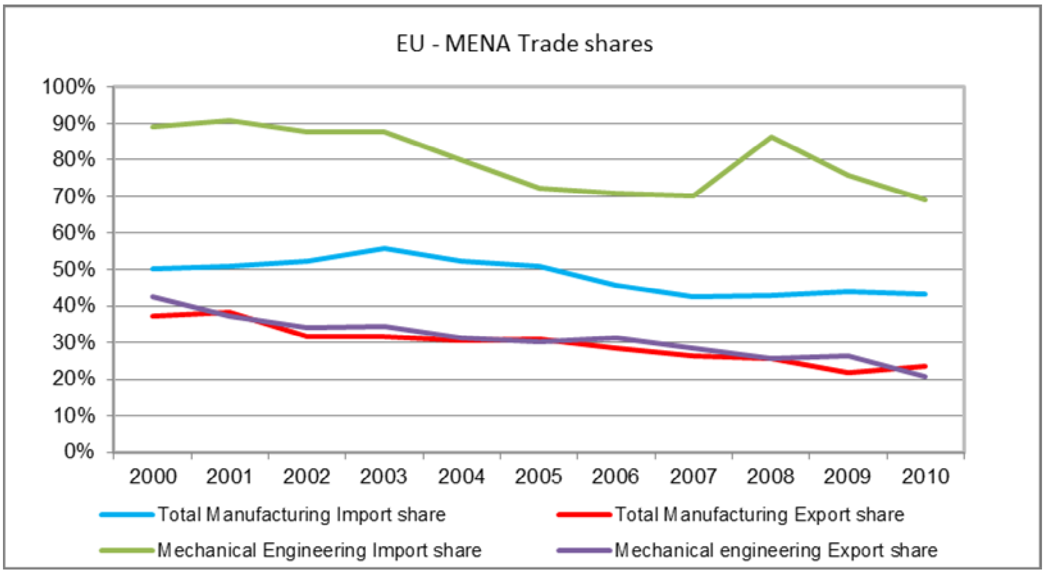
The Turkish ME trade balance deteriorated during the study period, although exports grew stronger than imports. The explanatory factor is the low level of machinery exports in 2000. The exports were driven above all by demand from non-EU countries, although specialization on ME in foreign trade has remained below the global average yet. This development indicates that Turkey is an emerging ME manufacturer. The bilateral ME trade deficit with the EU is much more pronounced than that for non-EU countries and has strongly growing. The EU's deliveries to Turkey grew at a higher pace than total machinery imports (Table 3.9)

3.2.1 Middle East and North Africa (MENA)

There exists no common definition of MENA. For the trade analysis MENA is comprised of the following countries: Algeria, Egypt, Libya, Morocco, Saudi Arabia, Sudan, Tunisia and United Arab Emirates. Particular attention will be given on the prospects for the region in Chapter 1 (strategic outlook) with regard to opportunities for the EU ME.

Global exports of MENA manufacturing goods grew by 14.8% per annum between 2005 and 2008, followed by a decline with average growth rates of 6.2% per annum. Analysis of time series suggest that – caused by the global crisis – exports dropped in 2009 by around one quarter and did not entirely recover in 2010. They accounted for € 405.5 bn in 2010. Global manufacturing imports grew by 16.6 % per annum between 2005 and 2008 and declined by 0.5% per annum in the years to follow. They amounted to € 258.8 bn in 2010. This gives MENA a positive global trade balance for total manufacturing of € 146.7 bn in 2010. With the global trade balance for total manufacturing being at € 199.4 bn in 2008, it was even larger than in 2010. Compared to 2000, the global trade balance for manufacturing goods more than tripled until 2008.

Figure 3.3: Evolution of MENA trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

MENA, however, has a negative trade balance for **total manufacturing goods** in bilateral trade with the EU. Imports were at € 111.9 bn in 2010 and exports at € 96.1 bn in 2010. Both exports and imports into the EU and from member states grew between 2000 and 2008 and dropped significantly in 2009, exports by 26% but imports only 14%. The initial positive bilateral trade balance of MENA, i.e. € 8.5 bn in 2000 and declined to € 5.7 bn in 2008, turned to a trade balance deficit of € 15.8 bn in 2010. The regional trade linkages show relatively high shares of imports from the EU, being 43% of total imports in 2010, whereas MENA's exports to the EU play a smaller role and came up to 24%. **For the period under consideration, the EU had lost weight of MENA's trade in both directions.**

Global MENA ME trade balance shows that exports had a value of € 11.6 bn in 2010. Imports were nearly four times higher at € 42.6 bn. Both global imports and global exports of machinery grew on average between 2000 and 2010. Imports by an annual average rate of 7.4% and exports by 4.3%. MENA's global trade deficit for machinery goods plummeted from € 9.5 bn in 2000 to € 30.9 bn in 2010. Three quarters of the global deficit came from trading with EU. MENA's bilateral trade balance with the EU for ME goods stood at € 17.0 bn in 2010. Imports of ME goods were at € 17.7 bn in 2010. The large bilateral trade deficit for mechanical engineering goods can solely be attributed to the nearly non-existent MENA ME exports to Europe. They amounted to around € 0.7 bn in 2010. In 2010, 68% of MENA's ME imports stemmed from the EU. In 2000, the EU share of machinery imports stood at 90% but showed a declining trend over the period under investigation. Exports to Europe only account for around 6.0% of MENAS's global ME exports (Figure 3.3).

Table 3.10: Trade performance of the Middle East and North Africa in mechanical engineering

Sector	Indicator	2010		Annual average growth rate in %		
				2000–05	2005–08	2008–10
MENA global trade Total manufacturing	Imports	bn. €	258.8	8.5	16.6	-0.5
	Exports	bn. €	405.5	12.4	14.8	-6.2
MENA - EU trade Total manufacturing	Imports	bn. €	111.9	8.8	10.2	-0.1
	Exports	bn. €	96.1	8.3	7.7	-9.6
MENA global trade Mech. engineering	Imports	bn. €	25.6	11.8	14.7	4.8
	Exports	bn. €	3.4	17.2	14.8	6.6
MENA - EU trade Mech. engineering	Imports	bn. €	17.7	7.2	21.7	-6.1
	Exports	bn. €	0.7	9.5	9.0	-4.4
				2000	2008	2010
Trade balances Manufacturing	Global[2)]	bn. €		60.3	199.4	146.7
	EU[2)]			8.5	5.7	-15.8
Trade balances Mechanical engineering	Global[2)]	bn. €		-8.0	-20.4	-22.3
	EU[2)]			-7.5	-19.3	-17.0
BI Mechanical engineering[3)]	Global[2)]	0 = neutral > 0 = advantage < 0 = disadvant.		-284.1	-262.1	-232.2
	EU[2)]			-271.5	-261.2	-245.6
RCA Mechanical engineering[4)]	Global[2)]			-274.3	-263.1	-248.0
	EU[2)]			-319.2	-332.1	-308.4

[1)] Production plus imports minus exports; [2)] Exports minus imports; [3)] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4)] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/MENA; t/r: Total manufacturing /all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

The comparative disadvantage of MENA in global trade with ME goods is confirmed by the BI, that indicates the specialization in trade. Its strong negative trend had been reduced between 2000 and 2010, caused by stronger exports to non-EU regions. This suggests that MENA has become a hub for ME exports. The RCA compares sectoral trade balances and indicates for MENA an above average dependency on machinery imports. Against this background the dependency from machinery deliveries originating from non-EU countries has grown stronger than from the EU. Despite MENA's close ties to EU, non-EU suppliers have successfully gained market shares (Table 3.10).

3.2.2 India

India's global imports of total manufactured goods amounted to € 269.6 bn in 2010. Global exports in total manufacturing were at € 173.3 bn for 2010. Global manufacturing imports as well as exports grew on average at double digit rates between 2000 and 2010.

The Indian trade deficit with the rest of the world broadened. Likewise, India's bilateral trade of manufactured goods with the EU grew, but at a lower pace. This indicates a shift from trade with the EU to non EU countries. India's bilateral trade with the EU for total manufacturing goods was slightly negative.

Growth rates of **global Indian machinery imports** were higher than for the EU between 2000 and 2008. However, between 2008 and 2010, ME imports from EU grew at 0.9% per annum on average while global imports declined at an annual rate of 4.4%. The EU share of India's machinery imports had fallen from 81% in 2000 to 57% in 2010 (Figure 3.4). The Indian machinery exports to the EU-27 grew below average of total machinery exports. It had lost some of its former importance as a destination for India's machinery, its share of total exports had declined from 45% in 2000 to 35% in 2010. However, this share is even higher than Chinese machinery exports to the EU.

The analysis of the **bilateral India - EU ME trade** for the period 2000 to 2010 displays a somewhat stronger growth of Indian exports than imports with annual average growth rates 14.1% and 13.1% respectively. The Indian deficit in the bilateral trade balance widened and in 2010 it had reached € 5.5 bn, equal to around 80% of Indian EU imports.

However, **non-EU regions' trade** linkages with India increased more than with the EU. ME imports grew at an annual average rate of 27% over the period under investigation and exports grew at annual rates of 17% each.

India's global imports of total manufactured goods amounted to € 269.6 bn in 2010. Global exports in total manufacturing were at € 173.3 bn for 2010. Global manufacturing imports as well as exports grew on average at double digit rates between 2000 and 2010. The Indian trade deficit with the world broadened. Likewise, India's bilateral trade of manufactured goods with the EU grew, but at lower pace. This indicates a shift from trade with the EU to non EU countries. India's bilateral trade with the EU for total manufacturing goods was slightly negative.

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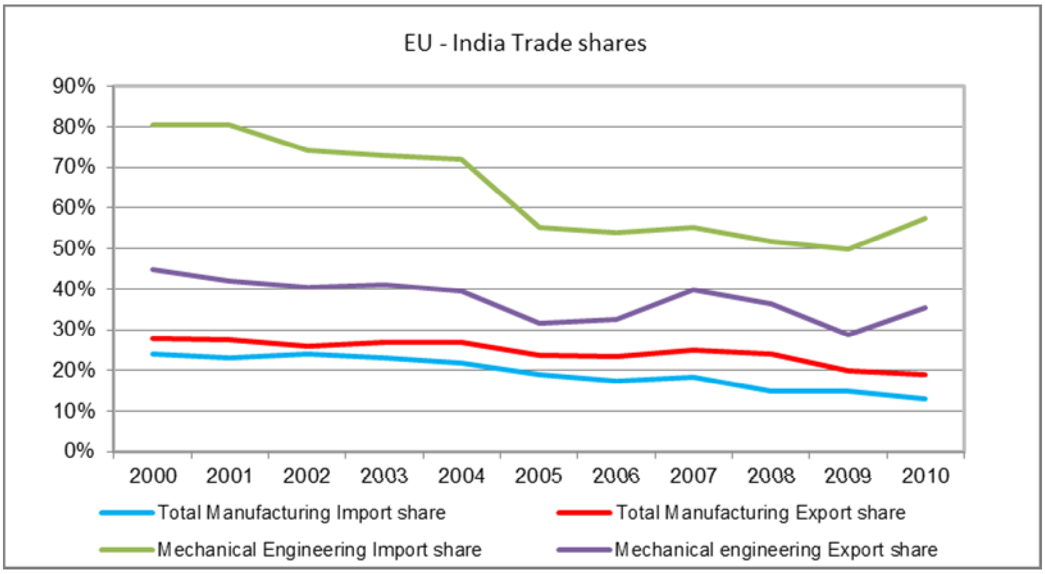
However, India's **non-EU regions' trade** linkages increased more than those with the EU. ME imports grew at an annual average rate of 27% over the period under investigation and exports by 19%.

Figure 3.4: Evolution of Indian trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Trade specialization, shown by the BI, indicates that for global machinery trade India faces a strong and not much decreasing disadvantage, while in bilateral with the EU the specialization index declined. The underlying reason is a stronger growth of Indian machinery exports to the EU than for total manufactured goods. In contrast, the RCA indicates a strong dependency of India from EU machinery deliveries, although the share of EU ME products of total India's machinery imports had declined significantly (Table 3.11).

Table 3.11: Trade performance of the Indian mechanical engineering

Sector	Indicator	2010		Annual average growth rate in %		
				2000 - 05	2005-08	2008 - 10
Indian global trade Total manufacturing	Imports	bn. €	269.6	14.7	23.6	12.8
	Exports	bn. €	173.3	12.0	15.3	18.4
India - EU trade Total manufacturing	Imports	bn. €	34.8	9.4	14.0	5.0
	Exports	bn. €	33.1	8.3	15.7	5.9
Indian global trade Mech. engineering	Imports	bn. €	12.3	21.2	26.0	-4.0
	Exports	bn. €	4.4	20.9	25.8	-4.0
India - EU trade Mech. engineering	Imports	bn. €	7.0	13.8	22.2	0.9
	Exports	bn. €	1.5	17.1	31.7	-5.3
				2000	2008	2010
Trade balances Manufacturing	Global 2)	bn. €		-10.7	-88.1	-96.4
	EU 2)			-0.8	-2.0	-1.6
Trade balances Mechanical engineering	Global 2)	bn. €		-1.6	-8.6	-7.9
	EU 2)			-1.6	-5.2	-5.5
BI Mechanical engineering 3)	Global 2)	0=neutral >0=advantage <0=disadvant.		-149.6	-84.0	-121.3
	EU 2)			-121.1	-42.1	-60.1
RCA Mechanical engineering 4)	Global 2)			-81.2	-50.0	-59.5
	EU 2)			-170.3	-133.0	-147.5

1) Production plus imports minus exports; 2) Exports minus imports; 3) Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); 4) Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i / j: Mechanical engineering / India; t / r: Total manufacturing / all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

India's imports of ME products only reached one sixth of Chinese demand in 2010. However, India has become an important growth market. Between 2000 and 2008 imports grew at annual rates above 20%. The breakdown during the financial crisis was almost entirely outbalanced in 2010. The global trade deficit with machinery broadened strongly. The EU, having been the predominant foreign supplier of foreign machinery, lost noteworthy shares in India's imports. Non-EU manufacturers increased their commodity deliveries to India at an annual average growth rate of 27% over the past decade, with EU manufacturer deliveries running only at half speed. India's trade balance with non-EU foreign machinery suppliers was nearly balanced in 2000 and has become strongly negative over the past decade.

3.2.3 South Korea

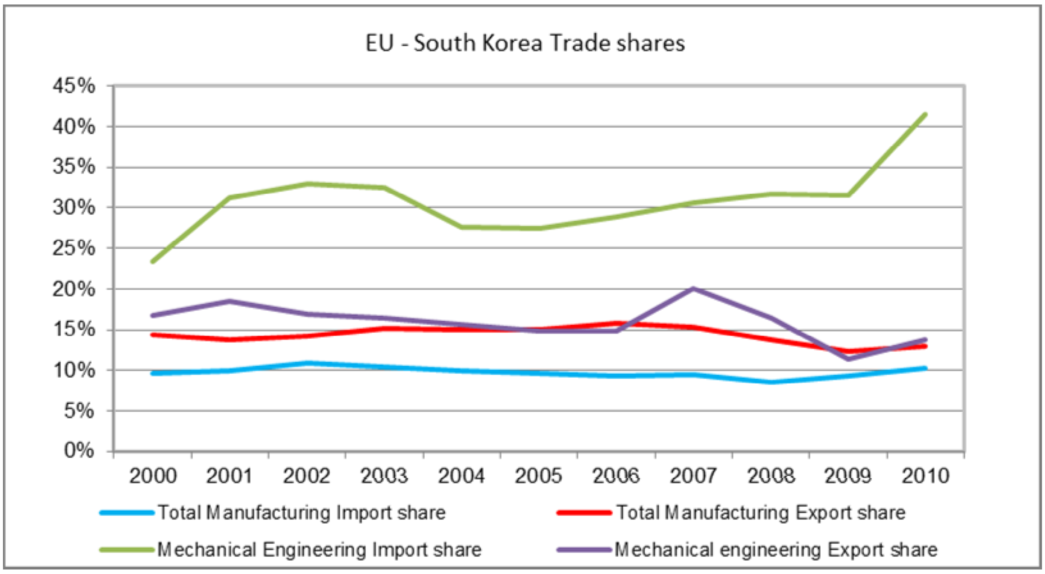
South Korea was one of the "Small Asian Tigers" of the nineties and has become a competitors at arms-length in the global markets for capital goods over the past two decades.

In trade with **total manufactured goods** the trade balance in 2010 reached a surplus of € 26.8 bn; imports amounted to € 271.3 bn and exports to € 298.0 bn. Imports grew on average at rates of 12.1% per annum between 2005 and 2008 and exports by 7.9%. Due to the financial crisis, exports plummeted in 2009 to € 260.6 bn from € 286.9 bn in the preceding year. However, in 2010 the 2008 peak was toppled. Total imports fell from € 295.4 bn in 2008 to € 231.5 bn in 2009. To date, the former peak gained in 2008 has not been reached ever since. South Korea's global trade balance for manufactured goods was positive throughout the years 2000 to 2010 except in 2008, when a deficit of € 8.5 bn € was recorded, caused by an extraordinary increase of imports by 13.7%, exports had only grown by 5.9%. The trade balance is extremely volatile. This might be partly caused by the size of the economy.

South Korea also managed to obtain a positive trade balance in **bilateral EU trade for total manufactured goods**. Exports amounted to € 38.7 bn in 2010 and imports climbed up to € 27.9 bn, generating a surplus of € 10.8 bn. Korean exports grew on average at 4.7% p.a. between 2005 and 2008, while imports grew on average at 8.0% in the same period. Exports had peaked in 2007 at a value of € 41.3 bn and declined for the subsequent two years to € 32.3 bn until an economic recovery took place. Imports only declined for one year, from € 25.4 bn in 2008 to 21.6% in 2009. The 2008 peak was already toppled in 2010 and total EU imports amounted to € 27.9 bn in 2010.

Similar to the global trade balance, the bilateral balance proves to be equally volatile. However, the Korean EU balance was positive throughout the past decade. In contrast, the trade balance with non-EU countries frequently shifted from surplus to deficit.

Figure 3.5: Evolution of South Korean trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

In **trade with ME products** South Korea is a net importer globally as well as in bilateral EU trade. The global trade balance for machinery goods figured at € -4.7 bn in 2000. The deficit proved to be volatile throughout the decade, but showed a clear tendency reducing the gap between imports and exports.

Global South Korean ME imports amounted to € 18.2 bn in 2010, its exports were at € 17.5 bn. Global exports grew on average stronger than imports between 2000 and 2010. In bilateral EU trade, the pattern was different, imports grew stronger than exports. Furthermore, the growth rates of global imports are lower than for bilateral imports showing an increasing linkage of ME trade between the EU and South Korea. This is also reflected in EU shares of South Korean ME imports. They increased from 28% in 2004 up to 42% in 2010. In the same period, the share of Europe on South Korean exports went from 16% in 2004 to a high of 20% in 2007 and declined to 11% in 2009 and 14% in 2010 (Figure 3.5).

The **bilateral EU ME trade** shows a clear tendency, an increasing Korean deficit. It balance broadened from € -1.7 bn in 2000 to € -3.6 bn in 2009 and € -5.2 bn in 2010. In contrast, South Korea's non-EU trade balance had turned into surplus in 2005. From then on, its non-EU trade balance increased from € 0.8 bn in 2005 to € 4.4 bn in 2010, with a sharp decline between 2006 and 2007.

Table 3.12: Trade performance of the South Korean mechanical engineering

Sector	Indicator	2010		Annual average growth rate in % 2000–05	2005–08	2008–10
South Korean global trade Total manufacturing	Imports	bn. €	271.3	3.9	12.1	-4.2
	Exports	bn. €	298.0	4.2	7.9	1.9
South Korea - EU trade Total manufacturing	Imports	bn. €	27.9	3.9	8.0	4.7
	Exports	bn. €	38.7	5.1	4.7	-1.1
South Korean global trade Mech. engineering	Imports	bn. €	18.2	4.2	7.0	-5.0
	Exports	bn. €	17.5	11.6	9.6	-5.7
South Korea - EU trade Mech. engineering	Imports	bn. €	7.6	7.6	12.2	8.7
	Exports	bn. €	2.4	8.8	13.5	-13.8
				2000	2008	2010
Trade balances Manufacturing	Global[2)]	bn. €		12.8	-8.5	26.8
	EU[2)]			10.2	14.1	10.8
Trade balances Mechanical engineering	Global[2)]	bn. €		-4.7	-0.5	-0.7
	EU[2)]			-1.7	-3.2	-5.2
BI Mechanical engineering[3)]	Global[2)]	0 = neutral > 0 = advantage < 0 = disadvant.		-65.5	-25.4	-36.6
	EU[2)]			-50.2	-7.8	-30.8
RCA Mechanical engineering[4)]	Global[2)]			-50.9	0.4	-13.4
	EU[2)]			-125.1	-112.4	-147.3

1) Production plus imports minus exports; 2) Exports minus imports; 3) Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); 4) Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/ South Korea; t r: Total manufacturing/all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

During the past two decades South Korea has become a competitor on eye level with developed economies in markets for manufactured goods. In global trade as well as in trade with the EU a trade surplus indicates the country's strength. In trade with ME products South Korea is a net-exporter in trade with non-EU countries. However, in machinery trade with the EU trade balance is negative. The advantageous position is confirmed by a growing share of the EU of South Korean ME imports. Throughout the past decade the deficit with the EU had broadened.

The BI on trade specialization shows a comparative – although shrinking - disadvantage for South Korea. The negative value is above all induced by the EU strength in the South Korean machinery market. The RCA index unveils a strong dependency of South Korea from EU machinery deliveries to meet domestic demand for capital goods.

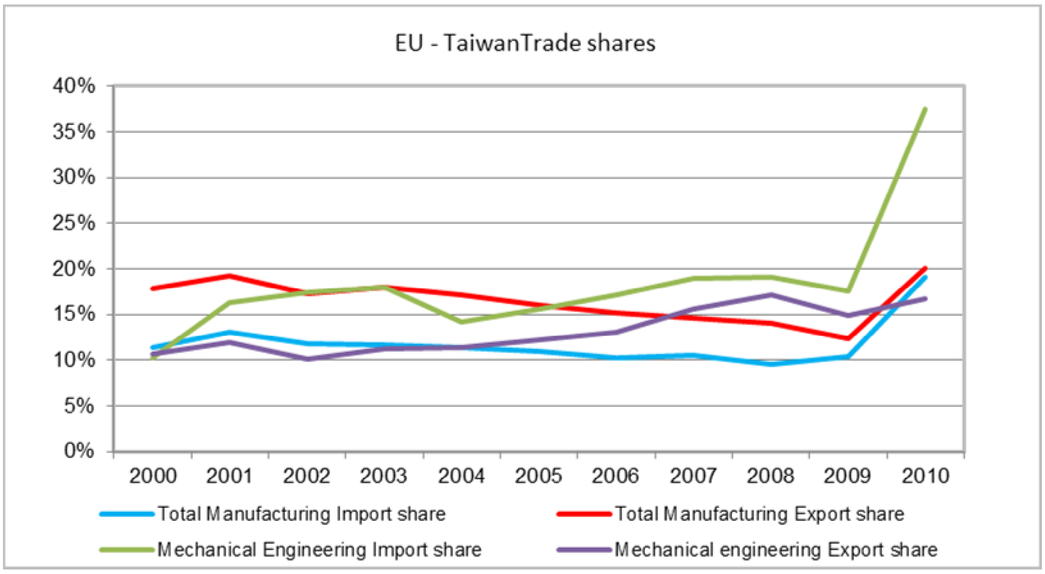
3.2.4 Taiwan

Taiwan is another one of the “Small Asian Tigers” that emerged during the early nineties as industrialized economies. The economy is even smaller than South Korea and has exploited its economic ties with China in recent decades.

Taiwan commands a surplus in trade with total manufactured goods. In 2010 **global exports of total manufactured goods** amounted to € 120.7 bn, imports reached € 77.4 bn. For most of the past decade imports declined. Even before the financial crisis hit Taiwan global imports were below the level of 2000. In 2008 they rose to € 121 bn, i.e. €12 bn below the 2000 level. Exports of manufactured goods peaked in 2006 with a value of € 11.9 bn and already declined in advance of the financial crises. This development can be explained by the size of the economy and major efforts to relocate production, primarily to China.

Taiwan’s trade balance for manufactured goods peaked in 2007. The surplus fell from € 50.9 bn to € 43.4 bn in 2010.

Figure 3.6: Evolution of the Taiwanese trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Taiwan’s **bilateral trade with EU** shows a surplus for total manufactured goods in bilateral trade with the EU. In 2010 imports were at € 14.7 bn and exports at € 24.2 bn. As for the global trade balance imports already declined between 2000 and 2008. Furthermore, exports fell on average between 2000 and 2005, then stagnated for three years, before plummeting to € 17.9 bn in 2009.

The Taiwanese **bilateral EU trade balance** peaked in 2006 at € 13.5 bn, which is one year earlier than the peak in the global trade balance was reached. In the following years, the country had to face a declining surplus. It consolidated in 2009 at € 7.8 bn and one year later already soared to € 9.4 bn. The EU’s share of Taiwanese total manufactured goods imports was between 10% and 13% in the years 2000-2009 and jumped up from

10% in 2009 to 19% in 2010. Europe's share on Taiwanese Exports decreased from 19% in 2000 to 12% in 2009 and jumped up to 20% in 2010 (Figure 3.6).

Taiwan **global trade with ME goods** shows a permanent deficit, globally as well as in bilateral trade with the EU. In 2000 global ME imports had amounted to € 19.2 bn. Imports proved to be volatile but showed a clear negative trend that bottomed out in 2009 at a value of € 11.0 bn in 2009 and only slightly expanded in 2010. ME global exports had stagnated between 2000 and 2008. In the course of the financial crisis export levels fell from € 11.3 bn in 2008 down to € 8.1 bn in 2009 and did not recover in 2010. Taiwan's deficit in global trade with ME products narrowed strongly, down from € 7.8 bn in 2000 to € 1.6 bn in 2008. The years after the trade deficit increased up to € 2.9 bn for the years 2009 and 2010. Much of this development was induced by bilateral trade with EU, a slowdown of exports to the EU and an increase of imports from EU.

The EU's share on ME imports of Taiwan was oscillating between 14% and 19% in the period 2000 to 2009. It has increased permanently until 2009. In 2010, the share jumped up to 37%. An increase in Europe's share on Taiwanese exports can also be spotted. While the share was at 12% in 2005, it was at 15% in 2009 and 17% in 2010 (Figure 3.6).

Table 3.13: Trade performance of the Taiwanese mechanical engineering

Sector	Indicator	2010		Annual average growth rate in %		
				2000– 05	2005–08	2008– 10
Taiwanese global trade Total manufacturing	Imports	bn. €	77.4	-2.2	0.6	-20.0
	Exports	bn. €	120.7	-1.0	4.4	-16.1
Taiwan - EU trade Total manufacturing	Imports	bn. €	14.7	-2.8	-3.9	12.8
	Exports	bn. €	24.2	-3.2	0.0	0.2
Taiwanese global trade Mech. engineering	Imports	bn. €	11.1	-5.3	-4.2	-7.0
	Exports	bn. €	8.2	-1.1	1.3	-14.7
Taiwan - EU trade Mech. engineering	Imports	bn. €	4.2	2.8	2.6	30.1
	Exports	bn. €	1.4	1.8	13.1	-15.7
				2000	2008	2010
Trade balances Manufacturing	Global[2)]	bn. €		26.0	50.4	43.4
	EU[2)]			13.3	12.5	9.4
Trade balances Mechanical engineering	Global[2)]	bn. €		-7.8	-1.6	-2.9
	EU[2)]			-0.8	-0.5	-2.8
BI Mechanical engineering[3)]	Global[2)]	0 = neutral > 0 = advantage < 0 = disadvant.		-21.3	-29.7	-22.0
	EU[2)]			-73.0	-10.0	-40.2
RCA Mechanical engineering[4)]	Global[2)]			-69.8	-47.9	-74.9
	EU[2)]			-111.8	-97.4	-160.5

[1)] Production plus imports minus exports; [2)] Exports minus imports; [3)] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4)] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/Taiwan; t r: Total manufacturing /all competing countries.

Source: Eurostat; VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

Taiwan is a small economy with strong ties to China. Relocation of manufacturing has affected Taiwanese trade. Over the past decade imports showed a clear negative trend already before the financial crisis. Exports moderately expanded until 2008. In the years to follow, they plummeted and in 2009 they undercut the level of 2000. A sustainable economic recovery did not take place. Taiwanese imports of machinery show an even worse development. On average for the whole period they declined at a rate of 5.3% per annum. The opposite happened with ME imports from the EU. They steadily grew up to 2008 at annual rates of 2.5% to 3.0%. The soaring imports the years after may exaggerate the positive evolution.

Likewise, Taiwanese ME exports to the EU have also been growing against the trend in trade with non-EU trade partners. It can be concluded that the EU has not only been successful in the Taiwanese market but also that trade linkages between Taiwan and the EU have intensified (Table 3.13).

3.2.5 Indonesia

In 2010 Indonesia's **global exports of manufactured goods** reached a level of € 119.0 bn, imports a level of € 102.0 bn. Imports grew on average stronger than exports between 2000 and 2010. Imports peaked in 2008 at a value of € 87.6 bn and plummeted by around 20% during the financial crisis to € 69.1 bn in 2009. Due to a dynamic recovery starting soon after, they exceeded the 2008 level already in 2010 and amounted to € 102.0 bn in 2010. Exports developed in parallel and peaked in 2008 at a value of € 93.2 bn in 2008. In 2009, they fell by around 10% down to € 83.5 bn. A strong recovery took place in 2010 and exports reached new record heights at a value of € 119.0 bn. Indonesia's trade balance was positive throughout the period under consideration.

Figure 3.7: Evolution of Indonesian trade

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Likewise, the **bilateral Indonesian trade balance for total manufactured goods** with the EU was in a surplus throughout the period under consideration, at a level of € 7.0 to € 7.5 bn. Imports from the EU grew at an average annual rate of 3.5% and exports somewhat lower at 1.8%. The growth momentum of Indonesian trade with the EU was well below that of non-EU trades. The EU's share of Indonesian imports of manufactured goods decreased from 13% in 2000 down to 6% in 2010, and the EU's share of exports from 17% in 2000 to 12% in 2010 (Figure 3.7).

The Indonesian **trade balance with ME products** shows a broadening deficit from € -3.3 bn in 2000 to € -8.3 bn in 2010. Indonesian ME imports in 2010 were far below that of South Korea and nearly the same as in Taiwan. Exports, however, were far lower than in any of the other countries. This underscores the status of Indonesia as a developing economy. However, global ME exports grew on average stronger than imports between 2000 and 2010 at 12.9% and 10.3% respectively. Due to the low level of exports the trade deficit had broadened.

Indonesia's **bilateral ME trade with the EU** is particularly low as compared to trade with non-EU countries. Moreover, its growth momentum is relatively weak and losing further importance. Indonesia's exports grew at an average annual rate of 10.4% between 2000 and 2010, and imports grew 6.4%. The EU's shares of Indonesian imports fell from 22% in 2000 to 15% in 2010 and for exports from 11% to 9%.

Table 3.14: Trade performance of the Indonesian mechanical engineering

Sector	Indicator	2010		Annual average growth rate in %		
				2000–05	2005–08	2008–10
Indonesian global trade Total manufacturing	Imports	bn. €	102.0	5.1	23.7	7.9
	Exports	bn. €	119.0	0.5	10.6	13.0
Indonesia - EU trade Total manufacturing	Imports	bn. €	6.4	1.1	7.7	3.2
	Exports	bn. €	13.7	-1.2	7.7	0.6
Indonesian global trade Mech. engineering	Imports	bn. €	10.4	6.0	18.3	9.6
	Exports	bn. €	2.1	14.2	15.2	6.4
Indonesia - EU trade Mech. engineering	Imports	bn. €	1.6	5.6	1.9	15.5
	Exports	bn. €	0.2	12.8	14.7	-1.3
				2000	2008	2010
Trade balances Manufacturing	Global[2]	bn. €		31.1	5.6	17.0
	EU[2]			7.0	7.6	7.4
Trade balances Mechanical engineering	Global[2]	bn. €		-3.3	-6.8	-8.3
	EU[2]			-0.8	-1.0	-1.4
BI Mechanical engineering[3]	Global[2]	0 = neutral > 0 = advantage < 0 = disadvant.		-226.1	-148.8	-156.5
	EU[2]			-267.4	-181.1	-180.4
RCA Mechanical engineering[4]	Global[2]			-245.3	-160.2	-175.4
	EU[2]			-340.8	-260.6	-286.7

[1] Production plus imports minus exports; [2] Exports minus imports; [3] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/ Indonesia; t/r: Total manufacturing /all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

Indonesia is a developing economy with strongly growing demand for capital goods. It commands a surplus in global trade with total manufactured goods, although Indonesia's global trade with ME products as well as the bilateral trade shows a permanent deficit. EU manufacturers do not play a significant role in Indonesia. The share of ME products in Indonesian imports is above the share of other manufactured goods, but with only 15% in 2010 well below the EU's share in most other important sales markets. The relative importance of bilateral trade with the EU had shrunk noteworthy over the period under consideration (Table 3.14).

3.2.6 Australia

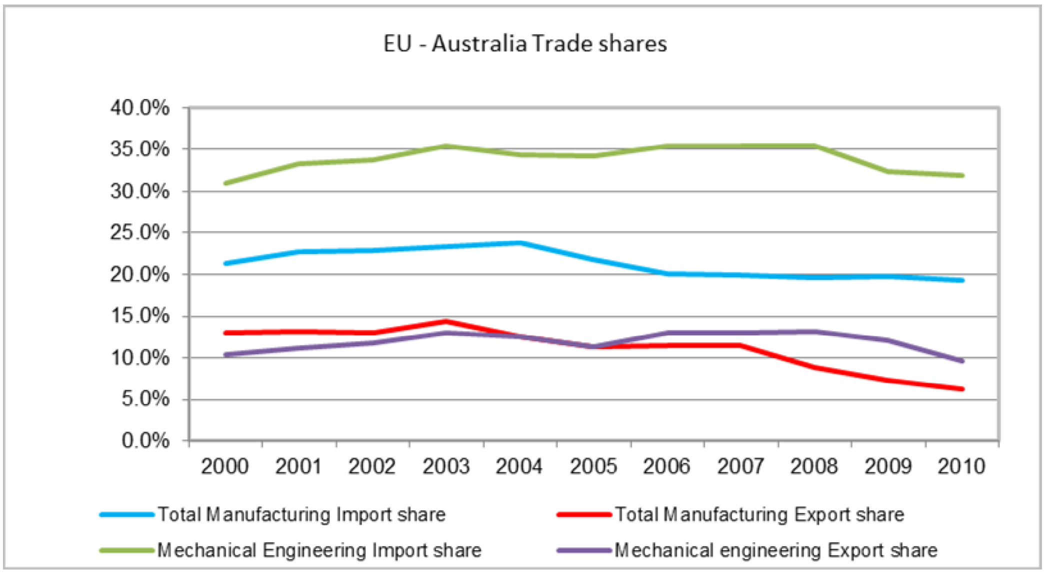
Australia is a country of major importance for the global economy because of its relative wealth of commodities. It strongly benefitted from soaring demand since the middle of the last decade. Australia's demand for fixed assets is driven by mining equipment.

For the first time since many years, the Australian **global trade for manufactured goods** showed a surplus in 2010. Exports amounted to € 155.9 bn and imports to € 138.4 bn. The trade deficit - observed since 2000 - had grown until 2004. It bottomed out at a value of € -13.7 bn and had decreased in the years to follow.

Likewise, the bilateral **Australia – EU trade for total manufactured goods** had been in deficit for the period under investigation. In contrast to global Australian trade it did not shift into surplus in 2010, rather it took an opposite direction, since the deficit had broadened. It is of note that the Australian global trade deficit had been caused by the EU. In trade with other non-EU countries Australia always had a trade surplus for the years in the study period.

Australia imported total manufactured goods from the EU worth € 26.7 bn in 2010, exports amounted to € 9.8 bn. For the period under consideration, the EU imports grew at an annual average rate of 5.6%, somewhat below the global increase of imports at an average rate of 6.6%. Exports destined for the EU grew at a weak rate of only 0.9%, whereas global Australian exports had been expanded by an annual rate of 8.5%. The EU's share on Australian imports was close to 20% from 2006 to 2010, slightly lower than the years before. Its share on Australian exports had peaked in 2003 with 14% and since then showed a declining trend down to 6 % in 2010 (Figure 3.8).

Figure 3.8: Evolution of Australian trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

The **global Australian trade with ME products** shows a permanent and growing deficit until 2008. Since then, it had stabilized at a level of € 10 bn. In 2010 imports were at € 13.2 bn and exports at € 2.8 bn. On average imports had been growing between 2000 and 2010 at an average rate of 6.8% and exports at 4.7%.

Likewise, the **bilateral Australian – EU trade with ME products** shows a broadening deficit up to 2008. The years after, it varied at a level of €3.5 to 4 bn. Imports stood at € 4.2 bn and exports at € 0.3 bn in 2010. Over the period under investigation, Australian EU imports had grown at an annual average rate of 7.1, stronger than machinery imports from non-EU regions. Exports had been growing at a rate of 3.9%, which is lower than the exports to non-EU regions. The EU's share of total Australian imports was at 31% in 2000 and increased up to 35 the following years. In 2009, Australian imports from the EU plummeted by 17% and only recovered moderately in 2010. This development was worse than for machinery imports from other regions and the EU share of Australian machinery imports fell back to 32% (Figure 3.8).

Table 3.15: Trade performance of the Australian mechanical engineering

Sector	Indicator	2010		Annual average growth rate in % 2000–05	2005–08	2008–10
Australian global trade Total manufacturing	Imports	bn. €	138.4	5.5	10.5	3.7
	Exports	bn. €	155.9	4.2	14.3	10.8
Australia - EU trade Total manufacturing	Imports	bn. €	26.7	5.9	6.7	3.1
	Exports	bn. €	9.8	1.3	5.4	-6.6
Australian global trade Mech. engineering	Imports	bn. €	13.2	8.6	8.1	0.5
	Exports	bn. €	2.8	3.6	3.7	9.1
Australia - EU trade Mech. engineering	Imports	bn. €	4.2	10.7	9.5	-4.7
	Exports	bn. €	0.3	5.4	9.0	-6.8
				2000	2008	2010
Trade balances Manufacturing	Global[2)]	bn. €		-4.0	-1.6	17.5
	EU[2)]			-6.6	-14.0	-17.0
Trade balances Mechanical engineering	Global[2)]	bn. €		-5.1	-10.7	-10.4
	EU[2)]			-1.9	-4.3	-3.9
BI Mechanical engineering[3)]	Global[2)]	0 = neutral > 0 = advantage < 0 = disadvant.		-124.9	-156.2	-154.9
	EU[2)]			-147.3	-116.2	-112.2
RCA Mechanical engineering[4)]	Global[2)]			-129.8	-170.2	-167.0
	EU[2)]			-189.7	-189.8	-174.5

[1)] Production plus imports minus exports; [2)] Exports minus imports; [3)] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4)] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/Australia; t/r: Total manufacturing /all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions
Australia is an important market for ME products, in particular the mining machinery. Investment in new mining capacities had driven demand for capital goods since the middle of the last decade. Australia had always been in need to import capital goods and the domestic engineering industry is insufficiently placed to meet the domestic demand. The EU commands a large portion of the Australian machinery market and its share on total Australian machinery imports had been growing. In contrast, the EU share of Australian total manufacturing goods imports had been falling during the period under investigation.

Foreign trade analysis shows that the dependency on machinery imports has not been reduced. The Balassa Index on trade specialization does not disclose any strengthening of machinery exports. Their share of total Australian exports had remained well below the share of machinery in worldwide exports (Table 3.15).

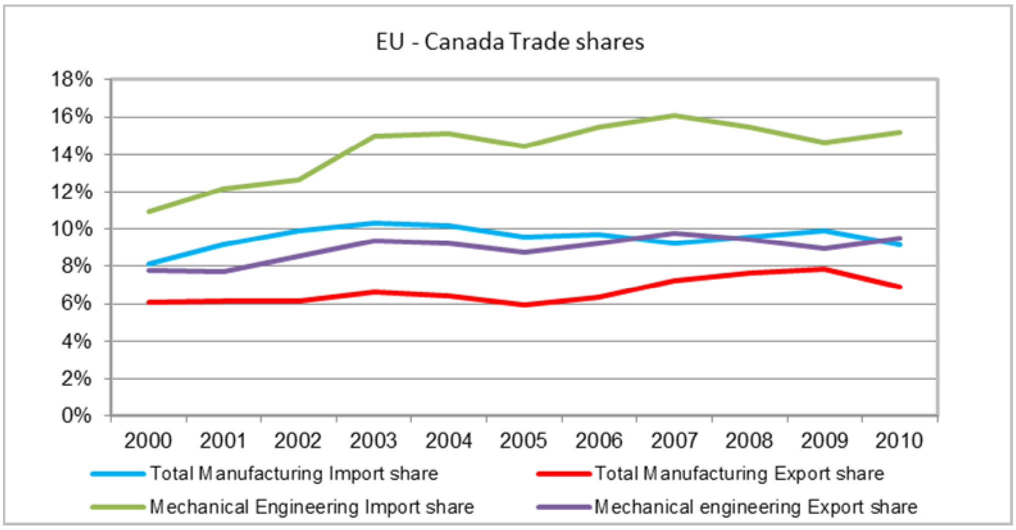
3.2.7 Canada

Canada is the only developed country among the economies analysed in the chapter on the EU's performance in important sales markets for ME products. Canada's manufacturing industry has a longstanding tradition. It is strong in the manufacture of transport equipment and has close ties with the US manufacturing sector.

Traditionally Canada's **global trade with total manufactured goods** shows a surplus. During the last decade, it peaked in 2001 with € 49.8 bn. The following years the surplus varied between € 30 to 40 bn. In 2009 exports plummeted by 27% and imports by "only" 17%, the trade surplus disappeared. In 2010 exports and imports grew at a similar pace. Canada gained only a small surplus.

The **bilateral EU-Canada trade with total manufactured good**s had always shown a deficit. Throughout the period under consideration it was volatile and did not show a clear tendency, it varied between € 7.0 bn in 2006 and € 2.4 bn in 2008. Between 2000 and 2010, Canadian exports to the EU grew an average annual rate of 0.9% whereas exports to other regions declined on average per year by 0.3%. Canadian imports from the EU grew at an annual rate of 2.5%, likewise stronger than Canadian imports from non-EU regions that increased annually at 1.3% on average. Since 2000, The EU's share of Canada's imports of manufactured goods grew slightly from 8% in 2000 up to 9% in 2010. The respective shares for exports are 6% and 7% (Figure 3.9).

Figure 3.9: Evolution of Canadian trade



Source: VDMA; Cambridge Econometrics; Ifo Institute.

Canada is, like other countries in the chapter on important sales markets for machinery, a net importer of ME products – globally as well as in terms of bilateral trade. The deficit of the **global ME trade balance** amounted to € 10.9 bn in 2010. Imports had been fallen from € 24.0 bn in 2008 to € 19.4 bn in 2009 and more than compensated the losses in 2010. They reached a new record peak of € 24.7 bn in 2010. Exports had declined from € 14.8 bn in 2008 to € 11.9 bn in 2009. They did not fully recover and reached a value of € 13.2 bn in 2010. Canada's global trade deficit with machinery had declined from € 9.2 bn in 2008 to € 7.5 bn in 2009, but broadened to a record value of € 11.5 bn.

Canada's bilateral machinery trade also reached a record deficit in 2010. The deficit had been broadened moderately throughout the period under investigation until 2009, followed by a new record rise afterwards. The Canadian imports of EU ME goods grew at an annual average rate of 3.5% between 2000 and 2010, stronger than global machinery imports that expanded only at a rate of 0.2%. Canadian exports to the EU increased by 1.9% per year whereas total machinery exports slightly declined at 0.1% per year.

The bilateral Canadian – EU machinery trade had intensified throughout the period under investigation. The EU's share of Canadian imports increased from 12% in 2000 to 16% in 2007 and since then fluctuated around 15%. The EU's share of Canadian machinery exports was at 8% in 2000 and had increased between 9% and 10% from 2001 on (Figure 3.9).

Table 3.16: Trade performance of the Canadian mechanical engineering

Sector	Indicator	2010		Annual average growth rate in %		
				2000– 05	2005–08	2008–10
Canadian global trade Total manufacturing	Imports	bn. €	290.2	-0.5	3.1	3.2
	Exports	bn. €	291.0	-0.7	2.2	-3.1
Canada - EU trade Total manufacturing	Imports	bn. €	26.5	2.8	3.0	0.9
	Exports	bn. €	20.1	-1.1	11.0	-7.8
Canadian global trade Mech. engineering	Imports	bn. €	24.7	-1.8	2.8	1.4
	Exports	bn. €	13.2	0.3	3.1	-5.6
Canada - EU trade Mech. engineering	Imports	bn. €	3.7	3.8	5.2	0.4
	Exports	bn. €	1.3	2.7	5.6	-5.1
				2000	2008	2010
Trade balances Manufacturing	Global2)	bn. €		45.5	37.2	0.8
	EU2)			-2.5	-2.4	-6.4
Trade balances Mechanical engineering	Global2)	bn. €		-10.9	-9.2	-11.5
	EU2)			-1.6	-2.3	-2.5
BI Mechanical engineering3)	Global2)	0 = neutral > 0 = advantage < 0 = disadvant.		-70.0	-61.4	-62.3
	EU2)			-45.6	-40.6	-30.4
RCA Mechanical engineering4)	Global2)			-76.4	-60.9	-62.8
	EU2)			-81.2	-88.3	-81.6

1) Production plus imports minus exports; 2) Exports minus imports; 3) Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); 4) Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/Canada; t/r: Total manufacturing / all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

Canada is a developed economy with close ties to the US. Apart from that, Canada is a net-importer of machinery. Its position in international trade had not changed over the period under investigation. Neither had the non-specialization - as indicated by the BI - been reduced nor had the comparative disadvantage in the machinery trade balance as – suggested by the RCA- improved. The EU share of total machinery imports is the lowest among the sales markets investigated in this chapter, primarily due to the close economic ties between Canada and the US. Throughout the period under investigation the Canadian EU trade relation had intensified, particularly the share of EU products of total Canadian imports had increased (Table 3.16).

