The German M&E industry: an analysis in the context of innovation

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Abstract： The purpose of this paper is to provide a broad picture of the German machinery and equipment (M&E) industry in the context of innovation. We analyze producer-customer interaction, learning by producing and interactive learning as key concepts of the innovation process in the M&E industry. Secondary data is used to describe empirically the main characteristics of the German M&E sector. A case study of the M&E industry in Chemnitz provides an inside view of the factors influencing the innovation capability of manufacturing firms from a geographic perspective.

Key Words： M&E industry, Germany, innovation, Chemnitz

Introduction

The Machinery & Equipment (M&E) industry[1] is the second largest industry in Germany (Statistisches Bundesamt, 2013a: 532). It provides investment goods to all parts of the economy (Kalkowksi and Manske, 1993: 62). As it mainly sells its products to other industrial companies, it is a crucial force behind productivity growth (Kinkel and Som, 2007: 2). The M&E industry is dominated by small and medium-sized enterprises (SMEs). In 2012, it employed one million people and was assessed to be one of the most innovative sectors in German industry (Statistisches Bundesamt, 2013a: 531). For decades, the label “Made in Germany” has been recognized as a guarantee for high-quality products. Today, German manufacturing companies are the world market leader in 16 of 31 M&E sectors (VDMA, 2014a: 31).

Despite this success, the soaring rise of competitors from emerging markets, especially China, poses a big challenge for the German M&E industry. Five years ago, the turnover of the two countries was at about the same level. In 2012, the turnover of Chinese M&E companies reached CNY 6,623 billion (NBS, 2013). This is more than three times higher

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[1] In this paper, the terms ‘Machinery and Equipment industry (M&E) and ‘Mechanical Engineering industry’ are used interchangeably. The secondary data, unless otherwise indicated, refers to the category ‘Maschinenbau’ in the German industrial classification of 2008 (WZ 2008).

than that of German companies (Statistisches Bundesamt, 2013a: 531). Nonetheless, it is expected that Germany will play a leading role in the M&E industry in the future. The ability of German companies to compete successfully on the world market will very much depend on their ability to innovate continuously. Innovations are recognized as a key factor underpinning the competitiveness of firms and the wealth creation of economies. An innovation is defined as “the implementation of a new or significantly improved product (good or service), or process, a new marketing method or a new organizational method” (OECD, 2005: 46). To create innovation, the regional and institutional environment of the M&E companies is vitally important.

In this paper, we provide a broad picture of the German M&E industry in the context of innovation. Therefore, we address the topic in several steps. In the first step, the concepts of Industrial Districts, Clusters and Regional Innovation Systems are briefly introduced. They provide a theoretical framework for understanding the emergence of innovation capabilities and their influencing factors from a geographic perspective (Liefner and Schaetzl, 2012). In the second step, we provide background information on innovation processes in the M&E industry. In the third step, we describe the main characteristics of the German M&E sector. In the fourth step, we analyze, how the M&E industry has developed during the major shifts of the region’s economic system using the example of the East German region of Chemnitz, the cradle of the German M&E industry. Finally, a discussion of the main findings and an outlook for the future of the M&E industry are presented.

Theoretical background: NIS, RIS and Cluster

The location of the innovating firm and its regional and institutional environment influence innovation processes. This is the key insight from several theoretical approaches that have been developed since the late 19th century, namely the concepts of Industrial Districts, Clusters, and Regional Innovation Systems.

The concept of industrial districts explains why the concentration of many firms of the same industry in one place is beneficial to all of them (Marshall, 1961). Firstly, firms and employees benefit from a large regional labor market that allows moving between firms. Secondly, suppliers and specialized service providers tend to develop in regions with a strong demand for their products by many customers. Thirdly, in places where similar firms concentrate, many people specialize in the required professions and skills, and share knowledge among friends and colleagues, known as knowledge spillover – a prerequisite for innovation. Several regional concentrations of M&E manufacturers in Germany have been described as industrial districts in the literature. One example is the packaging machinery industry in Western Germany (e.g. Mossig, 2000), another is the medical engineering industry in Tuttlingen (e.g. Halder, 2006). Firms in these industrial districts specialize in producing a rather narrow set of products, which is often based on a distinct, and commonly shared technology.

Cluster theory (Porter, 1998, 2000) goes beyond the concept of industrial districts in two ways. Firstly, its broader view not only looks at firms of the same industry, but also includes all other regional players that contribute to the use of a certain technology. These players are companies (manufacturers, service providers, suppliers, and customers), universities and public research organizations, public and private

intermediaries, financial institutions and government organizations. Secondly, cluster theory introduces the perspective of value chains, to be understood as the sequence of activities needed to produce a product or service. It argues that regional concentrations of firms may lead to substantial productivity gains. This may offset the advantages of other regions, for example low labor costs. In such a situation, a cluster may grow and develop some activities that could be expected to be located elsewhere if cluster-related productivity advantages were absent. In Germany, policy initiatives at all levels (federal, state, local) attempt to foster cluster development, including clusters based on activities in the M&E industry. Examples include the technical systems cluster in North Rhine-Westphalia and the applied micro-systems cluster in Baden-Wurttemberg (BMBF, 2012). Nonetheless, many observers and academics question the possibility and usefulness of political cluster “creation” (Kiese, 2008).

The concept of Regional Innovation Systems (RIS) originates from political science and sociology. A RIS comprises all regional actors in a certain field of technology (Cooke, 1998). Its understanding of the regional influence on innovation is similar to cluster theory. The main argument of the RIS concept stresses the outcome of continuous and frequent interaction of these actors. Interaction leads to the development of local institutions, i.e. local norms and conditions that govern interaction and lines of cooperation. These location-specific institutions shape the form and direction of interactive learning and innovation. Hence, from the RIS perspective, a region can be expected to develop individual innovation processes and outcomes. Institutions that facilitate interactive learning positively affect regional innovation efforts, while institutions that hamper interactive learning can also suppress innovation.