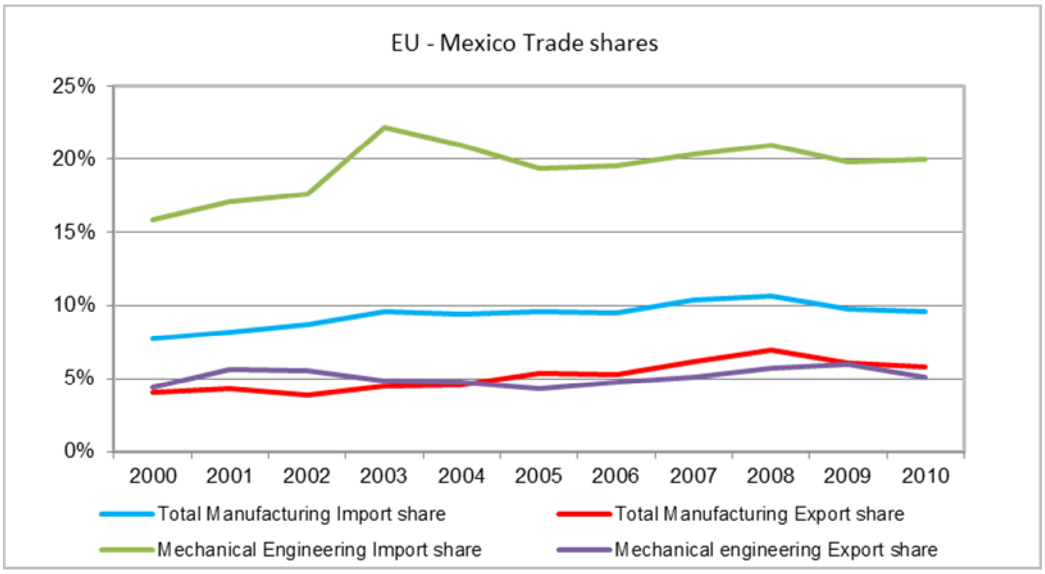
3.2.8 Mexico

Mexico is as well as Canada member of NAFTA. The US manufacturing heavily invested in production sites.

Mexico was a net importer of manufactured goods throughout the period 2000 to 2009. The first time in 2010 the **global trade balance with total manufactured** goods shifted into a surplus accountable to € 2.1 bn. Imports steadily increased from € 149.8 bn in the year 2003 onwards and peaked in 2008 at € 206.5 bn. In 2009 they plummeted down to € 164.8 bn by 20% and in 2010 the imports more than compensated for these losses. They reached a record height at € 222.9 bn. Likewise, exports increased from € 145.8 bn in 2003 to € 198.0 bn in 2008, before they declined to € 164.7 bn by 17% in 2009. In 2010 they grew at a rate of 37% up to € 225.0 bn.

The **bilateral Mexican - EU trade for total manufactured goods** fluctuated throughout the period under investigation between € 6 bn € and € 9 bn without a clear trend. Mexican imports from the EU peaked at € 21.9 bn in 2008. In 2009 they fell by 27% down to € 16.0 bn. The losses were nearly fully compensated in 2010 when they reached € 21.4 bn. Likewise exports to the EU peaked in 2008 (€ 13.7 bn), fell by 27% down to € 10.0 bn then and nearly took the former record position in 2010. On average for the period of analysis, Mexican imports from the EU grew at an annual rate of 4.1%, much stronger than global imports of total manufactured goods that only increased by 1.9% per year. The average annual growth rate for Mexican exports to the EU was 6.1%, while total exports only expanded by 2.3% per year. Mexican trade with the EU gained importance between 2000 and 2010 as compared to non-EU regions. The EU's share of Mexican imports of total manufactured goods slightly increased from 14.0% in 2000 up to 14.4% in 2010. In contrast, the weight of Mexican exports to the EU of total exports increased from 7.8% up to 12.2% (Figure 3.10).

Figure 3.10: Evolution of Mexican trade



Source: VDMA; Cambridge Econometrics; Ifo Institute.

The Mexican **global trade with ME products** had always been in deficit. It was highest in 2001 and at € 9.3 bn. Although the trade balance was volatile, a positive trend was identified that is reflected in the global RCA that shows a declining comparative advantage. In 2010 the trade deficit amounted to only € 5.2 bn. The improvement in the trade balance was achieved thanks to trade with non-EU countries. Mexican imports from this region only increased at 0.3% p.a., whereas exports to the region increased by 4.6% on average per year between 2000 and 2010.

The bilateral **Mexican machinery trade with the EU** shows a negative balance that fluctuated between € 2.2 bn in 2004 and € 3.2 bn in 2008. Mexican imports from the EU grew at an annual rate of 3.2% while exports to the EU increased annually on average by 6.3%. The Mexican foreign trade – just like the Canadian foreign trade - is marked by a growing intensification of relations with the EU. The EU share of Mexican machinery imports increased from 16% in 2000 up to 20% in 2010. The EU's weight of Mexican machinery exports went up from 4% to 5% (Figure 3.10).

Table 3.17: Trade performance of the Mexican mechanical engineering

Sector	Indicator	2010		Annual average growth rate in %		
				2000–05	2005–08	2008–10
Mexican global trade Total manufacturing	Imports	bn. €	222.9	-0.8	5.4	3.9
	Exports	bn. €	225.0	-0.9	4.8	6.6
Mexico - EU trade Total manufacturing	Imports	bn. €	21.4	3.4	9.2	-1.3
	Exports	bn. €	13.1	4.9	14.1	-2.2
Mexican global trade Mech. engineering	Imports	bn. €	18.0	-2.0	6.3	-0.1
	Exports	bn. €	12.8	3.6	4.2	7.9
Mexico - EU trade Mech. engineering	Imports	bn. €	3.6	2.0	9.1	-2.4
	Exports	bn. €	0.7	3.2	14.8	2.0
				2000	2008	2010
Trade balances Manufacturing	Global[2]	bn. €		-3.8	-8.4	2.1
	EU[2]			-7.0	-8.2	-8.2
Trade balances Mechanical engineering	Global[2]	bn. €		-8.5	-7.0	-5.2
	EU[2]			-2.3	-3.2	-2.9
BI Mechanical engineering[3]	Global[2]	0 = neutral > 0 = advantage < 0 = disadvant.		-68.2	-46.5	-39.6
	EU[2]			-60.3	-65.9	-53.2
RCA Mechanical engineering[4]	Global[2]			-69.3	-45.2	-34.8
	EU[2]			-133.3	-132.8	-122.0

[1] Production plus imports minus exports; [2] Exports minus imports; [3] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/Mexico; t/r: Total manufacturing/all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

Mexico is an emerging economy that benefitted much from its membership in the NAFTA by strong US investment in manufacturing facilities. Due to these strong economic ties the EU share of Mexican machinery imports is low as compared to many other developing economies. It came up to only 20% in 2010. The EU trade relations with Mexico were intensified during the past decade. In particular the EU gained shares in global machinery imports. The Mexican trade deficit in machinery to non-EU regions had narrowed between 2000 and 2010, indicating growing importance of Mexico as a machine manufacturing location. This development is reflected in the Balassa Indicator on export specialisation and in the RCA. Both indicators became less negative for the period under investigation for global machinery trade. This development was less pronounced for Mexican – EU trade (Table 3.17).

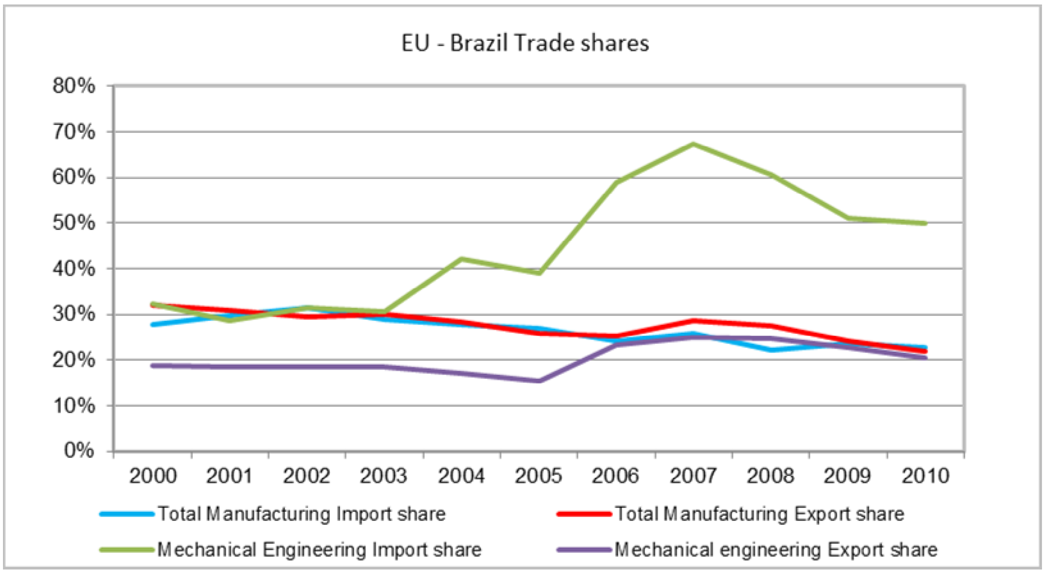
3.2.9 Brazil

Brazil is by far the largest Latin American economy. Traditionally, EU manufacturers have close relations to Brazil. Among the developing economies under investigation it has the longest tradition in advanced manufacturing and can trust on a know-how driven metal and transport equipment industry that has proven to be successful in the global aerospace industry.

Brazil's global trade surplus for total manufactured goods proved to be extremely volatile. In 2001, it amounted only to € 1.3 bn and strongly increased up to € 31.2 bn in 2007. In the year after, the surplus plummeted to € 12.6 bn and fluctuated in a range of € 10 bn to € 15 bn. In contrast to other countries analysed the financial crisis did not considerably affect the trade balance. Global exports of total manufactured goods steadily increased from € 62.2 bn in 2002 to € 130.3 bn in 2008, declined to € 106.3 bn in 2009 and reached a record height for the period under consideration in 2010 at a value of € 147.0 bn in 2010. Exports increased on average for the whole period at a rate of 9.7% per year. Imports started to steadily increase from € 42.7 bn in 2003 to € 117.7 bn in 2008, declined to € 91.5 bn in 2009 - and like exports – peaked in 2010 at a value of € 136.1 bn. Imports increased at an annual average rate of 8.5%.

Likewise, the **Brazil-EU trade balance for total manufactured goods** showed a surplus for the whole period analysed. However, it was extremely volatile. In 2003 it was at € 12.3 bn and increased up to € 26.2 bn in 2008, declined to € 21.5 bn in 2009 and jumped up to € 31.1 bn in 2010. This development had been driven by Brazilian exports to the EU. In 2000 they accounted only for € 19 bn and increased to € 35.8 bn in 2008, followed by a decline by 28% down to € 25.6 bn in 2009. The recovery in 2010 by 26% led to an export value of € 32.3 bn. On average for the whole period Brazilian exports to the EU grew at an annual rate of 5.7%, much lower than global exports. Imports stood at € 17 bn in 2000 and grew at a more moderate pace of € 26.2 bn in 2008, declined by 18% in 2009 to € 21.5 bn. In 2010, soaring imports led to a value of € 31.1 bn. The average growth rate for Brazilian imports from the EU was at 6.4%, likewise below the global imports growth rate. Europe's share on Brazil's import of manufactured goods decreased from 28% in 2000 down to 23% in 2010. The share of exports decreased from 32% in 2000 to 22% in 2010 (Figure 3.11).

Figure 3.11: Evolution in Brazilian trade



Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Most of the time, **Brazil's ME global trade balance** is in deficit. For the period under consideration it showed a slight surplus in 2004 and 2005, caused by soaring exports to and declining imports from non-EU countries. The global surplus turned into a deficit of € 4.0 bn in 2008, € 5.3 bn in 2009 and € 7.8 bn in 2010. Since 2005, global ME imports grew at high double digit rates. Only in 2009 the upward tendency was broken by a decline of 14%. In 2010, global exports increased by 44% and reached an all-time high of € 13.8 bn. Up to 2008, the driver behind this development was soaring machinery imports from Europe. Global Brazilian ME exports stood at € 3.2 bn in 2000 and steadily grew up to € 6.8 bn in 2008. In 2009 they faced a tremendous decline of 40% and did not fully recover in 2010 when they reached a value of € 6.0 bn.

Brazils bilateral ME trade with the EU shows a broadening deficit. In particular for the years 2005 to 2008 imports were soaring. The years after, the development was distorted by the financial crisis. For the period under investigation imports from the EU had grown at an annual average rate of 14%, much higher than imports from non-EU regions that increased at a yearly rate of only 3.9%. Total Brazilian ME imports show increasing shares for the EU, rising from 32% to 50%. Brazilian machinery exports to the EU nearly tripled between 2000 and 2008 from € 0.6 bn up to € 1.7 bn. In 2009 they considerably dropped by 45% and did not fully recover in 2010. Exports to the EU reached a value of € 1.2 bn. For the study period, the average annual growth rate was 7.5%. Exports to non-EU regions were expanded by 6.4% per year. The EU share of total Brazilian ME exports increased from 19% in 2000 up to 21% in 2010. (Figure 3.11)

Table 3.18: Trade performance of the Brazilian mechanical engineering

Sector	Indicator	2010		Annual average growth rate in %		
				2000–05	2005–08	2008–10
Brazilian global trade Total manufacturing	Imports	bn. €	136.1	-0.4	25.8	7.5
	Exports	bn. €	147.0	9.9	11.9	6.2
Brazil - EU trade Total manufacturing	Imports	bn. €	31.1	-0.9	17.9	9.0
	Exports	bn. €	32.3	5.3	14.2	-5.0
Brazilian global trade Mech. engineering	Imports	bn. €	13.8	-0.9	25.5	12.6
	Exports	bn. €	6.0	12.4	6.2	-6.1
Brazil - EU trade Mech. engineering	Imports	bn. €	6.9	2.9	45.5	2.2
	Exports	bn. €	1.2	7.9	24.3	-14.5
				2000	2008	2010
Trade balances Manufacturing	Global[2)]	bn. €		-2.3	12.6	10.9
	EU[2)]			1.9	9.6	1.2
Trade balances Mechanical engineering	Global[2)]	bn. €		-2.6	-4.0	-7.8
	EU[2)]			-1.3	-4.9	-5.6
BI Mechanical engineering[3)]	Global[2)]	0= neutral > 0 = advantage < 0 = disadvant.		-49.4	-52.5	-72.8
	EU[2)]			-101.8	-62.9	-79.5
RCA Mechanical engineering[4)]	Global[2)]			-55.5	-56.8	-90.6
	EU[2)]			-123.4	-167.3	-175.6

[1)] Production plus imports minus exports; [2)] Exports minus imports; [3)] Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); [4)] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering/Brazil; t/r: Total manufacturing/all competing countries.

Source: VDMA; Cambridge Econometrics; Ifo Institute.

Conclusions

Brazil, the largest Latin American economy has always had close economic ties to Europe. The EU ME has not only strongly benefitted from the high growth momentum of the Brazilian economy, but could increase its share of total Brazilian machinery imports up to 50%. Brazil is South America's manufacturing powerhouse and as such delivers manufactured products to neighbouring countries to a large extent. The non-specialization in Brazilian exports to the EU on ME – indicated by the BI for bilateral trade - has been reduced as a result of strongly growing machinery deliveries. This suggests that Brazilian competence as an emerging machinery supplier has improved and the EU market has come into reach. However, the dependency of EU deliveries for domestic investment in machinery has not been affected by this upgrading, as is shown by the RCA that has become even more negative throughout the period under investigation. (Table 3.18)

4 Assessment of competitive position of the EU Mechanical Engineering

This chapter provides the results of the analysis based on the more descriptive preceding chapters. Chapter 4.1 discloses structural trends of the EU ME driven by the challenges of globalization and changes in the industrial environment. Chapter 4.3 investigates in the performance of the EU ME and its major competitors in global trade. Chapter 4.2 tackles changes in the price competitiveness. Chapter 4.4 investigates changes in the value chains, their regional reach and trends in vertical co-operation. Special attention is paid to challenges for smaller enterprises. Chapter 4.5 highlights trends in the EU ME's product programme dedicated to stay on the leading edge of competitiveness by exploiting comparative advantages. Chapter 4.6 is dedicated to assess the technological competitiveness of the EU ME and the impact of the public R&D infrastructure and public schemes dedicated to strengthen the performance of the EU ME. Chapter 4.7 provides the concluding evaluation.

4.1 Recent trends in the EU Mechanical Engineering's structure

4.1.1 Mechanical engineering – a regionally anchored industry

The analysis of ME has highlighted specifics of the industry that are necessary for the understanding of its importance for the EU economy. ME is less capital intensive than many other manufacturing industries. Although labour is of outstanding importance, ME is not a low-wage industry. Quite the opposite, higher wages per capita than on average for the manufacturing sector indicate that not quantity but quality of labour is decisive (Chapter 2.1).

ME is an industry characterized by a sophisticated division of labour. Numerous subsectors are suppliers to other companies within the industry and the specialization is a prerequisite for the design and production of high-tech parts and components that define the outstanding quality and performance of final goods that are sold on the global market and establishes the EU manufacturers' high reputation.

ME is not only characterized by an intra-industrial but an inter-industrial division of labour. Upstream linkages to other metal industries, electrical engineering, the electronics industry etc. asks for a good industrial infrastructure as a prerequisite for a competitive ME. As a consequence **ME has always been a less "mobile" industry than for instance ICT with its longstanding tradition of global production networks for the exploitation of low-wage supply.**

Europe, as an industrialized region has always provided beneficial framework conditions for ME and contributed to its competitiveness. This advantage has lost some of its importance by emerging economies' industrialization. The upgrading of their infrastructure has reduced the European edge.

4.1.2 Regional specifics within the EU

After the breakdown of the Iron Wall the CEE had suffered a painful transition phase. Capacities had been dismantled and in spite of massive FDI workplaces were lost. For ME this phase lasted until the middle of the last decade**. Since then employment in ME has stabilized for the countries that had accessed the EU in 2004 indicating the end of the transition phase.**

To a certain extent a division of labour has emerged between the 15 "old" and the states that accessed 2004 and beyond. The share of R&D, marketing and sales of total workplaces is higher for companies from the "old" member states. Their eastern affiliates and independent CEE companies focus more on production and mechanical technologies (See for example "Gildemeister" in Chapter 2.2.6). This is not clear cut discrimination, but an important pattern of specialization, although, there are examples of independent companies - in the member states that have accessed in 2004 and later - building on their own competitive technologies and command noteworthy shares in international markets, such as the industrial groups WIKOV, CKD and Alta as mentioned in Chapters 2.3.4, 2.2.7.

The financial crisis had affected companies from all member states and induced a slump in demand followed by a dynamic recovery. However, the long-term analysis of indicators of relevance for price competitiveness has disclosed that companies' performance in countries with macroeconomic distortions have worsened noteworthy. **Spanish and Italian firms have suffered from poor macroeconomic framework conditions, although, generally speaking, business management, products and technology cannot be blamed for this development.** Above all smaller firms are afflicted by the macroeconomic problems, because they have only few opportunities to compensate for national disadvantages.

4.1.3 Globalization – a driver for structural change

Although ME has never been a frontrunner of globalization by FDI, international production networks have become more and more important since the late 1980s and early 1990s. Production in foreign markets is driven by different factors. Low-wages is only one reason among others, in particular to serve the low end of the product programme. The reduction of market access hindrances based on tariff and non-tariff barriers, or other forms of discriminations have been identified. The proximity to foreign clients has become an important reason for investments in large emerging markets with high growth potentials.

Generally speaking, two major objectives are driving the development:

- Market access to exploit the size and growth potential of foreign markets as described in Chapter 2.4.1 and the

- Exploitation of comparative advantages for production in foreign countries.

The latter can be of outstanding importance for companies who do not want to lose shares in volume markets. It is true that these segments – in most cases - only deliver low margins but they allow the exploitation of economies-of-scale that are crucial for companies' long-term sustainable strategic position. Admittedly, the relevance of low to medium-tech serial products for the competitiveness of companies is not in the focus of public policies around the world. Public policies are focused on the race to gain a technological edge over competing economies. **However scale effects and market shares must not be underestimated as a key-factor for companies' competitiveness.**

This strategic option – above all applied by large companies - has raised some concern from smaller EU manufacturers that cannot exploit similar opportunities from globalization. The large companies' imports from own foreign factories onto the Single Market put a tough challenge on their smaller EU competitors (See for instance: Chapter 2.3.4).

However, the Single Market is open to international competition and foreign companies have tapped the European markets likewise. Most concerned are markets for low and medium-tech products. While large European manufacturers counter this challenge by own foreign production, smaller firms frequently have to meet the challenge by a bundle of niche strategies, such as concentrate more on local needs, customized solutions, specific product features and additional services. **In particular in some market segments the very small industrial enterprises many firms will evolve towards handicraft businesses in the long-run.** Instead of manufacturing own products they will concentrate more on services and the assemblage of trade products, as can be observed for instance in the HVAC market where advanced technologies for heating, air condition provide new opportunities.

Numerous foreign companies have strengthened their foothold in the EU by FDI. European manufacturers have been acquired by foreign companies. Noteworthy activities of US, Chinese and Korean firms have been identified. But these are not the only foreign players in the Single Market. Traditionally Swiss companies have always commanded a big stake in EU ME. Japanese manufacturers had started massive FDI, frequently as greenfield investment, already during the mid-1980s.

These foreign players' activities are driven by diverse objectives, such as market access, broadening the product programme and access to technology. **In the long run most foreign players have become part of the game, even have set-up research units and participate in common, publicly funded research projects with other European players. However, the Chinese investment in European companies has been regarded more cautiously. It is assumed that some of these activities are primarily directed to get access to key technologies to strengthen Chinese competitiveness.** In contrast to most other foreign companies activities mutual advantages are not expected (See: Chapters 2.4.1, 3.1.3).

4.1.4 Structural changes

Since the early 1990s a strategic realignment is observable. By and by industrial conglomerates with stakes in quite different market segments have been dissolved and a concentration on core activities has been taken place. This might be explained by the manifold of growth opportunities in emerging economies and increasing pressure from new competitors. Business areas - that do not allow raising synergies - have been spun off and new companies created, as for instance KION, the former industrial truck business of Linde.

These activities must not be confused with companies' activities that are directed to become a full-hand supplier. M&A that pursue this objective are linked to becoming a problem solver for clients. A portfolio of firms and business areas is created to offer clients complete solutions. These can be specific production processes, the design and set-up of logistic systems etc. System engineering gains importance and contributes to the competitiveness of the EU ME. These technical services require a comprehensive knowledge of different technologies and the co-operation of highly qualified experts, a strength the EU manufacturers can trust on. Several examples have been identified during the investigation in the subsectors of ME. In particular in the subsectors machine tools, textile machinery and drives noteworthy activities have been identified that took place during phases of consolidation. Structural changes of the supply side have been driven by M&A to create system suppliers. In contrast to conglomerates the logic behind full-hand suppliers lies in the exploitation of synergies based on affiliated companies' complementarity of supply.

Over the past decades ME companies have adjusted to the needs of globalization. Larger and remote markets, as well as growing international competition have induced companies to focus on core competences and spin-off other business areas that do not at least provide opportunities to raise synergies. Simultaneously a trend to become full-hand suppliers has taken place, frequently linked with efforts to market engineering services and to be recognized as a problem solver. Complementary business areas have been accessed by M&A. Affiliated groups have emerged – sometimes based on strategic decisions to meet the challenges of globalization, but sometimes a crisis had forced a consolidation (See: Chapter 2.4.1).

Today, beside the traditional medium-sized enterprise of the EU ME groups of affiliated companies – in many cases previously independent firms - play an important role in the industry. These groups' advantages lie in the combination of smaller firms' flexibility with larger firms' potential to access global sales markets, their access to financial markets etc. Moreover, the increasing administrative burden by requests from clients that ask for certified processes, by strict and comprehensive technical and environmental regulation, health and safety provisions can be shared more easily within a group of enterprises. For instance, holding companies provide these services for their daughter firms that are governed like profit centres.

Private equity funds and other financial market players have become stakeholders of the EU ME. They have contributed to the structural change of ME. Large and well-known global players are the exception. Most of the financial players are specialists, focused on regions and/or industries. Their contribution to the evolution of industries has been highly controversial in the public discussion. For the EU ME numerous examples have been identified where financial players' involvement has eased structural changes and contributed to the survival of companies. Business areas that had run in difficulties have been restructured and regained competitiveness. Financial players have become important in cases of company succession for family-held firms. Negative aspects related to short-termism of financial players might dampen the picture a bit, but not much evidence has been found.

4.1.5 Changing upstream environment – challenges to ME firms

ME is dependent from the supply of energy intensive industries such as steelworks, castings industry and others. They face certain challenges from environmental legislation. Stricter emission regulations and Emission Trading Schemes (ETS) induce companies to keep capacities tight. This has caused some bottlenecks in supply from upstream industries during the last upswing cycle. For instance scarce coking coal had to be imported and foundries had to pass price increases on ME enterprises.

Small European enterprises have a weak bargaining power vis-à-vis suppliers of key components (e.g. controls) which are global players. These suppliers prioritize big volume customers and offer them large discounts which are not available for SMEs. This is a problem in particular for machine tool firms of which more than 80% in the EU are SMEs.

The strength of the EU manufacturers of construction machinery is to a certain extent based on close links to their suppliers of key component suppliers, e.g. for hydraulics and engines. In course of globalization these suppliers are attracted by emerging countries' growth markets. They set-up production sites in these markets and contribute to the upgrading of foreign competitors' products, for instance Chinese construction machinery manufacturers. It is feared that better opportunities to exploit scale effects in emerging markets could induce European component suppliers to dismantle capacities in the EU. **A breakup of linkages for the common development of high-tech components by key-suppliers specified for the needs of EU client companies, for instance from the construction machinery industry, will endanger the EU manufacturers' technological competitiveness.**

4.1.6 Changing sales market environment needs adjustments

ME is an industry that benefits much from proximity to client industries. In recent decades some changes have been taken place which in turn has influenced ME. Most obvious have been developments in the textile and clothing industries. Much of the production has been relocated to low-wage countries, and to a great extend proximity of equipment manufacturers has been lost. A noteworthy share of machinery production has followed suit and a consolidation process - driven by M&A- has taken place in Europe. In spite of the EU textile manufacturers' outstanding technological lead they had to adjust their production networks to the changed market environment. The number of EU workplaces has shrunk and the subsector's share of the EU ME output has fallen strongly. The EU production in some areas, such as spinning and weaving, has been concentrating more and more on the manufacture of those components that are of key importance for the performance of machinery, whereas most of the production is carried out abroad to contain costs for complete machines on competitive levels and not to lose proximity to clients. This development is already reflected in the structure of global trade by a higher share of parts on total textile machinery trade (See: Chapter 2.3.10). **The adjustment of ME to globalization is not only dependent on the EU enterprises' strategies and competitiveness, it is also driven by a changing economic environment, in particular the development of client industries in global competition.**

Not only the negative but the stimulating effects of proximity to client industries for ME can be highlighted by the subsector "textile machinery". In technical textiles EU ME exploits the advantages of proximity to clients from construction, the automotive and chemical industry. **Above all interdisciplinary applications such as for CFRP benefit much from the industrial infrastructure within the EU and the long-standing tradition in the co-operation of companies from different industries** (See for instance: Chapter 2.3.4 (Klingelnberg), Chapter 2.3.10).

4.2 Price competitiveness and profitability

In Chapter 3.1 the performance of the major competing economies in ME has been investigated. In particular large differences have been identified in labour productivity that - as a first guess – can be taken as an indication for an efficiency-based competitiveness. Japan is in the lead closely followed by US. Third in this ranking is the EU-27, but with a much lower level. This could be caused by the more heterogeneous EU economy with member states of quite different economic performance. However, the regional differentiation discloses that none of the member states comes close to the US or Japan. For the countries under investigation Germany shows the highest labour productivity at a level of around 70,000 €, more than 20% below the US ME labour productivity (Table 4.1).

Chinese ME's labour productivity had grown at an average rate of more than 10% per annum between 2000 and 2010. In 2010 it had reached 26,399 € - around half the EU-27's level. For some of the member states labour productivity is of similar size, for Poland and for the Czech Republic. The Slovakian ME' labour productivity is even lower.

Similar to labour productivity wages vary strongly among competing economies. The US ME is in the lead with wages per employee about 20% above the EU average. Japan is – in spite of a much higher labour productivity close to the EU. China lags far behind with wages of 11% of the EU average.

Even if labour costs are compared to Poland, the Czech Republic and Slovakia Chinese ME's wages per capita are much lower and only amount to one third. This gives China an edge in cost competition, because its labour productivity is of a similar magnitude as for these three member states.

The economic performance and profitability of the ME industries under investigation has been assessed by the Gross-operating Rate (GOR) and the Unit-labour costs (ULC). The GOR indicates the share of value added that remains - after labour costs have been deduced – to pay for other input factors and profits. The EU is lagging behind its competitors. The GORs for the US and Japan exceed the EU by 45% and 72% respectively. The Chinese GOR is more than double as high. For the ULC the picture is quite similar.

This static analysis of price competitiveness discloses a clear disadvantage for the EU as a whole. Even for the member states that had accessed the EU in 2004 - and enjoy much lower labour costs then the rest of the Community – price competitiveness is a matter of concern.

Table 4.1: Key figures on the economic performance of major competing economies in mechanical engineering

2010[1]			EU-27	USA		Japan		China	
					% EU		% EU		% EU
Output [2]	Current prices	bn. €	502.1	221.6	44.1	151.9	30.3	480.6	95.7
Value added	Constant prices	bn. €	157.5	103.0	65.4	66.2	42.0	161.4	102.5
Employees	Numbers	1000	2900.5	1130	39.0	684.6	23.6	6113	210.8
Labour productivity	Value added per capita[3]	€	54290	91125	167.8	96700	178.1	26399	48.6
Labour costs	Per employee	€	33243	39815	119.8	32420	97.5	3700	11.1
Gross operating rate[4]	Share of value added	%	38.8	56.3	145.2	66.5	171.5	86.0	221.8
Unit-labour costs[5]	Labour costs per output unit	€/€	0.61	0.44	71.4	0.34	54.8	0.14	22.9

[1] 2010 prices and exchange rates; [2] Turnover /production; [3] At constant prices; [4] (Value added-wages)/value added); 5) value added at constant prices per 1 € labour costs.

Source: Eurostat; national statistical bureaus; Cambridge Econometrics; Ifo Institute.

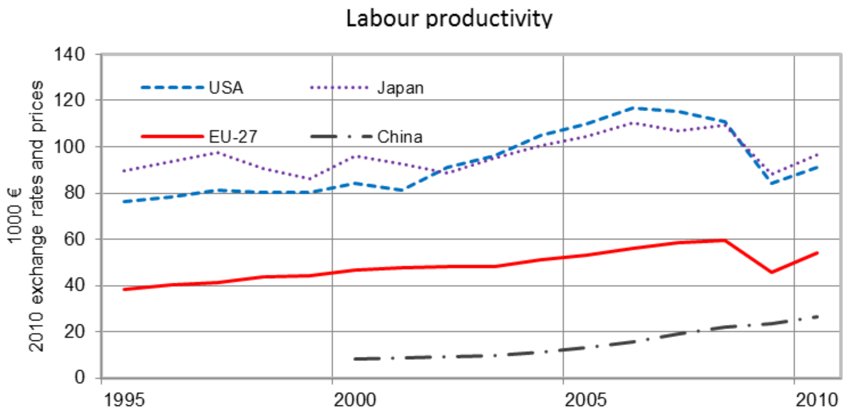
The evolution of ME over the period under investigation discloses for the EU a strong growth momentum that was driven by domestic demand but above all by exports, at an annual average rate of 5.8% between 2000 and 2010. During that time Japan and the US had suffered from a shrinking domestic demand, but also from a much lower growth than the EU with average annual rates of 1.5% and 0.8% respectively. Growth provides opportunities to raise efficiency and exploit economies of scale. The EU-27 ME increased its labour productivity at an annual rate of 1.5%. The US followed suit with productivity gains of 0.8% per annum, whereas for Japan productivity had stagnated. The EU-27 narrowed the productivity gap a bit. China an emerging competitor succeeded in yearly efficiency gains of 12.6% (Figure 4.1).

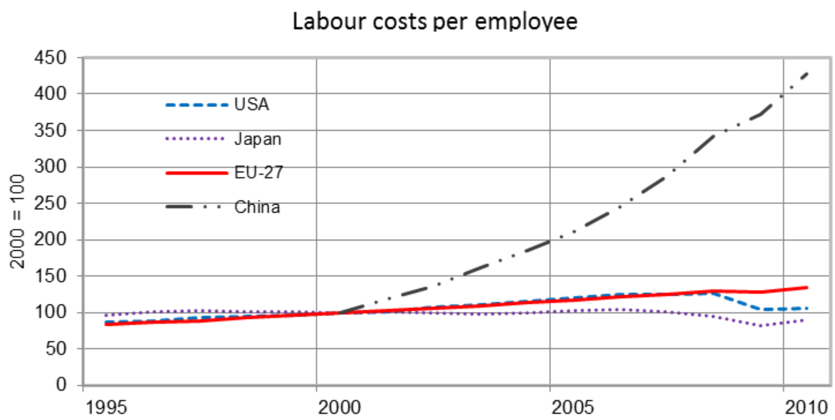
The US, Japan and the EU-27 could not hinder losses of workplaces in ME. Only China was able to increase the number of workplaces. The EU had lost around 15% of its workforce “only”, whereas Japan and the US ME had to reduce its staff by 27% and 23% respectively. For the US it can be assumed that the losses in workplaces had an impact on productivity growth. Marginal enterprises and workplaces got lost and contributed to a growing average labour productivity.

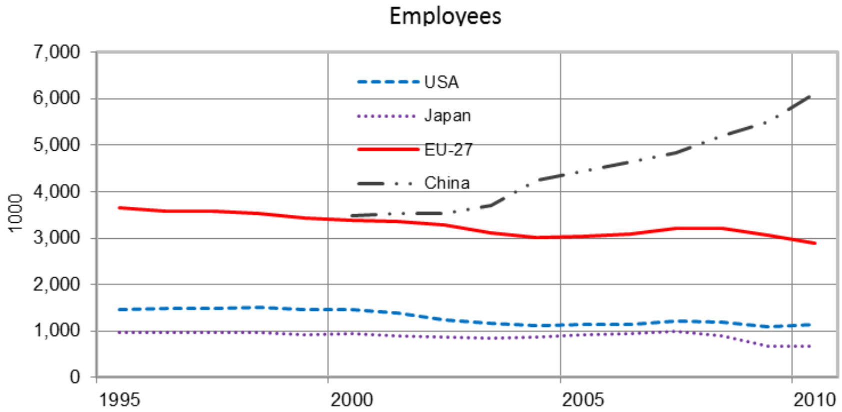
The Japanese ME strengthened its price competitiveness above all by wage moderation and a reduction during the financial crisis. Whereas employees in the US and the EU experienced wage increases. Until 2008 they were of similar magnitude, but during the financial crisis and the following breakdown of demand for machinery the US labour wage regimes proved to be less rigid than in the EU, per head labour costs shrank. On average over the whole period US labour costs grew at an annual rate of 0.6 between 2000 and 2010, whereas for the EU the growth rate reached a noteworthy 3%.

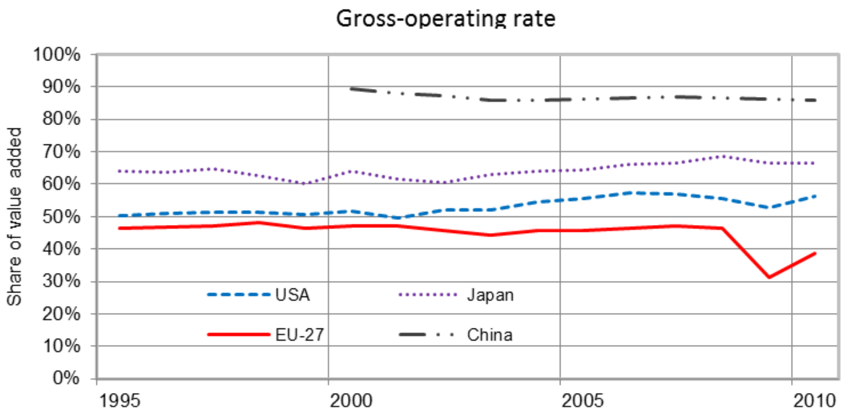
The lack of wage flexibility distorted the indicators for economic performance for the EU ME. The gaps of GOR and ULC broadened strongly and had not yet been reduced to former levels at the end of 2010. It will take some time until this gap will become narrower once more.

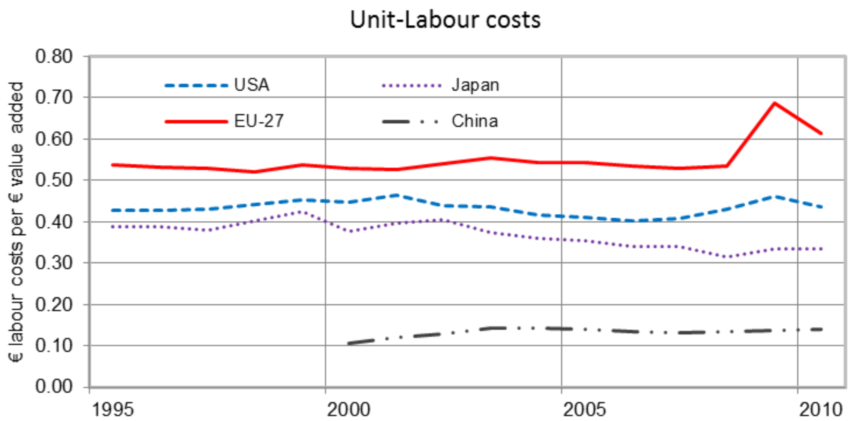
Figure 4.1: The evolution of key indicators for mechanical engineering of the major competing economies









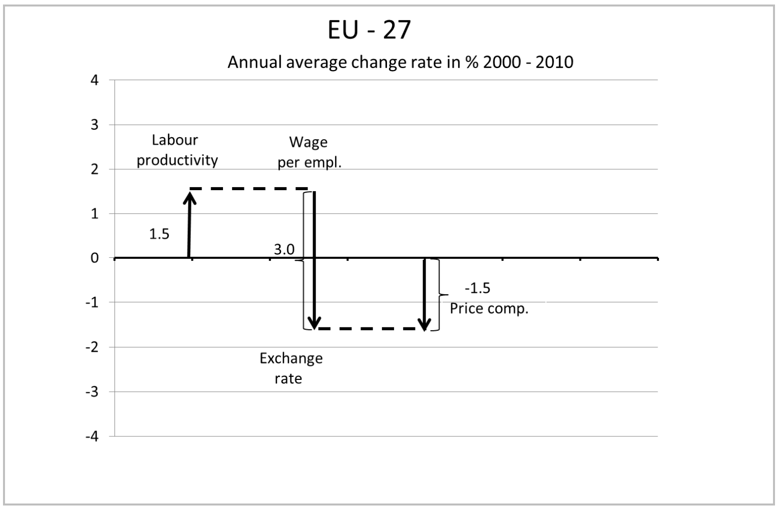


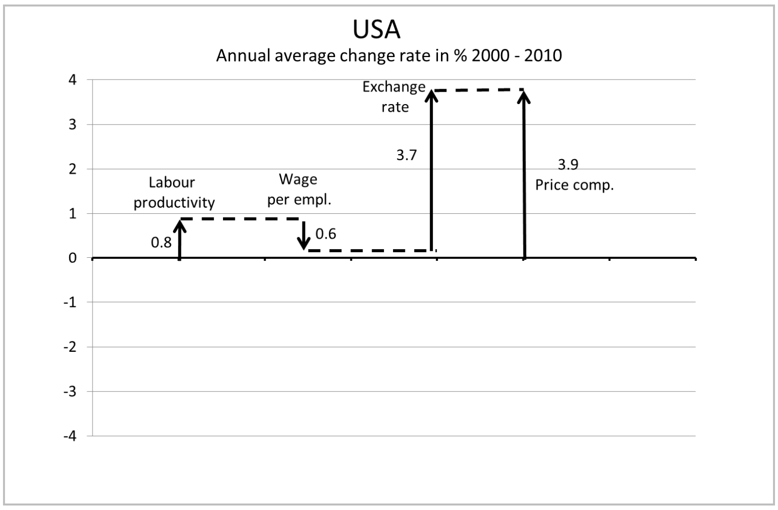
Source: Eurostat; national statistical bureaus; Cambridge Econometrics; Ifo Institute.

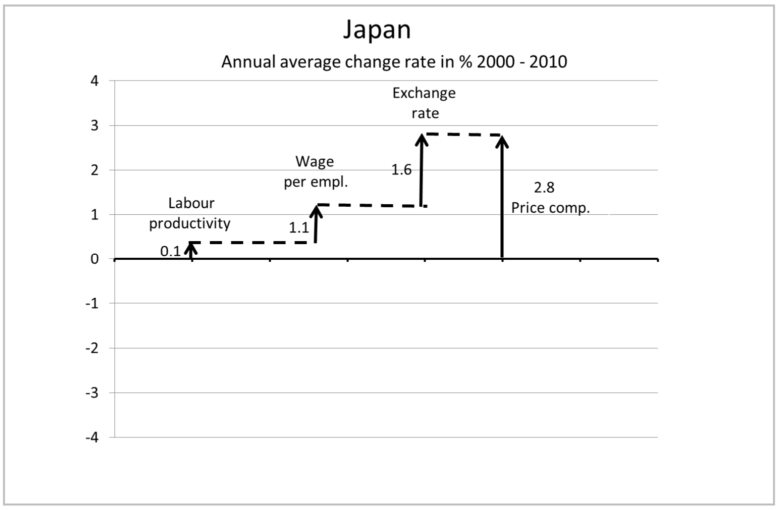
Figure 4.2 describes the changes in the price competitiveness by the application of annual average change rates for the period 2000 to 2010. Finally it takes into account the exchange rate variation over the period under investigation. Exchange rates are extremely volatile and have strong impacts on the "real" economies price competitiveness. They are hard to predict and cannot be met in the short- and medium-term by companies' decisions on locations for production. For the assessment of the following analysis it must be taken into account that in 2000 the Euro was extremely weak. In the meantime it skyrocketed. The following devaluation up to 2010 was not sufficient to reach the low levels of 2000. As compared to 2000 the competing countries' currencies are weak in 2010 and suspend pressure on competing countries' price competitiveness.

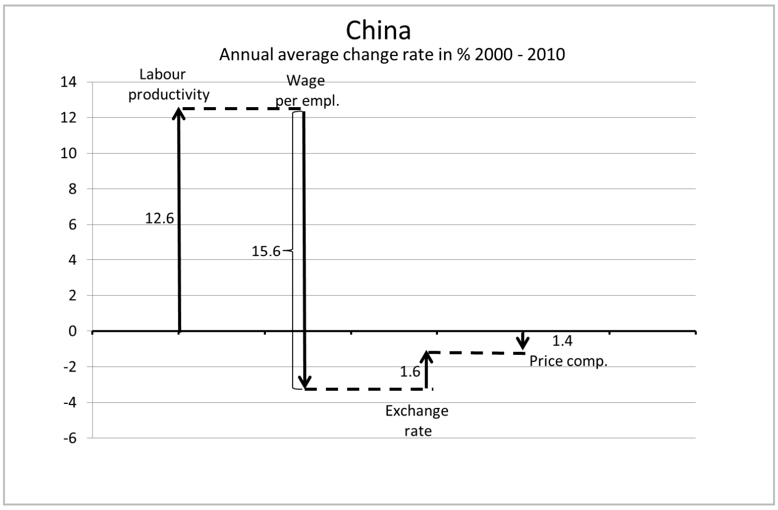
The EU had enjoyed a strong growth of labour productivity but this was more than compensated by wage increases. The residual growth rate of -1.5% indicates an annual worsening of ULC. For the US the development was somewhat better caused by lower wage increases. Moreover, as compared with 2000 a less strong USD contributed to an improvement of price competitiveness: All driving factors add up to 3.9%. For Japan wages declined at an annual rate of 1.1% and contributed much to price competitiveness. Here once more a weaker Yen has added to a growing price competitiveness that totalled at 2.8% for the Japanese ME. China is the only economy that had experienced worsening price competitiveness. Wage increases more than compensated gains in labour productivity. ULC had worsened at an annual rate of 3%. The Chinese Yuan 2010 was weaker than in 2000, but it could not make up for the losses for worsening unit labour costs. Price competitiveness shrank at an annual rate of 1.5%.

Figure 4.2: Changes of price competitiveness with regard exchange rate variation









Source: Eurostat; national statistical bureaus; Cambridge Econometrics; Ifo Institute.

Conclusions

The analysis in the price competiveness has unveiled some problems. Although labour productivity grew stronger than for the competitors from developed economies the economic performance measured by two indicators, GOR and ULC, is not satisfying.

This has been caused by a much lower labour productivity and wages that are of similar magnitude than for the US and Japan. Moreover, due to wage increases and a more rigid employment regime the financial crisis has not only worsened the economic performance, but the gap to the US and Japanese performance has broadened.

It was investigated if the low EU labour productivity has been caused by its heterogeneous economy. The figures for the member states unveil that a noteworthy disadvantage in labour productivity of roughly one fifth against the US and Japan exists even for countries such as Germany.

The Chinese ME has not only experienced high growth momentum in output but in labour productivity, but wages grew even stronger and more than compensated for the higher efficiency. The ULC declined by roughly 3% per annum and the GOR and ULC worsened. This development is understood of a typical catching up process for a manufacturing industry in an emerging economy (Balassa-Samuelson). Although the economic performance indicators have worsened they are much more advantageous as compared to the competing economies.

The Chinese labour productivity is only half of the EU. The Polish, Czech and Slovakian ME' labour productivity is of similar size, but wage levels are much higher and the economic performance indicators GOR and ULC disclose a worse performance. This is understood as a challenge for these member states to meet price competition. Many firms have become part of European production networks that tend to extend their regional reach.

The investigation in price competitiveness of the EU ME has not disclosed a convincing picture. The economic performance has been characterized by cost pressure and the situation has become even tighter. However, growth of the EU ME was much better, not only in the domestic market, but in foreign markets. The next chapter will focus on the EU's trade performance in view of its not convincing economic performance.

4.3 Trade analysis

Overview

The value of global trade with ME products came up to 539 billion € in 2010. As in production the EU is by far in the lead with a share of 37%. In 2000 the EU-27 only came up to 34%. The development was above all driven by soaring exports between 2005 and 2008. The large share in exports was already reached in 2010, although the former height was not yet reached.

New entrants access international market and contribute to global trade. In Table 4.2 the emerging economies, such as India, Brazil and Russia are hidden under the rubric "Others". This country group was third in growth ranking, behind the China and the EU-27. The US and Japan are lagging behind.

Table 4.2: Key figures for global trade with mechanical engineering products

Region	2010 billion €	Annual average growth rate in %				
		2000–10	2000–05	2005–08	2008–10	2008–09
EU-27	200.4	5.8	4.3	13.7	-1.8	-19.0
US	93.7	0.8	-2.6	6.2	1.4	-19.1
Japan	84.0	1.5	-0.6	3.6	4.0	-34.4
China	70.1	21.7	24.7	28.5	5.6	-15.5
Others	91	5.0	5.2	8.6	-0.9	-19.3
Total	**539.0**	**4.8**	**2.8**	**11.0**	**0.7**	**-20.9**

Source: Eurostat; Cambridge Econometrics; Ifo Institute.

Pattern of EU international trade

The EU-27 foreign trade with manufactured goods shows a deficit of €157 bn. It had broadened by around one tenth as compared to 2000. Over the period under investigation imports grew at an annual average rate of 4.7% and exports by 5.3%. For products others than mechanical engineering the trade deficit would have been much larger and grown stronger. For non-mechanical engineering the deficit in 2000 would have amounted to € 191.4 bn and € 275.5 bn in 2010 (Table 4.3).

The EU has a strong focus on ME and is by far in the lead in international trade. While exports had grown at an annual average rate of 5.8% throughout the period under investigation imports had increased only by 2.3%. The share of ME of total manufactured exports – despite the global financial crisis that hit manufacturers of capital goods more than others – had grown throughout the past decade and reached 15% in 2010. For imports the share had fallen down to around 6%. This development is reflected in the trade indicators. The BI shows a growing specialization of the EU-27 for ME in exports. The RCA indicates a favourable trade balance for the EU ME in relation to other manufacturing industries. The EU economy is less dependent on the import of ME products than of other industries.

Table 4.3: Key indicators for the EU-27 foreign trade

Sector	Indicator	2010		Annual average growth rate in %		
				2000–05	2005–08	2008–10
EU-27	Domestic de-mand[1)]Mech. engineering		374.2	1.4	9.7	-11.0
Extra-EU Trade Total manufacturing	Imports	bn. €	1500.6	3.8	9.9	-0.4
	Exports	bn. €	1343.9	4.8	7.6	3.1
Extra-EU Trade Mechanical Engineering	Imports	bn. €	81.2	-0.1	12.6	-6.2
	Exports	bn. €	200.4	4.3	13.7	-1.8
				2000	2008	2010
Trade balances Manufacturing	Extra-EU[2)]	bn. €		-142.4	-246.2	-156.7
Trade balances Mechanical Engineering	Extra-EU[2)]	bn. €		49.4	115.7	119.2
BI Mechanical Engineering[3)]	Extra-EU	0 = neutral > 0 = advantage < 0 = disadvant.		12.6	27.8	19.8
RCA Mechanical Engineering[4)]	Extra-EU			29.4	35.6	40.9

[1)] Production plus imports minus exports; [2)] Exports minus imports; [3)] Exports specialization: ln((Xij/Xtj)/(Xir/Xtr)); [4)] Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i/j: Mechanical engineering / EU27; t/r: Total manufacturing/all competing countries.

Source: Eurostat; national statistical bureaus; Cambridge Econometrics; Ifo Institute.

Bilateral trade with competing economies

Following the bilateral trade of the EU with major competing economies is evaluated. Table 4.4 presents the trade figures from the standpoint of the trading partner with the EU 27, because it might be of interest to compare bilateral trade with total trade of the trading partner.

It is one of the major global imbalances that the US has a large and increasing deficit in trade with total manufactured goods. For ME products the situation is quite different. The **global trade of the US ME** shows a growing surplus over the period under investigation. Of major importance are deliveries to NAFTA countries, Canada and Mexico. The US traditionally commands large shares in Latin America and Asia.

The US ME is strong as compared to other manufacturing industries of the US. This is confirmed by the Balassa Index (BI) that grew over the period under investigation. Likewise the Revealed Comparative Advantage (RCA) discloses an advantageous position of the US ME trade balance as compared to other industries.

Table 4.4: Global and bilateral EU trade with mechanical engineering products of major competing nations

USA		2010		Annual average growth rate in % 2000 - 05	2005-08	2008 - 10
US global trade	Imports	bn. €	80.0	1.7	-0.4	-2.0
	Exports	bn. €	93.7	-2.6	6.2	1.4
US - EU trade	Imports	bn. €	27.3	4.3	3.2	-7.1
	Exports	bn. €	17.7	1.8	8.6	-5.6
				2000	2008	2010
Trade balance	Global2)	bn. €		9.0	7.8	13.8
	EU2)			-9.2	-11.8	-9.6
Balassa Index3)	Global2)	0=neutral >0=advantage <0=disadvant.		18.2	19.9	25.0
	EU2)			-22.2	19.6	22.0
RCA4)	Global2)			58.6	61.0	66.3
	EU2)			-35.0	-17.2	-7.6
Japan		2010		Annual average growth rate in % 2000 - 05	2005-08	2008 - 10
Japanese global trade	Imports	bn. €	18.9	2.3	3.8	-1.4
	Exports	bn. €	84.0	-0.6	3.6	4.0
Japan - EU trade	Imports	bn. €	4.2	5.0	6.1	-7.9
	Exports	bn. €	14.1	5.9	6.6	-11.9
				2000	2008	2010
Trade balance	Global2)	bn. €		56.6	58.3	65.1
	EU2)			8.0	13.2	9.9
Balassa Index3)	Global	0=neutral >0=advantage <0=disadvant.		48.0	55.9	60.0
	EU			32.2	100.6	94.2
RCA4)	Global			132.4	139.8	142.8
	EU			53.8	73.3	82.5
China		2010		Annual average growth rate in % 2000 - 05	2005-08	2008 - 10
Chinese global trade	Imports	bn. €	75.3	14.0	7.5	17.2
	Exports	bn. €	70.1	24.7	28.5	5.6
China - EU trade	Imports	bn. €	28.0	13.4	15.2	16.8
	Exports	bn. €	18.9	15.8	21.2	0.9
				2000	2008	2010
Trade balance	Global2)	bn. €		-13.1	8.1	-5.2
	EU2)			-2.1	-1.9	-9.1
Balassa Index3)	Global2)	0=neutral >0=advantage <0=disadvant.		-89.4	-31.1	-36.0
	EU2)			-28.1	-16.4	-23.1
RCA4)	Global2)			-95.5	-9.8	-20.6
	EU2)			-141.9	-125.0	-130.6

1) Production plus imports minus exports; 2) Exports minus imports; 3) Balassa Index (Exports specialization): ln((Xij/Xtj)/(Xir/Xtr)); 4) Revealed Comparative Advantage: ln((Xij/Mij)/(Xtj/Mtj)); Explanations: X: Exports; M: Imports; i / j: Mechanical engineering / considered country; t / r: Total manufacturing / all competing countries.

Source: Eurostat; national statistical bureaus; Cambridge Econometrics; Ifo Institute.

The **transatlantic trade** with ME products is a bit different. The positive and growing BI indicates a stronger and even growing concentration of the US on ME exports destined to EU. Exports to the EU grew whereas imports grew at a lower pace. This improvement of the US trade with the EU has been caused by differences in the domestic economic development. The EU market for ME products grew while the US market shrank. All in all, the US deficit in trade with the EU, remained strongly negative.

Japan’s economy has traditionally been characterized by a large surplus in trade with manufactured goods. In 2010 the **global trade balance with manufactured goods** showed a surplus of 33.2 billion €, but it had markedly declined from 95.9 billion € in 2000. In contrast, the **trade balance for ME products** shows a growing surplus that amounted to 65.1 billion € in 2010. Without ME the Japanese global trade balance with manufactured goods would have become negative during the period under investigation.

The comparative advantage of the Japanese ME in relation to other domestic industries is confirmed by both trade indicators, for global trade as well as for bilateral trade with the EU. The Balassa Index’s (BI) growth indicates the cumulative specialization, particularly pronounced for bilateral trade with the EU-27. Likewise the Revealed Comparative Advantage (RCA) discloses the growing importance of ME for the Japanese trade surplus.

The Japanese machinery exports to the EU grew at an annual average rate of aroun 6% between 2000 and 2008. The years after exports collapsed, by 20%. This is owed to the financial crisis and an overvalued Yen. The Japanese share of the EU ME domestic demand only comes up to 4%. However, the Japanese ME has a long-standing tradition in global production networks. They shift production to more cost competitive countries and circumvent exchange rate volatilities. Japanese enterprises own numerous production sites in the EU and command higher market shares by local production.

Japan’s **trade surplus for total manufactured goods with the EU** was halved between 2000 and 2010. However, the Japanese bilateral trade surplus for ME products did not change much and indicates the relative strength of Japan in markets for ME products.

Chinas’ growing **global trade surplus for total manufactured goods** has become one of the concerns for distortions of the world economy. For ME products the situation is different. The trade deficit is growing despite a double digit expansion of Chinese production. The Chinese ME market has been growing by high double digit rates for more than a decade.

This global deficit of Chinese trade with machinery conceals large regional differences. This deficit originates from bilateral trade with the EU. Chinese imports grew at a similar rate as exports, on average per year by 14.6% and 14.2% respectively. The Chinese trade deficit broadened up to 9.1 billion €. China’s machinery trade with all other regions showed a deficit in 2000, but it turned into a surplus in 2010 of 3.9 billion €.

Although the trade indicators BI and RCA are negative and indicate that China has not yet a comparative advantage for ME as compared to other Chinese industries it must be confessed that for global trade – not for trade with the EU – the disadvantage had been reduced. In particular strong is the Chinese position in third markets with a noteworthy trade surplus.

The trade analysis unveiled that ME is an industry with comparative advantages in developed economies. All three, the EU, Japan and the US show a specialization on ME. The balances for trade with ME show surpluses, whereas for trade with total manufactured goods they are having a deficit, with the exception of Japan. If one excludes ME trade also the Japanese trade balance is negative.

The EU trade with the other major competing nations has unveiled that the EU commands surpluses with the exception of Japan. In bilateral trade with the EU the Japanes surplus did not show any trend between 2000 and 2010. This can partly be explained by lower growth of the machinery market. However, EU deliveries' growth was below that of total US machinery imports. Shares were lost to competing importers.

The performance of major competitors in the EU market discloses that the US and Japan have gained minor shares of the EU ME domestic market. However, China has become a significant player by import penetration. But it must be taken in mind the US and Japanese manufacturers own noteworthy production capacities within the EU. In contrast the EU-ME gained in their most important competing economies domestic markets noteworthy market shares. (Table 4.5)

Table 4.5: Penetration of major competing economies in the EU-27 market for mechanical engineering products

Market shares[1)]	Within the EU-27		EU-27 shares in….	
	2000	2010	2000	2010
USA	4.2	4.7	7.4	13.2
Japan	3.4	3.8	1.6	4.8
China	1.5	5.1	11.2	5.8
1) Share of imported machinery as a percentage of domestic demand.				

Source: Eurostat; national statistical bureaus; Cambridge Econometrics; Ifo Institute.

Bilateral trade with important sales markets

The investigation in the EU's bilateral trade with important sales markets disclosed for each region of destination surpluses for trade with ME products, what was not the case for total manufactured goods. The strength of the EU ME is confirmed by the fact, that for six of the economies the share of EU deliveries on total ME imports is 50% and higher. This indicates a strong dependency on EU machinery for these economies investment activities. For another six economies the share of EU ME products had been growing for the period 2000 to 2010. This underscores the – already above mentioned - gain of shares in global machinery trade, but here for distinct markets. As compared to total manufactured goods deliveries to important sales markets Table 4.6 highlights a specialization of the EU in the manufacture of ME products and a better performance in the economies of destination. For total manufactured goods the EU performance is worse. For five economies of destination the EU lost shares in their imports, only for one country the share grew.

Table 4.6: EU machinery trade with important sales markets

Destination	Mechanical engineering EU exports to…			Total manufacturing EU exports to…		
	bn €	Share[1)]	Performance[2)]	bn €	Share[1)]	Performance[2)]
MENA	17.7	69.2	-	111.9	43.2	-
Russia	14.1	92.7	=	86.3	53.7	=
Turkey	8.1	76.6	+	61.1	43.8	-
South Korea	7.6	41.5	+	27.9	10.3	=
India	7.0	57.3	-	34.8	12.9	-
Brazil	6.9	50.0	+	31.1	22.9	-
Taiwan	4.2	37.4	+	14.7	19.0	+
Australia	4.2	31.9	=	26.7	19.3	=
Canada	3.7	15.2	+	26.5	9.1	=
Mexico	3.6	20.0	+	21.4	9.6	=
Indonesia	1.6	15.0	-	6.4	6.2	-

1) Of the destination country's imports in %; 2) For the period 2000 to 2010 the EU's share was growing (+), about stable (=), declining (-)

Source: Eurostat; national statistical bureaus; Cambridge Econometrics; Ifo Institute.

Conclusions

It is remarkable that the US, a country leading in ICT technologies, and Japan, likewise a leading economy in ICT technology and the automotive industry, show comparative advantages in ME products and enjoy trade surpluses. **This supports the initially made assumption that ME is an industry with comparative advantages for developed countries in the era of globalization.**

The EU ME has performed pretty well in global markets, despite its not convincing price competitiveness. **It had gained shares in global trade in an environment marked by strongly growing emerging competitors.** Of outstanding importance is the success in the world's largest machinery market China. Although the EU exports to China did not grow as fast as domestic demand they grew much stronger than other foreign manufacturers' deliveries to the Chinese market. The EU-27 share of Chinese machinery imports had increased from 28% in 2000 up to 37% in 2010. It has also increased its share in the hard to access Japanese market. Only for the US machinery market some losses had been suffered.

The investigation in major sales markets disclosed that the EU ME commands important stakes in many emerging economies with bright growth perspectives. The industry has even gained shares in many target markets' machinery imports. **Altogether the trade analysis confirms that the EU ME possesses a promising starting position to be successful in coming years.**

4.4 Changes in the EU ME value chain

This Chapter investigates changes in the value chains, their regional reach and trends in vertical co-operation. Special attention is paid to challenges for smaller enterprises.

4.4.1 New organizational strategies – opportunities and threats for smaller firms

The centralization trend in customer industries (e.g. automotive) makes it difficult for SMEs to access big customers and respond to their needs. Consolidation and mergers in the machine tool industry and in other subsectors have taken place in Europe, but this is limited to the necessary adjustment to the more open and international market.

Large OEMs, especially of the transport equipment sector, are striving to concentrate on their core activities in production administration and R&D. The final target is to focus on system integration only and to command a large share in the sales market. These enterprises are about to outsource the manufacture of parts and components as well as the organisation of the value chain by subsystem supplier. At first glance this provides suppliers with the freedom to open-up new business areas. However these initiatives of the large OEMs are linked with additional requirements that cannot easily be fulfilled by ME companies. Sometimes they are even not in their reach because they cannot take the risks linked to comprehensive upfront investment in R&D and production.

OEMs show interest to reduce the number of **suppliers of parts and components** to contain their transaction costs. A first Tier supplier must have the management capabilities to organize its own value chain and take the responsibility for quality and timely deliveries. In case of quality deficiencies high penalty payments fall due. Beyond product integration suppliers have to offer life cycle services, such as maintenance, spare part stocks and repair. The shift of responsibilities and risks to suppliers has become most challenging. Frequently suppliers cannot trust in well-defined order volumes because they are only paid in line with clients' sales to final customers. Therefore they become dependent on markets they are not familiar with.

These organizational changes are feeding through the value chain down to lower tiers and have become a topic of concern for ME enterprises.

Manufacturers of capital goods are confronted with similar problems. They are not paid for the delivery of machinery and equipment only, but for the performance within the clients' production process. Suppliers have to guarantee uptimes of machines and response times for services, maintenance and repair. Machine manufacturers have worked hard to comply with these requirements. They have set-up quality assurance systems, generated statistics on machines' failure probabilities and the lifetime for components to contain their risks. Based on these statistics preventive repairs are carried out. With the use of remote operating status monitoring system breakdowns can be recognized in advance and downtimes markedly reduced.

These changes of clients' demand provide opportunities for EU ME manufacturers with a strong technological and organizational background. Stable, long-term relationships give them an edge over newcomers in the market, in particular from emerging countries.

However, purchasing power of large clients gives little room for bargaining even for leading companies in the markets. Risks have to be taken by machine manufacturers that cannot easily be assessed. **Smaller EU enterprises can hardly comply with the requirements of large client companies on higher levels in the value chain.**

In particular experts of the machine tool industry mentioned the difficulties for smaller companies to meet the increased requirements by large client companies. Another disputed topic is the ownership of product design between suppliers and their large clients. In particular manufacturers of precision tools have raised complaints that large clients claim ownership of designs based on the suppliers R&D activity.

For most part of ME the clients' purchasing power is less crippling than from clients of the transport equipment industry, but requirements are growing. Guaranteed product quality, delivery times and compliance with technical regulations, product and process documentation have become indispensible prerequisites to win contracts or to remain a member of a value chain. **In particular smaller companies have to work hard if they wish to comply with their clients' changed behaviour.**

4.4.2 Broaden the regional reach and co-operation

Large manufacturers are about to change their procurement strategies and expand their regional reach. As a consequence, competitive pressure is growing for subcontractors. Companies from other EU member states and outside the Single Market are invited for tender procedures. **It has been reported that above all smaller firms from southern member states – find it hard to meet the requests from their clients' activity to broaden the regional reach of the value chain.**

Larger manufacturers - going global - are frequently suggesting their subcontractors to relocate production to reduce costs or to follow suit to new production locations abroad to join their initiatives. Smaller firms are not always able to meet these requests. They cannot fund the necessary investment and take the risks. Above all such problems have been highlighted from the subsector "pumps and compressors", but it is a general issue for all subcontracting firms.

In few member states co-operation between clients and suppliers is an important pattern. This advantageous and long-term relationship between client firms and subcontractors is sustainable only if it is based upon mutual benefits from technology and know-how. Smaller companies benefit from this behavioural pattern and help them to meet the challenges of globalization. Germany was mentioned explicitly as an example for close relationships along the value chain. In other member states such a co-operation has no tradition, France and Spain were mentioned.

Cluster initiatives are dedicated to exploit regional strengths and provide SMEs with opportunities to meet challenges of globalization by co-operation. Their success is dependent on structural changes and the availability of system- and subsystem suppliers within clusters. This is a prerequisite to integrate regional manufacturers into international networks.[95] This requirement is underscored by larger firms' initiatives to reorganise their value chains. **There is a risk for cluster initiatives that outdated structures – regional narrow networks - are conserved with the help of public support and companies do not adjust to the needs of more open and global economies.[96]** This point was highlighted in interviews by Spanish experts but is valid for other countries too.

4.4.3 Regional patterns

The country reports provide comprehensive information on the division of labour within the EU ME. Of outstanding importance is central Europe with Germany, Austria, Switzerland, northern Italy, eastern France, the Czech Republic, Slovakia and Scandinavia. Apart from that there are numerous other strong regional clusters, such as the Basque country, the Île de France etc. Of specific importance has been the integration of the member states that accessed 2004 and later. They have become part of the EU ME's value chain. Western companies have contributed to the transition of the former socialistic economies by the acquisition of production sites. In some subsectors, for instance in textile machinery and machine tools even investments in the eastern know-how basis took place. R&D facilities have been acquired and expanded.

However, most of the FDI has been directed towards production. Wage differentials have been exploited for the manufacture of primarily mechanical parts and components. Frequently these intermediary goods have been delivered from the accession countries to western companies for the assemblage of final products. This division of labour that de facto has led to a shift of capacities from western to eastern parts of the EU has contributed to an improved price competitiveness of the total EU ME. **Finally it has contributed to the stabilization of the accession states' ME with a focus on the manufacturing of intermediary products since the middle of the last decade.[97]**

The situation for upstream metal industries that deliver a broad variety of intermediary products to ME has turned out to be somewhat different. During the early stage of the transition phase castings, welded parts, metal housing, cable harnesses etc. have also been manufactured in the accession states. However, in recent years much of this production has been relocated to non-EU eastern European countries and Turkey. Once more regional wage differentials and the upgrading of the accession states' economies have been driving forces for this development.

Asia has become more important as a supplier for the EU ME. Production locations owned by EU firms and Asian manufacturers have become integral part of the value chain. Because of much longer lead times than from European locations Asian deliveries consist above all of serial products. Small batch production and customization hinder

[95] An example for a successful subsystem integrator is the Italian company DEMA: Vieweg, H.-G. et al. (2009b) "FWC Sector Competitiveness Studies – Competitiveness of the EU Aerospace Industry", Munich, pp.126.http://www.sectorcompetitiveness.com/index.php/sector-competitiveness-studies).

[96] In Spain all regions (communidades autónomas) start their own clusters, not always with synergies among them. Beside Spain similar regional, frequently suboptimal policies found in Austria, Germany and the United Kingdom.

[97] As mentioned in the Chapters 2.2.6, 2.2.7, 2.2.8 there are numerous enterprises with strong product range and distribution channels in the accession states that command noteworthy shares in international markets. However on average for ME there is a focus on the production of intermediary products that has an impact on economic indicators, in particular labour productivity (See: Chapter 2.4.2).

procurement from Asia. **This division of labour between Asia and Europe gives Asian production facilities better opportunities for the exploitation of scale effects through the manufacture of serial products in larger batches.** This is in particular true for China and India with their large and strongly growing domestic markets.

Moreover Asia is an important supplier of all kind electronic components that is required for the control of machinery and the automation of processes. To a large extent these components are standardized products based on widely available technology and can be procured from numerous manufacturers. But there are high-tech specialities that are supplied by a few firms or even only one company globally. In many cases Japan is home of key-technologies owning' firms. This is not only the case for electronics, but also for materials with specific characteristics, as for instance Japan Steel Works (JSW), a manufacturer of purified steels and alloys. **The availability of key-technologies is an important point to understand the strength of the Japanese ME in spite of the distortion of its price competitiveness by an overvalued currency.**

4.5 Impact of changes in the product programme of the EU ME and competitiveness of supply

Price competition from emerging economies is most challenging for low and medium-tech products that are manufactured in large quantities. The comparative advantages of developed countries suggest to focusing more on comparative advantages in know-how driven products, customization and engineering. However, the mass markets on the lower end of technology provide opportunities for automated production and scale effects. A loss of these markets segments could threaten the strategic position of EU companies by a worsening cost structure. Moreover, foreign competitors could use margins generated by scale effects to invest in R&D, upgrade their products and increase competitive pressure. **EU ME firms use locations in low-wage countries outside the EU to control the lower end of their product programme in foreign and in the domestic market.**

The relocation of standardized products - manufactured in large batches - poses less logistic problems than small batch production and customization. Moreover, such products are more exposed to price competition. Above all these products are affected by globalization strategies, and the assessment of the production location is crucial for a company's success. In contrast, customization and small batch production are less cost sensitive. Moreover, the EU provides bright framework conditions for this kind of output. Qualified personnel - necessary for the execution of R&D and production - are available. **As a consequence decision making on production locations has led to a growing importance of small-batch and single-piece production within the EU ME, whereby serial products have been more frequently affected by relocation.**

As stressed in Chapter 4.1 structural changes of the supply side in connection with companies' growing interest to become full-hand supplier s have induced important movements in the supply. The product programme does no longer consist predominantly of hardware, the combination of machinery and equipment dedicated for the execution of specific production processes. Simultaneously engineering and the software designed to control systems have gained growing shares in the total supply of the EU ME. **The linkage of all these components, machinery and equipment, high-tech components,**

engineering and software to high-performance manufacturing systems has become an important feature of what has been ascribed as an enabling industry.

Technical services – complementary to machinery and equipment – are offered by the majority of EU ME companies, primarily by manufacturers of final goods. A German survey disclosed that 70% of the companies supply services and their share of services of total turnover is 12.3% (See: Chapter 1.3). For other member states no detailed information on this topic is available. The estimations of country experts lie between 10% and 15%. Interviews with sectoral experts unveiled that manufacturers of intermediary products have less opportunities to offer services and shares are much lower, between 5% and 10%. For manufacturers of final products the share of services is much higher, between 20% and 30%. **For all of the subsectors and all of the member states the interviewed experts mentioned a general tendency of a growing share of services of total output.**

By far, most of the services offered by ME are closely related to physical products.[98] These technical services do not open-up new business areas but strengthen the performance of EU companies in traditional market segments by the exploitation of comparative advantages, as for instance with after-sales-services that have been stimulated not only by the more complex products but by the application of ICT and the Internet. Clients are extremely interested in services such Remote Operating Status Monitoring to increase the uptime and security of their production processes.

Other services reach far beyond traditional business areas. Among them are the funding of clients' purchases, different forms of operator models and contracting. While operator models have a long-standing tradition in the large plant business contracting is a relatively new service offered by companies of the EU ME. Several examples have been identified in course of the fieldwork. In particular in the subsector "Pumps and Compressors" contracting has become a relevant business activity. Manufacturers of compressors have specialized in the development of complete systems for the supply of pressurized air. They do not only sell these systems but operate them for clients and are paid on the basis of demand for air and the system's performance. Further examples have been found for the subsector "Material handling"

It is obvious that the EU ME is no longer an industry that offers services complementary to its supply of machinery and equipment, but uses services to access new clients and exploit growth potentials.

98 For Germany the share of technical services of total turnover exceeds 90%, other services – of importance for the opening-up of new business areas – the reminder. Among these services are financing, operator models (BOT, BOOT) and contracting (See: Figure 6.1)

4.6 Performance of the EU ME in technological competition

4.6.1 ME as innovation enabler

ME is a key supplier of technology and capital investment goods to most other industries. The EU ME is particularly strong in the area of customized machinery and niche markets and is central to the innovation capacity of the manufacturing and other sectors. It is vital to the capability to provide high value added, thereby helping other strategic sectors of industry to achieve a competitive advantage. With increasing global competition, the life cycle of many products, including that of capital goods, has become shorter, requiring ever more investment in research, development and innovation.[99]

In 2009 the EU Competiveness Council recognised the central role that the manufacturing sector, including the mechanical industries, will play in Europe. These are the industries which are crucial to providing Europe with the technological solutions to the challenges of climate change, security of energy and green manufacturing.[100]

4.6.2 Resources to R&D – a methodological view

Innovation efforts in the ME industry and other sectors can be measured by expenditures on research and development (R&D) that private and public enterprises spend for performing innovation activities. For international comparisons basically there are two sources of data which can be used. The OECD has been collecting R&D data for Member and non-Member countries for many years. Information is also given about resources devoted to R&D in the private sector[101]. Whereas reliable data are available for the total private sector the situation on the level of industrial branches is less good. The OECD uses the UN International Standard Industrial Classification (ISIC), whereby the allocation to an industry class occurs for each enterprise as a whole, though some countries are able to break down the R&D for multi-product enterprises between their main lines of business. This can lead to a different grouping and classification of sectoral data particularly if different statistical databases are used. A typical example is the indicator “R&D-intensity”, the ratio of R&D expenditures and output.

A second source for private sector expenditure on R&D is the “EU Industrial R&D Investment Scoreboard” which has been conducted by the Institute for Prospective Technological Studies (IPTS) that is part of the Joint Research Centre of the European Commission. The annual Scoreboard presents information on the world’s top 1400 companies ranked by their investments in R&D. It contains data drawn from companies’ accounts, most recently for the fiscal year 2009[102]. There are 400 companies located in the EU and 1000 companies based elsewhere. The advantage of the Scoreboards’ methodology is consistency as each data set is derived from the respective accounting

99 European Commission, Enterprise and Industry Directorate-General (2007). The EnginEurope Report, Brussels.
100 Orgalime (2009). Manufacturing Matters, Brussels, http://www.orgalime.org/Pdf/Orgalime_manifesto.pdf
101 www.oecd.org/sti/anberd
102 Eurpean Commission (2010d). Monitoring industrial research: The 2010 EU Industrial R&D SCOREBOARD, Luxembourg, http://iri.jrc.ec.europa.eu/research/scoreboard_2010.htm

system. Since the OECD data are incomplete by sectors and countries we mainly use the Scoreboard data.

Generally speaking certain discrepancies of data arise from differing interpretations of the definition. Some companies may view a task as an R&D process while other companies view the same task just as engineering or production process. Data capture variability arises from differing information systems. Some companies have in place better systems than others for measuring the costs associated with R&D. This problem of data capture appears challenging for companies in the EU Member States. Fiscal variability arises from fiscal incentives based on the treatment of costs. So measurement variability therefore has an impact on the extent of R&D investment disclosure. For the interpretation of such variables between countries these caveats should be borne in mind.

4.6.3 Trends in corporate R&D expenditure

A report of the European Commission published 2008 revealed that since 1995 R&D intensity of European ME producing firms was growing.[103] By contrast, as a result of significant increases in EU-27 GDP and relatively small increases in R&D expenditure by the larger Member States, overall EU-27 R&D intensity has decreased from 1.86% in 2000 to 1.84% in 2006. At the same time, aggregate R&D intensity in Japan, South Korea and China have all increased considerably. **According to European Commission the main reasons for the decline in EU-27 R&D intensity are an insufficient growth in business R&D expenditure and the fact that EU companies invested more outside of Europe, in particular in emerging research-intensive countries, than non-European companies invested in Europe.**[104]

Table 4.7 is based on OECD figures and shows the expenditure on R&D of the ME industry for several countries in 2006. The leading country in terms of absolute figures is the United States spending 9.8 Billion US-$ (PPP), followed by Japan which spent 9.0 Billion US-$ (PPP). Germany ranked third, but spent only about half of the United States. Other European countries are markedly behind whereas not for all Member countries data are available. Merging R&D expenditure of European countries, France, the United Kingdom and others the EU comes closer to the levels of R&D in the United States or Japan. However, inefficiencies might arise due to multiple research activities on same topics in different Member States.

[103] European Commission (2008). A more research-intensive and integrated European Research Area – Science, Technology and key figures report 2008/2009, Brussels . http://ec.europa.eu/research/era/pdf/key-figures-report2008-2009_en.pdf

[104] European Commission (2008). A more research-intensive and integrated European Research Area – Science, Technology and key figures report 2008/2009, Brussels, p.3. , http://ec.europa.eu/research/era/pdf/key-figures-report2008-2009_en.pdf

Table 4.7: R&D expenditure in Mechanical Engineering 2006

Country	Mill. US-Dollar PPP
United States	**9848**
Japan	**9049**
Germany	4957
Italy	1093
Netherlands	656
Austria	548
Spain	514
Denmark	271
Czech Republic	173
Poland	71
Hungary	32
Slovak Republic	8
EU (10 member states)	**8323**

Source: OECD STAN database

ME belongs to the industries with medium-high R&D intensity. This group of industries is characterized by a share of R&D expenditure to sales between 2% and 5%. That means that the specific R&D investment is thereabout average. Other industries in this sector are e.g. electronics & electrical equipment, automobiles & parts, aerospace & defence, chemicals, household goods. In contrast to traditional mid-tech industries the sector alternative energy generation, has been growing rapidly over the latest available three years by the number and size of companies. These companies realise a strong increase in R&D expenses according to their sales growth.[105] It should be noted that numerous companies of the alternative energy sector are ME firms.

According to the Scoreboard report the impact of the financial crisis that started in 2008 and hit companies worldwide is fully reflected in the company accounts used for the 2010 Scoreboard. This was not the case for the report published 2008 where both, R&D investments and sales continued to grow. The 2010 scoreboard shows the effects of the economic downturn in 2009 on company financial results and input indicator such as R&D. Yet the slowdown of R&D expenditure was much lower than the slump in sales. This shows that worldwide corporate R&D expenditure proved resilient to the global recession, a sign of the strategic importance that innovative companies attach to R&D.

In 2009 R&D intensity in ME[106] increased more than in other industries. But this was only a statistical effect, because of a strong slump in sales. The worldwide R&D intensity in ME increased from 2.6 in 2007 to 3.1% in 2009. The most obvious increase (+ 0.8 percentage points) recorded US firms, probably due to even stronger declines in revenues than in other regions. Compared to the total economy the ME industry had a more marked growth of R&D intensity. This might be the result of a decrease in production, too.

105 Eurpean Commission (2010d). Monitoring industrial research: The 2010 EU Industrial R&D SCOREBOARD, Luxembourg, http://iri.jrc.ec.europa.eu/research/scoreboard_2010.htm

106 Industrial Engineering is a sector used by the Innovation Scoreboard survey that contains several industries similar to ME.

According to the EU Industrial R&D Investment Scoreboard in 2009 ME firms spent worldwide on average 3.1% of their sales on R&D (Scoreboard 2010). The EU sector's intensity in EU was at 3.6% higher as compared to 3.2% in the US and 3.0% in Japan (Table 4.8). In view of all regions EU ME firms' R&D intensity was higher.

Table 4.8: R&D intensity of large Mechanical Engineering enterprises

Industrial Engineering*	EU	USA	Japan	Total
2009	3.6	3.2	3.0	3.1
2008	3.2	2.6	2.6	2.7
2007	3.1	2.4	2.7	2.6
All Sectors				
2009	2.8	4.8	3.5	3.5
2008	2.7	4.5	3.4	3.3
2007	2.7	4.5	3.6	3.4

Source: EU Industrial R&D Investment Scoreboard 2010/2009/2008
Incl. commercial vehicles and ships

Across all industries R&D intensity was 3.5 % in 2009 worldwide. At 3.1% ME was below that figure on average. However R&D intensity in Europe was 3.6 whereas total R&D intensity was only 2.8 %. This indicates that in the EU ME is of higher importance for overall technological performance than in US and Japan where the sectoral figure was below total industries. These facts indicate that European based ME firms have a strong position in innovative competition. In order to maintain the advantage in international competition continued high R&D investments are crucial for the European ME industry.

4.6.4 Trends in corporate patent activities

R&D activities can either be measured by the inputs or by the outputs of R&D processes. The input side has been analysed above. The following section uses patents as indicators for the R&D output of the ME industry. The two periods 2006-2008 and 1999-2001 are taken for the analysis of developments. The data applied here follow the concept of "transnational patents" which avoids distortions resulting from the home advantage of domestic applications, so that a comparison of patent applications in different regions becomes possible.[107] Transnational patents comprise applications in patent families with at least one application at the World Intellectual Property Organisation (WIPO) by the PCT[108] procedure or an application at the European Patent Office. Patent families include those patent documents which protect the same invention on various markets.

For the analysis of patent activities in ME absolute numbers and growth rates for several subfields of the industry are used. In addition the sector's specialisation by region is calculated. For the analysis of specialisation, the relative patent share (Revealed Patent

107 Frietsch, R. and Schmoch U. (2010) "Transnational Patents and International Markets", Scientometrics, 82, pp.185.
108 The Patent Cooperation Treaty (PCT) is an international treaty, administered by WIPO

Advantage, RPA) is estimated[109]. It indicates in which fields a country or region is strongly or weakly represented compared to total applications. Positive signs mean that a technology field has a higher weight within the region than in the world. Accordingly a negative sign represents a below-average specialisation. Hereby, the comparison of the patent position of countries and regions is possible, regardless of size differences. In Table 4.9 patent activities in the ME sector are shown on the basis of four R&D-relevant technology fields.

In terms of the number of transnational patents the EU-27 commands an outstanding lead as compared to USA and Japan. Within Europe Germany accounts for the major part of applications followed by France and Italy. Germany has been applying for more patents than the US or Japan, too. The comparison of the two periods observed shows an increase of patenting worldwide. ME patents rose by 25.2%[110]. In Europe with 20.3% growth was below average. The highest increase achieved Japan, followed by Germany and Italy. In contrast applications stagnated in Switzerland and the United Kingdom. Most patents have been applied in the wide spectrum of special purpose machinery and in the field of power machines and engines. This is true for all countries, whereas US applications are below the average. US applications are relatively high at air conditioning and filter technologies.

The RPA index indicates that the EU-27 as a whole has been strongly specializing with its patent activities in ME compared to other countries. Basically this is true for all four technology fields, least in air conditioning and filter sector. The USA has no general patent specialization in ME. Only in air conditioning and filter technology a certain specialization is indicated. The specialization of Japanese R&D exists in machine tools and power machines and engines. Other technological areas are less important. Switzerland has a strong weight in the machine tool and special purpose machinery.

Within Europe Germany has a broad and most pronounced specialisation in ME. At machine tools the position is remarkably strong, but also at power machines and engines, agricultural and special purpose machinery. Italian R&D activities are focused on special purpose machinery and machine tools, having in mind absolute patent numbers as well. French applications indicate an emphasis in the agricultural sector and at power machines and engines. The UK shows no special focus on ME, with the exception of power machines and engines.

Due to a very low basis patent activities in China have been growing tremendously over the past decade, totally and in the ME sector. In the two time periods observed patent growth in ME was even higher than total Chinese patent growth. However the absolute numbers are still small, even more in terms of size of the country. In the years 1999 to 2001 China filed 120 patents in the ME technology fields observed. In the years 2006-

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109 Frietsch, R., Schmoch, U., Neuhäusler, P. and Rothegatter, O. (2011) "Patent Applications – Structures, Trends and Recent developments", Fraunhofer Institute for Systems and Innovation Research ISI.

110 The growth rate of total patent applications on all technology fields was 30.7% in the same time period.

2008 the number was 798, compared with 1023 in Switzerland and 1500 in the UK. The RPA index does not yet indicate any specialisation of China in the ME technology[111].

Table 4.9: Transnational Patent Applications in Mechanical Engineering 2006-2008 by selected countries

Country		ME technology field: Machine Tools	Special purpose machinery	Agricultural machinery	Power machines and engines	Air condition-ing and filter technology	Total ME
France	Number	345	687	129	818	381	2360
	RPA	-30	-9	40	12	7	-
	Growth (99-01=100)	98.2	111.6	82.5	150.6	127.3	120.1
Germany	Number	2478	3548	409	3933	1203	11571
	RPA	56	48	50	58	19	-
	Growth (99-01=100)	118.6	112.1	103.0	154.2	115.5	125.2
Italy	Number	476	1078	83	449	175	2261
	RPA	51	72	49	7	-16	-
	Growth (99-01=100)	127.1	116.1	94.9	129.9	154.6	122.2
United Kingdom	Number	238	448	34	586	194	1500
	RPA	-33	-18	-51	12	-26	-
	Growth (99-01=100)	91.5	83.7	54.9	150.1	86.0	101.9
EU-27	**Number**	**4269**	**7486**	**913**	**6704**	**2693**	**22065**
	RPA	26	34	42	28	9	-
	Growth (99-01=100)	111.4	108.4	101.5	148.2	122.6	120.3
USA	**Number**	**1708**	**2431**	**405**	**2504**	**1996**	**9044**
	RPA	-33	-43	-7	-38	9	-
	Growth (99-01=100)	126.1	85.2	144.4	131.5	127.3	113.6
Japan	**Number**	**1797**	**1860**	**94**	**3085**	**972**	**7808**
	RPA	11	-32	-81	21	-22	-
	Growth (99-01=100)	125.4	112.7	105.9	145.9	157.1	132.2
Switzerland	**Number**	**241**	**447**	**9**	**237**	**89**	**1023**
	RPA	34	47	-82	-9	-35	-
	Growth (99-01=100)	93.4	93.2	92.3	136.5	93.7	100.6
China	**Number**	**151**	**263**	**14**	**231**	**139**	**798**
	RPA	-60	-54	-87	-61	-46	-
	Growth (99-01=100)	746.5	773.5	1469.7	524.8	670.0	665.0
World	**Number**	**8902**	**14239**	**1594**	**13744**	**6723**	**45202**
	Growth (99-01=100)	120.4	110.7	111.8	145.3	135.4	125.2
RPA > 0, specialization in a technology							

Source: WIPO, EPO, Frietsch et al. (2011), Ifo Institute for Economic Research

[111] Thus far, China has an extreme biased patent activity focussing on communications and broadcasting engineering. In 2006-2008 nearly 20% of all Chinese patent applications related to these two technology fields.

The international comparison of patent performance in the ME industry indicates a strong technological position of European firms. The EU is strongly specialised in ME as measured by patent applications. Even though patent growth is somewhat below the world average the level of patent activity is very high: nearly the half of all transnational patents applied worldwide in the years 2006-2008 were filed by European firms, among these German manufacturers play an outstanding role.

4.6.5 Assessment of the technological competitiveness

ME is one of the core EU industries. Statistics have disclosed that the EU ME is among the leading economies with its input for R&D. The “innovation intensity”, as measured by the share of innovation expenditure of total sales, has shown that for large companies the EU position is even better. This indicator “innovation intensity” unveils that the EU ME is by far leading among the large competing economies. Moreover, the focus of large EU companies is on ME. The “innovation intensity” for activities dedicated on ME technologies is even higher than the innovation intensity dedicated on other technologies. This indicates that there is a comparative advantage for EU ME that does not exist for the other large economies under consideration.

The EU ME commands a strong technological position in international competition. This has been confirmed in interviews and concrete examples have been given. Above all in gear and drive technologies the EU is on the leading edge. The position is less outstanding in some advanced technologies supplied by upstream industries. This concerns above all electronics and optoelectronic components, an area in which the EU had been lagging behind more than two decades ago. Although the EU has caught up and competes on eye level there has remained a certain dependency on deliveries, in particular from Japan.

In material sciences the EU is among the global leaders, be it nano-technologies, CFRP etc. Above all in CFRP the EU commands a strong global position, as well in materials and material processing. This can be assigned to the know-how in different technologies and the ability of EU companies to co-operate in multidisciplinary projects. System engineering has become an important topic in international markets and is indispensable for the industrialization of emerging economies. Manufacturing know-how, the ability to automate and control complex processes have made EU manufacturers eligible suppliers of machinery, equipment and turnkey-plants. In these areas, where engineering services are key for high performance processes the EU is on the leading edge globally, competing above all with Japanese firms, in some areas with US companies. Korea has become an important competitor in plant engineering. However, its advantage builds much on beneficial funding conditions and to a lesser extent on technology.

4.7 Concluding evaluation of the EU ME's competitiveness

Structural changes contribute to competitiveness

ME is not only characterized by an intra-industrial but an inter-industrial division of labour. Upstream linkages to other metal industries, electrical engineering, the electronics industry etc. asks for a good industrial infrastructure as a prerequisite for a competitive ME. It is a less "mobile" industry than for instance ICT with its longstanding tradition of global production networks for the exploitation of low-wage supply. ME has always exploited the advantages of the broad industrial infrastructure in Europe. This has not changed although global networks have been created to build on comparative advantages in other regions and to improve access to remote markets.

Likewise downstream linkages are also of importance for the competitiveness of ME. Close ties to client industries and their specific needs have contributed to the EU ME as a global leader in manufacturing technologies. For instance, due to losses of capacities for the production of textiles and clothes in Europe the concerned machinery manufacturers have lost some of their former global predominance in technology and production.

Since the late 1980s ME has evolved from less integrated national industries towards a pan-European industry. Since the middle of the last decade the transition and integration of the economies that had accessed the EU in 2004 and beyond has been to a large part concluded. However, the integration of the EU ME and its cohesion has been dealt a blow by the erroneous macroeconomic developments in certain member states throughout the past decade. The financial crisis has brought the problems to light. Concerned member states' ME has suffered losses of competitiveness.

ME is an industry marked by smaller family owned companies. However SMEs that fall under the EU definition of up to 200 employees are not the backbone of the industry.

Over the past decades a consolidation has taken place in the EU ME. Companies have merged or been taken over by others. Medium-sized groups have been created that beside the typical medium-sized, family held and independent companies exist. These groups' advantages lie in the combination of smaller firms' flexibility with larger firms' potential to access global sales markets and to carry out larger research projects. Moreover, they can allocate the necessary resources to shoulder the increasing administrative burden by requests from clients and growing regulation.

Financial companies have gained importance in funding and even managing the restructuring of ME. The development of the EU ME towards an industry with larger units, be it individual companies or groups, has strengthened the industry's ability to meet the challenges of globalization and benefit from its opportunities.

The free circulation of products in the Single Market has tightened competitive pressure on smaller manufacturing firms that have been specializing in niche markets. Increasingly market shares are taken over by larger competitors that try to fully exploit their growth potential within the EU. In some of these market segments the very small industrial enterprises will have to put to test their business models. Numerous of these very small firms will evolve towards handicraft businesses in the long-run. Instead of manufacturing own products they will concentrate more on installation, services and repair.

Poor performance in price competitiveness

Of the four major competing economies in international markets for ME products the US, Japan and the EU-27 could not hinder losses of workplaces in ME. Only China was able to increase the number of workplaces. The EU had lost around 15% of its workforce "only", whereas Japan and the US ME had to reduce its staff by 27% and 23% respectively.