An empirical assessment of innovation in the M&E industry that seeks to use these concepts as a theoretical foundation can thus define a number of relevant indicators and success factors. Firstly, it follows from the concept of Industrial Districts that a regional concentration of firms itself is a crucial success factor. Hence, empirical studies look at absolute number and relative shares in certain regions. Both cluster theory and RIS call for an extension of this concept through focusing on the quantity and the quality of supporting private and public organizations that may contribute to knowledge generation and knowledge sharing. Collaborative linkages between actors in particular are seen as the key indicator for interactive learning and innovation. Empirical studies that argue along these lines thus attempt to assess collaboration frequencies and qualities, besides looking at the capabilities and efforts of the companies themselves (e. g. Liefner and Zeng, 2008; Zeng et al., 2011).

Innovation processes in the M&E industry

Innovation processes in the M&E industry are first and foremost focused on the needs of a particular customer. Kalkowski and Manske (1993: 63) use the expression ‘instructed innovation’ to highlight the importance of the customer to define the specification of the machine exactly. Through close producer-customer interaction in innovation processes the product specifications by the customer and the development of alternative technical solutions by the producer can co-evolve (Kalkowski and Manske, 1993; Hirsch-Kreinsen and Seitz, 1999). This characterization mainly holds true for the producers of single-item production. Less intense producer-customer interaction is required for small-batch

production or line production (Kinkel and Som, 2007: 3-4). These standardized machines are sold to a variety of customers.

Gruner and Homburg (2000) conducted a discriminant analysis to find out how customer interaction in different product development stages influences the success of new products. They conclude that customer interaction during idea generation, product concept development, prototype testing, and market launch increases the success of new products. The most significant effect of customer interaction is observed in the prototype testing stage. In this stage, the customer can provide detailed feedback on the prototype and the product design can still be adapted accordingly. Interaction during project definition and engineering stages yields no performance impact.

Innovation in the M&E industry is generated through learning by producing. The development of alternative technical solutions, tests of pilot machines, changes of machine components, their architecture and interaction are carried out in-house (Kalkowski and Manske, 1993: 67). The main resource required for this is the knowledge, experience and creativity of the engineers and technicians working for the producer. Therefore, the employees who constitute a company's mechanical engineering core determine the direction and outcome of product innovation (Kalkowski and Manske, 1993: 69).

Universities and R&D organizations, as well as business associations, can provide support in standardizing mechanical components and exploring the general suitability of fundamentally new techniques (Hirsch-Kreinsen and Seitz, 1999: 7). For many small German M&E companies the cooperation with universities is important. They use the R&D capacities of universities to substitute for a lack of internal resources (Kinkel and Som, 2007: 10). For larger companies, cooperation with universities or other research organizations has only a limited function in the innovation process. They are generally used to conduct joint tests of new components or technical solutions. These tests are often carried out at the site of the producer. Universities benefit from the collaboration with industrial firms. They analyze new technical solutions after they have been developed by the industry in order to understand their function in a systematic way. This is useful for teaching and future research (Kalkowski and Manske, 1993: 67).

Main characteristics of the German M&E sector

Manufacturing accounts for 23 percent of the German GDP, compared to 13 percent for the United States and 32 percent for China (World Bank, 2014). The M&E sector is the second largest German manufacturing sector after the automotive sector. In 2012, the industry generated a turnover of EUR 223.6 billion, equal to about 12.8 percent of the total turnover in manufacturing (see table 1). The German Engineering federation (VDMA) classifies the M&E industry into 33 subsectors. Among these, power transmission engineering, material handling technology, and machine tools are the three largest subsectors (GTAI 2013: 3).

The German M&E industry is the strongest in Europe, ahead of Italy and France (Eurostat, 2010).

With one million people working in this sector, a new employment peak was reached in 2012. The sector has been the top employer in German manufacturing for years. Table 1

gives a comparison of the eight strongest German manufacturing sectors on the basis of turnover, number of enterprises, and number of employees. The figures underline the importance of the M&E sector for the German economy.

Table 1: Turnover, Number of enterprises and employees of the ten largest German manufacturing sectors 2012