The Japanese ME strengthened its price competitiveness above all by wage moderation and even reduction during the financial crisis. It is of note that labour productivity did not change much throughout the past decade. In contrast, US and EU enterprises managed to increase labour productivity at annual average rates of 1.5% and 0.8% respectively between 2000 and 2010. Both of them were confronted with increasing wages. Until 2008 the wage trends were quite similar, but during the crisis the US labour wage regime proved to be flexible whereas the EU wage regime proved to be rigid. Despite strong growth of the EU ME's labour productivity – as compared to the competitors from developed economies - the economic performance has worsened above all caused by rising wages even during the crisis.

EU ME labour productivity at 54,290 € is much lower than for the US at 91,125 € and Japan at 96,700. However, wages are of similar magnitude than for both of these competitors. As a consequence the economic performance of the EU ME – as measured by ULC and GOR – is much worse than for each of the competing economies under consideration. However, this result must be valued also in relation to the EU manufacturing. The backwardness in labour productivity for EU in comparison with the US and Japan is a typical pattern.

The Chinese ME had enjoyed the strongest growth in labour productivity. In 2010 it came up to 26,399 €, half the EU ME's average. It has already reached the levels of the Polish, Czech and Slovakian ME. But these countries' wages are much higher than Chinese wages. This is understood as a challenge to meet price competition or to strongly upgrade products and technologies.

The investigation in price competitiveness of the EU ME has disclosed a non-convincing picture. The economic performance has been characterized by cost pressure and the situation has become even tighter during the financial crisis and beyond.

Excellence in international trade

It is remarkable that the US, a country leading in ICT technologies, and Japan, likewise a leading economy in ICT technology and the automotive industry, show comparative advantages in international trade with ME products in relation to the average of other manufactured goods. Both of these countries enjoy, as the EU-27, trade surpluses in ME. This supports the assumption that ME is an industry with comparative advantages for developed countries in the era of globalization.

In 2010 the EU ME exports amounted to 200.4 bn € whereas imports came up to € 81.2 bn. The trade surplus of € 119.2 bn had broadened throughout the past decade. In 2000 it was only € 49 bn. The EU ME has contributed much to contain the EU-27 overall deficit in trade with manufactured goods that had broadened over the period under consideration. For non-ME products the deficit was € 191.4 bn and even reached € 275.5 bn in 2010.

The EU ME has performed pretty well in global markets, despite its not convincing price competitiveness. It had gained shares in global trade in an environment marked by strongly growing emerging competitors, up to 37.2% in 2010 from 33.8% in 2000. Of outstanding importance is the success in the world's largest machinery market China. Although the EU exports to China did not grow as fast as domestic demand they grew much stronger than other foreign manufacturers' deliveries to the Chinese market. The EU-27 share of Chinese machinery imports had increased from 28% in 2000 up to 37% in 2010. The EU-27 had also increased its share of total ME imports in the hard to access Japanese market. Only for the US machinery market some losses had been suffered.

The investigation in major sales markets disclosed that the EU ME commands important stakes in many emerging economies with bright growth perspectives. The industry has even gained shares in many target markets' machinery imports. Altogether the trade analysis confirms that the EU ME possesses a promising starting position to remain successful in coming years.

EU ME's globalization supports competitiveness

Asia has become a more important supplier for the EU ME. Production locations owned by EU firms and Asian manufacturers have become an integral part of the EU ME value chain. Asian deliveries consist above all of large batch, medium-tech products, whereas in Europe the share of small batch production and customization of total output grows. This division of labour between Asia and Europe provides European manufacturers with opportunities to remain price competitive in medium-tech serial production. They do not leave market segments that - not by margins - but by volume are of crucial strategic importance and can be used by emerging competitors as gateway. Competitors from low-wage countries could more easily enter machinery markets and by permanent upgrading cause cut-throat competition. EU ME firms use locations in low-wage countries outside the EU to control the lower end of their product programme in foreign and in the domestic market.

Growing sophistication of products and services strengthens EU ME's position

EU ME firms have been busy to become full-hand suppliers to offer their clients complete solutions. Their product programme does no longer consist predominantly of hardware but combine machinery and equipment dedicated for the execution of specific production processes. Simultaneously engineering and the software designed to control systems have gained growing shares in total supply of the EU ME. The linkage of all these components, machinery and equipment, high-tech components, engineering and software to high-performance manufacturing systems has become an important feature of what has been ascribed as an enabling industry. The share of services has been growing over the past decades.

This development has certain implications on the performance of the EU ME. Firstly, comparative advantages of the EU ME with its qualified staff experienced in cross-disciplinary co-operation, its knowledge in process technology is a unique feature that differentiates the EU ME's supply from emerging economies competitors. Secondly, these services present an additional value added and create workplaces for high qualified staff. These services are well suited to compensate to a certain extent for losses in and relocation of low-value added production. Thirdly, even totally new business areas can be accessed such as BOT and contracting. Fourthly, these new business areas are less dependent on the investment cycles with their volatility. These services cushion the cyclicality of ME's business activity.

Global leader in ME technologies

EU ME is among the leading economies with its input for R&D. Its innovation intensity is not only higher than for the major competing economies under consideration. Moreover in contrast to the US and Japan the EU ME's innovation intensity is higher than for all other EU industries on average. This highlights the outstanding strength of the industry and underscores its comparative advantage in international competition.

The EU ME commands a strong technological position in international competition, in particular in mechanical technologies. The technological strength of the EU ME is distributed over a broad range of subsectors. This is a specificity of the EU. Neither Japan nor the US can build on a comparable breadth of technological excellence. Most pronounced is the EU lead in drives and gears. In material sciences the EU is among the global leaders. Above all in CFRP the EU commands a strong global position, as well in materials and material processing. This can be assigned to the know-how in different technologies and the ability of EU companies to co-operate in multidisciplinary projects. The EU ME's position is less outstanding in some advanced technologies supplied by upstream industries. This concerns above all electronics and optoelectronic components. Although the EU has caught up the former Japanese lead and competes on eye level there has remained a certain dependency on deliveries.

5 Framework conditions

5.1 Market regulation

5.1.1 New Approach and New Legislative Framework

The concept of harmonized standards plays an outstanding role in the framework of the New Approach Directives. Manufacturers have to ensure the conformity of their products with essential requirements of the relevant directives. The conformity assessment is facilitated by harmonised standards in the sense that if a product is designed in line with a harmonised standard, it is presumed to be in conformity with the essential requirements. However, the new approach does not ban product innovations that are not designed in accordance with harmonised standards. Manufacturers are not obliged to follow the road of harmonised standards to demonstrate the conformity of this product with the essential requirements.

On 7 May 2003 the Commission issued a Communication to the Council and the European Parliament entitled “Enhancing the Implementation of the New Approach Directives”. In its Resolution of 10 November 2003 the Council confirmed the necessity of extending the application of its principles to new areas and recognised the need for a clearer framework for conformity assessment, accreditation and market surveillance. On 13 August 2008 the New Legislative Framework (NLF), the further development of the New Approach for marketing of products, was published in the Official Journal. The framework consists of two complementary pieces of legislation, a Decision and a Regulation.[112]

Decision 768/2008/EC on a common framework for the marketing of products is intended to harmonise specifications regarding definitions, obligations for economic operators, Notified Bodies, conformity assessment procedures, safeguard mechanisms and CE-marking. The Decision addresses legislators and provides a toolbox for future legislation. It covers elements already included in existing legislation (e.g. notifying bodies (NoBos), safeguard clause). Regulation (EC) 765/2008 sets out the requirements for accreditation and market surveillance relating to the marketing of products. It covers elements not yet included in existing legislation. The Regulation lays down rules on the organisation and operation of accreditation of conformity assessment bodies. It provides a framework for the market surveillance of products including for controls on products from third countries and lays down general principles of the CE marking. The Regulation is binding and came into force from 1 January 2010. The provisions of the Decision can be used

[112] 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.

immediately but to be operational they need to be fed into existing Directives when they are revised. The NLF is a horizontal measure which has the objective of removing remaining obstacles to free circulation of products and intends an essential improvement for trade in goods between EU Member States.

The current Machinery Directive (2006/42/EC) is a revised version of the first version of the Machinery Directive which was adopted in 1989. The new Machinery Directive has been applicable since December 2009. The Machinery Directive and the NLF have been appreciated by the industry. Sufficient leeway is given for the design of innovative products and the administrative burden is adequate. The NLF has been dedicated to create more consistent framework conditions by mutual adjustment of directives. Stakeholders of ME reported that this has not yet been concluded and directives of major relevance for ME have to be revised to meet this target. More efforts should be put on this subject.

Beyond the Machinery Directive a broad range of other directives has to be taken into account by ME companies. They refer to product safety, such as the Boiler Efficiency Directive (1992/42/EEC, BED), to efficiency, such as the Energy-Using Products Directive (2005/32/EC, EuP), to compatibility, such as the Electro-Magnetic Compatibility Directive (2004/108/EC, EMC).

5.1.2 Market surveillance

Generally speaking, the harmonisation of the European regulation contributes to the competitiveness of European manufacturers. They can better exploit economies of scale. The design of variants for different Member States is no longer necessary. However, the European regulation eases market access also for non-EU competitors. For instance hindrances to transatlantic trade for European companies who want to tap into the US market exist by a non-harmonised regulatory system on the federal, state and local level whereas the US access to the EU market has been eased by harmonised regulation.[113]

The openness of the EU-market to foreign companies highlights the necessity of comprehensive and efficient market surveillance to immediately identify non-complying products. Surveillance is most important for products originating from third countries. Non-compliant imported products from third countries have remained a point of major concern. However, officers are not qualified to identify problematic deliveries. As a consequence, imported CE-marked products are traded within the Single Market, although they do not comply with EU provisions. Beyond non-compliance with EU provisions the sale of counterfeit products is another problem related to insufficient market surveillance.

In contrast to consumer goods, market surveillance is not sufficient in markets for intermediary and capital goods. There are clear deficiencies in how market surveillance is carried out in Europe. There are insufficient resources and insufficient controls. However, lack of capacity and resources at Member State level, as well as varying degrees of enforcement in different Member States, create an uneven level playing field. The

[113] Berden, K. et al. (2009) "Non-Tariff Measures in the EU-US Trade and Investment – An Economic Analysis", Rotterdam.

disclosure of infringements against EU provisions is almost completely dependent on companies' investigations into the sales markets. Further legal enforcement is necessary to safeguard the objectives pursued by European directives on environmental protection, health and safety in the workplace.

The most efficient solution to these problems would be checks at the borders. The need for such a solution is underscored by the current market surveillance as it is carried out within the Single Market. 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 little has changed, and the situation is assessed by stakeholders of the industry as by far not satisfying. It is vital that Member States step-up cooperation and build up resources dedicated to market surveillance (e.g. Italy only has a staff of 6 people for this task). The non-European manufacturers in particular have to improve their compliance with these provisions.

It is asked for the investment in on-the-border controls to improve market surveillance. Currently EU manufacturers complying with strict European provisions face unfair competition from non-EU manufacturers that distribute non-compliant machinery in the Single Market and are not detected by public authorities.

5.1.3 National provisions hampering free trade in the Single Market

Harmonisation on the European level has been a success story in the abolition of market access barriers in the Single Market. This is above all true for provisions that can be met by the design of products. This concerns among others the Machinery Directive, the Boiler Efficiency Directive (1992/42/EEC, BED), the Energy-Using Products Directive (2005/32/EC, EuP) and the Electro-Magnetic Compatibility Directive (2004/108/EC, EMC) and others. Provisions from these directives are Community-wide acknowledged and problems are exemptions.

However there are other directives that can be problematic by their legal involvement. Here the Waste from Electrical and Electronic Equipment Directive (2002/95/EC, WEEE) and the Directive on the Restriction of Hazardous Substances, the RoHS Directive 2002/95/EC are examples. These directives draw on Article 174 EC Treaty and concern the protection of the environment. The measures under Article 174 are taken without prejudice of Article 96 (creation of the Single Market). Moreover Article 176 refers to protective measures under Article 175 and gives freedom for national regulators to introduce more stringent protective measures. This can pose some problems to the free circulation of machinery and ask for additional design activities and the procurement of different parts and components to meet specific national requirements.

The transposition of directives under the framework directive on the introduction of measures to encourage improvements in the safety and health of workers at work (Council Directive, 89/391/EEC) into national law and the interpretation by national bodies sometimes cause difficulties and hampers free access to other Member States. If different national provisions on health and safety in the workplace exist it is not sufficient to design machinery in compliances with EU directives. Due to interviews with stakeholders of ME more important as potential barriers are provisions dedicated on the safety and health in the workplace. De facto European directives define minimum requirements. Stricter national provisions on the safety and health in the workplace can be put into force. Moreover, national authorities - responsible for the supervision of compliance with health and safety regulation – sometimes have different views on the compliance of machinery with provisions and ask for additional measures.

A harmonization of the European-wide regulation on health and safety in the workplace is needed to abolish remaining barriers to the free circulation of machinery in the Single Market.

5.1.4 Multiple requirements for manufacturers of intermediary products

ME is an industry with a sophisticated vertical division of labour. Numerous subsectors of ME are manufacturers of intermediary products that are delivered to a broad range of different industries. These companies face specific challenges from provisions. They do not only have to meet provisions for their own products. They have to have in mind provisions of relevance for their clients. A company that provides intermediary products to more client industries is confronted with the multifunctional problem to produce parts and components that comply with differing provisions. Such a problem incorporates the threat of conflicting goals.

Such problems have been articulated by manufacturers of pumps and compressors gears and drives, air conditioning and ventilation, in particular in compliance with the directive EuP 2009/125/EC, setting requirements on energy-using products. They have to meet the requirements specified for their own product groups. However, these products are delivered into many other industries and intermediary product manufacturers have to take into account their clients' needs so as to meet the EuP' specifications for different applications. The necessity to have an eye on all relevant provisions and to be up-to-date to the current body of relevant legislation for different applications is hardly possible even for large companies. For smaller companies it is impossible to take into account the legal framework conditions in different market segments. This complex legal framework limits their opportunities to access new markets and to risk spreading by supplying products into different markets.

The problem that parts and components are covered by different transpositions of one directive, e.g. the EuP, along the value chain is an unnecessary overregulation. This is not only a burden for companies, but incorporates the risk of counterproductive results with regard to the objectives pursued by EU policies, and should be abolished.

5.1.5 Internal combustion engines and mobile machinery

Mobile machinery faces specific problems with European regulation that have a strong impact on the companies' cost structures. These are above the exhaust gas Directive's (Directive 2000/25/EC) provisions. The manufacturers have to invest heavily in the development of internal combustion engines that comply with the waste gas provisions. There is a tendency that the requirements for provisions are derived from provisions for the automotive industry. However, cars operate in a more stable environment than mobile machinery that eases the compliance with strict waste gas provisions. For mobile machinery that operates in a rough environment under quite different working conditions it is much more challenging to meeting strict provisions similar as for automobiles. In combination with the comparable low number of units produced the costs caused for the development of high-performance and low-emission engines as a share of total R&D are high and even exceed 50% for some engine manufacturers. This cost burden that does not provide economic advantages to users of mobile machinery underscores the need for market surveillance to create an even level playing field in competition.

The temporal sequence to introduce ever stricter waste gas provisions gives little room for manufacturers to collect sufficient information on the long-term stability of recently developed engines, as well as on costs caused by maintenance and repair of the more complex systems necessary to meet low maximum values for emissions. It is asked for a deceleration of regulatory changes to give companies the opportunity to learn from the long-term performance of mobile machinery under real working conditions.

For tractors there is a sophisticated set of type-approval legislation covering safety (occupational and road) as well as environmental aspects. This system is of extremely high importance for tractor manufacturers. There is a tendency within the EU institutions to more and more copy requirements from the automotive sector to the tractor legislation, which creates a lot of technical and legal challenges, as tractors are not built for transport only and are not sold to consumers. Especially the introduction of the car distribution and maintenance requirements via the type approval procedure endangers the functioning system for tractors and should be abolished.

For off-road machinery, free circulation within the Single Market is hampered by non-harmonization of roading approvals in the EU. Multiple approval procedures are costly and lengthen time to market by a considerable degree. Although an investigation has been conducted around a decade ago, no initiatives were taken in order to find a solution.[114]

5.1.6 Energy related regulation

The directive ErP 2009/125/EC on energy using products is of importance for many of the ME's products. Its implementation for the industry's different products is linked to certain obstacles. One point that has been raised by stakeholders of ME: The success of the implementation lies in the scope of the activity. The product group must be to a certain extent homogenous with regard to the objectives pursued. The implementation of provisions for heterogeneous product groups incorporates the threat of less adequate requirements. The implementation of the Energy-Related Products Directive (ErP), with its specific provisions on pumps, has been perceived as a successful solution by companies.

These obstacles must be taken seriously, because the ErP interferes in product innovation and affects the freedom of design. Poorly implemented provisions could put a brake on the pace of technological progress and endanger the EU ME's competitiveness. Well-designed provisions can contribute to innovative solutions and increased resource

[114] Vieweg, H.-G. and Dreesen, M. (2001) "Restrictions of the Free Circulation of Off-road Machinery in the EU – Final report", Munich. http://www.pedz.uni-mannheim.de/daten/edz-h/gdb/01/gesam.pdf.

efficiency that sets standards. New product features incorporate the potential for an improved competitiveness that can be exploited in international markets.

5.1.7 Self-regulation

Traditionally the regulatory framework is set by policymakers and companies have to comply with provisions. More frequently self-imposed commitments have become a tool to reach political objectives. Representatives of an industry agree on common rules and member firms agree on a self-obligation. This gives an industry the opportunity to design rules to meet political guidelines by provisions in line with its specific needs. In particular for the implementation of provisions for product groups that fall under the EuP self-obligations can contribute to a more efficient regulation.

One example has been mentioned by the European Sectoral Committee for machine tools. This kind of machinery falls under the scope of the EcoDesign Directive as energy-using products. Energy efficiency of machine tools will become an even more important issue with growing regulatory/legal requirements towards more sustainable modes of production. No mandatory measures for this product group are set up yet even if a study is on-going. The European Sectoral Committee, CECIMO, has already launched an initiative for a self-regulatory system to decrease the energy consumption of machine tools.

5.1.8 Reliable regulatory environment

Generally speaking, the harmonization of the technical framework has contributed much to the free circulation of goods in the Single Market and has been appreciated by the industry. However, the interest of policy makers to permanently improve regulation, in particular on areas of environmental protection and working conditions is tying up R&D and design capacities to develop products that comply with latest provisions. Frequent changes in these areas limit the resources of companies to innovations dedicated to provide value added to clients that ask for ever more efficient machinery and production systems. This can turn out to be counterproductive for EU companies' technological competitiveness in international markets if they cannot keep the pace in the race to provide best performing machinery to clients.

Time is an important factor for the creation of a reliable and stable regulatory environment. This truism is underscored by problems that have been raised by the revision and implementation of directives on recycling, 2002/95/EC (RoHS) and the use of hazardous substances, 2002/95/EC (WEEE). Due to stakeholders of ME policy changes in the process of redesigning the directives have caused unexpected effects.

It is asked for well-founded decisions on the introduction of new provisions and changes of EU directives. On the one hand this means an evaluation of the potential improvements gained by new regulation. On the other hand, an impact assessment is asked for on the question what do these changes mean for the industries affected by new regulation. Moreover, frequent changes of provisions should be prevented by a ban after the introduction of new rules to revise regulation.

Only in the case that a new provision has turned out to be problematic changes should be possible. An example is provided by the revision of the market surveillance that has turned as not-fulfilling the targets envisaged.

5.1.9 Smaller firms

Typically smaller firms' advantage in competition lies in their size or better smallness that provides them with more leeway to adapt to a changing environment. However, they cannot afford sufficient staff to engage employees with all of the legal framework, its changes and an increasing regulation. This said, it is quite obvious that public policies that are not only directed towards an improvement of working conditions, protection of the environment and the creation of a sustainable economy but provide supportive framework conditions for smaller companies have to be extremely careful not to overburden these companies.

One important point in this respect is the creation of reliable and stable framework conditions. Frequent changes are counterproductive.

The RoHS Directive 2002/95/EC and the Reach Directive 2006/121/EC have been mentioned as examples for smaller firms to meet provisions. The directive on the restriction of hazardous substances requires that electrical and electronic parts do not contain banned substances. Smaller firms have to trust that suppliers comply with EU provisions. They do not own the know-how and the necessary equipment as their larger competitors to guarantee compliance and bear the risk. A similar problem is raised by the registration, evaluation and authorisation of chemicals, as outlined in the REACH directive to ensure the safe use of chemicals for the environment and human health. While bigger firms employ specialized staff, such as chemical engineers, to comply with EU requirements, smaller firms have to engage costly external technical services, because they do not employ such specialists and have to pay for specialized external consultants.

It will not be easy to introduce strict regulation and simultaneously take into account the problems that are faced by smaller firms. Impact assessment of European regulation on SMEs is an important issue taken into account by the Commission. In the area of internal combustion engines a positive example was highlighted by stakeholders of ME. It already has been stressed that the compliance with minimum waste gas provision is challenging – even for large manufacturers producing engines in large quantities. In most cases smaller numbers of engines are produced by smaller enterprises and for instance, for engines manufactured below 5,000 units per year the introduction of norms has been decelerated by the Commission. The delayed procedure provides some opportunities to smaller enterprises to benefit from the experience of larger manufacturers to find technical solution. This approach is valued as a sufficiently conciliatory procedure by industry experts for smaller enterprises.

5.1.10 International standards

To a large extent EU standards are developed together with ISO and are accepted internationally. In particular in areas where Europe is globally leading in technology the EU industry has opportunities to set the pace and direction of developments. The commitment to international activities should be elaborated as far as possible to bundle efforts and to reduce non-tariff technical barriers.

For instance in the area of gears and drives European activities to come to global standards have been successful. Technical barriers to trade are a minor problem. Some difficulties have been reported for exports to the US that gets its own way in standardization based on ASTM, a particularity that is not limited to gears and drives. Also other subsectors reported some problems with specific US approaches for technical standards.

However one area of standardization has been mentioned where the EU regulation is not committed to build on an international agreed approach. In the area of mobile machinery the EU industry has been strongly involved in UN-ECE and OECD standardization initiatives, but the EU pursues a different approach. The industry values this stance as counterproductive and requests a global harmonization of requirements and contributes to this objective via ISO standards.

5.2 Knowledge: R&D, innovation, and product development

Since long innovation processes have been characterised by an increasing integration of different science and technology disciplines. Likewise, for manufacturing and ME industry nanotechnology, materials technology, information technology and new and flexible production systems are key innovation drivers. Future technological developments will continue to integrate technologies from multiple scientific disciplines in a “convergence” that will have profound effects on innovation and competiveness of the engineering industry. In addition to technological developments organisational and managerial change is crucial for the innovativeness of firms. Hence, aspects of planning, supply chains, cooperation and professional competence are complementary determinants for industrial competiveness in the global economy. The technologies mentioned establish major opportunities for two classes of manufacturing in which Europe has a strong global competitive position, namely materials processing and engineered or manufactured goods industries. The output of the engineering industries delivers innovative products, processes and services into the value chains of most others industrial sectors of strategic importance to Europe e.g. energy, transport, chemicals, pharmaceuticals and construction.

The manufacturing industry was hit hard by the current financial crisis and is experiencing its sharpest decline in decades. In response to the economic crisis, the European Union has generated a *Recovery Plan*[115], which contains three cooperative technology research programmes embedded within it, to accelerate progress towards the following European objectives:

- Energy efficient (Green) Car
- Energy efficient buildings
- Factories of the Future.

[115] http://ec.europa.eu/research/index.cfm?pg=newsalert&lg=en&year=2009&na=na-130709

All three research programmes are relevant for the ME industry. Most important is the Factories of the Future initiatives because it comprises the core activities of ME to provide production technologies to clients industry. Many subsectors of ME can benefit from this initiative.

Also relevant for the ME sector is the European Strategic Energy Technology Plan (SET-Plan). The SET-Plan was adopted by the European Union in 2008 and is a first step to establish an energy technology policy for Europe. It is the principal decision-making support tool for European energy policy, with a goal of

- Accelerating knowledge development, technology transfer and innovation;
- Maintaining EU industrial leadership on low-carbon energy technologies;
- Fostering science for transforming energy technologies to achieve the 2050 Energy and Climate Change goals;
- Contributing to the worldwide transition to a low carbon economy by 2050.

At the beginning six priority technologies were identified as focal points for European Industrial Initiatives (EIIs): Wind, solar, electricity grids, bioenergy, carbon capture and storage and sustainable nuclear fission. Technology roadmaps serve as a basis for strategic planning and decision making.[116] Another EII followed.[117]

Another EU research programme that affects ME is the Nanotechnologies, Material Science and Engineering and Production Systems programme (NMP) (2010-2015) which is running under the FP7 and will also run under the FP8. In addition, in many member states national programmes promote scientific and industrial R&D in the area of production technologies. The three technology fields mentioned above are used subsequently to structure main R&D trends in ME.

Public schemes for industrial R&D in the area of production technologies are applied in most important economies, in particular in competing economies USA, Japan and China.

Materials and nano-technology

New materials and nano-materials are potentially suitable for applications in innovative machinery and production systems. Often the industries which use such production equipment can realize resource and cost savings by more efficient processes, fewer material input, longer life cycle and service life.

A very important field of application for nano-materials in the ME industry is the modification or coating of surfaces of components or tools[118]. Thus, depending on the required function of the item specific properties can be attained which make the production process more reliable, efficient or effective. With this, it must be taken into

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116 European Commission (2009a). Investing in the Development of Low Carbon Technologies (SET-Plan), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels COM (2009) 519.

117 European Commission, Joint Research Centre (2009b). Technology Map of the European Strategic Energy Technology Pan (SET-Plan), Part–I: Technology Descriptions, Luxembourg.

118 VDI-Technologiezentrum (2009) „Meta-Roadmap Nanomaterialien“, Düsseldorf.

account that requirements for durability and stability of such functional surfaces and coatings in a production environment are much higher than in the consumer sector.

In many manufacturing processes cleanness or non-stick surfaces play an important role. Nano-scale films or addition of nano-particles in coatings can be used to minimise interaction with materials, which are processed in the respective application. E.g. nano-scale non-stick coatings can improve extrusion or injection moulding in polymer processes. For printing presses colour and oil repellent coatings based on nano-scale sol-gel materials for ink rollers and conveyer belts have been developed. So cleaning efforts can be reduced and often functionality can be improved. For instance, the durability of long-term stable coatings in cases of strong mechanical load is an important R&D target.

In order to increase the lifecycle machines and plants components have to be protected against corrosion. In many cases the respective surfaces are exposed to increased chemical and mechanical stress. In the past often compounds containing chromium VI were used which are extremely noxious. Alternatively nano-scale conversion coatings can be applied. Another tribological target is the increase of wear resistance of highly stressed surfaces. Nano-particulate ceramic coatings can significantly extend lifetime of cutting tools and forming dies. It is worth to mention that nano-technology is also a surface technology option to avoid vacuum coatings at the production of mass production. Finally also components of polymeric materials can be made more wear resistance by nano-scalic fillers.

Production processes often take place at high temperatures. In such cases lifecycle of components can be enhanced by using thermal protective layers. Potential nano-materials therefore are e.g. nonporous layers or metal-ceramic nano-composites.

The economical generation of electricity by wind power implies large-scale generators. Thus mechanical loads arise and often are intensified by harsh climate conditions as in the case of offshore use. Light, but wear resistant rotor blades can be manufactured of polymer composites with carbon-nanoparticles like carbon nanotubes or graphenes. The industrial implementation of this technology depends on the availability of economically priced pure carbon-nanoparticles. Nano-composites provide wear protection resistant to corrosion while at the same time a decrease of brittleness of the protective coatings. Thus cost-effectiveness of wind turbines increases by longer lifecycles and less maintenance.

Apart from surface applications new materials also play an important role as construction materials. The diffusion of lightweight technologies has been developed for resource and energy saving in numerous manufacturing industries such as vehicle and aircraft construction. Processing of aluminium, magnesium, titanium, high-strength steels, polymers, fibre reinforced plastics and ceramics have been permanent challenges for the machinery industry in order to meet the demands of industrial customers. Those materials are not only important for customers' applications but also for the design and manufacturing of machinery itself. Fibre reinforced plastics, in particular carbon fibre reinforced plastics (CFRP) are extreme lightweight materials. They are characterized by high stiffness and strength with regard to its density. This group of material is especially suited for dynamically moved parts and is therefore potentially applicable in ME, e.g., to reduce the mass of fast moving machine heads in machine tools. R&D goals associated with CFRP are e.g. reducing component masses and inertia of mass as well as minimizing coefficient of expansion. Product benefits can be smaller motors, energy saving, improved maintainability, longer machine run times.

Net-shape or near-net-shape manufacturing technologies have gained industrial significance to produce structural parts made of a wide range of materials, namely metals, ceramics and polymers. Transferring traditional low-cost net-shape manufacturing processes to novel material classes, such as advanced metallic materials (e.g. inter-metallics), functional ceramics (e.g. bio-ceramics) or structurally reinforced composites (e.g. metal-ceramic or polymer nano-composite materials) will lead to completely new possibilities in the design of components and to significant savings in materials and processing costs.

Engineering and production systems

The products and systems of ME are targeting the manufacturing industry to a large extent. Manufacturing industry is still the driving force of the European economy, contributing approximately 22% of the EU gross national product and providing more than 30 million jobs. It is very diverse and covers a wide range of specific processes ranging from extracting minerals to assembly of very complex products such as planes and computers, with many intermediate processing steps in a long chain of industrial suppliers and customers. The sector faces an intense and growing competitive pressure in global markets.

Main competitors of European companies are traditionally the US, Japan and Korea, but emerging countries such as China and Brazil have been coming along and increasingly compete with European firms in their home market as well as in third markets. Furthermore global warming and growing demand for energy and resources induces manufacturing companies to address these challenge and produce goods more efficiently, with less material, less energy and less waste.

Under these conditions R&D in the ME industry is primarily focused on the following goals:[119,120]

- cost efficiency, with extensive adoption of standards in production machinery, equipment and controls, and massive use of the lean approach,
- life cycle cost models,
- reducing of development time by design-to-engineering systems for customized products,

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119 European Commission, Ad-hoc Industrial Advisory Group (2010b). Factories of the Future PPP, Strategic Multi-annual Roadmap, Brussels.

120 IPA/VDMA (2007) „Strategic research agenda MANUFUTURE-DE“, Stuttgart, http://www.manufuture.de/20071121_1_ManagementSummary_final.pdf

- optimised consumption of resources through the use of energy and material efficient processes and machinery, smart energy management with extensive recovery of heat and dissipated energy,
- increased focus on high added value components/goods through the use of enabling processing technologies and enhanced materials,
- adaptability through a modular approach in production systems, in order to maximise autonomy and interaction capability of machinery,
- higher and more stable product quality through increased process robustness and accuracy, while ensuring an easy process maintainability,
- increased re-usability of production systems towards global interoperable factories, which are able to provide services and develop products anytime and anywhere, independently of the technologies, culture or language in use in the different production sites and
- new products, requiring new manufacturing technologies adapted to new features.

Hence several R&D innovation areas have been deduced:

Sustainable manufacturing

Manufacturing industry needs to be able to design and produce goods using a sustainable approach. Sustainable in production terms means energy efficient with a minimal environmental impact, compliant to the regulatory constraints and fulfilling the safety and health requirements, while ensuring profitability for economic growth. Support for "de-manufacturing" or advanced recycling of products and production process waste is equally required. Research has to satisfy both environmental and customer needs, generating high added-value products, related processes and technologies to meet functionality requirements as well as growth conditions and occupational safety. Thus innovation activities aim at environmental friendliness, economic growth and social well-being.[121]

Machinery and plant designs using technologies for resource efficiency and cleaner manufacturing , can make cuts in energy consumption, depending on energy intensity, by monitoring the process conditions and the resources used in production, replacing and up-dating equipment, configuring systems according to differentiated processing needs. In the medium-term in manufacturing production an average increase of energy efficiency up to 30% is expected.[122] According German estimates of the process automation industry energy savings of between 10 and 25% could be achieved at plants within the German process and manufacturing industry alone, simply by using automation technology[123]. Potential savings could even be higher in other countries with an older stock of production machinery.[124] In many industries material costs substantially determine the

121 European Commission, Ad-hoc Industrial Advisory Group (2010b). Factories of the Future PPP, Strategic Multi-annual Roadmap, Brussels.

122 Bullinger, H.-J. (2011) „Maximaler Gewinn mit minimalen Ressourcen", in: Handelsblatt, March 31st ,2011.

123 Schröter, M., Weißfloch, U. and Buschak, D. (2009) „Energieeffizienz in der Produktion – Wunsch oder Wirklichkeit", Fraunhofer ISI, Karlsruhe, November 2009.

124 ZVEI (2010). High-tech environmental and climate protection – Automation: putting energy efficiency first. Zentralverband Elektrotechnik- und Elektronikindustrie e.V., Frankfurt am Main

price of final goods. In Germany 2007 material cost amounted to 45% of production costs, personal costs only account for 18%. Experts assume that 20% of materials costs can be saved in the coming years.

European scientists and industry representatives emphasize objectives as follows[125]:

- High efficiency and near-to-zero emissions in manufacturing processes: Optimised self-adaptive and fault-tolerant strategies, which lead to higher productivity and reduced energy consumption and process emissions (dust, air, water, noise, waste, etc.). Control intensive designs by usability of integrated automation and control systems. Production equipment able to improve energy recovery capabilities as well as self-cleaning production systems.
- Alternatives to energy-intensive processes based on advanced production systems: Production solutions enabling low resource input. Use of surface treatments and functionalization, development of compact processes.
- Improved use of renewable resources at factory level: development of new solutions for greenhouse gases emissions, in particular by using alternative materials and innovative technology application.

Regarding economic growth the focus lies on solutions with high potentials in terms of cost reduction supported by advanced decision making tools and correlated to optimisation of resource and equipment efficiency:

- Smart and agile maintenance approaches that may increase the lifetime and energy efficiency of the production equipment and reduce its maintenance cost. At maintenance process level R&D address e.g. maintenance flexibility, conflict handling in volatile production environments and predictive maintenance planning and scheduling by using advanced embedded information devices. At equipment level, R&D aims at increased lifetime of critical components and reliability.
- Innovative re-use of equipment and integrated factory lay-out design with higher cross-sector standardisation and modular approach. New approaches intend to leverage all potential synergies between concurrent process and building design, as well as best practises for de-manufacturing, dismantling, recycling and value chain extension.

In terms of social well-being a main objective is to develop new forms of interaction between processes, machinery and human beings in such a way that future factories can be operated profitably and at the same time provide a stimulating environment for the employees, and make the most from their skills and their knowledge through life-long learning and training. The eco-factory approach aims to create an environment for humans that will provide the best conditions for coping with products with a short cycle time and a high variability, for handling possible ups and downs in economic cycles, for quick adaption of manufacturing capability and for the development of knowledge. Starting points are:

[125] European Commission, Ad-hoc Industrial Advisory Group (2010b). Factories of the Future PPP, Strategic Multi-annual Roadmap, Brussels.

- Adaptive and responsive human machine interfaces: Advanced adaptive and responsive technical devices enable the creation of such environments.
- New human-robot interactive cooperation in advanced factory environments. Effective collaboration between robots and humans requires the use of an efficient interface whereby a human can communicate and interact with a robot almost as efficiently as he would do with another human.
- Development and adaptation of organisational structures and leadership for sustainability. To generate such knowledge and make it more tangible for the day to day operation of an enterprise, new forms of interdisciplinary research are needed, to understand the correlations of such areas as financial decision mechanisms and ethical business strategy with continuous business success.

ICT-enabled intelligent manufacturing

The application of Information and Communication Technology (ICT) in ME dates back various decades. But there are still large potentials for ICT applications in production processes. In the future an important focus will lie on the adaptability of production systems and their integration within flexible business models and processes in an increasingly globalised industry, requiring continuous change of products, processes and production volumes. Main research areas related to ICT-enabled intelligent manufacturing include:

- Technologies and tools which enable adaptive and fault tolerant process automation, control and optimisation. Such systems also require smart sensors and industrial IT systems. For ex-ante and ex-post quality control testing and validation systems for robotics-based and other automated systems are needed. Equally new metrology tools and methods are important in order to develop self-learning and adaptive procedures for process and quality control.
- Intelligent models providing details of design intent, as well as with better predictive capabilities can help reduce the need for physical prototyping or the erection of pilot plants. ICT-based modelling encompasses material and component properties and variations of these, and helps to identify impacts of corrosion, stress, temperature etc.

In addition to the technical and process data management perspective, product lifecycle management for all design information and analysis results requires synthesis methods and tools to adequately design products. As sustainability assessment includes economic and social as well as environmental issues, classical lifecycle assessment may prove inadequate for a holistic approach based on a consistent set of information on materials, components, products and energy.

New manufacturing systems

Under the conditions of global competition manufacturing in Europe requires production systems that are simultaneously sufficiently flexible and robust, reliable and cost effective. Optimisation of such complex manufacturing systems relies increasingly on humans, advanced machinery, ICT and efficient use of resources. The following main research areas have been identified[126]:

- Flexible adaptive production equipment, systems and plants for rapid (re)configurations and optimal energy use. Industrial markets often are characterised by a turbulent and uncertain demand for highly customised products, of a complexity with is in constant increase. Financial conditions push manufacturers to reduce investments in production resources over time and sustainability issues impose that machines are able to efficiently and ecologically support the production of new future products without being substituted. All this requires high flexibility and permanent adaptation of machines, process equipment and production systems to products and process evolution, with special consideration to traditional industries[127].
- Research and development activities include new system architectures with self-adaptive machine structures based on mechatronic modules, multi-layer controls and highly redundant measurement, sensing and actuator structures. New equipment, machines and production systems require less shop-floor space, by means of reduction of peripherals, optimisation of cycles and process planning. Solutions of choice include components based on intelligent materials or combinations of passive and active materials (engineered materials) to increase the adaptability of production systems. Additionally options are new hybrid production systems for manufacturing and assembly, based on improved robotics and automation technology for cooperative production tasks between humans and robots. Hereby the goal is equipment which intelligently co-operates with human workers, flexibly reacts to glitches by seeking for substitutes.
- Individualised production is a concept of design and dimensioning of all elements of a production system, which allows a product program with high variance and dynamics at production costs similar to mass production. Key elements of individualised production are product program and architecture, production process and resource structure. One-piece-flow represents the ideal situation in which products are individually developed and manufactured and flow as single unit through production and supply chain. Precondition for the one-item-flow is a construction and production optimised with regard to setup times.

Flexible production processes ask for adequate equipment, which can be run at full capacity with, at the same time, low investment and inventory costs. The research focus lies on the development of modular production systems, machinery components and handling systems which flexibly can be integrated into diverse value added chains[128]. A reasonable compromise between the cost effectiveness of fully automated handling systems and the flexibility of manual handling are semi-automated concepts.

[126] European Commission, Factories of the Future, Strategic Multi-annual Roadmap, Brussels 2010

[127] European Commission, NMP Expert Advisory Group (2009c). Position Paper in Future RTD Activities of NMP for the Period 2010-2015, Brussels.

[128] Kleiner, M. and Maevus, F. (2007) „Untersuchung zur Aktualisierung der Forschungsfelder für das Rahmenkonzept "Forschung für die Produktion von morgen", Institut für Umformtechnik und Leichtbau", University Dortmund.

Future manufacturing technologies will move towards the manufacturing of topologically three-dimensional (3D) optimized parts with complex internal structures such as conductive and cooling channels and material gradient structures. Miniaturisation of products and production appliances and integrated compact systems design are considered to be crucial issues for future manufacturing. Consolidation of the manifold of design and simplification of parts, multiple materials and the reduction of manufacturing and assembly costs must be addressed too. Examples are rapid micro-manufacturing technologies, 3D micro-parts production as well as micro-factory and micro-manufacturing systems.

Demand for tools dedicated to production planning, in-situ simulation and for open reconfigurable and adaptive manufacturing systems will grow[129]. The focus lies on new methods and tools for machine design and operation monitoring, considering the need of production systems to evolve in line with products and processes. Advanced interactive graphical user interfaces are needed. Such tools allow workers to deal with the complexity of simulation and decision systems embedded in machines and production lines.

Innovative solutions are needed to support customization and "make-to-order" strategies in automotive, electric and electronic component industries, improving methodologies through quality control and the increase of efficiency. Hereby intelligent measuring systems for zero-defect manufacturing play a role as well as knowledge-based self-learning systems. In this context efforts are being made to optimize process capability by means of In-Process or Pre-Process measurements taking advantage of machines equipped with sensors for quality monitoring. Relevant factors are selected assuring adequate performance through signal analysis and machine-self-learning.

Conclusions

The EU has made available different programmes and schemes to incite and support companies' R&D policies. They comprise all important areas of technologies that are assessed as promising and of crucial importance for future success of ME in global competition. As compared to R&D policies made available by the most important competing economies it becomes obvious that there are great concordances in the selection of important technologies in spite of quite different framework conditions and comparative advantages (Chapter 3.1). This indicates that the success in maintaining and improving the supremacy of the EU ME will be strongly dependent on an efficient use of public resources and the design of schemes in line with the industry's strengths and exploitable potentials.

The US is on the leading edge in a broad range of advanced technologies. In particular its R&D expenditure for ME is well above other competing economies (Table 4.7). However, the consequences of technological progress on the creation of workplaces are not quite clear. Generally speaking, for all of manufacturing and in detail for ME the

129 European Commission, NMP Expert Advisory Group (2009c). Position Paper in Future RTD Activities of NMP for the Period 2010-2015, Brussels.

track record on employment has been poor for the US. This said it will be of outstanding importance to select the most promising technologies for R&D programmes that are in line with the needs of the industry.

In Chapter 4.6.3 the European Commission was cited with the finding that the main reasons for the decline in EU-27 R&D intensity are an insufficient growth in business R&D expenditure and the fact that EU companies invested more outside of Europe, in particular in emerging research-intensive countries, than non-European companies invested in Europe. The attractiveness of non-European locations for EU companies to carry out R&D should be investigated. If there are specific constraints and disadvantages for R&D in Europe it will be of importance to understand the driving factors for relocation and try to improve framework conditions. This understanding should also contribute to a more efficient design of EU programmes and schemes.

Among all technologies of relevance for ME three fields are valued as of key-importance:

- **Research on power generation and the exploitation of alternative sources of energy:** Globally growing demand, increasing scarcity of oil and gas, as well as environmental pollution present enormous challenges. The EU ME is a global leader in power generation technologies. The SET-Plan comprises all relevant technologies. In particular research on gas turbines and their application with different gas qualities is understood as of outstanding importance for an efficient use of biogas. With regard to renewables it will be important to pursue above all technologies that are close to an economic break even. Due to the public debt crisis governments will only have limited resources to subsidise investment and use of alternative energies in coming years. Growing constraints have already been perceived in wind power generation.
- **Material science:** Ferrous and non-ferrous metals are of outstanding importance ME. New materials, compounds and composites – as measured by their amounts – are of minor importance. However, they are crucial for high performance machinery and to go beyond the physical and chemical limits set by conventional materials. In this area the development of CFRP and its processing is understood as a new material that incorporates the potential to have a widespread impact on many of the ME's subsectors. However, a critical bottleneck is processing CFRP. A breakthrough in manufacturing technology is needed to come to a noteworthy dissemination of this new material beyond the aerospace industry.
- **Manufacturing technologies:** The focal point of ME lies in the provision of manufacturing technologies to most of its client industries, be it machinery or key components for processes or complete manufacturing systems designed to a clients' specific requirements. Moreover, ME is an important user of manufacturing technologies itself. In particular, machine tools are crucial for an efficient production and high-precision machining of parts that are indispensible for high-performance machinery that have contributed much to the reputation of the EU ME in global markets. The **Factories of the Future** is a well-suited initiative of the EU Commission to foster innovation in production technologies.

5.3 Labour force and skills

This section will look into the labour market conditions for the ME sector: How many people are employed in the companies in the sector, at which skill levels? Is the supply of labour with the right skills sufficient in view of the demand – currently, and in the future?

Providing answers to these questions require statistical data and information about:

- Employment in the sector
- Employment in the sector per skill level
- What are the right skills
- And for each of these skill types or qualifications, what is the current and future supply of labour.

In order to be of relevance for educational planning and labour market policy, these analyses furthermore should take into account at least national differences.

The analyses below employs data from publically available databases at Eurostat and OECD supplemented by information from Cedefop's medium terms skill forecasts[130] and qualitative information from this sector itself and other relevant sources. The analysis could be refined considerably by using Eurostat micro data, which would allow linking directly NACE, ISCO and ISCED variables at the individual level. Further, methodological approaches and data from the US (O*NET and the Bureau of Labor Statistics' Employment and Occupational projections could be exploited further[131]. The scope of the present study has not allowed us to pursue this approach, but it can be recommended that further work is undertaken in this direction.

Reasonably recent and historical employment data are obtainable at NACE 2-digit level from Eurostat. The analyses of employment trends and the distribution of employment below therefore refer to NACE 28, "Manufacture of machinery". Whenever we refer to "the sector" in this section, it refers to NACE, 28 Rev. 2. This sector definition does fully correspond with the delineation of the mechanical engineering sector as defined in the terms of reference for this study, with the exception of repair and installation.

Concerning employment data per skill level, these are only obtainable for NACE at the broad level (Manufacturing), and only for three ISCED skill levels (low, medium, and high skills). These skill levels are so aggregated that they provide very little useful information for policy makers and education planners. The medium skill level in a manufacturing company will for example include employees in the production, but also those in sales, marketing and administration. In addition, as the data are only available for the entire broad manufacturing sector, the consequence is that the figure for e.g. employed at the high skill level includes not only engineers, specialists, and managers in mechanical engineering, but also finance directors in food processing, human resource managers in the textile industry etc. etc. Hence, data on skill levels will only be touched upon briefly and interpreted with the utmost caution.

130 Cedefop (2009) "Future skill needs in Europe: medium-term forecast. Background technical report", Publications Office of the European Union, Luxembourg, http://www.cedefop.europa.eu/EN/Files/3051_en.pdf

131 O*NET: The occupational classification and database used in the US. http://www.onetonline.org/ The employment and occupational projections can be accessed at the website of the Bureau, http://www.bls.gov/

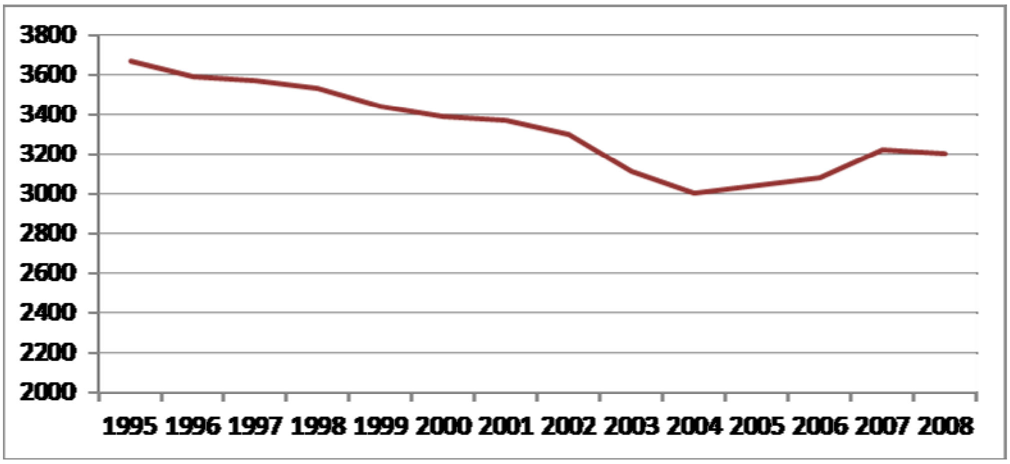
In order to provide a more precise picture, we have analysed data on employment by occupational categories[132]. Again, these data are only available at the broad NACE levels. Data on the supply of labour are even more difficult to obtain. The following analyses use data for NACE 28, manufacture of machinery. Whenever we refer to “ME” or to “the sector” below, the reference is to NACE (Rev. 2) 28 or to NACE (Rev. 1) 29. For the assessment of skill needs, it would be highly relevant to use vacancy data. The vacancy data available in Eurostat are however only reasonably complete up to and including 2007, which means that it is not relevant to use this dataset in the assessment of current and future needs.

5.3.1 Overall development in employment

In all 2.93 million people between 15 and 64 are currently employed in manufacture of machinery in EU 27[133].

Overall, employment in ME decreased by 12.6% between 1995 and 2008. Figure 5.1 below shows the development of total employment in ME in EU27 since 2000. Employment decreased up to 2003 followed by a slow growth up to 2008, after which employment fell again.

Figure 5.1: Total employment in Mechanical Engineering in EU27, thousands



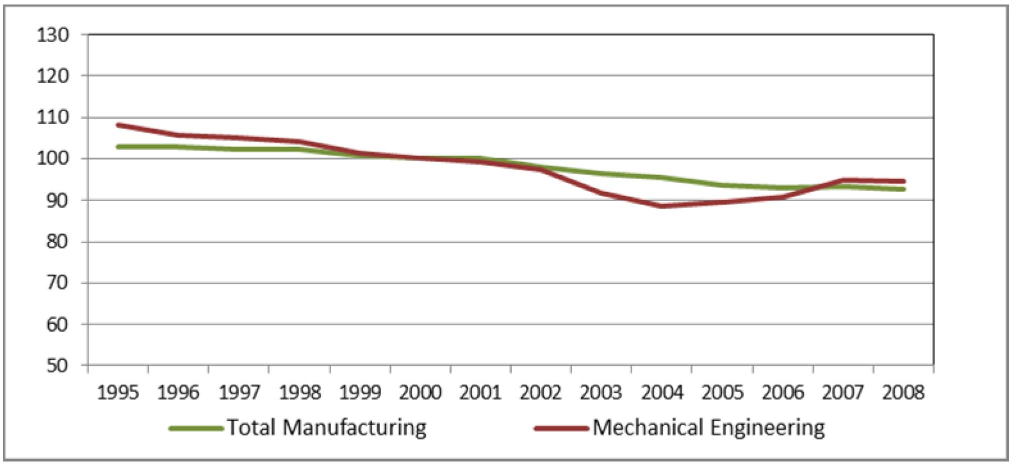
Source: Eurostat, Labour Force Survey, own calculations

The fall is to be expected in an economic downturn. However, if we compare the development of employment in ME to the overall development of employment in manufacturing (see Figure 5.2), ME employment has been fluctuating more, indicating that the sector is more prone than manufacturing industries on average to react to economic cycles.

132 According to the ISCO classification of occupations at broad level The occupations relevant for the sector are: Legislators; senior officials and managers; Professionals; Technicians and associate professionals; Craft and related trades; workers; Plant and machine operators and assemblers; Service workers and shop and market sales workers; Elementary occupations; Clerks

133 NACE (Revision 2) 2-digit breakdown, 28. This and following figures are from Eurostat unless otherwise referenced.

Figure 5.2: Employment trends in Mechanical Engineering and total manufacturing, EU27. Index figures, 2000 = 100

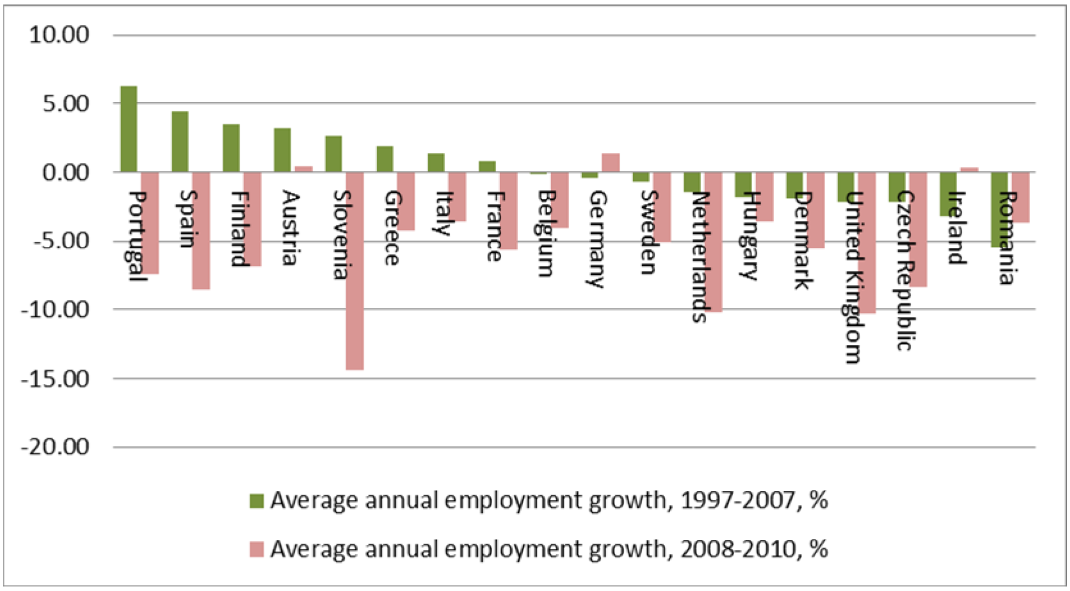


Source: Eurostat, Labour Force Survey, own calculations.

5.3.2 Country trends in employment

Behind this overall picture of the development of employment in ME the reality at national level is much more complex and varied. Figure 5.5 below shows the average annual growth in employment in ME in 18 European countries before and after the crisis[134].

Figure 5.3: Average annual employment growth in Mechanical Engineering in European countries1997-2007 and 2008-2010, %



Source: Eurostat, Labour Force Survey, own calculations

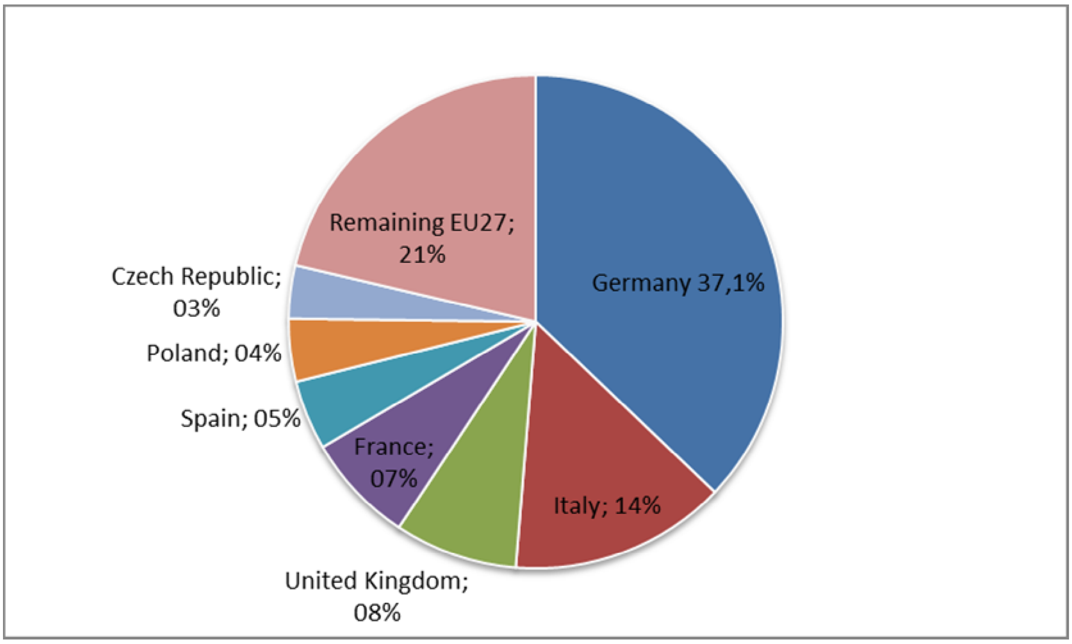
[134] The data series for the remaining countries (Luxembourg, Latvia, Slovakia, Poland, Bulgaria, Cyprus, Malta, Lithuania and Estonia) are incomplete.

As the figure shows, a number of countries experienced a positive employment growth in ME before the crisis. This group includes a number of Mediterranean countries (Portugal, Spain, Greece, Italy), but also Finland, France, Austria and Slovenia. Among these countries, only Austria has experienced (slightly) positive employment growth rates after 2008.

In the remaining countries, ME experienced employment losses already before the crisis to a lesser (Germany, Belgium, Sweden) or larger (Romania) extent. In Germany and Ireland, employment development following the crisis has on average been positive, and in Romania, the job losses appear to continue at a slower rate, but for the remaining countries, job losses have accelerated after the crisis.

The jobs are quite unevenly distributed across Europe. Figure 5.4 shows European countries'[135] share of the total employment in manufacturing of machinery in Europe. As the figure illustrates, German companies contribute more than a third of the jobs in ME in Europe followed by Italy, the United Kingdom and France, who between them contribute another two thirds of jobs in the industry.

Figure 5.4: Share of total European employment in manufacture of machinery, 4th quarter of 2010, EU27.



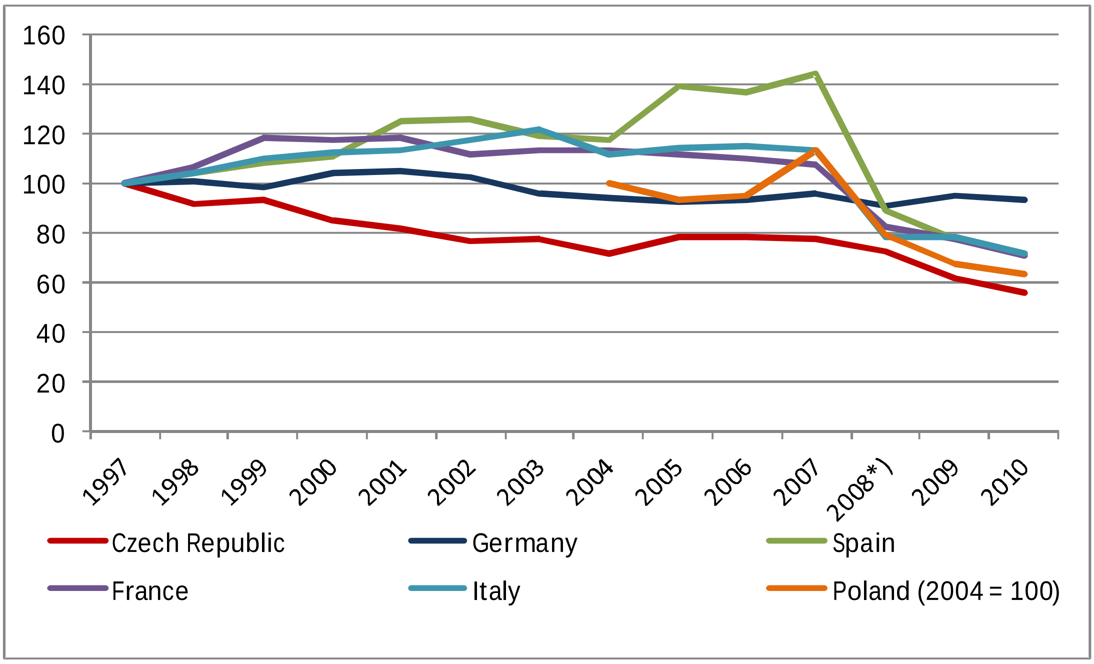
Source: Eurostat, Labour Force Survey, own calculations

Looking back to 1997, the development of employment has been quite different in these countries, however. Figure 5.5 illustrates the development of employment[136] between 1997 and 2010 for the six Member States with the highest share of European employment in Mechanical Engineering. The figure shows that in all these 6 countries, employment in the sector was less in 2010 than in 1997, most pronounced in the Czech Republic and in Poland, where employment in Mechanical engineering in 2010 was only two thirds of

[135] EU member states plus candidate countries.
[136] The figure shows index figures, as the difference in the magnitude of the absolute employment figures prevent us from comparing them within one chart.

that in 1997. Spain experienced rapid employment growth in the sector up between 2004 and 2008 followed by a just as rapid decrease to 70% of the 1997-level. France and Italy experienced a slow growth up until the crisis, while the decline in employment in Germany set in already in 2001.

Figure 5.5: Development of employment in Mechanical Engineering, Countries with the largest share of European Employment in Mechanical Engineering. Index, 1997 = 100



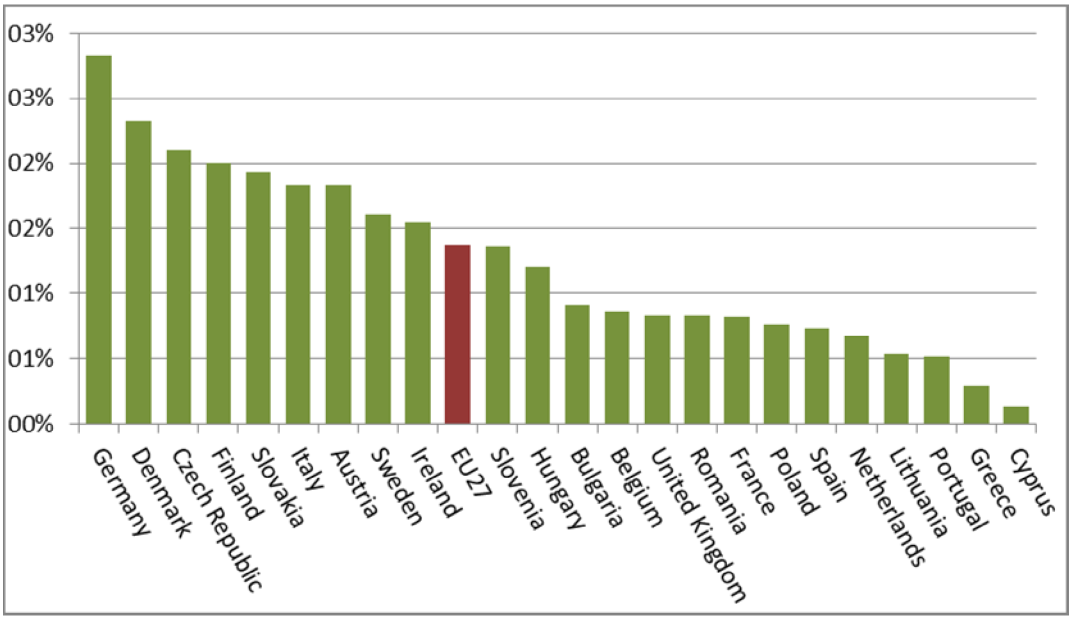
Source: Eurostat, Labour Force Survey, own calculations.

**) 2008 marks the shift from NACE rev. 1.1 to NACE rev. 2.*

5.3.3 National importance of ME as an employer

If we want to judge the importance for 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 5.6 shows ME's share of employment at the national level. This share varies between 0.1% (Cyprus) and 2.8% (Germany), and has in most countries remained fairly constant since 2008.

Figure 5.6: Employment in manufacturing of machinery as a share of total employment in EU Member States. 4th quarter 2010



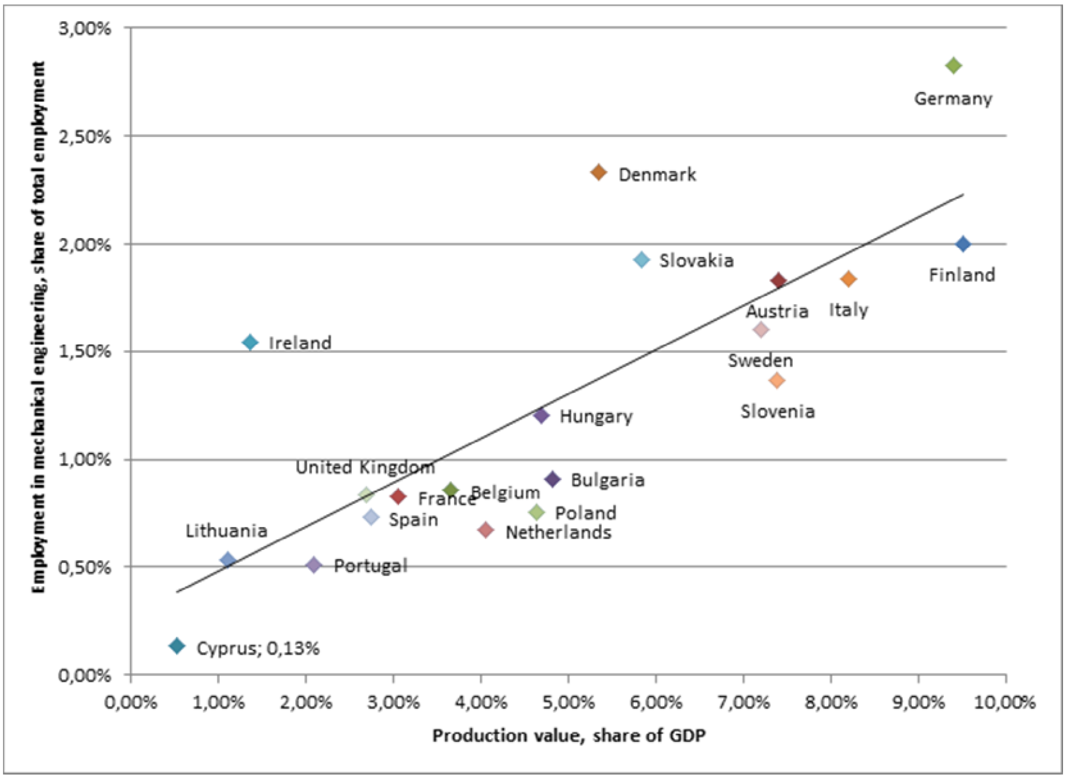
Source: Eurostat, Labour Force Survey, own calculations. Estonia, Latvia, Luxembourg and Malta are left out due to missing data.

Just like Germany has the largest share of European employment in the sector, the national importance of the sector is also largest in Germany. But it is followed by a number of countries, where the numerical size of sector employment is not visible at the European scale, but where the sector nevertheless is an important employer, notably Denmark, the Czech Republic and Finland. In these three countries the sector accounts for 2% or more of total employment. At the other end of the scale, the sector's share of employment is particularly negligible in Lithuania, Portugal, Greece, and Cyprus.

Finally, we can relate the relative importance in each country of the employment created in mechanical engineering to the relative importance of the sector in the economy. Figure 5.7 shows this relationship for each country for 2008[137]. The figure indicates a positive correlation between the share of employment in the sector and the share of GDP produced. However, there is considerable variation which reflects differences in productivity in the sector between the Member States: for instance, the Swedish ME industry produces 7.2% of GDP with 1.6% of its employed labour force, while the Irish ME industry using a similar share (1.55%) of the employed labour force produces only 1.3% of GDP. Strikingly, the ME industries of Germany, Denmark, and Ireland all produce a much smaller share of GDP than their share of employment would warrant.

[137] Regrettably, these data are not available for later dates.

Figure 5.7: Production value of mechanical engineering as a share of GDP and employment in ME as a share of total employment. 2008.



Source: Eurostat (sbs), own calculations. The Czech Republic, Estonia, Greece, Latvia, Luxembourg, Malta, and Romania are left out due to missing data.

5.3.4 Sub-sector developments

For the changing relative importance of sub-sectors to employment, clues may be taken from ex-post figures as well as projections of employment per subsector that are available from the US, see Table 5.1. These figures give an indication of which subsectors are expected to create increasing numbers of jobs in the future and which sub-sectors are expected to contract, employment wise.

Table 5.1 Ex-post and projected annual rates of change in employment in machinery manufacturing in the US.

Industry	Employment		Output	
	Average annual rate of change		Average annual rate of change	
	1998-2008	2008-18	1998-2008	2008-18
Agriculture, construction, and mining machinery manufacturing	0,0	0,3	0,0	3,0
Industrial machinery manufacturing	-3,4	-2,6	0,7	-0,5
Commercial and service industry machinery manufacturing	-3,5	0,0	-1,1	1,2
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	-2,1	-2,8	0,8	0,9
Metalworking machinery manufacturing	-4,0	-0,1	-1,1	1,4
Engine, turbine, and power transmission equipment manufacturing	-0,9	-0,7	1,7	3,4
Other general purpose machinery manufacturing	-2,9	-0,9	0,0	1,4
Machinery manufacturing, total	**-2,4**	**-0,8**	**0,2**	**1,8**

Source: US Bureau of Labor, Employment projections, extraction. Red cells indicate decrease, yellow no change, and green cells growth.

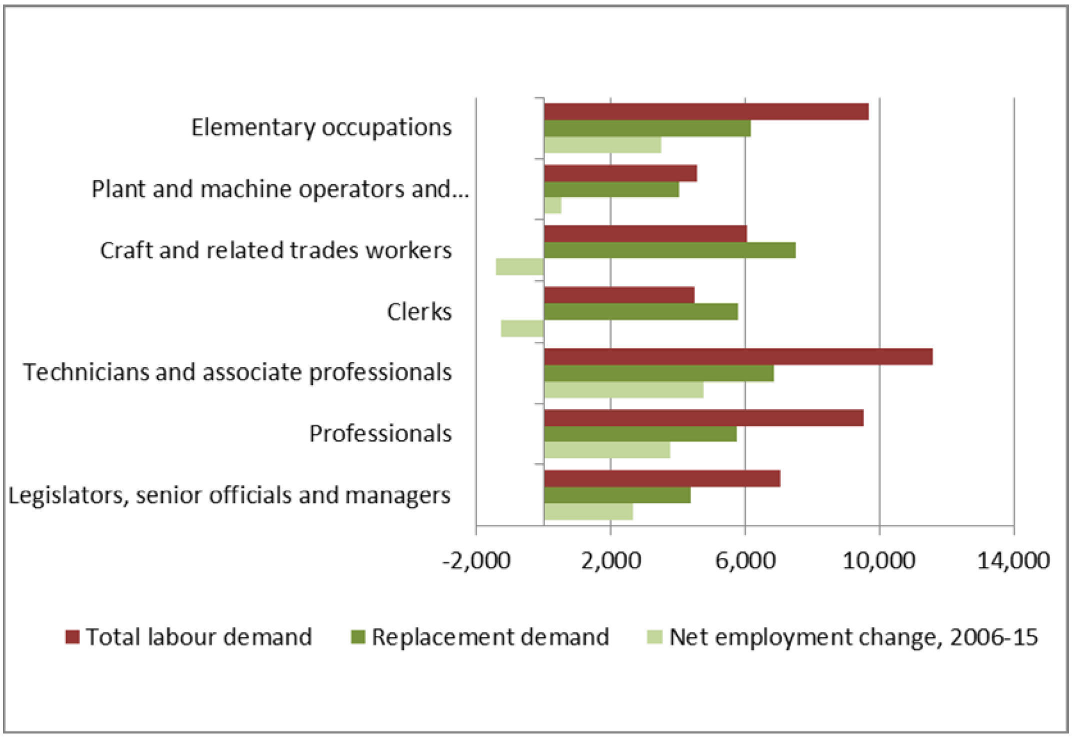
The table shows that overall, and in spite of an average annual growth of output of 0.2% between 1998 and 2008, employment declined by on average 2.4% each year in the US. This is in line with the historical development in Europe. Likewise, in spite of positive expectations to future output growth, employment in ME is expected to continue to decline up to 2018. The Bureau of Labour expects the decline to be considerably slower than was the case before 2008. Employment growth is foreseen only in one subsector: Manufacturing of agriculture, construction, and mining machinery.

5.3.5 Occupational structure and qualifications

The coincidence of positive output and negative employment growth is closely linked to productivity growth, and in this sector to technological improvements which facilitate efficiency. As we have seen earlier, the sector has experienced a steady growth in productivity. This well-known phenomenon in industrial development is frequently accompanied by a shift in the occupational structure of companies and an upwards shift in the skills and qualifications of the workforce.

A major study undertaken by Cedefop of future skill need and skill supply in broad sectors in Europe can contribute to the overall understanding of the challenge facing ME, albeit not as detailed as could be wished for in order to enable a targeted educational effort in European countries. The study team has modelled the demand for labour by occupations across all sectors by projecting figures for net employment creation and replacement demand from 2006 – 2015. The resulting figures per occupation are illustrated in Figure 5.8.[138]

Figure 5.8: Aggregate replacement demand and labour demand (all sectors) per occupation. In Europe[139]



Source: Cedefop (2009), Future skill needs in Europe: medium-term forecast.

As the figure indicates, a sizeable demand for *professionals*, *technicians* and *associate professionals* is expected towards 2015 across all sectors. In these occupational categories, we find the engineers and technicians working in ME. The figures indicate that persons with technical skills will be in high demand all over Europe, and ME will face competition from other sectors (like the aerospace and the automotive sector). The implications for ME are described by SEMTA, the UK Sector Skills Council for Science, Engineering and Manufacturing Technologies. SEMTA sums up the skills challenges for ME thus:

"Although overall employment is declining, there is still a need for the sector to recruit – particularly managers, skilled craftspeople and operatives. A lack of technical and practical engineering skills is the major cause of skill-related problems. The biggest skills gap is in CNC machining. Strategic management, entrepreneurship and technical skills such as advanced design skills are crucial to improving productivity. There is also a need for the current workforce to have skills that make them more flexible and adaptable.

By 2014 skilled craftspeople and operatives are expected to make up a lower proportion of the workforce. High-value work will bring opportunities for more managers, professionals and technicians. Support occupations within the sector such as administration, sales and customer

[138] Occupations which are not relevant for the sector are not included in the figure.
[139] EU25 + Norway and Switzerland.

service will also grow."
http://www.semta.org.uk/employers/mechanical/sector_overview.aspx

As already mentioned, European data on qualification levels are only available at broad NACE and ISCED levels. Hence, on the basis of these data it is not possible to assess the magnitude of the changes in the relative job creation between the subsectors within the ME sector or the shift between occupational profiles within the workforce of companies in the sector.

5.3.6 Evidence at the national level

At the national level however, more detailed data are available in a number of countries.

In *the UK*, Semta, the Sector Skills Council for Science, Engineering and Manufacturing Technologies, monitors the development in the industries in the sector. The box below is a summary of key facts concerning employment in the sector from 2008. The Semta overview discloses specifics of the British mechanical equipment sector with its dominance of extremely small enterprises that are not typical for mechanical engineering.

UK Sector Overview[140], key facts

- 274,300 people are employed in the mechanical equipment sector.
- The sector needs over 67,000 people to replace those retiring or leaving their jobs between 2005 and 2014.
- The mechanical equipment sector is characterised by small firms: 73% of sites employ between 1 and 10 people.
- Skilled craftspeople that have completed a trade apprenticeship make up 30% of the workforce.
- 12% of the workforce has no qualification.
- 32% of the workforce does not have a qualification at S/NVQ Level 2[141] or above.
- 24% of people working in the sector hold a qualification at S/NVQ Level 4 or above[142]. This is below the average for all sectors in the UK.
- An annual growth rate in employment of –1% is predicted for the sector.

Source: Semta. Data from 2008. http://www.semta.org.uk/employers/mechanical/sector_overview.aspx

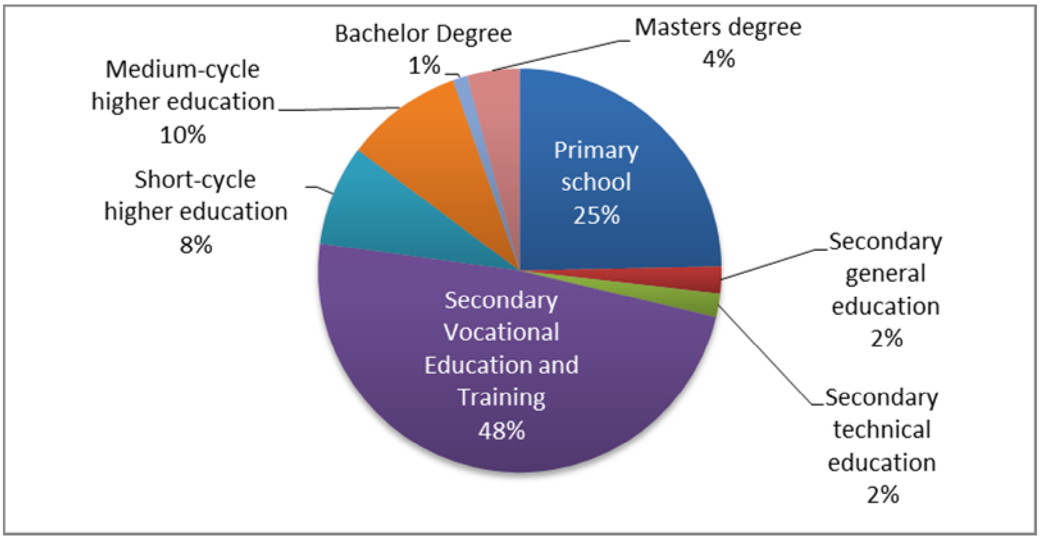
In *Denmark*, Statistics Denmark monitors the composition according to level and type of qualification of the Danish workforce in different industries. The distribution of employees in manufacturing of machinery by level and type of qualification is shown in Figure 5.9. Almost half the workforce has a vocational education or training (VET) qualification, a quarter has a higher education and another one quarter has only primary school education as their highest qualification. Historical data are only available from 2008 and 2009, but there was no significant change from 2008 to 2009.

140 The sector definition of Semta is not fully compatible with the definition of the sector used by the present study. Semta's sector definition covers: machinery for the production and use of mechanical power – for example steam or gas turbines, marine engines and their components; pumps, taps, valves, compressors and components such as bearings and gears; weapons such as tanks and other fighting vehicles and ammunition; and machine tools and machinery used in the manufacture of domestic and industrial products

141 Approximately corresponds to lower secondary level

142 Higher education levels.

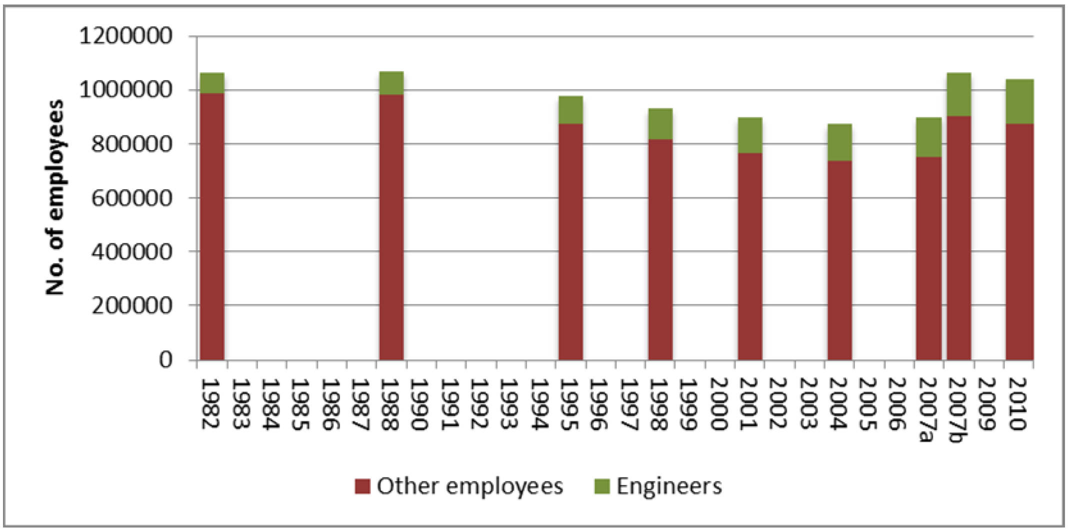
Figure 5.9: Qualification levels of employed in manufacturing of machinery in Denmark 2009



Source: Statistics Denmark, http://www.dst.dk/, own calculations

The last example indicates that the educational level of employees in ME is relatively high compared to other manufacturing industries. And not only is the skill level high, it is also increasing, according to findings of the German engineering association, who conducts regular views of engineers' employment in different sectors. The trend in the employment of engineers in ME in Germany is shown in Figure 5.10.

Figure 5.10: Development of the share of engineers in employment in Mechanical Engineering in Germany 1982-2010



Source: VDMA 2010143, own calculations[144].

143 VDMA: Ingenieure im Maschinen- und Anlagengebau. Ergebnisse der VDMA-Ingenieurenhebung 2010.
144 In 2007, the methodology was changed, resulting in a break in the series.

As the figure illustrates, the share of engineers among staff in ME has more than doubled over the period 1982-2010, from 7% in 1982 to more than 16% in 2010, indicating that the skill level has increased considerably in the sector.

5.3.7 Evidence at sub-sector level

A still more detailed sub-sector level (but still in Germany), ZVEI (the German association of electro-technical and electronics industry) in 2010 carried out a survey among its members concerning the engineering staff[145]. 93 companies, equivalent to a response rate of 31.4%, responded to the survey.

Among the main results of the survey were:
- The share of engineers among employees in the electro-technical and electronics companies has increased considerably, from less than 15% in 1988 to more than 20 in 2009;
- But at the same time, the engineers who are in the labour force are ageing – the average age has been steadily rising since the 1980s and is now at 46 years.
- The share of new graduates entering the workforce is not increasing in proportion to the rise in demand;
- Perhaps as a consequence, the share of ‘other academics’ among newly recruited with a higher education in 2009 is quite high (35%);
- While the share of machine engineers has decreased, the shares of electronics engineers and “other” engineers have increased, and the companies expect to hire more electronics engineers in the future as well;

According to the VDMA report, jobs of engineers in ME are mainly in R&D (44%) and in sales (16%); It appears that that employees whose initial education is within engineering take up non-engineering positions in the ME industries:
- 8% of the employed engineers work in the production and delivery of services,
- 9% of engineers are employed in administration or as managers.
- More than 60% of CEOs and top managers ME are engineers.

In other industries such positions would typically be filled by candidates with a background in economics or business studies. Along the same lines, the ZVEI figures indicate that engineers are well represented among management in the sub-sector, but the ZVEI survey also reveals that there is significant differences according to company size: The larger the company, the fewer engineers at the top levels.[146]

[145] For a presentation of the results of the survey, see http://www.zvei.org/fileadmin/user_upload/Forschung_Bildung/Ingenieurumfrage_2010_final.pdf

[146] Technological know-how is of importance for engineering companies not only in departments, such as R&D and production. For instance, in sales departments engineers are indispensable. Engineering products are in need of explanation and clients’ requirements need technical solutions. In procurement the need for engineering know-how is of similar importance. Engineering know-how might not be an indispensable prerequisite in other companies’ departments, but eases communication and understanding. Responsibility for larger contracts is a top management responsibility and explains that even CEOs hold a technical degree. This is especially true for medium-sized enterprises, for larger firms the organizational differentiation gives more room for a division of management and technical functions.

To sum up, while robust comparable statistical data are not available at a level which would allow an estimate over the overall labour and skill needs, the information from countries and sub sectors all point to the same trends in the composition of the work force in the sector:

- An overall decrease in the work force relative to output (increasing productivity)
- A comparatively high and increasing share of employees with a qualification at or above the level of a skilled worker (technicians and engineers)
- A comparatively high and increasing share of academic staff (mainly engineers)

5.3.8 Current skill needs and skill shortages in the EU for different types of work

In the survey to associations, we asked about their perception of the labour market for specific types of employees.

Most of the eight associations that responded[147] were concerned that there are bottlenecks to fill certain occupations/job functions in the companies. They are not in full agreement as to which types, but show a pattern (Table 5.2). The associations generally see no problem concerning the supply of qualified staff for positions in *management* or *sales*, while there are shared concerns about the supply of *engineers* (two associations see this as a bottleneck, three experience scarcity). There are only two respondents who express that the supply of engineers is sufficient. Even more pronounced is the bottleneck for *Machine operators* (one experiences bottlenecks, while six see scarcity). This lack is regionally focused and problems have been highlighted above all from representatives of member states which do not offer a formal apprenticeship curriculum. The Spanish association SERCOBE complained about the abolition of such an educational scheme long-time ago. The picture is less clear concerning the remaining occupational categories.

Table 5.2: Short term demand and supply as perceived by associations

Labour Sufficiency of supply Job type	Sufficient	No need currently	Scarce	Bottleneck
Machine operators			1,2,6,7,8	3, 5
Engineers	3,4		2,5,6	1,7
Reseachers/scientists	4		3,6	7
Production control/planning	4	1,2	3,7	5
Other qualified blue collar	3,7		1,8	
Management services, sales	1,2,3,6,7	4		

Source: Survey to associations in ME.

In the UK, SEMTA has summed up the situation concerning skills gaps thus: 23% of sites have skills gaps, while 20% of sites have hard-to-fill vacancies.

[147] 1: Fachverband Maschinen und Metallwaren Industrie, Austria; 2: European Sectoral Committee Compressors, Pumps, Valves; 3: EUROMOT; 4: Eurovent; 5: VDMA; 6: VDMA-FEM; 7: CECIMO; 8: Federation des Industries Mecanique (FIM)

The German figures from VDMA[148] show that 55% of the companies in ME expect to recruit more engineers. Only 1% expect to recruit fewer. The companies expect skills gaps in the following areas:

- International activities (73%)
- Research and development and construction (62%)
- Sales (61%)
- Services (49%)
- Materials management (45%)
- Production (43%)

The associations were asked what knowledge and which skills would be needed in the companies in the future, and by which groups of employees. Only three companies, one association (VDMA) and a European Sectoral Committee (EUROMOT) answered this question. The replies are shown in the table below

Table 5.3: Skills required to a larger extent over the next 3-5 years in different jobs in ME companies

Job type / Skill types needed	Management/ administrative staff	Scientists/ academics	Engineers	Skilled workers
ICT skills	C1	C1, C2	C1, C2	C1
Linguistic skills	C1, C2, C3	C1, C2, C3	C1, C3,E	C1, C3, A
Cultural issues	C1, C2		C1	
Management skills			C1,A, E	
Marketing/sales skills	C1, C2	C1	C1	C1
Communicative skills	C1, C2 E	C1	C1	C1
Technical skills	C1	C1, C2	C1, C2	C1, C2

Legend: C1: Kalfrisa, company producing heat recovery equipment etc.; C2, VanDerLande Industries, company producing baggage handling equipment; C3: Imedexsa, company producing metallic structures (towers); A: VDMA; E: EUROMOT.

Even though this is little to go by, there are some observations to be made from the table: The skill type most in demand appears to be linguistic skills. All companies agree that these will increasingly be required among management and administrative staff, and two out of three, that they will also be required in engineers and skilled workers.
At the opposite end of the scale, management/administrative skills appear not to be in demand. The only group of employees who will need these skills, according to one company, the association and the Sector Committee, is the engineers.

[148] A summary of the results is available at http://www.cemat-network.com/fileadmin/Documents_and_Pictures/02_News_Presse/VDMA/VDMA_Ingenieure_im_Maschinenbau_2010_02-11-2010.pdf

In the same vein, FFMI, the Austrian association for machine and metalware industries, has indicated that whilst skills within sales and marketing skills are increasingly required, such skills should be developed on the job, as marketing graduates are eloquent academics that are not of much use for engineering companies'.

Thus, when a shortage of engineers is reported, it appears that some of it may be due to a tradition or culture in ME companies to fill positions in top management and staff functions like marketing and communications with engineers rather than business graduates or economists. However, for most of the medium-sized enterprises technological know-how is crucial not only for the understanding of product innovation, but for the understanding of clients' needs and the opening-up of new market segments.[149]

CECIMO calls for education of engineers to include more practical subjects like information about standardisation, compliance as well as use of engineering tools such as IT programmes (example Pro Engineer, Solidworks) in the amount of time allowing the students to use the tools and knowledge immediately. Environmental and energy efficiency issues to be included in the curriculum.

There is little evidence in the survey to illustrate companies' or associations' reaction to identified skill needs. The only concrete example comes from Austria, where English language is being introduced in technical education (engineers, VET and short cycle higher education).

5.3.9 Availability of skilled staff

The previous sections indicate that ME companies in the very near future will require a skills and knowledge base which differs from that of the existing staff. There are basically two (not mutually exclusive) approaches to improving the competence base of the sector: Recruitment of staff with profiles that better match new needs; and competence development of the existing staff.

Recruitment base

The available statistics at European level are not sufficiently detailed for a quantitative assessment of the supply of the employment potential with the specific types of VET qualifications required by the ME sector.

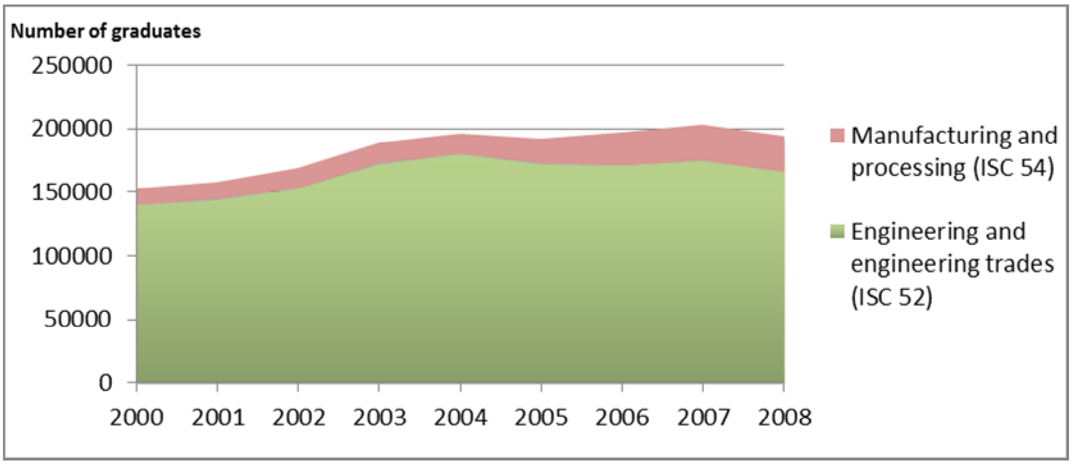
As companies expect to recruit more engineers and as engineers are at the same time considered by some of the associations to be in scarce supply, a further look at the supply of engineers is merited. For engineers, supply data are available in the form of information about the number of engineering graduates (excluding construction engineers) subdivided according to the broad fields of study of the ISCED classification[150]. The relevant codes are ISC 52 Engineering and engineering trades, which includes studies within engineering drawing, mechanics, metal work, electricity, electronics, telecommunications, energy and chemical engineering, vehicle maintenance, and surveying; and ISC 54 Manufacturing and processing, which includes studies within

149 Only in few market segments – characterized by large batch production – marketing is an issue for strategic decision making.

150 For an overview of the classification, see http://www.uis.unesco.org/TEMPLATE/pdf/isced/ISCED_A.pdf

food and drink processing, textiles, clothes, footwear, leather, materials (wood, paper, plastic, glass, etc.), mining and extraction. The development in the number of graduates is shown in Figure 5.11**.**

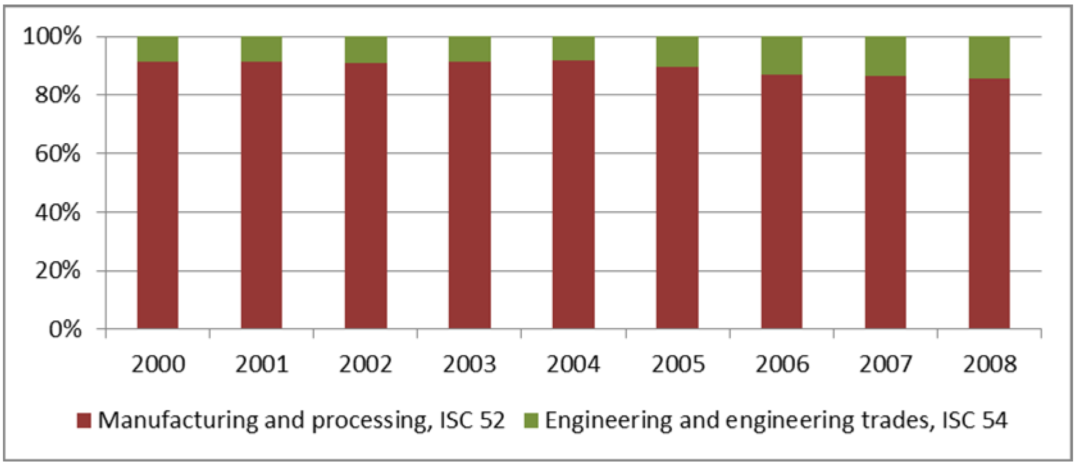
Figure 5.11: The development in the total number of engineering graduates in 14 EU member states151 by field of study (ISC 52 and ISC 54 accumulated)



Source: OECD Stat, own calculations

The figure shows that the number of engineering graduates from the two fields of study has increased by almost on third between 2000 and 2004, followed by a decline and a recovery up to 2007and finally decreased of about 10,000 in 2008. The number of graduates within ISC52 (engineering and engineering trades) immediately appears as the most relevant measure of the supply of potential employees at this educational level for ME. A closer look at the figures reveals that although the number of graduates within this broad grew by 20% over the period, the growth within ISC 54 was much faster, so that its share of the total number of graduates in the 14 EU Member States was 14.5% in 2008 as against 8.5% in 2000, see Figure 5.12.