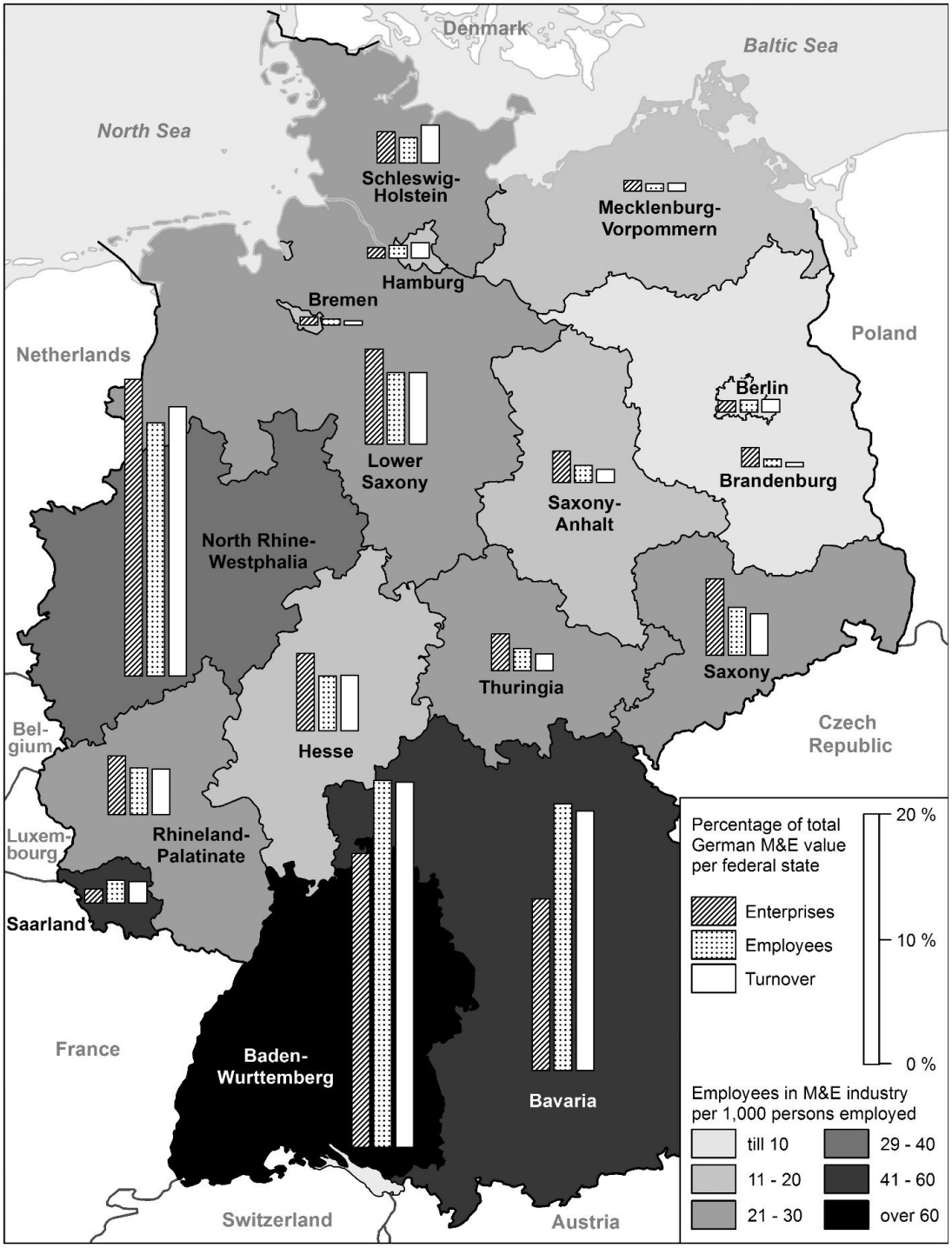
	Turnover in EUR mn	Number of Enterprises	Number of employees (in 1000)
Manufacturing	**1 741 862**	**44 163**	**5 923**
Manufacture of motor vehicles, trailers and semitrailers	359 795	1 314	761
Manufacture of machinery and equipment	***223 637***	***6 112***	***1 000***
Manufacture of food products	148 933	5 352	494
Manufacture of chemicals and chemical products	144 885	1 583	324
Manufacture of basic metals	108 658	1 065	254
Manufacture of fabricated metal products, except machinery and equipment	104 662	7 430	637
Manufacture of coke and refined petroleum products	100 222	65	18
Manufacture of electrical equipment	86 354	2 212	404
Manufacture of rubber and plastic products	73 412	3 180	374
Manufacture of computer, electronic and optical products	66 828	1 855	281

Source: Statistisches Bundesamt, 2013: 531.

The four largest customers of the M&E industry are the manufacturers of chemicals and chemical products, electrical equipment, motor vehicles, trailers and semitrailers (automotive), and food products (GTAI, 2013: 3). With a combined turnover of EUR 740 billion and about two million employees, these industry sectors are main pillars of the German economy. The economic strength of these industries provides the basis for the performance of the M&E industry.

The M&E industry in Germany has a decentralized structure. In terms of economic strength, Baden-Wurttemberg's M&E sector is the strongest, accounting for about 30 percent of turnover and almost a third of employees. North Rhine-Westphalia and Bavaria rank second and third. Companies in these three states together account for 70 percent of German M&E turnover and employees. The three states are also the most populous German states. To draw meaningful conclusions about the importance of the M&E sector in the German states, it is thus helpful to have a look at the relative figure employees in the M&E sector per 1000 people in employment. The relative figures reveal that Saarland, Germany's smallest territorial state, also has a strong M&E industry. Of every 1000 people employed, 50 work in the M&E sector. The prominent position of Baden-Wurttemberg as the leading state in the M&E industry is also visible here. The number of employees in the M&E sector per 1000 employed people is 73. This is almost as high as the combined figures of Bavaria (45) and North Rhine-Westphalia (34). Altogether, companies spread around West Germany generate about 93 percent of German M&E turnover. Saxony is the powerhouse of the M&E industry in the new federal states. Within Saxony, the region of Chemnitz, known as the cradle of the German M&E industry, is particularly strong.

Figure 1 illustrates the spatial distribution of M&E enterprises, employees and turnover in Germany. **Fig. 1: Spatial distribution of M&E enterprises, employees, and turnover in the German Federal States in 2012**



Source: By the authors; data from Statistisches Bundesamt, 2013a: 352, 2014; cartography: L. Diehl.