Figure 5.12: Relative shares of graduates in 14 EU Member States in the two fields of study ISC52 and ISC 54, 2000-2008



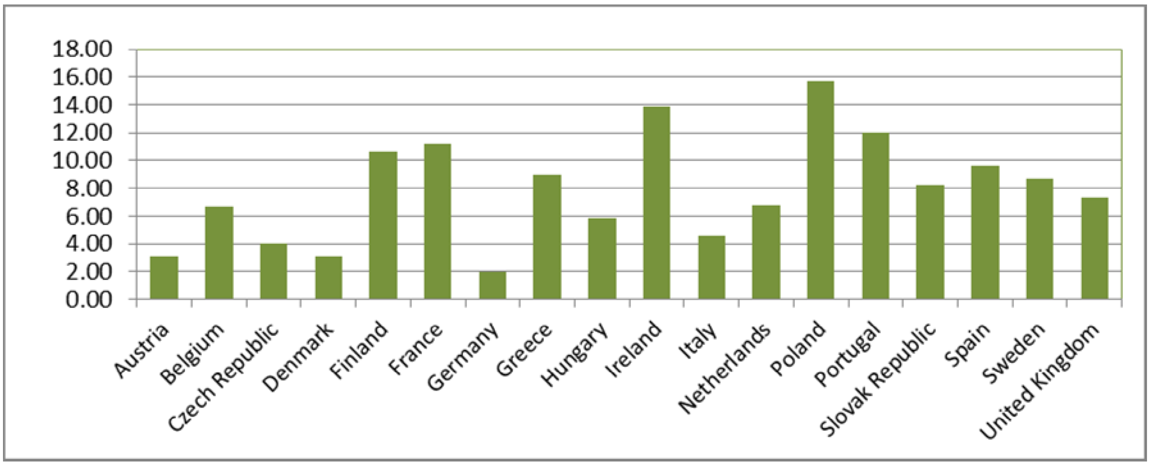
[151] Data are missing from the non-OECD members: Bulgaria, Cyprus, Estonia, Latvia, Lithuania and OECD. Slovenia only became OECD member in 2010. Data series are incomplete for Greece, Ireland, Luxembourg, Poland, Portugal and the UK.

Source: OECD Stat, own calculations

At a first glance, the figure appears to indicate that there has been decrease in the share of engineering graduates – and since 2004, also in the number of graduates – in the fields of study from which ME companies most probably recruit graduates. We would however warn the reader against drawing too far-reaching conclusions based on these data. *First*, engineering studies within the broad field ISC 52 not only target ME, but also other sectors (e.g. public supplies, telecommunications, the ICT sector, to mention just a few). *Second,* it cannot be ruled out that graduates whose studies are classified as ISC 54 find employment in ME. Third, the data series do not cover the whole EU27, and some of the data series are incomplete, cf. footnote148.

Following a hypothesis that ME companies requires engineering skills in the same proportion no matter in which country they are located, we have calculated the number of engineering graduates in European countries against the employment in ME in the same country. The result is shown in Figure 5.13.

Figure 5.13: Engineering graduates (ISC 52 and 54) as a share of employment in Mechanical Engineering 2000-2007



Source: OECD stat and Eurostat, own calculations

First, again we have to recall that most of the ISC 54 obviously will never be employed in ME companies, whereas many graduates of ISC 52 will end up being employed in electrical engineering or the automotive industry. Having said that, the figure suggests that the supply of engineers per employee in the ME sector varies considerably across Europe. Poland tops the list with almost 16 new engineering graduates per 100 employees in ME, while ME in Germany, Austria and the Czech Republic have access to less than 4 engineering graduates per 100 employees in ME.

This observation does not, however, take into account the fact that labour markets are increasingly transnational or even global for employees with high-level qualifications. It also does not take into account the fact that variations between subsectors may influence the demand for specific types of qualifications. Finally, even though we have excluded construction engineers from the analysis, the remaining number of engineers includes graduates with many different specialisations, of which only a fraction is relevant for the ME sector. A sizeable share of engineering graduates, for instance, earns their degrees in

ICT-related fields or bio-engineering, both of which are of no immediate relevance to ME. Therefore, the statistical information gives only a very rough estimate which should not lead us to make too firm conclusions (like e.g. ME has access to relevant engineering expertise in Ireland or Poland, or that a there are recruiting problems at this level in Germany or Austria).

5.3.10 Future occupational profiles

The quantitative approach taken in large-scale studies[152] above assumes that there is a one-to-one relationship between occupations, skills and qualifications. I.e.: An engineer (qualification) with a relevant specialisation will take up a job as engineer (occupation) using his engineering skills (and knowledge) to carry out the tasks.

This is however a very simplified approach which is unable to capture the complex reality in the companies. To exemplify, the evidence from the desk study indicates that engineers (qualification) hold jobs that have very little relation to their initial qualification as engineers, most strikingly many small engineering firms are managed by engineers who holds positions as CEO.

A different approach to assessing the skill needs in a sector is the qualitative, stakeholder oriented approach: You ask the stakeholders (companies, associations, training institutions etc.) about their experience of the labour market situation and their expectations to the future. For a short term view this approach is relevant, because the labour market for ME, according to the associations, is strongly regional. Hence, stakeholders' reflections on developments in regional clusters, in companies, in the subsector, in the regional educational and training institutions, etc. are highly relevant to that region. In the following section, we look into this type of evidence to get me response to the survey to sector associations to questions about labour markets for specific types of employees.

Concerning future skills profiles, a Danish foresight study[153] identified three job profiles for skilled workers in ME 2020:

Future skills profiles for skills workers in mechanical engineering

1. **"Opter"**
   (A linguistic merger between 'machine tool operator' and 'setter'). It is expected that production of long series in facilities with a low level of automation will disappear over the next decade. In this type of production, operators have traditionally played a major role. The main tasks of 'Opters' wills be conversion, maintenance, commissioning and quality control - and possibly prototype production. Where long series are still produced, machines will be replaced by equipment requiring less manual operation (increased automation and use of industrial robots).
   Employees with the 'Opter' profile will have to handle far more machines and focus on programming them, i.e. setting and changing settings as production varies. There will be a

[152] E.g. Cedefop's studies of medium terms skill needs and skill supply in Europe and the projections by the British Skill Co
[153] Industriens Uddannelser (2010). New Insight: Fremtidens jobprofiler i industrien 2010. ("Future job profiles in manufacturing"), Copenhagen, http://viewer.zmags.com/publication/ad47d33d#/ad47d33d/1

move away from 'one man, one machine', towards teams of 'Opters' operating a facility or an assembly of machines. Hence, communicative and collaborative skills will be a requisite at this level.

2. **"Blacksmith/welder – the creative craftsman"**
Production of long series will be taken over by welding robots, but there will be two essential job functions for an employee with a smith/welder profile in the future:
- Production of large unique structures
- Production of smaller products in short series
Instead of producing many identical products, blacksmiths will over the next decade move more towards a role as creative craftsman. The job function is characterised by varied tasks and the employee must be able to independently select the appropriate professional techniques and materials and not be dependent on the existence of drawings or instructions (…). On the technical side, the blacksmith/welder will be required to operate with more materials. The technical requirements to welding will increase because of the introduction of new materials. In all, fewer, but more specialised blacksmiths/welders are required in the sector.

3. **"Fitter" (Assembler)**
The automation of long lines will lead to a decreasing demand for assemblers. Assembly work will continue to be relocated to low wage countries, and high volume productions will only take place at highly integrated plants with limited need for manual assembly. There will however still be a demand for fitters for production for the European markets. In addition, fitters will be needed in operations being prepared for outsourcing or relocation. In this case, the task of the fitter will be to develop, test and commission various production processes. These tasks will require both analytical skills and adaptability. In some cases, automation and technical solutions means that the customer can take care of final assembly. But relocation may also require that fitters accompany the equipment to the new location, with associated increased demands on language and communication skills.

5.3.11 Skills needed as a result of strategic developments in the sector

A detailed assessment of future skill needs in the sector assumes that detailed information is available, at least at sub-sector level. The previous analyses have demonstrated clearly that the sector cannot be viewed as a homogenous body – the variations with respect to framework conditions, technologies, business models, markets, localisation in global value chains, and performance are substantial. Statistical information is too coarse to give relevant clues, and the survey to associations and companies has only elicited a limited amount of information, so the responses cannot and should not be interpreted as hard evidence of the needs of ME companies. Therefore the following section will look at skill needs which can be deduced from trends and drivers for the development of the sector and – to a certain extent – its sub-sectors.

Identifying *technical* or *occupational* skill needs at the level of the sector as an input to development of curricula in educations for technicians or engineers is hardly meaningful. Future technical skill needs will vary considerably between sub-sectors and depend critically on available technologies, on the state of the art of the type of product produced, and on market and regulatory conditions. Such skill needs need to be inferred at a lower level. Further, the more specialised the skill needs, the stronger the argument that skills should be provided through continued skills development rather than integrated in the initial curriculum. This argument goes for staff at all levels.

The analysis above however points to the need for companies in ME to develop the skills of their workforce in a range of more generic fields:

Skills for working with technological innovation

In chapter 4, it was pointed out that increasingly, new technologies integrate knowledge and technologies from multiple scientific disciplines in a "convergence" that will have profound effects on innovation and competiveness of the engineering industry. Materials technologies merge with ICT developments and biochemistry in new types of production equipment and products. If ME companies are to utilise such converging technologies to remain competitive, they will require technical staff (from skilled workers to engineers), who are able to use and integrate know-how and techniques from a variety of disciplines, and are able to perform in cross-disciplinary teams. Due to the extreme diversity and the pace of technological change and the considerable lead time of developing curricula and educating technicians and engineers, it will probably be unwise to envisage a situation where the curriculum of the initial education of technicians and engineers is expanded to include all these new fields of knowledge and instruments. Likewise, one can doubt the wisdom in creating still more specialised educational paths for skilled workers and engineers. In addition to core technical skills (for example in ICT), the rapid introduction of new technologies require skills that can be learnt mainly in a working environment or using methods of teaching that relate closely to workplace learning[154].

Generic skills for managing organisational change

The survey responses as well as the statistical analyses point to a strongly increasing complexity of the business environment of ME companies. Hence, the companies will need to strengthen their competences to comply with the increased need for planning, managing supply chains, cooperating with (global) suppliers and customers on innovation. Such skills include advanced management skills, cultural and linguistic skills and business skills. As the increasing complexity of the business environment is not particular to the ME sector, clues to skill needs may be taken from other sectors. An analytical report from 2010[155] about employers' perception of skills of graduate employees identified a set of skills and capabilities that graduate employees need to have (ranked by importance):

- team working skills;
- sector-specific skills;
- communication skills;
- computer skills;
- ability to adapt to and act in new situations;
- good reading/writing skills;

154

OECD (2009). *Working Out Change. Systemic Innovation in Vocational Education and Training* elaborates on systems, knowledge base and learning processes that underpin the development of innovative skills in the workforce, Organization for Economic Co-operation and Development, Paris.

155 European Commission (2010): Flash Eurobarometer 304: Employers' perception of graduate employability .Analytical report, pp 5-12

- analytical and problem-solving skills;
- planning and organisational skills;
- decision-making skills;
- good with numbers;
- foreign language skills;

Value chain specific skill needs

As already mentioned, the output of the engineering industries delivers innovative products, processes and services into the value chains of most others industrial sectors of strategic importance to Europe e.g. energy, transport, chemicals, pharmaceuticals and construction. These value chains are increasingly long and complex, and consequently, innovation of products and processes in the value chain requires the collaboration between the companies making up the chain. In order to contribute to innovation and competitiveness, management and staff of ME companies will therefore increasingly require an acute understanding, not only of the requirements of the industries that they immediately supply, but also of the requirements of the end users of their products and services, and of the social and political agendas shaping demand. In particular, ME companies will need to pay attention to possible changes in demand for their products related to energy, climate and the environment. For example, suppliers of agricultural machinery will need to be more attentive to new types of agriculture (energy crops, organic farming) as well as to the changing environmental and climate-related requirements on the agricultural sector. Business and communication skills will increasingly be required at all but the very lowest level of production and innovative skills at all levels.

Cluster-specific skill needs

ME companies are frequently parts of clusters involving diverse sectoral competences in order to create value based in a particular technology or area of application (e.g. nano-technology, bio-tech, automotive). In order to reap the full advantages of participating in a cluster-collaboration involving companies from different sectors in addition to research institutions and educational establishments, the companies require the organisational skills to utilise the access to know-how and skills present in a cluster.

5.3.12 Human resources policy with regard to flexibility of employment

On the basis of the survey to associations and companies in the sector, some observations can be made based on the associations' perception of their members' challenges and strategies. The associations were asked which strategies they and their members adopt in view of recruitment difficulties.

There is no University for applied sciences in technologies in Austria, leading to insufficient numbers of qualified applicants for positions in ME. Therefore, mechanical engineering companies recruit staff from CEE and as far away as Kazakhstan. They frequently get applications from southern Member States, but linguistic problems and lack of mobility present a challenge to recruitment.

In the subsector compressors, pumps, and valves, the association mentions compensation for overtime as the most important instrument to counter shortage of qualified labour.

The associations were asked about any steps they have taken to ensure that their member companies can recruit qualified staff in the future. They were given five options:

- Image campaigns in mass media
- Recruitment campaigns targeting universities and/or vocational schools
- Introduction of wage incentives (relative to other industries competing for the same types of staff)
- Introduction of other types of incentives
- Lobby towards more public finances for education in science and technology

Five of the associations carry out or participate in recruitment campaigns targeting universities and/or vocational schools.

The Federation des Industries Mecanique (FIM) co-operates with the French Ministry of Education to improve the image of the industry and to improve the sector's access to young people. One result of the cooperation is a scheme where pupils in school are given the opportunity to work part time in the industry to bring work closer to young people

5.3.13 Conclusion

The labour market and skills conditions in the ME sector in Europe are extremely varied due to different technology and market conditions in sub-sectors, and huge variations in productivity. Labour markets appear still to be quite regional, so that bottlenecks and shortages can easily occur. Regional and in-company competence development initiatives are insufficient to keep up with new technical requirements. Some companies have tried to reduce skill shortages by attempting to recruit technical staff from abroad, but language remains a challenge.

ME companies rely heavily on engineers and skilled technicians. As a share of total employment the qualified technical staff has gained noteworthy weight over the past decades. This development is in line with the increasing technical content of machinery and equipment and the growing share of services. System engineering and more complex solutions to meet clients demand for efficient production solutions are drivers of this trend. Moreover, the requirements to develop resource efficient processes to meet clients' needs and comply with the EU regulation have gained importance.

The demand for engineer is also driven by demography. The average age has been growing steadily. Two factors are driving the demand: the trend to more sophisticated and service driven technologies and the growing need to replace retiring engineers. This development is aggravated by the fact that ME enterprises are competing with the large players from the automotive and aerospace industries to attract engineers. This is in particular a challenging task for medium-sized enterprises that do not have fetching brands and cannot offer similar incomes.

ME has been acknowledged as an enabling industry that is crucial for the competitiveness of a broad range of downstream industries. ME has also been recognized as an "immobile" industry that cannot as easily relocate production locations as the IT industry. Traditionally high and growing qualification requirements are further specifics of ME that makes it less vulnerable than other manufacturing industries to emerging countries competition. But it must be taken in mind that they are busily upgrading their workforce technological intelligentsia. Measures have to be taken to meet the challenge.

5.4 Corporate finances

5.4.1 Changes in financial markets and enterprise funding

The global economic crisis hit ME by a high double digit breakdown of demand. Then, financial conditions became tight. Not only long-term funding of investments and large projects were hurt, but also the funding of the day-to-day business was affected by the reduction of current account credit lines. The turnaround in the real economy has led to soaring new orders and businesses have recovered. However, the financial markets have remained in troubles.

Since the Greek sovereign debt crisis had emerged during the first half of 2010 the problems have become more severe. The sovereign debt crisis puts a brake on public spending. The coming years will be marked by consolidation. Funding of public projects will remain under strict control in coming years. The situation has become even worse by the emerging crisis in the private banking sector. Default claims, rating adjustments as well as a stricter regulation of banks reduce banks' ability and preparedness to engage in lending. In particular companies in crisis-hit member states are affected. Their financial environment has shifted from extremely beneficial funding conditions with too low interest rates to tightened conditions.

Within Europe around 70% of corporate lending is banks' business, in the US only 40%. It is expected that banks lose importance and new players enter the market for corporate funding, many of them are investors - that before the crisis - had provided funds to banks as intermediaries. Financial players, such as BlueBay, M&G, are about to tap the market for financing smaller enterprises. For larger ME companies direct access to the financial markets will become more important. This has been a trend already observed since the turn of the millennium and it could accelerate.[156]

The European Commission has been busy to improve the financial environment in Europe by numerous initiatives. Round tables have been organized to bring together bankers and SMEs to identify barriers for finance that are encountered by SMEs. Special attention has been paid to new and up-to now not widely applied funding instruments, such as guarantees, venture capital and microcredit. A better functioning of private equity has always been high on the agenda and these initiatives have become even more of importance in recent years.

The European Investment Bank and the European Investment Fund have lending and investment programmes that can be accessed not only by large, but by small enterprises. Of special importance for peripheral countries' enterprises are the structural funds JEREMIE and JASMINE. Additionally with the European Progress Microfinance Facility (EPMF) microcredits to small enterprises are offered. To ease access and make known

[156] Alloway, T. and Wigglesworth, R. (2011) "New lenders move to fill the gap left by ailing banks", in: Financial Times, October 6th, 2011, p.26.

the schemes the EU has created the Enterprise Europe Network and launched the Access2Finance website. In 2008 and 2009 EU Finance Days for SMEs had been carried out to make the available schemes better known. SMEs of crisis hit member states can access these funding sources.

Special attention has always been paid for funding R&D to raise the pace of innovation by public institutions. EU budgets have been made available through the Competitiveness and Innovation Programme (CIP) as well as by the Framework Programme for Research and Development with its Risk Sharing Facility to contribute to enterprises' funding of research activities. They have gained importance to incite companies not to reduce their efforts during the phase of difficult funding conditions.

Much has been done to improve the financing for smaller enterprises by the EU, national and regional governments. However, these initiatives will only contribute to dampen the negative effects from financial markets. A fundamental change in funding conditions for manufacturing companies, large as well as small ones, will happen only when distortions from the sovereign debt and private banking crisis will be fading away in a couple of years.

5.4.2 Interest of financial investors in mechanical engineering

In times of economic uncertainty, banks are reluctant to lend money to corporations. However, firms still require financing for expanding, development R&D or marketing of innovations. In these times, external sources for financial means such as venture capital investors or private equity funds become more and more relevant. But how do investors value ME?

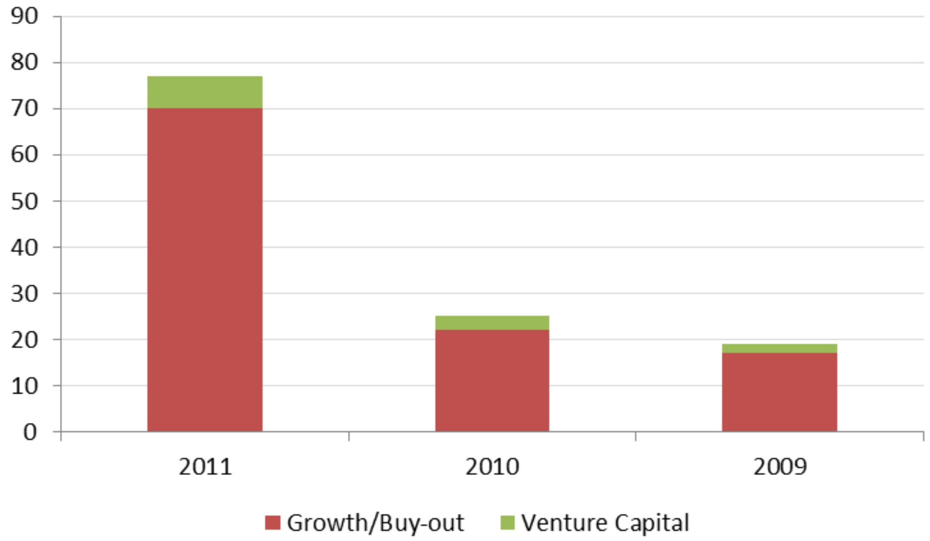
According to a study from the procurement service provider Inverto AG, engineering industries and in particular ME were the most preferred target industries for private equity investors. Here, funds ar above all provided to smaller firms with an established position in the market. However, also firms are interesting that might have some financial distress but own a solid business model. The study states that 88% of the surveyed private equity funds invest in mature businesses while 54% also select firms in their growth phase of the life cycle. 25% engage in restructurings and only 8% invest in start-ups.[157]

Even though smaller firms are the most interesting targets, investors seem to be flexible and on the hunt for a good opportunity. The engineering industries are the clear favorite and mentioned by 75% of the respondents, ME still gets 58%.

The question of which one would be the most attractive industry was asked in a study carried out by the "Bundesverband Deutscher Kapitalbeteiligungsgesellschaften". The results for a three-year-comparison are depicted in the diagram above. Interestingly, ME experienced a tremendous increase in attractiveness from 2010 to 2011. While attractiveness for venture capital has remained on a low but stable level, this increase was mainly driven by growth- and buyout-financing. Ranked fourth attractive industry, the ME was mentioned by 70% of respondents in 2011 for growth financing and buy-outs. Only seven percent of the respondents mentioned attractiveness for the venture capital investors.

[157] http://www.maschinenmarkt.vogel.de/themenkanaele/managementundit/finanzen/articles/61400/

Figure 5.14: Attractiveness of engineering industries and ME for private equity investors



Source BVK; calculations by Ifo.

We need to note that the investment industry experienced a general upswing between 2009 and 2011 which resulted in a systematic increase in attractiveness of most target industries. Still, the engineering industry climbed substantially. While in the years before, the engine building industry was placed on rank eight and six in 2010 and 2009 respectively, it was the fourth most attractive industry in 2010. This industry has gained investor awareness and convinces with good figures.[158][159][160]

The figure depicts that ME has been relatively unattractive for venture capital firms but was a consistently relevant target for growth- and buy-out-financing. Interestingly, the industry as a whole became more attractive for investors over the last three years. However, that was mainly driven by growth- and buy-out-financing.

The venture capital industry is traditionally dominated by investments in green-technology-, medical, bio-tech and IT-ventures. Such firms usually develop innovations that, for a long time, generate no revenue and need capital to market their product. Unable to finance themselves, they are pretty much dependent on external sources of money. While ME is an innovating industry most companies are well-established and finance most of their innovations by their own cash-flow. They are less dependent on funding by financial investors.

Growth-financing provides firms with capital to grow and expand their business. This might include financing a new factory, expanding internationally or developing new product lines. A buy-out implies acquiring a controlling interest in a more mature

[158] Bundesverband Deutscher Kapitalbeteiligungsgesellschaften (2011): Private Equity-Prognose 2011 – Erwartungen der deutschen Beteiligungsgesellschaften zur Marktentwicklung
[159] Bundesverband Deutscher Kapitalbeteiligungsgesellschaften (2010): Private Equity-Prognose 2010 – Erwartungen der deutschen Beteiligungsgesellschaften zur Marktentwicklung
[160] Bundesverband Deutscher Kapitalbeteiligungsgesellschaften (2009): Private Equity-Prognose 2009 – Erwartungen der deutschen Beteiligungsgesellschaften zur Marktentwicklung

company which often entails the introduction of new strategies[161]. For these two forms of private equity investing, ME has become a fairly relevant target over the last two years. ME had suffered a major breakdown in 2009 and capacities were redundant. In 2010 the utilization had increased due to a strong recovery and in 2011 more and more ME companies have reached capacity constraints and the industry has become more attractive for financial investors. Now, parts of the industry require financial means to expand capacities and handle demand.

In general, private equity investors pursue a medium- to long-term strategy for such investments. While three out of four investments are held for up to five years, the other ones even think about keeping the investment for a longer period. Most of surveyed investors stated, that the deal volume ranges from 50 to 500 million euro.[162]

The growing attractiveness of ME for financial investors in recent year relaxes the strain of companies somewhat, caused by banks' growing reluctance to give loans. ME companies are recommended to better exploit these funding channels.

5.5 Openness of international markets

5.5.1 Overview

The European technical regulatory system has turned out to be exemplary for the abolition of technical barriers to trade (TBT). The United Nations has launched an initiative for international harmonisation that is structured similar to the EU approach. The principles and procedures introduced by the European Commission for the harmonization of the EU technical regulatory framework have been recognized internationally as advantages.

The stalling of the multilateral trade negotiations, the so-called Doha Round, has led to bilateral trade negotiations to reduce barriers to trade. The US has been leading this development and started to negotiate a Free Trade Agreement (FTA) with Korea a couple of years. However, domestic resistance prevented the ratification of the treaty.

The European Commission has successfully pursued the arrangement of bilateral treaties with numerous countries. The treaty with Korea has already been put in force. From the industry's standpoint the Commission could have been even more efficient with these initiatives, if it would strategically identify countries that are of special interest. This means the selection of countries for negotiations by their market size, growth potential and the existence of noteworthy barriers to trade.

Beyond strategic initiatives it is of importance to monitor the compliance of all players in bilateral trade with the trade agreement. Emphasis should be put on the solution of frictions to trade within the day-to-day business. The non-conformity of associated trading partner countries should prompt immediate reaction of the Commission and the threat of penalties.

[161] EQT – Annual Review 2010 (http://eqt.sidvisning.se/annualreview2010/)
[162] http://www.maschinenmarkt.vogel.de/themenkanaele/managementundit/finanzen/articles/61400/

5.5.2 United States

The US market is very specific with respect to technical regulation and customers' preferences. An important aspect of the US framework conditions is product liability. Although this point is primarily dedicated for the safety of consumers there is concern that in the future it can have an impact on capital goods too. The Foreign Management Legal Accounting Act (FMLAA) asks for a US representative who in case of regress will be made responsible in a US court. It is not quite sure if this act will remain limited for manufacturers of consumer goods or likewise for manufacturers of capital goods. In particular for smaller enterprises the FMLAA could become too great a hurdle to overcome.

The US technical regulatory system is different from the EU. There are EU-US agreements on mutual recognition of certificates. By US law European exporters are not obliged to apply for UL-certification, but frequently client companies ask additional ULC-certificates.

Of general importance 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 provision can 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 machine installations is carried out by local authorities ("Fire Marshall") that are frequently not sufficiently educated for this task. The EU should put some pressure on US authorities to launch a harmonization initiative.

The compliance with the legislation on safety in the workplace is supervised by OSHA and AHJ. Problems have been reported by EU firms to meet provisions. In case of non-compliance machines with EU certificates are shut down by OSHA or AHJ representatives.

Buy American clauses in public procurement procedures prove only to be problematic in case of public procurement. However, Buy American clauses even affect EU subcontractors of US clients that are suppliers to public institutions. With regard to the product programme only few sectors are affected by Buy American clauses, for instance waste water processing. Wind power manufacturers are affected because renewable energy projects are heavily subsidised.

5.5.3 Japan

The access to the Japanese market is not hampered by noteworthy tariff or non-tariff barriers. The low share of foreign companies in Japanese markets is explained by numerous cultural and behavioural factors. Japanese prefer to work for domestic companies. Moreover, clients pose tough requirements on after-sales services, maintenance, repair and spare part deliveries in the case of capital goods. It is an initial barrier to trade for companies to set-up local facilities and offer service around the clock for only a small number of machines installed in the Japanese market. The opening-up of the market requires a strategic decision based on the preparedness to invest in a contested market with technological excellent domestic competitors and a lengthy time until the break-even will be reached.

5.5.4 China

China's accession to the WTO has contributed to its integration into the global economy. China has eliminated 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. Since then the privatisation of large state-owned enterprises (SOE) has made progress. They have set-up new capacities as well as foreign investors that have been eager to exploit opportunities from eased market access.

The expansion of capacities has stimulated competition and put pressure on profits in the Chinese domestic market. The situation has been aggravated by deficiencies in markets, in particular financial markets. Easy access of Chinese companies to funds via the poorly regulated banking system contributed to this development. Local authorities' interest in workplaces has added to good financing conditions. In the long-run this will hurt the development of the Chinese economy by misallocation of resources. However, the beneficial financial conditions lead to unfair competition for non-Chinese companies, not only in the Chinese market but also in their home markets and third countries.[163] Growing Chinese FDI makes this an urgent topic as EU firms do not have comparable financial framework conditions. Quite the opposite must be expected, the lasting banking and public deficit crisis will aggravate the situation in coming years.

In spite of the opening-up of China for foreign investors their activities remain 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 carry out.[164] The categories reach from "encouraged" down to "prohibited". Even for industries - categorised as "encouraged" and FDI is welcomed - the framework conditions are not transparent and can be designed for a specific M&A project. Frequently takeovers are not allowed and JVs are required by public authorities, e.g. in the power generation equipment industry.[165]

JVs with Chinese companies incorporate the threat of uncontrollable know-how drain. Although China incorporated most of the requirements of the World Intellectual Property Organization (WIPO) into national law in course of the accession to the WTO 2001, the legal governmental enforcement activities regarding IPR are insufficient and lack transparency.[166] The linkage of industrial policy's interest in the creation of JV and the deficiencies in the protection of IPR is a threat to foreign investors. Both of these themes need to be tackled within the WTO or in bilateral talks. The EU Commission has to put pressure on China and remind public authorities that, as a member of the WTO, China has

[163] 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.22. http://trade.ec.europa.eu/doclib/docs/2007/february/tradoc_133301.pdf
[164] For the tasks of the NDRC see: http://en.ndrc.gov.cn/mfdic/default.htm
[165] This classification is part of the overall industrial policy pursued by the NDRC, see: http://en.ndrc.gov.cn/hot/W020060531535875002958.jpg
[166] 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 introduce institutions and the respective regulation to guarantee IPR in line with WIPO.

Since China has become a member of the WTO the opening up of the market has made progress. But not all barriers to trade have been abolished. For a transition period numerous tariffs remain in force. Foreign trade experts mention an average charge of 5% for ME products. But it is of note that there is a strong variation of tariffs and for certain products tariffs have remained prohibitive. These tariffs are not in line with the WTO treaty and DG Trade should negotiate the abolition of these tariffs.

In the past high-tech imports were supported by preferential schemes to stimulate upgrading of the Chinese economy. These schemes have been abolished and the delivery of advanced machinery, for instance machine tools and textile machinery are charged with import duties.

For products with specific safety risks, such as pressure vessels, third-party testing is required as in most other countries. However, Chinese authorities do not accept European certificates and a Chinese notified body has to carry out the task. Chinese certifiers have to travel to Europe, check the manufacturer's production facilities and quality assurance systems.[167] This is at least an expensive and time consuming process that aggravates access to China and raises concerns of espionage. One solution could be mutual recognition of certificates and third-party testing, but the Chinese regulatory system is not sufficiently transparent and the quality of notified bodies is not secured by the Chinese accreditation procedures.

5.5.5 Russia

The outdated Russian technological regulatory system, Gosstandard, is about to be replaced. Since a couple of years it is under revision and the Federal Agency on Technical Regulation and Technology (Rostechregulierovanie) in close cooperation with the EU. The EU machinery directive was taken to lay a foundation for the new regulation. Some of the more important topics for ME products have already been tackled in course of the replacement of the old system, such as low voltage-, fire protection and the protection of machinery applied in explosive atmospheres in line with EU directives.
In 2002 Russia, Belarus and Kazakhstan have agreed upon the creation of a tariff union within ten years. It will be put in force at the end of 2011. The three countries are about to create a common technological regulation that will be based on the renewed Russian regulatory system: It will be updated in concordance with the EU regulation and further ease the access to these markets.

Public funding schemes are available in Russia for upgrading agricultural industry. Subsidised interest rate credits are offered only for locally manufactured tractors and agricultural machinery. Foreign manufacturers can benefit from these schemes only if local content exceeds certain thresholds, for combined harvesters it has to exceed 50%.

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[167] The regulation is based on the China Compulsory Certificate (CCC) that was only introduced 2003. But this has not contributed to a more reliable and transparent system. See:
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.

Although most of the global brands run production facilities in Russia, they struggle to meet these requirements.

5.5.6 Turkey

Turkey is associated to the EU and most of the EU technical regulatory system has been transposed in national law, in particular the machinery directive. European norms have been taken over. However Turkish norms have remained in force and sometimes raise problems. One of the few product groups where problems have been reported is precision tools that do not fall under the machinery directive.

The organisation of the Turkish Normeninstitut (TSE) was reorganized from scratch and has become an efficient service body. The customs clearance works well. Problems have only been reported in trade with non-EU countries. In particular Chinese certifications (CCC) and Russian certifications (GOST) are not accepted in Turkey.

5.5.7 Middle East

The countries of the Arabian peninsula (with the exception of Yemen) have agreed upon the creation of a single market similar to the EU with a common currency and trade policy. However it has not made much progress so far. The GCC asks for an import duty of 5%. Beside this general tariff national duties exist. Imported ME products need a Certificate of Conformity (CoC). Generally speaking, the provisions are not challenging. International standards are obligatory, but specifications are not available. The underlying reason is to warrant an internationally recognised level of safety.

Sometimes ad hoc changes in regulations and application of provisions raise problems. In most cases solutions are not reached in adequate time. Public authorities do not react quickly enough. Although there is no detailed technical regulation certification is a topic of concern. There is no transparent provision if and when external certification is a requirement. There is some arbitrariness in these decisions. For third-party testing European notified bodies, such as Intertec and SGS are accredited in the Middle East. It is asked for a red tape procedure on the EU level that contributes to an accelerated solution and reduces frictions in trade (see Overview).

Within the UAE a local representative is not obligatory by law but indispensable de facto. However, there exist laws that regulate the relationship between foreign manufacturers and their local representatives. Much power is given to this local representative who is liable for any claim against the manufacturer of the imported goods. In a case the representative is eligible to bloc further imports and he even is allowed to retain payments for goods already delivered.

5.5.8 India

The opening up of the Indian economy has only started a couple of years ago. However, protection of smaller businesses has remained an important subject of public policies. Tariff barriers hamper trade. There are several duties that are adding up. The payments to public authorities can increase even further by local duties on imported machinery.

In contrast there exist no major technical barriers to trade with India. This is explained by the low level of industrialisation and state of technology. It is expected that this will change in coming years. The Bureau of Indian Standards (BIS) has to increase efforts to meeting the requirements of a more technological driven and complex manufacturing industry.

In how far these activities will turn out to become barriers to trade for EU manufacturers will be strongly dependent on European initiatives to support the development of the Indian regulatory system. The EU is asked to contribute to the development of India's technical regulatory system to ease access for European companies to one of the largest and strongest growing market in coming years.

5.5.9 Central and South America

Since long countries of the regions are negotiating the creation of a single market, the MERCOSUR. Nearly no progress has been made so far. This has turned out as a problem for the trade negotiations between the EU and MERCOSUR. Stakeholders of ME have called into question if MERCOSUR is an adequate counterpart for the EU in trade negotiations if member cannot overcome their internal differences. Moreover, conflicting interests in agricultural policies aggravate negotiations. No tangible progress has been made in negotiations to abolish trade barriers.

One of the few agreements reached by MERCOSUR is a common tariff for imported goods. Even this is subject to national regulation. Argentina has abolished all import tariffs to foster the upgrading of its business sector. Likewise Brazil has abolished all tariffs with the exception of those categories of machines where domestic supply is available. This kind of protection has raised concerns because a clear and transparent match of two machines is nearly impossible. The EU should take action to lift these provisions and to ask MERCOSUR members to strive for common solutions in international trade.

5.6 Structural change and geographic cohesion

ME has been characterized as a regionally anchored industry. This has been caused by a sophisticated division of labour among firms that are specializing on the design and manufacture of high-performance parts and components. This industrial infrastructure is decisive for the manufacture of final products of outstanding quality and process characteristics. Since the mid-1980s the former - more or less - national value chains have evolved to European networks. By its structure a European ME has emerged.

Since the breakdown of the Iron Wall central and eastern European countries have been integrated in the ME value chain. The focus was on those countries that accessed the EU in 2004 and beyond, creating the EU-27. The division of labour between old and new member states has been analysed in Chapter 2.4.2. The new member states' ME focuses more on production of intermediary products, in particular mechanical parts than ME enterprises from the old member states. Due to the distortions during the transition phase many enterprises of the new member states were not able to survive independently and remain strong players in international markets, in spite of sometimes outstanding technological competence.

The investigation of economic indicators discloses that the transition phase had come to an end during the middle of the last decade. Employment has stabilized, but simultaneously the improvement of the economic performance has been slowing down as shown by the evolution of unit-labour costs (Figure 2.21). This finding underpins the challenge for production locations in the new member states by Chinese competitors in the area of price competitiveness. While labour productivity is of similar magnitude wages in the Czech Republic, Poland and Slovakia are much higher than in China (Chapter 4.2). The new member states' companies have to further increase their know-how and the ability to manufacture more advanced products to justify current wage levels to meet the Chinese challenge and not to lose workplaces in course of globalization.

Although regional focuses exist further on the European integration has made much progress over the past decades. It has led to a real European ME with strong cross-national ties that have created new supra-regional dependencies. Regions – well-known for their concentration and strength in ME production - have become dependent on supply from other European areas. A division of labour along comparative advantages within the EU has emerged and contributed to its strength.

However, the past decade was marked by macro-economic distortions that had a negative impact on the cohesion of member states' economies. Until the financial crisis the growing divergence was concealed by lose borrowing conditions and low interest rates, too low for some peripheral economies. The macroeconomic distortions have become burdensome for ME companies in the concerned countries. For Italy and Spain the economic performance of ME has been investigated in course of the project. A clear indication is given that the situation has worsened (2.2.3, 2.2.4). This might have affected large companies to a lesser extent that have the opportunity to exploit the opportunities of globalization and own foreign production sites. However, smaller enterprises do not have the opportunities to compensate for worsening domestic conditions abroad. The macroeconomic distortions put strain on the EU's regional cohesion caused by a loss of competitiveness.

The EnginEurope report fragmented European markets as a weakness for the industry.[168] In fact to a certain extent national provisions hamper free trade in the Single Market, but the integration of the market for ME products has made much progress, barriers are the exception to the rule (Chapter 5.1). Market access has become an important driver of structural change and cohesion of ME. This has become above all a challenge for smaller companies with a focus on regional market niches that had not been accessed by larger players in the past. Smaller enterprises reported that competitive pressure has been growing in recent years, from non-EU and EU-players. They will have to put their business model to the test.

[168] European Commission, Enterprise and Industry Directorate-General (2007). The EnginEurope Report, Brussels, p.11.

The on-going cohesion will lead to a more competitive ME that can exploit economies of scale in the Single Market. This development will strengthen the companies' ability to increase productivity and improve their economic performance.

6 Strategic outlook

6.1 Medium-term outlook

6.1.1 Impact of the global economic crisis on ME

Trends in Mechanical Engineering between 2008 and 2011 (1st half)

Overall, Mechanical Engineering (ME) production in the EU27 (EU) dropped by around 10% between 2008 and the first half of 2011[169]. This development was underpinned by a sharp fall (of over 25%) in 2009 as production picked up in 2010 (by around 10%). There is evidence for the assertion that the recovery has continued so far in 2011.

Alongside this, employment level in ME also dropped by 10% between 2008 and the first half of 2011. However, unlike the sharp fall and recovery seen in production, employment in ME fell by just over 5½% for the consecutive years 2009 and 2010. Employment levels have started to pick up again in 2011 to date.

Table 6.1: Trends in key indicators for Mechanical Engineering, 2008-2011H1 (indices, 2005=100)

Sector	Indicator	Units		Year			
				2008	2009	2010	2011[2)]
Manufacturing	Production index	2005 = 100	level	107.4	91.7	98.6	103.6
ME[1)]				119.9	88.4	97.8	107.5
Manufacturing	Employment index	2005 = 100	level	99.5	92.4	89.0	89.4
ME[1)]				105.9	100.0	94.4	95.8
Manufacturing	Productivity[3)]	2005 = 100	level	108.0	99.2	110.8	115.9
ME[1)]				113.2	88.4	103.6	112.2
Manufacturing	Labour costs index	2005 = 100	level	110.7	103.9	104.3	107.7
ME[1)]				117.9	110.9	111.4	118.5
Manufacturing	Lab. cost per worker	2005 = 100	level	111.3	112.4	117.2	120.4
ME[1)]				111.3	110.8	118.0	123.7
Manufacturing	Unit labour cost[4)]	2005 = 100	level	103.1	113.3	105.8	103.9
ME[1)]				98.3	125.4	113.8	110.2

[1)] ME = mechanical engineering; [2)] Average of first 2 quarters; [3)] Production/employment;
[4)] Wage per 1 unit of production (index, 2005 = 100).

[169] Note, only data for 2011Q1 and 2011Q2 were available.

These trends are reflected in outcomes for productivity which was facing a sharp fall in 2009, with production output dropping at higher percentages than employment. The sustained fall in employment and the recovery in production in 2010 led to a sharp increase in productivity in 2010. Notwithstanding this, it was around 8½% below the level of 2008. Since the beginning of 2011 to date, further rise in productivity occured as the growth in production has outpaced the recovery in employment.

Although productivity fell sharply in 2009, average labour costs in ME were largely unchanged as total labour costs fell by around the same rate as employment. Average labour costs picked up in 2010 as total labour costs were largely unchanged while employment continued to fall. This growth has continued in 2011 as wages and salaries in ME have increased more than employment figures.

The net result of these trends was a sharp increase in ME unit labour costs in 2009 (around 27%). ME unit labour costs decreased back in 2010 of 10%, as production recovered and employment continued falling. In 2011, it dropped further but remained around 12% above the 2008 level.

6.1.2 Quarterly trends in Mechanical Engineering in 2010 and 2011

Looking in more detail at the quarterly profile for the period between 2010Q1 and 2011Q2, we can get a better picture of the recovery in ME in 2010 and 2011.

Table 6.2: Quarterly trends in key indicators for Mechanical Engineering in the EU, 2010Q1-2011Q2 (indices, 2005 = 100)

EU-27	Quarter					
	2010Q1	2010Q2	2010Q3	2010Q4	2011Q1	2011Q2
Production						
Manufacturing	95.8	98.4	99.4	101.0	103.4	103.9
ME[1)]	90.7	95.3	100.1	104.6	106.4	108.6
Employment						
Manufacturing	89.1	89.0	88.8	89.0	89.3	89.6
ME[1)]	94.6	94.3	94.1	94.7	95.4	96.2
Productivity[2)]						
Manufacturing	107.5	110.6	111.9	113.5	115.8	115.9
ME[1)]	95.8	101.1	106.4	110.5	111.6	112.9
Labour costs						
Manufacturing	103.3	103.9	104.5	105.5	107.0	108.4
ME[1)]	108.7	111.0	111.8	113.8	117.2	119.8
Lab. cost/worker						
Manufacturing	115.8	116.7	117.7	118.5	119.8	120.9
ME[1)]	114.8	117.7	118.8	120.2	122.8	124.6
Unit labour costs[3)]						
Manufacturing	107.8	105.5	105.2	104.4	103.5	104.3
ME[1)]	119.8	116.5	111.7	108.8	110.1	110.3

[1)] ME = mechanical engineering; [2)] Production/employment; [3)] Wage per 1 unit of production (index, 2005=100).

The overall conclusion is a sustained and gradual recovery and an improvement in the competitive performance. ME production in the EU increased in each quarter between 2010Q1 and 2011Q2. Apart from a minor dip in 2010Q2 and 2010Q3, the same development accounts for employment. As a result, productivity levels in ME increased in every quarter in 2010 and 2011H1, with a particularly fast increase over 2010, followed by slower growth in 2011.

Besides that, the average labour costs in ME have also increased in each consecutive quarter over 2010Q1-2011Q2, as total wages and salary levels in ME have increased at a faster rate than employment. Their increase, however, did not equal the increase in terms of productivity.

Overall, the result has been a sharp fall in unit labour costs over 2010 with rather stagnating unit labout costs in ME between 2010Q4 and 2011Q2. Unit labour costs in ME fell by around 8% between 2010Q1 and 2011Q2.

6.1.3 Mechanical Engineering in 2011 compared to 2008

Given these trends and patterns analysed in ME during 2008 and 2011 and explored above, the underlying question remains of how developments changed and what ME's prospects are at present compared to 2008H1, at the onset of the economic crisis.

Table 6.3: Quarterly levels in key indicators for Mechanical Engineering in the EU, 2008 cf 2011 (indices, 2005 = 100)

EU-27	Quarter					
	2008Q1	2008Q2	2008Q3	2008Q4	2011Q1	2011Q2
Production						
Manufacturing	112.6	110.0	107.0	100.1	103.4	103.9
ME[1]	123.3	123.4	119.7	114.2	106.4	108.6
Employment						
Manufacturing	100.6	100.1	99.5	97.7	89.3	89.6
ME[1]	106.1	106.0	106.4	105.2	95.4	96.2
Productivity[2]						
Manufacturing	111.9	109.8	107.6	102.4	115.8	115.9
ME[1]	116.2	116.4	112.5	108.6	111.6	112.9
Labour costs						
Manufacturing	110.5	111.1	111.0	109.8	107.0	108.4
ME[1]	116.9	117.9	118.8	118.1	117.2	119.8
Lab. cost/worker						
Manufacturing	109.8	111.0	111.6	112.3	119.8	120.9
ME[1]	110.2	111.3	111.7	112.2	122.8	124.6
Unit labour costs[3]						
Manufacturing	98.1	101.0	103.7	109.7	103.5	104.3
ME[1]	94.8	95.6	99.3	103.4	110.1	110.3

[1] ME = mechanical engineering; [2] Production / employment; [3] Wage per 1 unit of production (index, 2005 = 100).

A few trends may deserve particular attention despite the gradual and steady recovery in ME seen over 2010 and early 2011:

- ME production in the EU was 13% lower in 2011H1 than in 2008H1;
- Employment in ME was around 10% lower in 2011H1 than in 2008H1;

As a result,

- Productivity levels in 2011H1 were 3½% lower than in 2008H1;
- A small increase in total labour costs between 2008H1 and 2011H1 coupled with the 10% fall in employment means that average labour costs increased by around 12% over the same period;
- Unit labour costs in ME in the EU were 15-16% higher in 2011H1 than in 2008H1.

The conclusion is that after sharp falls in production and competitiveness in 2009, Mechanical Engineering in the EU has staged a steady and gradual recovery in 2010 and 2011. Notwithstanding this, it can be noted, that by 2011H1 it had still not recovered to 2008 levels of activity and competitiveness.

6.1.4 Mechanical Engineering compared to Manufacturing

To add further context to the trends in Mechanical engineering it is worth comparing it to the sector of manufacturing, which is much broader in scope.

Between 2008 and 2011 the output in manufacturing followed a similar trend as mechanical engineering. However, the drop in production levels in 2009 was comparably less strong and the recovery in 2010 and 2011 was at a slower pace. For the period 2008 to 2011, the overall fall in production in the manufacturing sector has been less considerable than in ME.

The employment rate in manufacturing dropped more sharply than compared to ME in 2009. It decreased further in 2010, but less strong as in ME. Meanwhile, the recovery of employment in manufacturing for 2011 has not been as strong as recorded for ME. Overall, employment in manufacturing fell by around 10% between 2008H1 and 2011H1, similar to the development in Mechanical Engineering.

Productivity in manufacturing fell in 2009, with the fall in ME at a much faster rate. It then recovered strongly in 2010 with a continuing trend in 2011, albeit at a more modest pace. Compared to ME, the recovery in manufacturing has been less strong. Since the fall of production in manufacturing was not as strong as the fall in employment, productivity in manufacturing were 4½% higher in 2011H1 than back in 2008H1. During the same period, productivity levels were 3½% lower in ME.

Average labour costs in manufacturing increased slightly in 2009, when average labour costs in ME fell. Nevertheless, during 2008 and 2011H1, the average labour costs in ME have increased at a faster overall rate than average labour costs in manufacturing. Average labour costs were 9% higher in 2011H1 than in 2008H1, compared to an increase of 12% for ME.

The result of these patterns and differences is that unit labour costs in manufacturing increased considerably in 2009 and subsequently decreased in 2010 and 2011H1.

However, the increase in 2009 and the declines in 2010 and 2011 were not as fast as those experienced in ME. Therefore, we can conclude that that while unit labour costs in ME were 15-16% higher in 2011H1 than in 2008H1, they only rose by 4¼% in manufacturing.

6.2 Investigation in selected future oriented markets

6.2.1 Middle East and North Africa (MENA)

The Middle East and North Africa (MENA) has traditionally close ties with Europe. The political and economic development had been hampered by autocratic governments. For large parts of the population the social situation has deteriorated for many years. MENA is a net importer of foodstuff and has suffered from growing global demand and price increases over the past decade. The region’s oil exporting countries have been better off than others, since they could pay for imports with hard currencies. However, the food and oil importing countries have struggled to pay for the urgently needed commodities. As a consequence the latter countries suffer from macroeconomic distortions, soaring public debts, high inflation rates and current account deficits.

Despite all of these difficulties MENA experienced high growth rates between 2000 and 2010, i.e. on average 4.8% p.a. for the aggregated countries. However, attempts to stabilize real income for broad levels of the population and for most countries have been insufficient and unemployment figures are on a double digit rate and for young people it is even double as high as on average for the population. The region’s governments tried to appease the people with growing subsidies for food and energy. As a consequence public deficits have increased considerably. The Egypt government, for instance, increased wages for public workers by 20% in 2011 – despite the financial situation and tight public budgets. In connection with the distortions of the economic activity by public unrest and the “Arab spring” movements, the estimated deficit ratio for 2011 has been increased from 8.6% of GDP to around 11%. The IMF has prevented state bankruptcy with a standby facility.[170]

Countries, such as Tunisia and Egypt where the overthrows of governments have opened-up opportunities for new and more democratic systems new governments have yet to be elected. For Tunisia and Egypt elections have been announced to be carried out already 2011. This will be a challenging exercise and the new governments inherit an arduous legacy. It remains unclear when and how the then elected governments will succeed in improving the living standards of the masses. Most likely, the heterogeneity of different groups that joined forces to overthrow the current government poses the initial stumbling block that has to be passed. Heterogeneous political and economic interests reach from those put forward by the Islamic Brotherhoods to democratic reformers and representatives of the old guard that try to defend former privileges and economic latifundia. In Egypt there are three different groupings of relevance for political renewal: Small secular groups, the National Association for Change and the moderate fraction of

[170] Hakimian, H. (2011) “The Economic prospects of the „Arab Spring“: A Bumpy Road Ahead”, in: Development Viewpoint, Number 63, Centre for Development Policy and Research (CDPR) http://www.soas.ac.uk/cdpr/publications/dv/file69272.pdf

the Muslim Brotherhood. Above all these divergent parties the High Military Council has the power to decide if and how the political transformation will go on.[171]

In this context, the "Deauville Partnership Program", launched by the G-8 in May 2011 is of importance since it is dedicated to support reforms towards democracy and provide financial support for a social and economic transformation. The Program involves the International Monetary Fund, the World Bank, the African Development Bank and the European Bank for Reconstruction and Development (EBRD), the Islamic Development Bank, as well as the United Nations Stolen Asset Recovery Initiative. A total amount of USD 20 billion for Tunisia and Egypt are under discussion to be spent for the years 2011 to 2013. The European Investment Bank will contribute another € 3.5 billion. Moreover, the EU will support the region's transformation primarily through already existing relations and agreements, such as the Union for the Mediterranean.[172]

Although the World Bank is upbeat on the prospects for MENA it acknowledges the massive challenges ahead to dissolve the macroeconomic distortions and to get back to a path of functioning markets. Moreover, it warns of future risks, and problems to overcome the current subsidies for food, energy, wage rises and high share of public employment. Many of these problems have been exacerbated by measures that have been taken to reduce social tensions and public unrest. A short-term abolition of these - non-sustainable – measures may yet bring about another destabilising factor. A large portion of the international funds to bolster the transition of the countries will be used for consumptive expenditure and not for investment.

The short-term prospects for MENA differ strongly between countries in dependence of foreign trade balances. The oil exporting economies, among the Gulf Corporation Council Countries (GCC) earn sufficient hard currencies to pay for food imports and subsidies. Price increases for oil exports ease pressure from bills for imported food. On average their growth rates have not been much affected by the Arab Spring. Consequently, their GDP will expand on average by 4.3% in 2012 and show similar growth momentum as in the advent of the financial crisis. The developing oil exporting countries, among them Algeria, Iran and Iraq are expected to enjoy a remarkable acceleration of growth in 2012 expected by some to even exceed pre-crisis levels. However, the oil importing countries with close EU-ties are most affected. Egypt and Tunisia have suffered from a slowdown of economic activity caused by public unrest. In particular tourism revenues broke down. Morocco that has introduced some reforms has not been affected by mass demonstrations. Its growth rates will increase in 2012, but it will not reach levels seen before the crisis. Already these former levels were not sufficient to stabilize employment. This will put much pressure on governments to contain social tensions.[173]

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171 Asseburg, M. and Roll, S. (2011a) „Ägyptens Stunde null? Akteure, Interessen, Szenarien", in: SWP Aktuell – 10, Berlin, http://www.swp-berlin.org/fileadmin/contents/products/aktuell/2011A10_ass_rll_ks.pdf

172 Asseburg, M. (2011b) „Der Arabische Frühling", in: SWP-Aktuell – 17, Berlin, http://www.swp-berlin.org/fileadmin/contents/products/aktuell/2011A10_ass_rll_ks.pdf

173 Ianchovichina, E. et al (2011) "World Bank Middle East and North Africa Region – Regional Economic Update May 2011 – MENA Facing Challenges and Opportunities, http://siteresources.worldbank.org/MENAEXT/Resources/EDP_MNA_2011.pdf.

Much of the growth expected for 2012 will be driven by public expenditure and subsidies for the people to improve their living standards, above all in the countries affected by public unrest that are currently about to stabilize. Only if the governments succeed in carefully budgeting the medium-term public expenditure and significantly reduce subsidies, –the confidence of investors will be restored and a sustainable development can be expected. If this suggestion should prove right and broad levels of the population participate in increasing welfare the region could exploit its high growth potential based on a young and growing population. Only under these circumstances and simultaneously growing industrialization – not yet of global significance to date – MENA will a much more attractive and important market for machinery production. Turkey's attempts to strengthen its influence in the region could be understood as a shining example, by the creation of secular Muslim state and its economic success.

However, in the short-and medium-term the GCC and other oil exporting countries will remain the major important MENA markets for machinery, not those affected by public unrest. Finally, and for the case of Lybia, a military government or strong role of the army in the future government, strong demand for the reconstruction of harbours, refineries, oil production and transport can be expected.

Table 6.4: Perspective for MENA countries

	Real GDP Growth (Annual percentage change)					Fiscal balance (in percentage of GDP)					Current account balance (in percentage of GDP)				
	2008	2009	2010 est.	2011 proj.	2012 proj.	2008	2009	2010 est.	2011 proj.	2012 proj.	2008	2009	2010 est.	2011 proj.	2012 proj.
MENA region	**5.4**	**2.0**	**3.9**	**4.8**	**4.8**	**12.3**	**-2.6**	**0.0**	**2.2**	**3.6**	**15.0**	**1.4**	**5.1**	**6.4**	**7.4**
Oil Exporters	**4.9**	**1.1**	**3.6**	**4.6**	**4.5**	**15.7**	**-1.8**	**1.8**	**4.3**	**5.9**	**18.7**	**2.9**	**7.7**	**9.0**	**10.2**
GCC Oil Exporters	**6.0**	**0.5**	**4.2**	**5.0**	**4.8**	**24.2**	**0.8**	**5.4**	**8.3**	**9.7**	**23.9**	**6.7**	**10.8**	**12.7**	**14.0**
Bahrain	6.1	2.6	3.5	3.9	4.9	4.9	-8.7	-5.2	-2.4	-0.3	10.6	1.6	3.6	6.1	7.4
Kuwait	5.6	-4.4	1.9	4.5	5.0	19.9	19.3	16.5	17.2	20.9	40.7	29.2	29.3	30.2	31.7
Oman	12.3	3.6	4.8	4.7	3.9	13.9	2.2	6.9	7.6	6.5	9.1	-2.2	2.6	3.3	3.6
Qatar	15.8	9.0	18.5	14.3	9.2	10.9	13.0	9.4	12.2	14.3	33.0	15.7	22.7	38.0	34.9
Saudi Arabia	4.2	0.6	3.7	4.2	4.4	32.5	-6.1	-0.8	2.7	3.3	27.8	6.1	6.7	5.6	7.2
United Arab Emirates	5.1	-1.0	1.0	3.1	4.0	20.4	0.4	9.9	13.4	15.0	8.5	-2.7	7.3	7.7	10.7
Developing Oil Exporters	**2.9**	**2.1**	**2.5**	**3.9**	**3.9**	**1.2**	**-5.5**	**-3.7**	**-1.5**	**0.3**	**9.8**	**-2.4**	**2.9**	**3.8**	**4.6**
Algeria	2.4	2.4	2.4	4.1	4.1	7.7	-6.6	-8.0	-7.0	-3.4	20.2	0.3	5.6	5.4	5.9
Iran, Islamic Republic of	2.3	1.4	1.5	3.0	3.0	0.0	-2.7	0.4	2.3	2.0	7.2	2.6	6.7	7.2	7.3
Iraq	9.5	4.2	2.6	11.5	11.0	-3.3	-14.2	-12.2	-8.2	3.3	12.8	-25.7	-13.5	-9.2	-3.0
Syrian Arab Republic	5.2	4.0	5.0	5.5	5.6	-2.8	-5.5	-4.4	-3.4	-3.5	-1.9	-2.4	-2.3	-3.5	-3.6
Yemen	3.6	3.9	8.0	4.1	4.2	-4.5	-10.2	-5.6	-5.0	-4.7	-4.6	-10.7	-5.2	-4.8	-4.6
Oil Importers	**6.8**	**4.9**	**4.9**	**5.3**	**5.7**	**-4.6**	**-5.7**	**-6.8**	**-6.2**	**-5.5**	**-3.9**	**-4.4**	**-4.8**	**-4.1**	**-3.8**
Oil importers with GCC links	**6.8**	**6.5**	**6.5**	**6.3**	**5.8**	**-8.6**	**-8.9**	**-7.9**	**-7.1**	**-6.0**	**-15.8**	**-11.5**	**-13.1**	**-11.9**	**-12.0**
Djibouti	5.8	5.0	4.5	5.4	6.0	1.3	-4.9	-0.5	0.0	0.0	-27.6	-17.3	-14.5	-19.4	-25.4
Jordan	7.6	2.3	4.0	5.0	5.5	-8.8	-10.3	-7.4	-5.0	-4.0	-9.6	-5.1	-9.5	-6.5	-6.6
Lebanon	9.3	9.0	8.0	7.0	6.0	-8.8	-8.1	-8.5	-8.7	-7.5	-19.8	-15.5	-15.4	-15.2	-15.1
Oil importers with EU links	**6.5**	**4.6**	**4.6**	**5.1**	**5.7**	**-3.9**	**-5.1**	**-6.6**	**-6.0**	**-5.4**	**-1.8**	**-3.2**	**-3.2**	**-2.7**	**-2.3**
Egypt	7.2	4.7	5.1	5.5	6.0	-6.8	-6.9	-8.2	-7.9	-7.3	0.5	-2.3	.2.0	-1.7	-1.3
Morocco	5.6	4.9	3.5	4.4	5.1	0.4	-2.2	-5.0	-3.3	-2.4	-5.2	-5.0	-5.3	-4.4	-3.9
Tunisia	4.5	3.1	3.8	4.8	5.0	-1.0	-3.0	-3.0	-2.8	-2.6	-3.8	-2.9	-4.5	-4.1	-3.7

Source: World Bank Data

6.2.2 The demand potential of less exploited renewable energies

Geothermal Energy

Until now, we are literally standing on a tremendous energy supply. The earth's core reaches temperatures of around 5000-6000°C, which continuously flow to the surface. With temperature decreasing by 3°C every 100m of depth, the energy content in a depth of 3km is estimated to amount to 3 million quads which equal 5.4e[14] barrels of oil on the US territory only. In an approximation, these geothermal resources might provide energy for the next 30,000 years.[174]

Yet, and according to the U.S. Energy Information Administration (EIA), the share of geothermal energy only rose 0.022 percentage points from 2004 to 2008 ranging at a comparably low 0.362% of total U.S. energy consumption. Only solar energy has a lower share among the renewable energy sources of available resources.

Considerable potential can be seen in further exploiting geothermal energy, in light of the obvious advantages of this technology. Besides being a fairly reliable and secure source of energy, geothermal energy is also very environmentally friendly compared to conventional sources of energy . While an average coal power plant emits 2,191 pounds of carbon dioxide per megawatt-hour, a geothermal plant emits only 60 pounds which is roughly 97% less[175] .

In terms of market leadership, the US are currently far ahead of the market when it comes to geothermal technology. Other main competitors are lagging behind and start from a lower level. In Germany, for instance, geothermal projects still take between four to six years from start to implementation due to the lack of experience. Furthermore, geothermal projects have to compete with the oil industry for drilling capacity. Therefore, high oil prices induce more exploration for oil fields which implies a tremendous surge in drilling costs, which almost doubled for the years 2006 and 2007 as compared to the years 2002-2005[176]. A further impediment to the rapid exploitation of geothermal fields is the exploration of new fields which imply economic risk as it is hard to estimate ex-ante the amount of resources generated. Typically, 50-75% of total project costs (which can range between € 15 and 70 m) have to be paid up-front[177] which puts a certain risk on the project. Therefore, geothermal projects still largely depend on governmental subsidies.[178] Additionally, the energy production potential of geothermal systems is determined by the pressure decline caused by production.[179] Therefore, reinjection is an important factor in sustainably managing geothermal resources.

However, signs are pointing in the right direction. Worldwide installed capacity for heat generation in 2010 amounted to 50,584 MWt which is an increase of 79% versus 2005. Similarly, the installed capacity for power generation increased by 20% to 10,715 MW over a five year period. In 2010, a total of 526 power plants are available worldwide, 40% of them installed in the US.

From an ecologic point of view, the prospects for this industry appear to be fairly bright. As countries all over the world seek to reduce emissions, demand for clean energy generation is likely to increase; in this respect, geothermal energy has a clear advantage over conventional fossil fuels. For the time being, however, it remains an energy source

[174] Green, B. and Nix, G. (2006) “Geothermal – The Energy under our feet”, National Renewable Energy Laboratory.
[175] Green, B. and Nix, G. (2006) “Geothermal – The Energy under our feet”, National Renewable Energy Laboratory.
[176] Bundesverband Geothermie
[177] Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
[178] Bundesverband Geothermie: http://www.geothermie.de/wissenswelt/geothermie/einstieg-in-die-geothermie/risiken.html
[179] Axelsson, G. and Stefansson, V. (2003) “Sustainable Management of Geothermal Resources”, International Geothermal Conference, S12 Paper 075, pp.40-48.

that is strongly dependent on subsidies. Regulatory instruments like carbon dioxide taxes might contribute to growth in the geothermal energy industry and reduce the restrictions caused by tight public budgets.

Wave Energy

There is little doubt about the infinite supply of wave energy. Wind is generated by uneven solar heating and transforms some of its energy to form waves by passing over open water. The theoretical total world-wide potential from this source is assumed to be 100,000TWh per year (global electricity consumption is around 16,000 TWh/year)[180]. Estimates for the currently feasible resource exploitation range from 140-750 TWh per year; however, it is assumed that this might eventually increase to around 2,000 TWh/year[181] which would almost satisfy 13% of global demand.

A major asset of wave energy is that it is at a maximum supply in the winter season when also demand for energy is peaking. However, wave energy supply is more volatile than energy demand which results either in a shortfall in the summer or an excess in the winter.[182] Wave energy is fairly predictable given that waves and their respective height can easily be forecasted using satellite images. Moreover, no waste is produced in the process and it is fairly inexpensive to operate and maintain. In addition to that, wave energy offers a solution to the “not in my backyard” issue as it is located at a fair distance from the shore and is generally not visible.[183]

However, there are some environmental considerations. First of all, the accidental spill of toxic fluids used in these systems due to leaks might be a problem; although this could be resolved by close monitoring and selection of nontoxic liquids. Secondly, careful selection of sites for wave energy conversion (WEC) devices is mandatory as otherwise other sea space users such as commercial shipping and fishing could be affected. Further, the installation and securing the devices to the ocean floor might have a negative impact on marine habitat. Another concern is that wave height could decrease due to WEC devices which would have a detrimental effect on sediment transport and on biological communities. It is further estimated that WEC devices cause a reduction in waves in the magnitude of 10-15% with a decreasing tendency within a few kilometers.[184]

The predicted costs for generating electricity from wave energy have decreased significantly but still average around 10 Cent/kWh which is more than twice the average price for a kWh in the EU.[185] However, this estimate is commonly assumed to further decrease as technology advances and firms become more efficient through production experience.

[180] European Ocean Energy Association (2010). Brussels, http://www.eu-oea.com/index.asp?bid=232#Tidal%
[181] Thorpe, T.W. (1999) “A brief review of wave Energy”, http://www.mech.ed.ac.uk/research/wavepower/Tom%20Thorpe/Tom%20Thorpe%20report.pdf
[182] Leishman, J.M. and Scobie, G. (1976) “The Development of Wave Power – A Techno-Economic Survey”, Economic Assesment Unit National Engineering Laboratory, East Kilbridge Glasogow.
[183] Global Energy Partners LLC (2004): Final Summary Report: 2004 Offshore Wave Power Project.
[184] U.S. Department of the Interior (2006). Wave Energy Potential on the U.S. Outer Continental Shelf.
[185] European Ocean Energy Association (2010). Brussels, http://www.eu-oea.com/index.asp?bid=232#Tidal%

A major obstacle to the development of wave energy technology is the lack of incentives or subsidies from the state or federal governments. In the US for instance, besides the funding of one wave power plant in Hawaii by the US Navy, the emerging technology has received little help; even the current federal renewable energy tax credits do not cover ocean energy. [186]

The biggest challenge for the industry is to deploy full size prototypes firstly to prove performance at sea and secondly to gain experience with the technology. Pushing the technology to a point where it can prove being competitive with other sources of renewable energy will be pivotal for its economic survival. [187] Further funding of research will be necessary to reduce technology cost, improve efficiency and reliability and identify suitable sites. The technology is far from being a source for energy generation and for a long period many subsidies have to be spent until an economical application will be possible.

6.2.3 Long-term prospects for services

ME has become an industry with a strongly growing share of services over the past decades. Most of them are closely related to changes in the product programme. Companies provide increasingly sophisticated machinery and comprehensive production systems that are not self-explaining. Installation, set-up and training of operators has become more time consuming.

Services are perceived as strategies to reduce pure price competition, and many companies are inclined to tap into these markets.[188] This is not only a business area for large corporations but also for medium-sized enterprise that offer their clients contractor services (see: Chapter 2.3.2). The growing share of services must be understood against the background of comparative advantages in Europe that build upon engineers and technicians educated in a more comprehensive way than in competing economies.

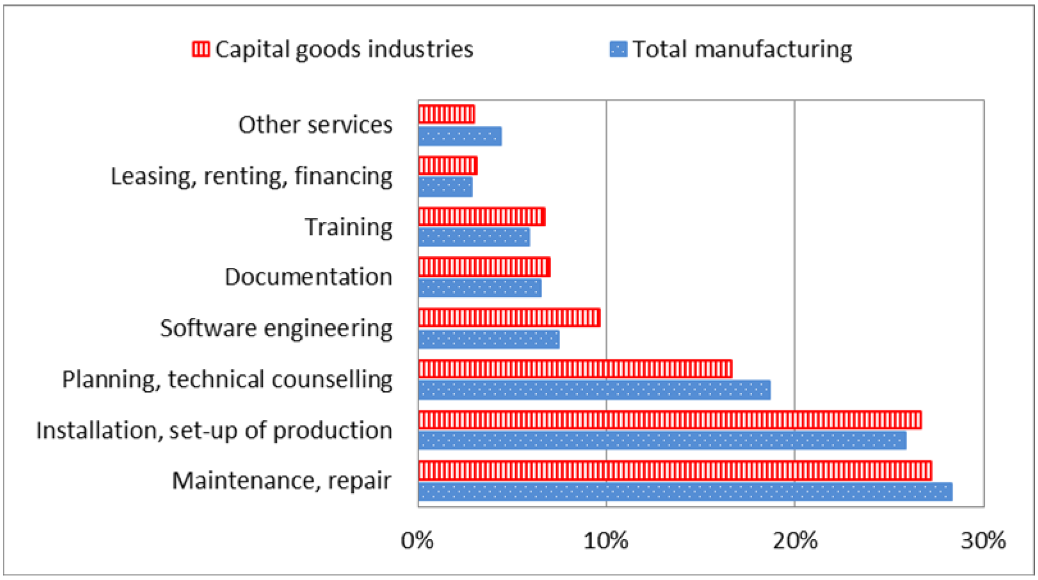
There is an even more challenging sales strategy: project financing models, above all offered by large firms. Several models exist, for example, Build-Own-Operate-Transfer (BOOT) consists of the construction of a plant for a client who does not pay back immediately. The ME firm owns and runs the plant and is paid by the revenues. Finally the ownership is transferred to the client. This is a big business in the global market that does not only require technical expertise but funding strength and access to financial markets. It has been mentioned as an important topic in interviews. However, in a globally competitive environment, these services are also a factor of concern. Asian competitors can offer good financial conditions – backed by their governments - and increasingly exploit this advantage to gain market shares.

The services offered to clients by manufacturing industries were subject of an investigation by the German Federal Statistics Bureau. It provided representative results and reliable figures differentiated by the kind of service. Within the investment goods industries, i.e. metal working, mechanical and electrical engineering, electronics,

186 http://www.window.state.tx.us/specialrpt/energy/renewable/ocean.php
187 European Ocean Energy Association (2010). Brussels, http://www.eu-oea.com/index.asp?bid=232#Tidal%
188 European Commission, Enterprise and Industry Directorate-General (2007). The EnginEurope Report, Brussels, p.26.

measurement and optics industries, around 70% of all enterprises sell a considerable amount of services. On average it accounts for up to 12.3% of their total turnover.[189] Around 15% of these services are a result of technical counselling and related pre-sales services, approximately one quarter is attributable to installation and set-up activities. Another big share is taken by maintenance and repair. Other services, such as the funding of purchases, project financing and the operation of production are of much lower importance. However, all these figures relate to average numbers. In the market segments where these services are offered they are of key-importance.

Figure 6.1: Kinds of services supplied by German fixed asset manufacturers - Share of total service sales in %



Source: Federal Statistics Bureau of Germany; calculations by Ifo.

6.2.4 Conclusions

The investigation in selected future oriented markets has disclosed that there are large potentials that can and should be exploited. The MENA region is of major importance as a sales market for the EU ME, although non-EU manufacturers showed a better performance in recent years. The Arab Spring has been – at least to a certain extent – triggered by growing economic problems. For the succumbing newly elected governments, macroeconomic distortions are a threatening burden. In particular, the oil and food importing countries are strongly affected and it will take years until a sustainable public budget will be reached. Foreign commitments on development aid are directed to prevent public insolvency, pay for food and energy. Particular reason for concern stems from the situation in those countries closely linked to the EU. It will take some years until a broad economic recovery will stimulate investment activity and demand for machinery strongly in these countries heavily affected by the crisis. Reason for optimism gives the example of Lybia where the infrastructure for oil production, refining and transport had been damaged during wartime and must now be reconstructed.

[189] Nearly 30% of ME enterprises in Germany do not offer any services. Therefore on average for the German ME the share of services of total output was only at around 8.7% in 2002, due to the representative survey of the Federal Statistical Bureau. See: Reinhard, M. and Vieweg, H.-G. (2007) „Bedeutung von Betreibermodellen“, in: Betreibermodelle für Investitionsgüter – Verbreitung, Chancen und Risiken, Erfolgsfaktoren, Stuttgart, pp 176.

Once successfully repaired, further demand for machinery can be expected to sustain the oil exploitation and exports.

In the era of growing scarcity of oil and gas and the threat of climate change, renewable energy sources play a primary role in overcoming these problems. The remaining question is in how far the currently less exploited renewables, e.g. wave energy and geothermal energy, can contribute to a solution. The potential energy supply of both resources is undoubtedly gigantic with pilot projects carried out to investigate in the feasibility. Regarding wave energy, many technical problems remain to be solved still to assess ex-ante the economic costs involved for reaching a break-even point. The specific costs of CO2 avoidance as compared to other alternative energies can justify further investments (See: Chapter 6.4.5). For geothermal energy more know-how and expertise would be needed, and the US is ahead of the game, behind Iceland. The advantages of this energy resource is strongly dependent on geological structures, i.e. the availability of high-temperatures not too deeply in the earth. Investment opportunities have to be decided on a case by case judgement. One of the problems related to geothermal energy are high sunk costs if the investment fails to provide energy in the long-run. Once more, decisions should be made in line with CO2 avoidance costs, to prevent a misallocation of resources. To conclude, for insufficiently exploited but more researched renewables, e.g. wind power, a cautious stance should be adopted. A step by step should be pursued in the face of debt-driven public budgets.

The growth potential of services has already been proven throughout past decades. Most of these services are closely related to the provision of physical products. But even the provision of services has shown stronger growth than the output of machinery. To a large extent, services are not directly linked to clients' investment decisions. Insofar services contribute to cushioning the cyclical nature of the business activities of ME enterprises.

In recent years, an increasing share of non-technical services are offered by ME enterprises. They concern funding of clients' investment. Different models are applied for this purpose. ME firms offer their clients to run production facilities or even become contractors to their clients. All these activities open-up new business opportunities. These developments will stimulate growth of ME in the coming years. However, not all of this anticipated growth will happen within the ME industry and will be traceable in statistical terms. ME companies will run some of these services in separate companies that are not subsumed under ME in the official nomenclature.

The growing supply will build on the comparative advantages of the EU and reduce price competition with emerging players in the market. In particular services such as contracting will lead to a more steady business activity of ME firms. However, the effects will remain limited always having to consider investment cycles.

6.3 Long-term outlook

This section addresses the long-term growth potential of the mechanical engineering sector as well as the future development of productivity in this sector. Combining growth and productivity allows assessing future employment developments.

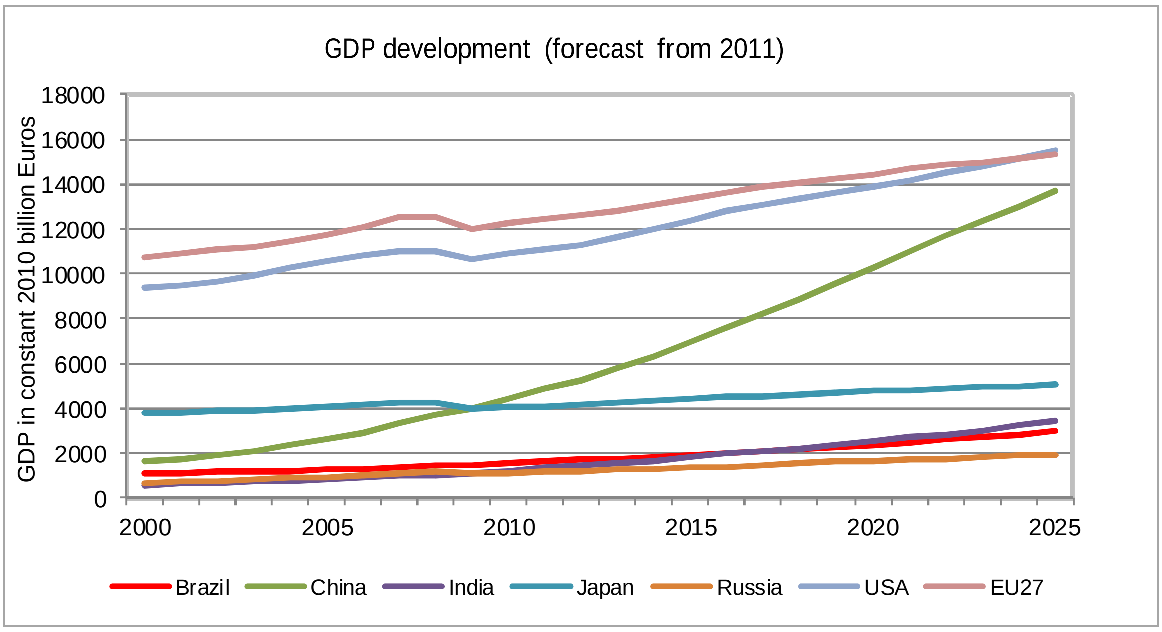
6.3.1 Economic growth potential

The future growth potential of ME is assessed in several steps. First, long-term GDP projections are calculated for the EU27 and a set of relevant competing economies, namely the BRIC countries, the USA, and Japan. Second, shares of manufacturing from GDP and of mechanical engineering from manufacturing are derived. A combination of these elements allows to compare expected future developments in the ME sector.

Development of ME is largely dependent on a country's overall economic development. A first step to assess future growth potential of the ME sector is therefore to assess overall economic development of a country. Two different data sources are used to compile a long-term economic outlook for the EU27, the US, Japan, and the BRIC. First, data from IMF's World Economic Outlook is used to account for the historical development of GDP as well as for medium-term GDP forecasts from 2011 to 2016. Second, projections from Goldman Sachs are used for long-term GDP forecasts from 2017 to 2025.[190]

The country with the largest growth potential is clearly China, nearly reaching levels of the EU27 and the US by 2025. The other BRIC countries, especially Brazil and India, also show strong growth but remain much smaller in absolute size compared to China.

Figure 6.2: Forecasted GDP development



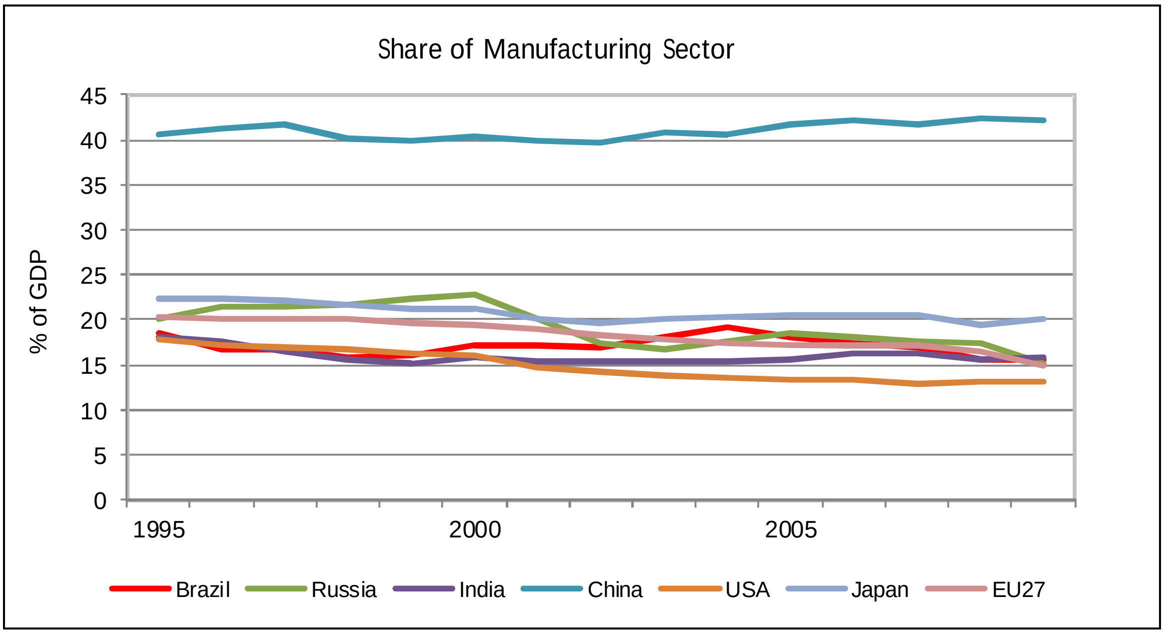
Source: IMF, Goldman Sachs.

As a next step, manufacturing's share of total GDP has to be assessed. Data from UNCTAD shows that most countries have manufacturing shares of around 15% to 20% of GDP. China is a clear outlier with manufacturing accounting for more than 40% of GDP. Developments within each country have been quite stable in the last years, with a

[190] The projections from Goldman Sachs are from their Global Economics Papers No: 99 and No: 192.

little more dynamics in the period of the financial crisis. Therefore long-term development of manufacturing shares is assumed to be stable, with shares expected to revert back to pre-crisis levels by 2012.[191]

Figure 6.3: Share of manufacturing sector as % of GDP



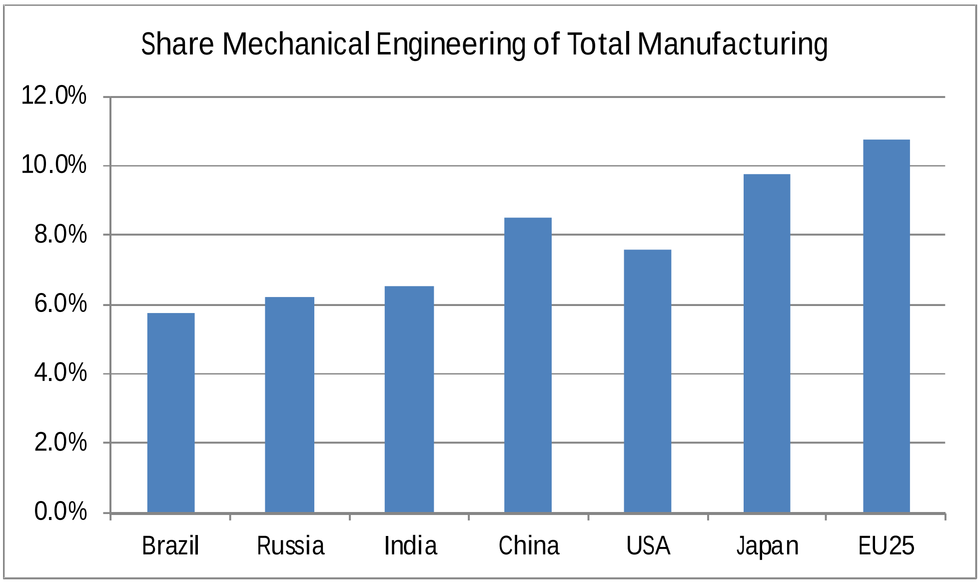
Source: UNCTAD.

In addition to the size of manufacturing as a share of GDP, the size of mechanical engineering as a share of manufacturing has to be assessed to be able to predict future growth potentials for ME. No clear trends could be identified of how shares of mechanical engineering evolve as a share of manufacturing. As most countries showed a fairly stable development of these shares, the long-term development of mechanical engineering shares can also been assumed to be stable.[192] Shares of mechanical engineering vary substantially, with the EU27, Japan, and China having the largest shares and Brazil, Russia, and India having the smallest shares.

191 2010 values are assumed to go back to 2008 levels, while shares for all following years are assumed to go back to 2007 levels.

192 Availability of data on the relative size of ME and manufacturing differed. For the further calculations, an average share for the years 1995 to 2010 has been calculated.

Figure 6.4: Share of mechanical engineering as % of total manufacturing



Source: Cambridge Econometrics, KLEMS.

The long-term growth potential of mechanical engineering is then calculated by taking the GDP projections and multiplying them with the manufacturing share and the mechanical engineering share.

The total market size for ME of the seven analysed countries plus the EU27 is growing steadily, going from € 527 bn in 2010 to € 928 bn in 2025. Even though all individual countries and the EU-27 are able to grow, China will be clearly dominating the world output of mechanical engineering products by 2025.

However, this growth scenario concludes the development of the mechanical engineering sector only from domestic GDP development and does not consider the special importance of trade for this sector. For the EU-27, around 40% of growth in the mechanical engineering can be accounted from trade-induced demand. Therefore, a second scenario is derived in which 60% of the growth is generated domestically, whereas one third is generated by increased demand of the world market. To do this, weighted average growth rates of the BRIC countries, Japan, and the USA are used to proxy an increasing global demand in mechanical engineering.

Using this second scenario, the EU27 would be able to achieve a market size of €232.0 bn by 2020, compared to the predicted market size € of 204.7 bn stemming from the base scenario.

Table 6.5: Development of mechanical engineering output by selected countries

	Value added in bn. €					
	2000	2005	2010	2015[1)]	2020[2)]	2025[2)]
Brazil	11.0	13.2	14.2	18.8	22.6	27.2
China	28.2	58.4	161.4	248.0	329.4	410.1
India	6.3	8.4	12.8	19.3	26.0	34.4
Japan	89.7	96.2	66.2	75.4	81.0	86.3
Russia	9.8	10.8	12.1	14.9	17.6	20.8
USA	123.7	124.5	103.0	115.5	129.7	144.9
EU27	158.0	160.8	157.5	178.3	193.2	204.7
EU27 with trade				183.5	208.4	232.0
Total	426.7	472.4	527.1	670.2	799.6	928.3

[1)] Based on GDP forecasts from IMF; [2)] Based on GDP forecasts from Goldman Sachs

Source: Own calculations.

The relative distribution of the mechanical engineering can best be observed when comparing developments of individual output shares of the eight analysed economies. China's share is projected to reach stunning 44.2% of the overall analysed market, compared to 30.6% in 2010. Brazil and India will be able to extend their market shares slightly, but will not be able to become players of comparable size to the EU-27. Russian shares will stagnate at low levels. Even though the EU27 and the USA will experience absolute output growth of the mechanical engineering sector, they are clearly losing ground regarding shares: the EU27 will go back from 29.9% in 2010 to 22.0% in 2025, whereas the US is expected to lose weight from 19.5% to 15.6% in the same period.

Table 6.6: Projected relative size of mechanical engineering sectors (baseline prediction)

	Share of value added in %[1)]					
	2000	2005	2010	2015	2020	2025
Brazil	2.6%	2.8%	2.7%	2.8%	2.8%	2.9%
China	6.6%	12.4%	30.6%	37.0%	41.2%	44.2%
India	1.5%	1.8%	2.4%	2.9%	3.3%	3.7%
Japan	21.0%	20.4%	12.6%	11.3%	10.1%	9.3%
Russia	2.3%	2.3%	2.3%	2.2%	2.2%	2.2%
USA	29.0%	26.4%	19.5%	17.2%	16.2%	15.6%
EU27	37.0%	34.0%	29.9%	26.6%	24.2%	22.0%

1) GVA in focal country divided by GVA of all analysed countries

Source: Own calculations.

If one considers the alternative scenario introduced above and explicitly considers trade as an important growth driver of the EU27 mechanical engineering sector, losses in output shares for the EU27 are more moderate. In this scenario, the EU27 would still be able to maintain an output share of 24.3% by 2025, compared with an output share of 22.0% for the baseline scenario.

Table 6.7: Projected relative size of mechanical engineering sectors (trade scenario)

	Share of value added in %[1)]					
	2000	2005	2010	2015	2020	2025
Brazil	2.6%	2.8%	2.7%	2.8%	2.8%	2.8%
China	6.6%	12.4%	30.6%	36.7%	40.4%	42.9%
India	1.5%	1.8%	2.4%	2.9%	3.2%	3.6%
Japan	21.0%	20.4%	12.6%	11.2%	9.9%	9.0%
Russia	2.3%	2.3%	2.3%	2.2%	2.2%	2.2%
USA	29.0%	26.4%	19.5%	17.1%	15.9%	15.2%
EU27 with trade	37.0%	34.0%	29.9%	27.2%	25.6%	24.3%
1) GVA in focal country divided by GVA of all analysed countries						

Source: Own calculations.

Looking at expected growth rates allows for another complimentary view of future developments in ME. Regarding growth rates, China is clearly leading from 2000-15. From 2015-25, growth rates of the other BRIC countries will become similar or even higher than China's growth rates. Japan, the US and the EU27 are expected to have significantly lower growth rates throughout the whole period of analysis. Growth rates for the EU27 differ between the baseline scenario and the scenario including trade by around 1%.

Table 6.8: Projected growth rates in mechanical engineering

	Annual average growth rate in %				
	2000-05	2005-10	2010-15[1)]	2015-20[1)2)]	2020-25[2)]
Brazil	3.8	1.4	5.8	3.8	3.7
China	15.7	22.5	9.0	5.8	4.5
India	6.0	8.7	8.7	6.1	5.7
Japan	1.4	-7.2	2.6	1.4	1.3
Russia	1.9	2.2	4.3	3.4	3.4
USA	0.1	-3.7	2.3	2.4	2.2
EU27	0.3	-0.4	2.5	1.6	1.2
EU27 with trade			3.1	2.6	2.2
[1)] Based on GDP forecasts from IMF; [2)] Based on GDP forecasts from Goldman Sachs					

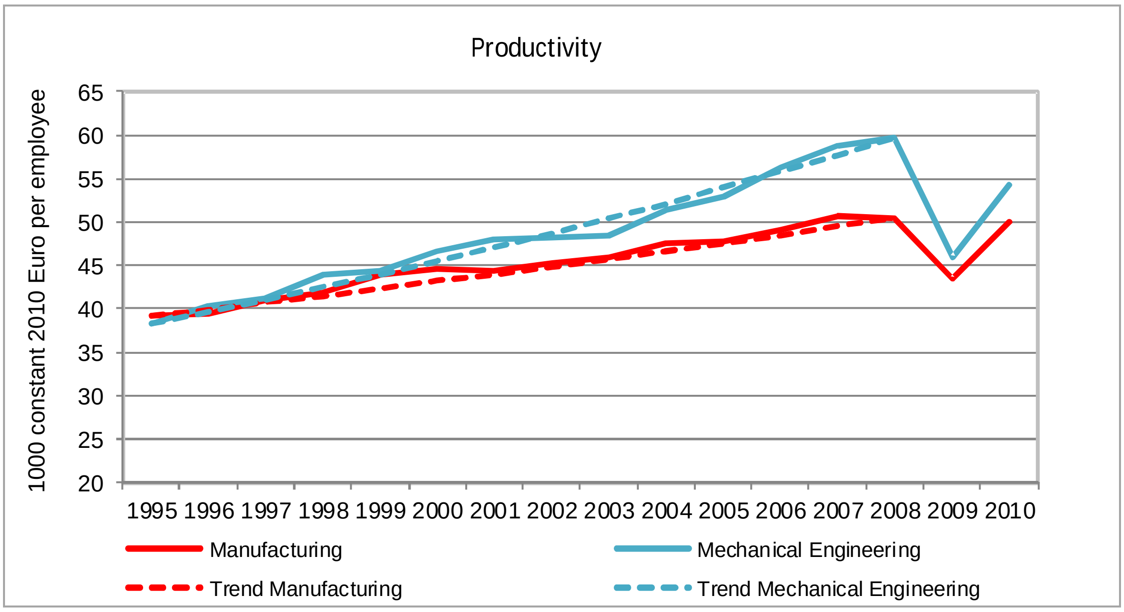
Source: Own calculations.

6.3.2 Productivity development

In addition to overall developments in output, the development of labour productivity is another key area of interest, as only sectors achieving continuous productivity improvements are able to stay competitive in the long run.