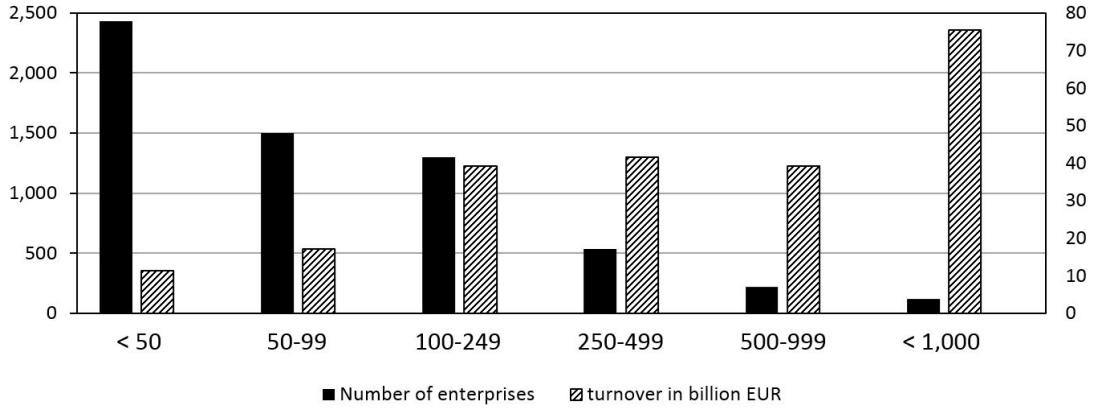
In the following analysis, we focus on four major characteristics that distinguish the German M&E sector from that of other countries:

(1) the dominant role of SMEs
(2) the M&E industry's high export rate
(3) the unique German educational system
(4) the innovation capacity of German M&E companies

The dominant role of SMEs

The German M&E sector is dominated by SMEs. 85.6 percent of all companies have fewer than 250 employees. More than one in three companies even has fewer than 50 employees. 12.4 percent of all companies have 250 to 999 employees. Large companies with more than 1,000 employees account for two percent (see figure 2).

Fig. 2: Number of enterprises and turnover in the German M&E sector according to company size in 2012



Source: By the authors; data from: Statistisches Bundesamt, 2013a: 532.

SMEs with fewer than 250 employees, companies with 250 to 999 employees and large companies with more than 1000 employees each contribute about one-third of total industry turnover.

In Germany, SMEs are known as the 'Mittelstand'. They often combine stable family ownership with a focus on producing high-quality products. These companies are privately owned and their strategy is focused more on long-term growth than on short-term profits. The Mittelstand have a special business culture characterized by long-term relationships between family owners and employees which are based on mutual trust and integrity. Family owners feel responsible for their employees and for the location as well, especially if the company has existed at that location for decades (Böttcher and Linnemann, 2008). Employees have strong ties to the company, meaning that fluctuation of employees, which poses significant challenges for companies in other countries, is not a common problem in German SMEs. The flexibility and long-term growth strategy of SMEs was revealed during the 2008/2009 crisis, when many manufacturing companies of the Mittelstand suffered severe hardships. One approach for coping with the crisis was the application of the Short-Work Scheme. The employees' total number of working hours were reduced to avoid layoffs. As compensation, the government paid for part of their lost wages. Altogether, the introduction of the short-time work saved approximately 500,000 jobs in Germany (OECD, 2009: 70). As a consequence, the German industry could

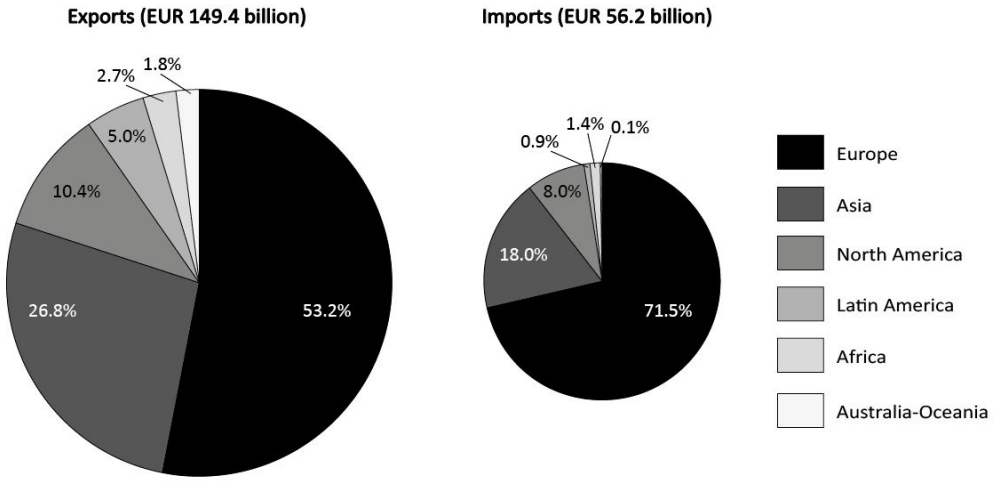
recover comparatively fast. Rather than having to undertake a time-consuming search for new suitable employees, the companies could immediately restart their production as demand increased.

German SMEs are often experts or even global market leaders for one special technology niche. SMEs which combine global leadership and a low level of public awareness are called ‘Hidden Champions’ (Simon, 2007). They seem to be especially interesting for Chinese mergers and acquisitions. Two famous examples are the acquisition of Waldrich Coburg by Beijing No. 1 Machine Tool Plant and the acquisition of Putzmeister by Sany Group (Nicolas, 2014: 107). How these acquisitions will affect the innovation capability of these companies, is still an open question which might be very interesting for further innovation research in the future.

The M&E industry’s high export rate

With 60.1 percent, the M&E industry has one of the highest export shares in German industry (Statistisches Bundesamt, 2013: 531). In 2012, the exported machinery was worth EUR 149.4 billion, while imports amounted to EUR 56.2 billion (VDMA, 2014a: 27). The leading export countries are China (11.4 percent), the USA (9.4 percent) and France (6.4 percent) (id: 23). More than every second machine from Germany is exported to a European country, while every fourth machine is sold to Asia (see figure 3).

Fig. 3: Export and Import Markets 2012



Source: By Source: By the authors; data from: VDMA, 2014: 23-24.