Productivity development of manufacturing and mechanical engineering in the EU27 shows a clear and steady upward trend from 1995 to 2008. Initially, both ME and total manufacturing had very similar levels of labour productivity. Labour productivity showed almost a linear upwards trend during the study period from 1995 to 2008, but ME has been able to achieve higher growth rates. During the financial crisis, both sectors experienced a strong decline in labour productivity, which is typical for a crisis during which employment is not reduced as strong as demand goes down. Keeping employment at a higher level than required during the main phase of the crisis, has eased fast recovery after the crisis, as capacities can be immediately increased again. This strong upturn in productivity can already be observed for 2010.

Figure 6.5: EU27 productivity development for manufacturing and mechanical engineering



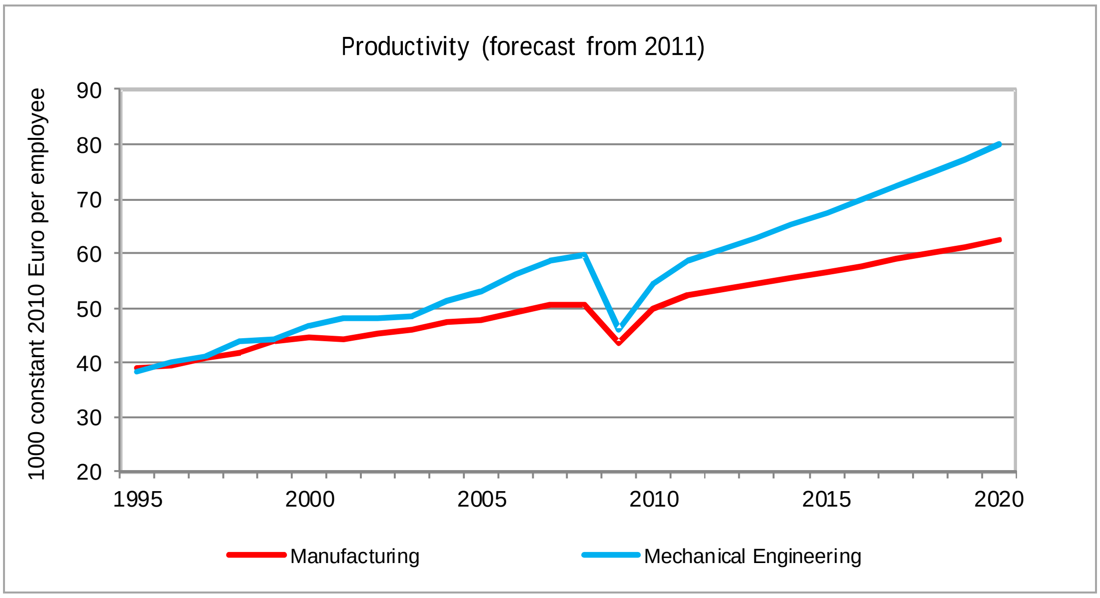
Source: Cambridge Econometrics.

The long-term trend in productivity suggests a stable growth rate in manufacturing as well as in ME productivity. Actual development fits together very well with the long-term trend from 1995 to 2008. Average annual growth rates in productivity are 2.0% and 3.5% for manufacturing and ME respectively. As these growth rates have been very stable for more than a decade in the pre-crisis period, it is assumed that productivity continues to grow at these growth rates after the recovery from the crisis.

Using these growth rates, EU27 productivity can be expected to significantly grow throughout the forecasted period until 2020. Labour productivity in mechanical engineering is expected to reach € 67,400 in 2015, up from € 54,300 in 2010. By 2020 EU27 labour productivity has the potential to go up to € 79,900.[193]

[193] All productivity measures are reported in constant 2010 Euro per employee.

Figure 6.6: Forecast of EU27 productivity development until 2020

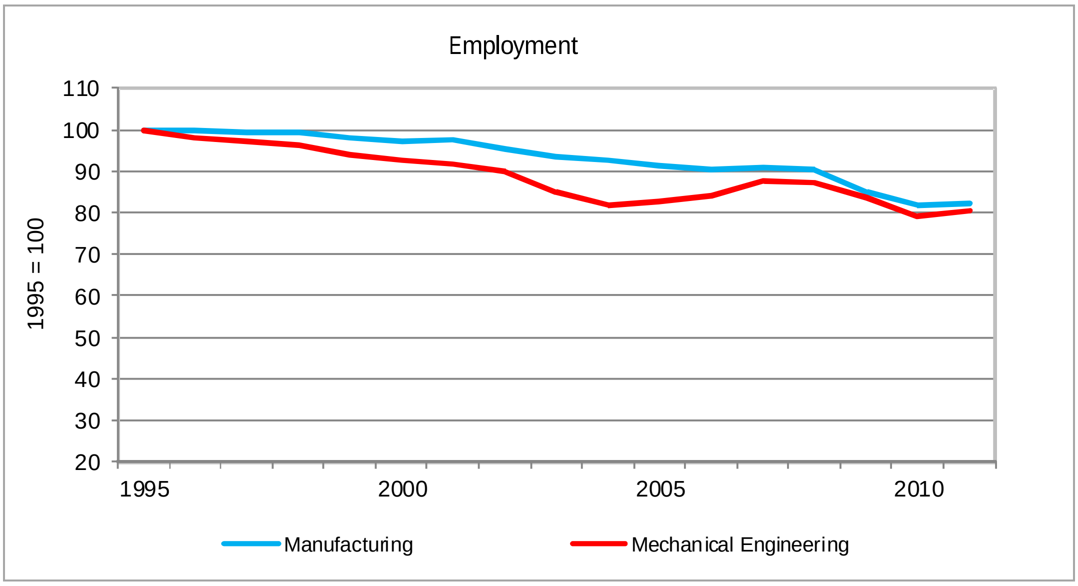


Source: Cambridge Econometrics.

6.3.3 Employment implications

Having formed expectations about growth of the ME sector and about developments in labour productivity allows triangulating expectations about development in employment. The period beginning with 1995 saw an overall decline in employment both in manufacturing and in mechanical engineering. However, this overall downward trend could be reverted for the mechanical engineering sector in the economically successful years from 2004 to 2007. In the following years of the financial crisis, employment in ME dropped again. Total employment in ME fell from 3.7 mn employees in 1995 to 3.0 mn in 2004, then up to 3.2 mn in 2007 and down to 2.9 mn in 2010.

Figure 6.7: Relative development of employment in manufacturing and mechanical engineering



Source: Cambridge Econometrics.

Employment projections can be calculated by multiplying the employment as follows:

$$Employment_t = Employment_{t-1} * GVA\_growth_{t,t-1} / Productivity\_growth_{t,t-1}$$

Assuming (as before) a yearly productivity growth of 3.5% and inserting the growth rates in gross value added obtained by the prior analysis, a projection for future employment can be tempted. As expected GVA growth rates in the EU27 manufacturing sector are consistently below the expected increase in productivity, declining employment is expected. Projected ME employment is expected to shrink to 2.8 m employees in 2015 and to 2.5 m employees in 2020, which represents a significant decline compared to the 2.9 m employees in 2010. Considering the more optimistic EU27 growth scenario that considers trade-induced growth, reductions in employment level would be more moderate. Levels of 2015 employment would be 2.9 m and in 2020 2.7 m people would be employed in mechanical engineering.

To conclude, the anticipated consistent absolute growth in the following years. However, this growth may not be robust enough to compensate the growth in labour productivity, leading to a net loss in employment. The evolution of EU ME must be valued against the background that domestic demand is expected to be dampened for several years by urgent measures to overcome the public debt and private banking crisis. Without success on global markets and stimulation by emerging economies growth the ME's perspectives would be worse.

6.3.4 Conclusions

Both of these paths of development highlight the importance of ME's alignment with global trends. Strong growth can only be generated if the EU companies are successful in emerging economies' markets. These countries do not only provide opportunities for growth but for the exploitation of scale effects which is a decisive factor for the companies' long-term competitiveness. The EU ME's success in foreign markets throughout the past decade was impressive and underscores that EU companies produce the products needed for the industrialization of emerging economies. They are on the leading edge of technology and particularly strong in supplying resource-efficient processes. As a conclusion, the EU ME is an enabling industry not only in domestic markets but in global markets. The success in the latter markets will be decisive for the future competitive position of EU ME.

Promising areas, such as resource- and energy-efficient products and technologies, technologies to fight climate change and alike can add positive effects to the evolution of the EU ME that commands a leading position in international markets. However, public schemes – dedicated to support technical progress in these areas – will only provide noteworthy additional growth stimuli if they take into account international markets with their specific needs.

The success of Chinese manufacturers of solar cells in the EU highlights the necessity not only to become a technology leader. Simultaneously it is necessary to trust in companies with the potential and the ability to raise the means necessary to pursue global strategies.

Moreover, in contested markets it is extremely important for companies to supply budget-priced products. This means that resource efficiency is only one criterion, as in the case of CO2 emissions, foreign clients' decisions will strongly be dependent on the level of CO2 avoidance costs.

6.4 Recommendations

6.4.1 Organisation and industry structure

During past decades ME went through phases of consolidation. Larger companies and groups of companies have emerged through M&A. However, ME has remained an industry with predominantly medium-sized, frequently family owned enterprises. These firms are the backbone of the EU ME. SMEs – up to the threshold as defined by the EU – are not the predominant players of ME. Many SMEs face growing competitive pressure from EU and non-EU manufacturers that are about to gain additional market shares in the EU Single Market.

It is recommended that **SME**s suffering from growing competitive pressure screen their business model to explore possibilities to extend the supply of service. Beyond maintenance, repair and overhaul even the installation and operation of trade products should be taken into account besides own production. For instance more sophisticated heating and air conditioning equipment provides additional opportunities for SMEs to enter new market segments, that are more service-driven.

It is recommended to **public authorities** who pursue cluster policies to find solutions how to integrate SMEs in value chains. However, there exists a major risk that industrial structures – non-competitive in the era of globalization - are preserved and must be subsidised permanently (See for example: Chapter 2.2.4). An indispensible prerequisite for successful cluster policies lies in the existence of at least one enterprise with management abilities and financial resources to become a subsystem supplier. On the one hand such an enterprise must be perceived as a reliable and risk-taking supplier by potential clients. On the other hand such an enterprise must be willing and able to co-ordinate subcontracting regional SMEs.

ME is marked by a sophisticated division of labour. In the era of globalization, the regional coverage of value chains has been permanently expanded. EU companies as members of former stable value chains have been increasingly confronted with potential competitors from other member states or even non-EU countries in bidding processes to apply for a subcontract. International price competition is a challenge for most EU companies. Non-price arguments such as flexibility, quality, know-how, just-in-time deliveries support successful biddings. But it is questionable if these arguments remain valid in the long-run with growing international competition.

It is recommended that **EU enterprises** as members of value chains try to change their business model and become subsystem suppliers. Opportunities are provided by larger client companies that show increasing interest in outsourcing parts of their own production. Simultaneously they want to employ only a limited number of suppliers. These subsystem suppliers become responsible for several subcontractors, coordinate work, guarantee quality and timely deliveries. This provides opportunities to reduce price pressure and to win contracts. Other award criteria, such as the competency to provide sophisticated systems, access to cost-efficient subcontractors, management abilities and a stable, long-term reliable supply relationship gain much importance for companies with production sites in the EU.

Suppliers in value chains are vulnerable to price competition. Within the EU – even within the new member states - wages are high as compared to global levels and labour contracts are rigid.

It is recommended that **EU enterprises** with domestic locations strengthen their position with their clients by putting more emphasis on non-price features. An important factor for success on competition is based on life-cycle involvement. Increasingly OEMs ask for the delivery of spare parts, coverage of guarantees and services throughout the whole product life cycle and value their suppliers on their viability and long-term reliability. OEMs themselves are more and more confronted by their clients to provide services throughout the entire life-cycle.

Going global has become an important topic in strategic decision-making. One barrier to overcome lies in the nurturing of close ties to subcontractors that are risk-averse with regards to a foreign market entry or cannot allocate the necessary resources to invest in remote production locations.

It is recommended that EU enterprises that are about to invest in remote markets try to convince and support their traditional subcontractors to follow. The search for new subcontractors usually bears risks. Well-known good quality suppliers should be supported to remain in the value chain. In some EU member states good experiences have been made with trustful co-operations along the value chain. The willingness of suppliers to take the risks is strongly dependent on mutual trust and confidence.

6.4.2 Market regulation

The EU has performed fairly well in market regulation and the abolition of barriers to trade. A focal point highlighted by representatives of the industry is market surveillance, albeit by far not considered sufficient.

It is recommended that the **EU Commission** reviews Directive 765/2008. A more adequate solution is required, based on the same institutional incorporation in all member states and equipped with a staff satisfying by qualification and by capacity. Representatives of the industry have suggested market surveillance at border crossings. This would be perhaps the most efficient solution to identify non-compliant imports. Feasibility should be investigated (See: Chapter 5.1.2).

Public policies directed towards health, safety, resource efficiency and environmental protection are of general importance for a long-term sustainable economy and society. The corresponding directives are implemented that way that national provisions can ask for even stricter rules. Moreover, national authorities sometimes use different criteria, for instance in assessing the safety of a workplace. In these policy areas some barriers to trade have not been and so far be abolished by legislative acts. It is in that respect crucial to create stable and reliable framework conditions.

It is recommended that the **EU Commission** takes a cautious stance with the introduction and review of directives and closely communicates with industry stakeholders. It is suggested to avoid unnecessary changes of provisions and to agree upon a time span between two changes. This time span must take into account the companies' efforts to find a technical solution for their products to comply with the latest provision (See: Chapter 5.1.8).

In particular smaller firms struggle to meet regulatory requirements. Insofar the preceeding recommendation on long-term stable and reliable framework conditions is above all relevant for smaller firms. A good example to take into account smaller' firms difficulties is given by waste gas provisions for internal combustion engines. For engines – manufactured in smaller units per year – the introduction of stricter rules was delayed. This gave smaller firms the opportunity to learn from larger companies' experiences.

It is recommended that the **EU Commission** takes into account potential problems of smaller enterprises with new regulation. For instance smaller enterprises do not have the internal expertise to comply with the RoHS Directive and have to purchase external know-how. Timely information and a sufficient time horizon for the implementation are crucial prerequisites to adapt to coming provisions.

It is recommended that **industry's associations** give a hand to smaller enterprises to comply with provisions. Associations provide services to their member. This means for instance for the example above that the associations pool expertise that can be accessed by members at a convenient price (See: Chapter 5.1.9).

Self-imposed obligations (or self-regulatory initiatives, SRI) can become important tools by policy makers to pursue political objectives. Such procedures incorporate several advantages, such as the identification of enterprises with regulation and the opportunity to suggest solutions with regard to their scope of action.

It is recommended that the **EU Commission** is open towards self-imposed obligations and suggest the **European Sectoral Committees** to prepare proposals together with national associations and companies.(See: Chapter 5.1.7).

It has been reported that the EU Commission is open to CECIMO's initiatives to suggest a SRI. However, European Sectoral Committees and industry's association do not have experience with that kind of policy tool and hesitate to apply it as the framework for the development and also the implementation of SRIs is not well defined.

It is recommended that the **EU Commission** takes self-imposed obligations seriously and provides a reasonable base to allow the industry to find and implement suitable solutions via SRIs.

In the area of technical regulation, the EU is a model for others with regard to its openness to international co-operation and its close contact with international organisations. However, in the area of mobile machinery, the Commission pursues a different strategy although EU companies have been busy to develop internationally agreed standards together with UN-ECE and the OECD.

It is recommended that the **EU Commission** reviews its current position on this subject (See: Chapter 5.1.10)

6.4.3 Financial markets

The European financial markets are not sufficiently developed as compared to the US. Banks have always played an outstanding role in enterprise funding. This is in particular true for the medium-sized ME enterprises. Close linkages to a bank have been beneficial in former times. Due to the financial crisis it has become more urgent to explore alternative funding channels.

It is recommended that **EU companies** – even smaller ones – become more transparent for financial players and new funding channels (See: Chapter 5.4). They should make publicly available reports on business activity and their outlook. This is understood as a preliminary step to make the company better known to potential investors.

It is recommended that **industry associations** inform the economic journals and media on a regularly basis on business climate and expectations. An exchange of views between financial institutions and member companies should be arranged.

The EU has made many efforts to ease funding for smaller enterprises. Much information has been circulated by the Commission.

It is recommended that **industry associations** use their close contact to member firms to a targeted spread of information.

6.4.4 Labour market

A structural downside of the EU labour market compared to competing nations in the study is the limited labour mobility caused by social, cultural and linguistic differences between Member States. In combination with the demographic developments in many EU countries bottlenecks in the labour supply must be expected. In spite of the Bologna process, cross-border flexibility of qualified staff has remained limited.

It is recommended for a better understanding of the present and future human resource situation to **introduce regular monitoring of supply of and demand for skilled labour**. The investigation in the labour market has unveiled that reliable statistics are scarce.

Another shortcoming of the EU labour market has been identified by the time series analysis for the investigation in the economic performance. The slump of output and the low capacity utilization caused by the financial crisis had no measurable impact on the increase of wages per capital for EU ME, in contrast to the US and Japan where wages decreased. The rigidity in collective wage agreements has led to a deteriorating economic performance and price competitiveness compared competing economies.

It is recommended that **industry associations** and trade unions find solutions to better comply with cyclical fluctuations of business activity that occasionally affect ME. This is an important topic for ME being more prone to fluctuations than most other industries. This suggestion will contribute to the will of companies not to lay off qualified personnel during a crisis that will urgently be needed during the following recovery.

As other manufacturing industries ME suffers from a decreasing interest of qualified professionals in manufacturing and technical industries, hence leading to a potential shortage of skilled labour. Further increasing is the fact that ME is a medium-sized industry that competes with the automotive industry and the aerospace industry to attract young professionals qualified for occupations in metal working industries. Not only wage levels but well-known brand names give transport equipment companies an edge.

> It is recommended that companies and entrepreneurs associations start image campaigns. Much focus should be laid on societal topics of major importance. ME is an industry of outstanding importance for sustainability, energy savings, fight agains the carbon footprint and reduction of waste. This knowledge is not widespread and could attract young professionals that do not only want to protest against climate change but become an active environmentalist, for instance.

Engineers have always been the backbone of the industry. Their share of total employment has strongly grown over the decades. Beyond the above average development of workplaces for engineers in ME the demographic situation contributes to the urgent need of the industry. Engineers are the drivers of important changes in the ME's product portfolio towards more sophisticated machinery, production systems and industrial services (see: Chapter 5.3.6).

> It is recommended that companies intensify their efforts to co-operate with universities, start job exchanges and try to become more visible in the public.
>
> ME has remained a male domain. It is recommended that companies try to attract more women. Public authorities should contribute with horizontal measures to improve the infrastructure for childcare. In particular large companies have the potential to provide an attractive environment for women that has to be added by specific
>
> It is recommended to national and regional governments to improve working conditions in MINT disciplines at universities and give more room to the education in natural sciences already at the primary and secondary level.

The combination of qualified labour on different levels is an important ingredient to attain a competitive company. Top qualifications have always been in the focus. However, sometimes medium qualifications present the bottleneck to further thrive in a business environment. Problems have been identified with qualified technicians such as machine operators, toolmakers, service personnel etc. Most urgent was the demand in EU member states that do not offer apprenticeship schemes or similar vocational trainings.

> It is recommended that companies and their association take initiatives supported by their governments to introduce formal career pathways that can help to fill a gap in labour qualification that gains more and more importance for an industry that provides increasingly sophisticated machinery and technical service to clients.

6.4.5 Innovation environment

Growing constraints in public funding ask for more efficient R&D schemes. ME is an industry with a global reach and contributes much to the reduction of the EU-27 trade balance deficit. ME's growth potential is much dependent on its access to the large remote markets. Its products are urgently needed for the industrialisation of emerging economies. As a consequence, R&D should put more emphasis on enforcing ME's competitiveness in sales markets beyond the EU.

It is recommended that the **EU Commission** analyses the advantages provided by R&D locations and framework conditions outside the EU, in particular in research-intensive emerging economies that attract business R&D from EU firms (see: Chapter: 4.6.3). Special attention should be paid to Japan. Since long the economy is in the doldrums, but R&D efforts have remained on top of the OECD countries. Moreover, the share of private enterprises is well above other developed economies. The global markets' needs have always been in the focus of Japanese R&D efforts (see: Chapter: 3.1.2). Such a stance could contribute to further improve ME's position in global markets. In particular with regard to the long-term prospects for the EU and the global economy continuing efforts to build on past successes are instrumental for ME in international trade in the future (Chapter 6.3).

Three areas of technology have been identified as of outstanding importance for ME: Research on power generation, material sciences, in particular CFRP, and manufacturing technologies.

It is recommended that the **EU Commission** puts much emphasis on technological progress in these areas. Funds should be concentrated on projects most promising for strengthening competitiveness.

ME is the key-industry to meet the targets to become a low-carbon economy. All kind of power generation technologies are based on its products. A broad range of technologies for low-carbon power generation and the use of renewables are available. However, not only is the progress in these technologies challenging and expensive, also the installation and operation needs a lot of subsidies to provide incentives for private businesses to invest. Capital intensity is much higher than for conventional power plants. With regard to the public debt crisis and its long-term impact on public expenditure, sound economic decision-making is crucial to allocate the necessary resources to meet the EU's self-imposed targets on reductions in CO_2 emissions.

It is recommended that the **EU Commission** puts much emphasis on those technologies with the lowest CO_2 abatement costs. A ranking of technologies according to this criteria, an assessment on future savings and the economic break-even should guidelines on the distribution of research projects and budgets. This will contribute to a most efficient use of scarce public funds. The societal payback periods can be reduced. Above all technologies based on low CO_2 abatement costs will be attractive for clients from emerging economies and contribute to the EU ME's long-term success.

All economies under consideration compete on technological leadership in the same high-tech areas. In particular the US and the EU economies suffer from growing budgetary constraints ultimately limiting their public research budgets (see for the US: Chapter 3.1.1).

It is recommended that the EU Commission puts much emphasis on those technologies with the highest potential to become a global leader. A more focused approach that takes into account the EU-27's comparative advantages. If it is closely related to the EU as a competitive location for production , the positive effects can be two-fold: Firstly, such a strategy raises the possibility for gaining a unique position at the forefront of technological development. Secondly, the transmission of a leading position in advanced technologies also trickles down to create positive spill-over effects on workplaces in manufacturing.

6.4.6 Access to third markets

The current stalling of the multilateral WTO negotiations is a barrier to future success of the EU ME in international markets.

It is recommended that the EU Commission takes the initiative to reopen the proceedings.

The European Commission has successfully pursued the arrangement of bilateral treaties with numerous countries and contributed to the success of EU ME in international markets.

It is recommended that the EU Commission strategically identifies countries that are of special interest as valued by market size and growth potential. Those economies with few conflicting interest as for instance with agricultural products should be selected for further bilateral trade negotiations.

Beyond strategic initiatives it is of importance to monitor the compliance of all players in bilateral trade with trade agreements. Particular emphasis should be attributed to the compliance of players with the provisions of an agreement, putting in place effective sanctuary measures.

It is recommended that the EU Commission introduces the possibility of sanctions against misbehaviour that can be put in force without delay.

In transatlantic trade there are close contacts between public authorities to reduce trade barriers. In contrast to current efforts to reduce barriers by the EU market, the access of the US market is considerably more difficult due to the non-harmonization of provisions. Internationally speaking, different requirements set from national administrations create barriers to trade.

It is recommended that the EU Commission puts more emphasis on these internal problems of the US market.

Although China has become a member of WTO in 2001 and incorporated most of the requirements of the World Intellectual Property Organization (WIPO) into national law much remains to be undertaken in view of implementing a fair competitive framework.

It is recommended that the EU Commission pursues a strict strategy to encourage China to introduce at all institutions the necessary provisions to abolish existing deficiencies in the protection of IPR.

It is recommended that the EU Commission closely monitors whether Chinese industrial policies and FDI restrictions are aligned with WTO agreements.

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Annex Fieldwork

Organisation	Country	Contact Person	Position	Kind of contact
				Face-to-face, phone, mail
		Sectoral committees / sectoral representatives		
CECE / CEMA European Sectoral Committee	Belgium	Ralf Wezel	General Manager	Phone conference
CECIMO European Sectoral Committee	Belgium	Filip Geerts; Marek Gerczy• ski	General Manager	Phone conference
EUROTRANS European Sectoral Committee	Germany	Dirk Decker	Executive Director	Phone conference
Euroturbines European Sectoral Committee	Germany	Matthias Zelinger	Executive Director	Phone conference
EUROMOT European Sectoral Committee	Germany	Paul Zepf / Peter Scherm	Technical Manager	Face-to-face
Eurovent European Sectoral Committee	Belgium	Joop Hoogkamer	Executive Director	Phone conference
VDMA / CEMATEX European Sectoral Committee	Germany	Thomas Waldmann	General manager	Phone conference
VDMA Materials Handling and Logistics	Germany	Peter Günther	Managing Director	Face-to-face
VDMA Taps and valves	Germany	Christine Lindenau	Chief Economist	Mail
EUROPUMP European Sectoral Committee	Belgium	Guy Van Doorslaer	Bridgehead Manager	Phone conference
		National associations		
ANIMA National Ass.	Italy	Andrea Orlando / Marcello Chiriaco	Director General	Phone conference
Chamber of Commerce and Industry	Slovenia	Janja Petkovšek	Director	Phone conference
FIM National Ass.	France	Buronfosse	Industriepolitik	Phone conference
FMMI National Ass.	Austria	Berndt-Thomas Krafft	Industriepolitik	Phone conference
SERCOBE National Ass.	Spain	José Ignacio Pradas-Poveda	Director for Institutional Relations and Strategic Development	Face-to-face
VDMA National Ass.	Germany	Josef Trischler	Head of Business Administration	Phone conference

		Companies		
IMEDEXSA	Spain	Casar de Cáceres	CEO	Mail
KALFRISA S.A. Non-domestic cooling	Spain	André Izuzquiza	CEO	Mail
Van Den Landen Company Intralogistics	The Netherlands	Jan van der Velden	Manager Distribution Systems	Face-to-face
KSB	Germany	Werner Schreiner	Head of Branch, Munich	Face-to-face
		Specific topics		
VDMA	Germany	Ulrich Ackermann	Head of Foreign Trade Department	Face-to-face
VDMA	Germany	Juliane Krause	Expert on Russia and Central Asia	Face-to-face
VDMA	Germany	Gabriele Welcker Clemens	Expert on North America	Face-to-face
VDMA	Germany	Susanne Engelbach	Expert on Latin America	Face-to-face
VDMA	Germany	Alexander Koldau	Expert on Near and Middle East	Face-to-face
VDMA	Germany	Oliver Wack	Expert on East and South Asia	Face-to-face
VDMA/NAM	Germany	Gerhard Steiger	Director General NAM	Face-to-face
VDMA	Germany	Bernhard Hagemann	Director Drive Technology Research Associaton	Face-to-face
Danish Trade Fairs	Denmark	Carina Bruun	Head of Project	Face-to-face
AGORIA	Belgium	Peter Perremans	Advisor	
Cesare Galdabini spa	Italy	Dr. Ing. Luigi Galdabini	Managing Director	Face-to-face
Comau S.p.A.	Italy	Massimo Mattucci	Business Development Consultant	Face-to-face
ABB AB	Sweden	Ove Leichsenring	Business Development Swedish Sales, Robotics	Face-to-face

Abbreviations

AC	Air conditioning
ASTM	American Society for Testing and Materials
AMP	Advanced Manufacturing Partnership
BI	Balassa Index
bn.	Billion
BOT	Built-Operate and Transfered
BOOT	Build-Own-Operate-Transfer
CAD	Computer aided design
CCPIT	China Council for the Promotion of International Trade
CCUS	Carbon Capture Utilization & Storage
CEE	Central and Eastern European Economies
CEN	European Committee for Standardization
CETIM	Centre technique des industries mécanique
CE-market	Consumer Electronics Market
CFRP	Carbon Fibre Reinforced Plastics
CO_2	Carbon dioxide
CSP	Compact Strip Production
CSTP	Council for Science & Technology Policy
CZ	Czech Republic
DC	direct current
DE	Germany
DOC	Department of Commerce
ECU	Engine control unit
EII	European Industrial Initiatives
EMAA	European Mediterranean Association Agreement

empl.	Employment
EMU	European Monetary Union
EPBD	Energy Performance and Buildings Directive
ES	Spain
Et al.	And others
ETS	Emissions Trading System
EU(-27)	European Union
EUR	Euro
FDI	Foreign direct investment
FMLAA	Foreign Management Legal Accounting Act
FP7	The Seventh Framework Programme
FP8	The Eighth Framework Programme
FR	France
FTA	Free Trade Agreement
GDP	Gross domestic product
GERD	Gross expenditures on R&D
GHG	Green House Gas
GNP	Gross national product
GOR	Gross-Operating Rate
GPS	Global positioning system
Green-IT	Green computing refers to environmentally sustainable computing or IT
GVA	Gross value added
HVAC	Heating, ventilation and Air conditioning
ICE	Internal-combustion engines
ICT	Information and communication technologies
IP	Intellectual Property
IPR	Intellectual Property Rights

IPTS	Institute for Prospective Technological Studies
ISIC	the UN International Standard Industrial Classification
ISO	International Organisation for Standardisation
IT	Italy
JP	Japan
JV	Joint venture
KW	Kilowatt
ME	Mechanical Engineering Industry
MENA	Middle East & North Africa
M&A	Mergers and Acquisitions
MW	Megawatt
NACE	Nomenclature Générale des Activités Économiques dans les Communautés Européennes
NAFTA	North American Free Trade Agreement
NASDAQ	National Association of Securities Dealers Automated Quotations
NIST	National Institute of Standards & Technology
NLF	New Legislative Framework
NMS	Network Management Systems
NMP	Material Science, Engineering and Production Systems programme
NRMM	Non-Road Mobil Machinery
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturers
PCT	Patent Cooperation Treaty
PIMS	Profit Impact of Market Shares
PJ	Peta Joule
PL	Poland

PPP	Private Public Partnership
RCA	Revealed Comparative Advantage
RPA	Revealed Patent Advantage
RoHS	Restriction of Hazardous Substances
rpm	Revolutions per minute
R&D	Research and Development
SEI	Strategic emerging industries program
SET	Strategic Energy Technology plan
SF	Finland
SK	Scandinavia
SME	Small and medium sized enterprises
SOE	State-owned enterprise
S&T	Medium- and Long-Term National Science and Technology Programme
STBP	Science & Technology Basic Plan
TBT	Technical Barriers to Trade
thsds.	Thousands
TIP	Technology Innovation Program
ToR	Terms of reference
UK	United Kingdom
UN-ECE	Economic Commission for Europe
US	United States of America
USD	US-Dollar
US-$ (PPP)	Conversion in US-Dollar, using Purchasing Power Parities
VDMA	Non-profit organization, representing the local machinery and industrial equipment manufacturers in Germany
WEEE	Waste Electrical and Electronic Equipment

WIPO	World Intellectual Property Organisation
WTO	World Trade Organization
3D	Three-dimensional

Annex 1

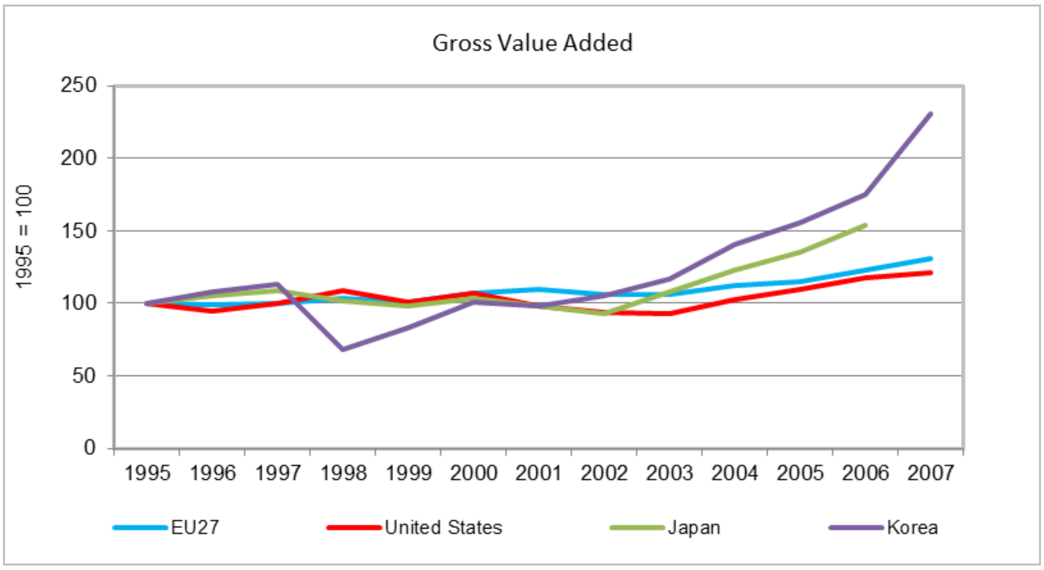
The performance of important competing economies in mechanical engineering

The economic performance of four important competing economies in ME, the US, the EU, Japan and Korea is analysed on the KLEMS database that has been set-up for sectoral international comparisons.[194] The sectoral aggregation is not fully compatible with the well-defined ME based on NACE Rev. 2. However, general tendencies can be observed and provide insight on the economic performance for the period 1995 up to 2007, the most recent available year. Although the do not fully match the results of the cost competitiveness analysis carried out in Chapter 3 they support the general tendencies and assessments.

As goods produced in ME are tradable goods, national ME industries can only survive in the long run if they are able to stay competitive with regards to other countries. This section aims to compare developments in ME of the European Union with some major competitors. The three countries for this comparison (United States, Japan, and Korea) have been selected as they give a good overview about different types of competing countries.

If one regards the growth pattern of gross value added (Figure 7.1), one can see that Europe performs mainly similarly than the United States, but Japan and the even more emerging South-Korea outperform the European Union by far.

Figure 7.1: Gross value added for the European Union and major competitors



Source: KLEMS; Calculations by Ifo Institute.

[194] K= Capital, L=Labour, M=Materials, S=Services (KLEMS) http://www.euklems.net/

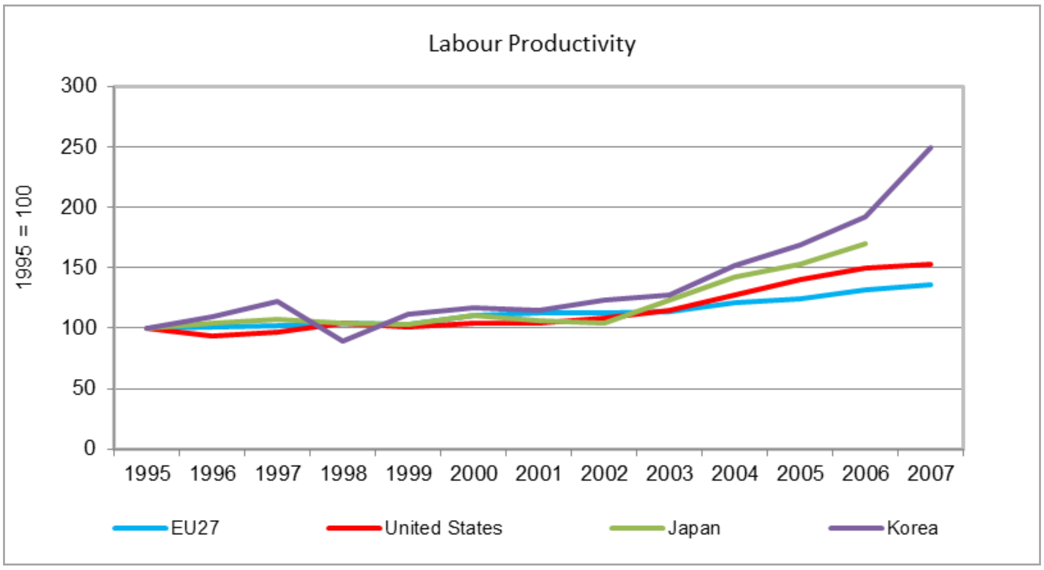
A similar ranking is provided when assessing the evolution of efficiency of labour input by labour productivity- measured as real value-added per employee (Figure 7.2). However, it must be kept in mind that levels of labour productivity differ strongly among the economies.

Table 7.1 Labour productivity of major competing economies in Mechanical Engineering, 2006[195]

Economy	National currency	Exchange rate	EUR
EU-25	53.97	1	53.97
Japan	15026.18	146	102.92
South Korea	22727.73	1200	18.94
USA	92.81	1.25	74.24

Source: KLEMS; Calculations by Ifo Institute.

Figure 7.2: Labour productivity for the European Union and major competitors

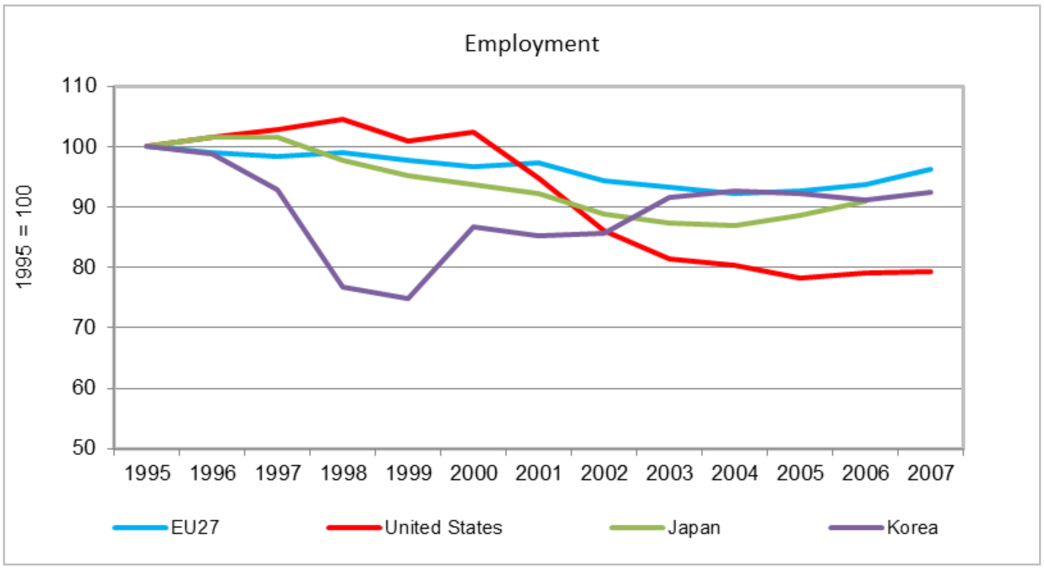


Source: KLEMS; Calculations by Ifo Institute.

As discussed before, changes in labour productivity can either be driven by a selection effect or by real productivity upgrades. Development of employment can be used to assess the relative importance of these two effects. Figure 7.3 plots how employment evolved over the time period from 1995 to 2007. Development of employment is quite heterogeneous across the different countries, but all countries have lower 2007 employment levels compared to 1995. The United States experienced the largest decline in employment, with most of the decline happening between 2000 and 2003. Japan and the EU experienced a very similar development, with declining employment numbers until 2004 and a slight recovery thereafter. Korea has already been able to improve its employment numbers from 1999, but experienced a major setback in the years before. As employment numbers have been fairly stable in recent years, selection effects have likely not been big drivers in pushing productivity.

195 Thess figured deviate strongly from those mentioned in the EnginEurope Report, see: discussion below Table 2.1 and cannot be explained by exchange rate variation. However, the message is similar. The EU is lagging behind the US and Japan.

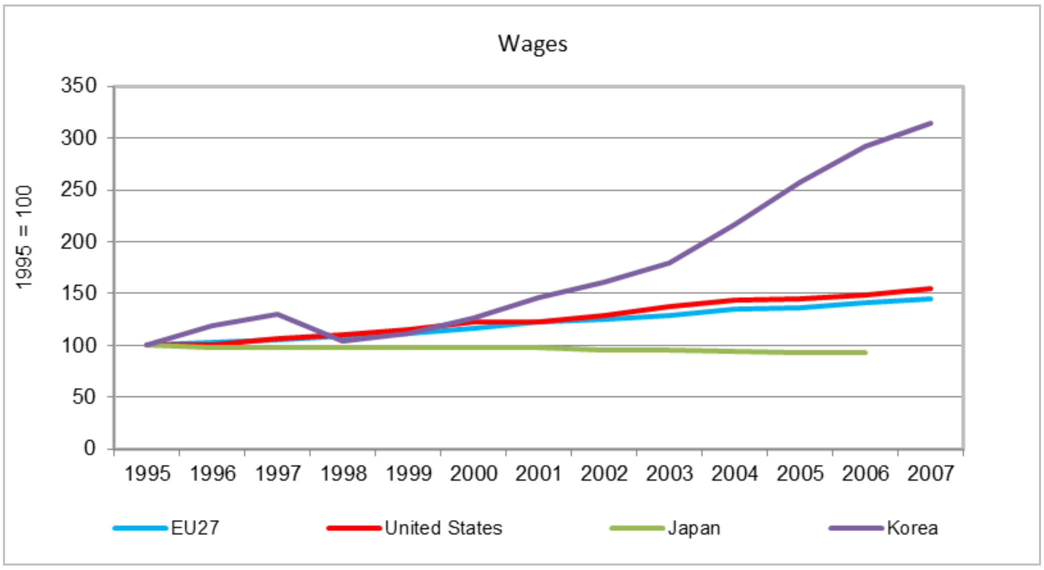
Figure 7.3: Employment for the European Union and major competitors



Source: KLEMS; Calculations by Ifo Institute.

Wages are assessed in a next step (Figure 7.4). Not surprisingly, wages show fairly different developments across the countries. Japan experienced a long-term deflation process, which did not allow for wage increases. Europe and the United States experienced moderate wage developments. Finally, Korea, being the least developed comparison state, experienced rapid wage increases of more than a factor of three over the observation period from 1995-2007.

Figure 7.4: Wages for the European Union and major competitors



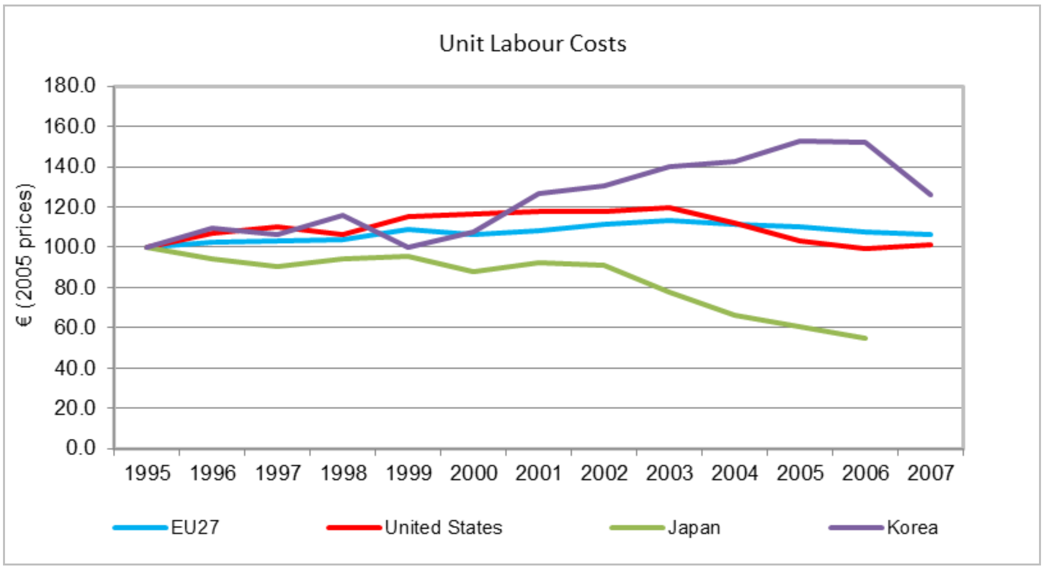
Source: KLEMS; Calculations by Ifo Institute.

Finally, unit labour costs[196] are used to assess the overall effect created by productivity

[196] Measured as the ratio of nominal wages to real GVA

gains and wage increases. As shown in Figure 7.5, Europe and the United States have been able to keep their development of unit labour costs relatively flat, but developments in Japan and Korea have starkly different outcomes. Korea more than compensated its productivity increase with large wage increases, which in turn lead to increases in unit labour costs. In contrast, Japan did not at all increase wages, so all productivity gains lead to declined unit labour costs.

Figure 7.5: Unit labour costs for the European Union and major competitors



Source: KLEMS; Calculations by Ifo Institute.

The analysis of the four countries provides important initial results that will be discussed in detail in the subsequent chapters. The different developments of the wages are – to a high degree - consistent with national inflation. The employment shows different developments over the period under consideration, but with the exception of the US the net balance is quite similar. Losses are contained in a narrow range. Only the US ME shed off one fifth of total employment. The decrease in employment suggests a noteworthy loss in marginal workplaces that - with regard to the magnitude - had an impact on productivity growth that exceeded that of the EU. Having in mind the much higher level of the US labour productivity in 2006 its lead against the EU-27 has widened further. The gap in labour productivity between the EU and Japan has also widened. With regard to the much better employment record than the US this is an indication for an improved economic performance of the Japanese ME.

Annex 2

Data Description

The source of the data for the comparison of mechanical engineering in 2008 and 2011 was the Eurostat short term business statistics which covers key Industry, Construction and Services indicators by sector defined by the NACE rev 2 industrial classifications. These indicators used are presented as indices indexed as 2005 = 100.
The indices are for the EU27 as a whole. Mechanical engineering is defined as sector C 28 which is the manufacture of machinery and equipment n.e.c. The manufacturing series is defined as sector C to use as a broad benchmark to compare the trends in mechanical engineering with.

The data is available as an annual, quarterly and monthly series except for the labour cost index which is only available as an annual and quarterly series for the EU27. The quarterly series is seasonally adjusted.

The production index is a measure of the volume of output over time. The employment index is a measure of the total no of people employed in the industry sector. The productivity index is derived from the dividing the Production index by the employment index thus giving a measure of the volume of output per worker. The Labour cost index is the wages and salaries index which reflects the total remuneration to workers.