Overall, Germany is the world leader in the export of machinery. With a share of around 17 percent of global trade, Germany is well ahead of the USA (13 percent), China (12 percent) and Japan (11 percent) (VDMA, 2014a: 28). Germany is at the top of the global trade share in 16 and in the top three in 25 out of 31 internationally comparable M&E subsectors (see table 2). China ranks second with 7 first and 21 top-three positions.

The main products exported are sophisticated machine tools. For these high-quality products, there is a demand in industrialized countries as well as in emerging markets that need to develop their own manufacturing capabilities.

The high export rate reveals that the German M&E industry, like the whole German economy, is heavily export-dependent. Despite the frequently discussed risks of

dependency, the German economy has thus far mainly benefited from the exports which generate profits, thus, creating more jobs.

Table 2: German M&E subsector positions in global trade share; Percentages of global trade share

Rank 1
Cleaning systems (28.5%); Measuring and testing technology (27.3%); Printing and paper equipment and supplies (26.1%); Textile machinery (24.7%); Fluid power equipment (24.6%); Industrial furnaces and burners (22.9%); Plastics and rubber machinery (22.8%); Food processing and packaging machinery (21.7%); Woodworking machinery (21.7%); Power transmission engineering (21.0%); Materials handling technology (19.0%); Agricultural machinery (18.2%); Process plant and equipment (16.4%); Pumps (15.7%); Compressors, compressed air and vacuum technology (15.4%); Precision tools (15.0%).
Rank 2
Machine tools (18.9%); Firefighting equipment (15.0); Power Systems (14.4%); Valves and fittings (12.8%); Air-handling technology (10.8%).
Rank 3
Gas welding (14.8%); Machinery for metallurgical plants and rolling mills (11.6%); Lifts and escalators (11.3%); Engines and systems (7.8%).
Not ranked under the top three
Construction equipment and building material machinery; Mining equipment; Semiconductors, flat panel display production equipment; Garment and leather technology; Foundry machinery; Safes and strongroom installations

Source: Compilation by the authors; data from VDMA, 2014a: 31.

The unique German educational system

To ensure the quality and innovation outcome of M&E companies a highly skilled workforce is crucial. In Germany, 72.7 percent of the workforce (Statistisches Bundesamt, 2013a: 78) have received vocational training or hold an academic degree.

Germany is famous for its dual education system, which combines on-the-job training with classroom-based training. The practical training is carried out in the company. The specialized theoretical education and some general education classes take place in vocational schools. Since this skilled worker training has proven to be successful, this ‘classical’ dual education is increasingly being supplemented with ‘dual study programs’ for high school graduates. In technical subjects relevant to mechanical engineering, many graduates use the combined study programs at vocational colleges and universities of applied sciences. Germany is also home to a number of leading technical universities which focus on engineering and technical subjects (e.g. RWTH Aachen University, Karlsruhe Institute of Technology, and TU München).

In 2012, 77,775 students received a university degree in engineering (Statistisches Bundesamt, 2013b: 13). Among these students, 56 percent graduated in mechanical engineering/process engineering and electrical engineering (id: 15), which are the most relevant subjects for the M&E industry. Altogether, the number of graduates from engineering study programs has more than doubled since 2004 (id: 13). In contrast, the

number of young people undergoing the classical vocational training has been decreasing for years. This development is partly a result of demographic change, but is also due to the fact that more and more young people are deciding to study rather than participate in the classical vocational training. The Association of German Engineers (VDI, 2011) has regularly warned of a shortage of skilled workers and engineers that may influence the innovation capability of German companies in the future. To what extent the impact of demographic change will hit the German M&E industry depends on many factors, and cannot be answered at this time.

The innovation capacity of German M&E companies

The innovation process is influenced by a variety of factors, which makes measuring innovation difficult. In the literature, many indicators are used to assess the innovation capacity of companies and industry sectors (e.g. Gault, 2013). Each indicator describes individual aspects of the innovation process. To consider the whole innovation process from the idea generation to the market introduction of new products and thus create a broad picture of the innovation capacity of German M&E companies, we use the following three different types of innovation indicators:

(1) Input indicators: R&D personnel and innovation and R&D expenditure

(2) Throughput indicators: cooperation and the use of external knowledge

(3) Output indicators: number of patents, share of new products/ turnover (degree of newness of the new product).

R&D personnel and R&D expenditure are prerequisites for a high innovation performance. The share of R&D personnel of all employees in the M&E industry is 7.2 percent. In 2011, a total number of 40,463 employees of German M&E companies dedicated themselves to R&D (Stifterverband Wissenschaftsstatistik, 2013: 7). About half of all R&D staff held an academic degree, while 43 percent had received technical vocational training (see table 3).

Table 3: R&D employees in the German M&E industry 2011

	Total number	Percentage
Engineers	18,877	46.7
Technicians	17,560	43.3
Other personnel	4,027	10.0
Total	40,463	100.0

Source: Stifterverband Wissenschaftsstatistik, 2013: 42.

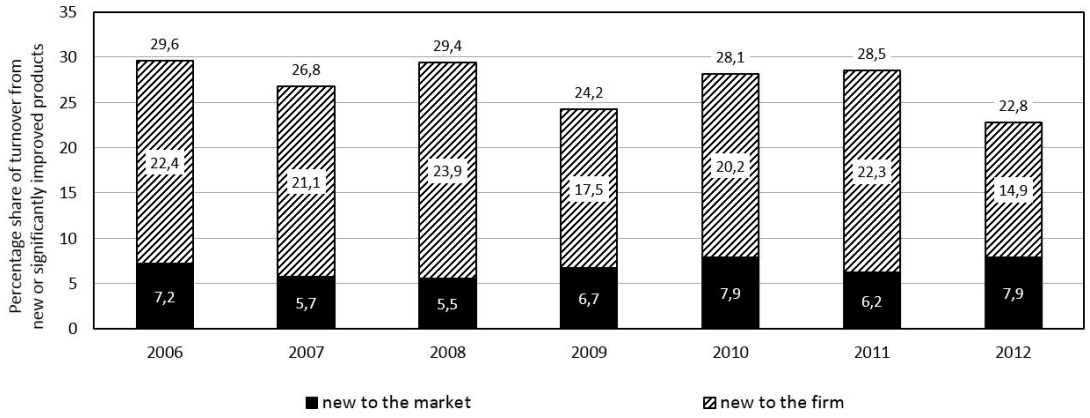
The industry needs both the ideas of the engineers and the practical skills of technicians to implement innovative ideas. This numerical balance of engineers and technicians can thus be regarded as a key strength of the German M&E industry. In 2012, the industry spent EUR 13.3 billion on innovation (VDMA, 2014b: 6). The composition of this innovation expenditure mirrors the complexity in the interplay of factors influencing the innovation process. Besides R&D expenditure, innovation expenditure comprises expenditure for the acquisition of machinery, equipment, software and external knowledge for innovation projects, expenditure for product design, construction, service design and other preparations for the production and distribution of innovations,

expenditure for training related to innovation projects, and expenditure for the market introduction of innovation (id: 6). The ratio of expenditure by M&E companies to total turnover (innovation intensity) is about 6 percent. In 2012, the R&D expenditure of German M&E companies amounted to EUR 5.8 billion (id: 3). About 90 percent of this total R&D expenditure was spent on internal R&D carried out in the company (Stifterverband Wissenschaftsstatistik, 2013: 8). R&D expenditure is mainly financed by the industry itself (94.8 percent). Only 1.9 percent is funded by the state, while 3.2 percent is financed from abroad (id: 18).

Collaboration between science, research and industry is an important element for innovation success. Therefore, cooperation and the use of external knowledge are important throughput indicators for assessing innovation in M&E companies. The German innovation survey (ZEW, 2014) provides information about external cooperation of M&E companies in innovation processes between 2010 and 2012. One-third of M&E companies active in innovation worked together with external partners in innovation projects. Customers from the private sector are the most important external initiator of innovation in the M&E industry. Almost half of all companies with innovation describe this group as a very important information source. Science is less important as an external driver of innovation processes, but useful for the formal and informal cooperation in innovation projects.

The number of patents and the share of new products (grade of newness of new products) are two indicators related to the innovation output. Companies use patents to protect their own knowledge. In 2012, 29 percent of all M&E patents granted from the European Patent Office were from German companies (EPO, 2014). In this statistic, Germany ranks first, ahead of the USA and Japan. The use of patent numbers for measuring the innovation output of companies is nonetheless limited because it does not measure the total number of patents for two reasons: firstly, the willingness to register patents increases with the company size (e.g. Nagaoka et al., 2010). It depends on the available financial and human resources of a company. Secondly, patent applications must be published after a period of 18 months, which makes copying easy for other companies. As a consequence, some companies reported that they would limit the number of patent applications in the future (Spiegel Online, 2008). The share of new products is an innovation indicator which measures the result or outcome of the innovation process. Unlike patents, which relate to technical inventions, this indicator focuses on the market success of new products. The grade of newness of the new product is also of particular interest. The product can be new on the micro-level (to the firm or customer) and/or new on the macro-level (to the world, market or industry). In 2012, the share of turnover from new or significantly improved products (market launch within the last three years) in total turnover was 22.8 percent (ZEW, 2014: 3). Regarding this indicator, the M&E industry ranks fourth behind the automotive (51 percent), electronics (31 percent) and IT and telecommunications (24 percent) sectors. Two-thirds of these products are new to the firm. One-third are products new to the relevant market. Figure 4 presents the development of the share of new products of total turnover since 2006. The columns illustrate the shares of turnover generated by products new to the relevant market and products new to the firm.

Fig. 4: Percentage share of turnover from new or significantly improved products in total turnover



Source: By the authors; data and draft from: ZEW 2014: 3.

Among all products new to the market, 77 percent were new to the world market (VDMA, 2014b: 12). This demonstrates the strong innovation performance of German M&E companies.

The German Government and many initiatives at the federal and regional level attempt to strengthen the innovation capability of German M&E companies. Therefore, they revert to theoretical findings and promote science and industry networks to fuel the development of the M&E industry further. ‘Innovation clusters’ create an environment, in which actors from companies, universities, public and private research institutions as well as investors within one region find favorable conditions for collaboration. They are a brilliant example for science-industry networking in Germany. This paper will now briefly introduce the “Fraunhofer Innovation Cluster” - a popular German example of cluster initiatives.

Fraunhofer Innovation Clusters are regional, application-oriented clusters between industry and research. The Fraunhofer Society is Europe’s largest applied science research organization. Of 80 Fraunhofer research institutes spread across Germany, 17 are specialized in M&E-related topics (GTAI, 2013: 9). The objective of these clusters is to provide interdisciplinary research in specific projects by combining existing research and development resources. The clusters act as innovation drivers and interfaces between industrial and academic partners. They thus support the further development of regional competences. The project work is funded by the federal state, the industry and the Fraunhofer Society. One important innovation cluster related to the M&E industry is the Fraunhofer Innovation Cluster for Mechatronic Machine Systems in Chemnitz.

Chemnitz: the leading M&E location in East Germany

In the next step we take a closer look at the M&E industry in the region of Chemnitz. There are three good reasons to do so: firstly, it is currently very relevant. Chemnitz is the biggest mechanical engineering hub with the highest concentration of mechanical engineering companies in East Germany. Secondly, it is interesting from a historical perspective. Chemnitz is known as the cradle of German mechanical engineering. Thirdly, it is a vivid example of interdependencies. The huge changes in the state and economic

system as well as demographics show a significant impact on the local M&E sector. This provides interesting insights from a geographical perspective.

With more than 240,000 inhabitants at the end of 2012 (Statistisches Landesamt Sachsen, 2013: 37), Chemnitz is the third largest city in the Free State of Saxony. The city is part of the urban agglomeration Chemnitz-Zwickau, one of the main economic regions of the new federal states. Chemnitz is characterized by a high concentration of M&E manufacturers, whereas Zwickau is dominated by the automotive industry. Aue and Schwarzenberg, two smaller cities in the south of the Chemnitz-Zwickau region, are known for iron and metal processing.

The infrastructural situation of Chemnitz is competitive with other locations of similar size. The city is located at the junction of two motorways. With Leipzig/Halle airport and Dresden Airport there are two international airports within a distance of 70 kilometers.

Chemnitz is home to the Chemnitz University of Technology. In 2013, about 11,200 students were enrolled there (TU Chemnitz, 2014). The department of Mechanical Engineering has more than 1,700 students. Within a radius of 35 kilometers, there are three other universities with a focus on technical subjects: the University of Applied Sciences Zwickau, the University of Applied Sciences Mittweida, and the Freiberg University of Mining and Technology. Furthermore, two Fraunhofer Institutes, two Helmholtz Institutes, and three industrial research institutes focusing on the M&E industry are located in the region.

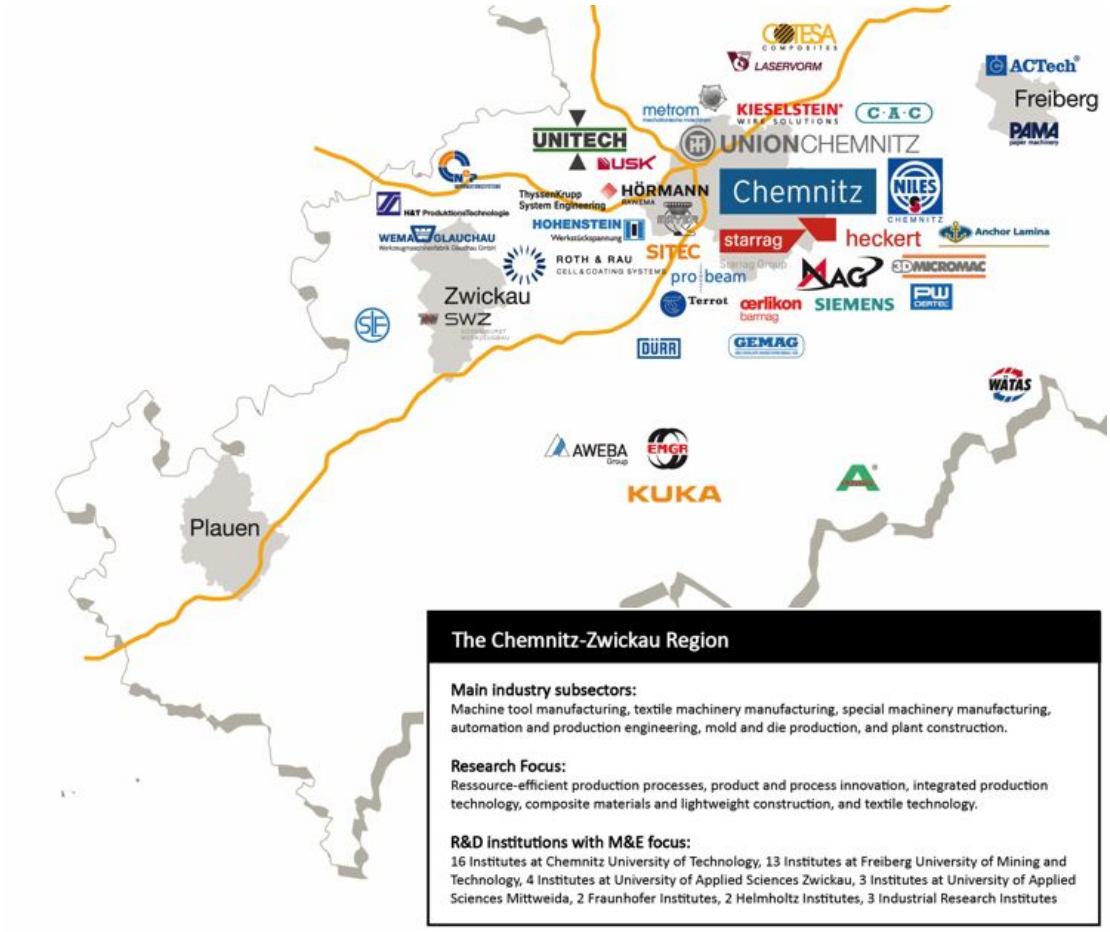
Chemnitz is the biggest mechanical engineering hub in East Germany. The city's economy is strongly based on the manufacturing industry. The main industry sectors are mechanical engineering, metal processing, vehicle manufacturing, information technology and microsystems technology (CWE, 2008: 2). The M&E industry is strongly dominated by SMEs. Altogether, there are 100 M&E SMEs within the city borders and more than 500 in the Chemnitz region (id: 2). The production of M&E companies in Chemnitz focuses on the manufacturing of machine tools, textile machinery manufacturing, special machinery manufacturing, automation and production engineering, mold and die production, and plant construction. Statistical data about the manufacturing industry in Chemnitz and its surrounding region is only available for companies with more than 20 employees. Altogether, Chemnitz has 33 M&E companies with more than 20 employees, 181 M&E companies are located in the Chemnitz region (Statistisches Landesamt Sachsen, 2014b). These companies employ about 3,600 people[2]. The M&E sector is the manufacturing sector in Chemnitz with the most employees. In 2012, it generated a turnover of EUR 634 million, which ranks the M&E sector second after the automotive industry. The M&E companies export share accounted for 57.2 percent in 2012. This share is clearly higher than Saxony's average of 48.3 percent, but still lies behind the German average of 60.1 percent (Statistisches Bundesamt, 2013a: 531). Figure 5 provides an overview of the M&E industry in the Chemnitz-Zwickau region.

Three traditional and famous mechanical engineering companies from Chemnitz are UNION Werkzeugmaschinen GmbH Chemnitz, Niles-Simmons-Hegenscheidt group and Starrag-Heckert GmbH. UNION Werkzeugmaschinen GmbH Chemnitz, for instance, was

[2] These and the following figures refer to companies with more than 20 employees.

founded in 1852 and is one of the oldest machinery tool companies still active worldwide (UNION Werkzeugmaschinen GmbH Chemnitz, 2014).

Fig. 5: M&E industry in the Chemnitz-Zwickau region



Source: adapted and translated from Wirtschaftsförderung Sachsen GmbH (2014)

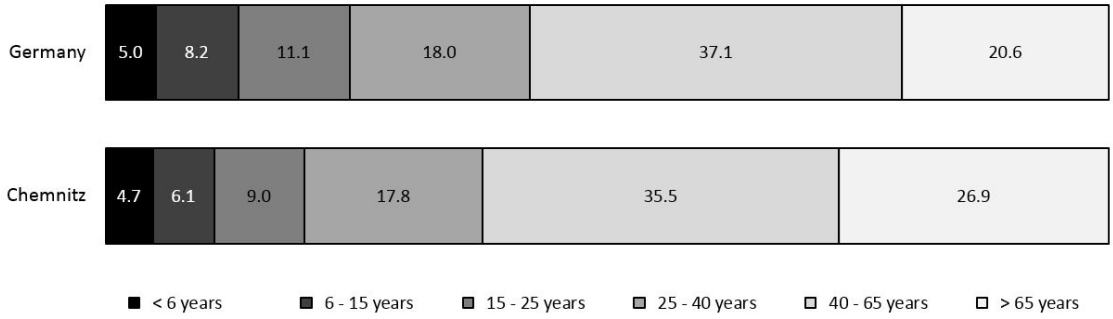
Chemnitz is known as the cradle of the German mechanical engineering industry. This is due to the fact that German industrialization started in Chemnitz over 200 years ago with the mechanization of cotton spinning. At that time, Chemnitz was a center of textile manufacturing. In 1848, Johann von Zimmermann founded the first factory for the construction of machine tools in mainland Europe there. In the 1930s, when Chemnitz was at its economic and demographic peak (360,000 inhabitants), it was known as the “Manchester of Saxony”. The city remained the German manufacturing hub until it was almost completely destroyed in World War 2. During the GDR era, the former district of Karl-Marx-Stadt was one of the main industrial centers of the GDR region (CWE, 2008: 2). After German reunification Chemnitz and the whole former GDR faced a lot of challenges. The governmental decision that East German firms had to compete immediately in the free market led to tremendous economic hardships. The reunification revealed the technological backwardness and low productivity of East Germany’s manufacturing plants. The former advantage of the GDR region - low labor costs - was erased by the introduction of the new currency. The formerly large, state-owned companies were privatized and restructured to create 1,094 mainly small and medium-sized companies (id: 5). In the wake of unification and restructuring from a state-

controlled, centrally planned economy to a social market economy, companies had to increase productivity heavily in order to be competitive and ensure their survival. Therefore, the systemic over-employment had to be reduced which led to a sudden rise in unemployment.

Between 1990 and 2010, the city of Chemnitz lost almost 25 percent of its inhabitants. Until 1994, the main reason for population decrease was migration to the West, by mainly young and highly skilled people. It shifted towards migration from the city to the surrounding region in the second half of the 1990s. Since the turn of the millennium, the main reason for population loss has been high mortality (CWE, 2008: 3). In the last couple of years, the decline was able to be stopped. Since 2006, the city's migration balance has been positive, and today the number of inhabitants is even rising. Nonetheless, the impact of these historical changes is still an ongoing process and heavily influences the labor market of Chemnitz and its surrounding region.

Figure 6 shows the age structure of Chemnitz in comparison to the age structure of Germany. 26.9 percent of Chemnitz' inhabitants are older than 65. The share of young people is comparatively low.

Fig. 6: Age structure of Chemnitz and Germany 2011 in percent



Source: By the authors; data from: Statistisches Bundesamt, 2013a: 31, Statistisches Landesamt Sachsen, 2014a.

The migration of the young generation in the 1990s, which is missing as the parental generation today, is the reason for a massive decline of pupil numbers in recent years (CWE, 2008: 5). Additionally, many young people decide to study rather than to participate in vocational training. As a consequence, the companies face the challenge of meeting the rising demand for apprentices and skilled workers. The various actors in the city and within the region are tackling these problems. They work together and try to strengthen the location at different levels.

The good reputation of the Chemnitz University of Technology and the city's affordable housing and living costs are helping to attract increasing numbers of young people from other regions in Germany and abroad. Since 2004, the number of new students registering at Chemnitz University of Technology has increased by 45 percent (TU Chemnitz, 2014). For the future of this region, it is crucial that graduates can be kept in the region by creating attractive jobs with appropriate salaries. Therefore, the challenge for those responsible is to strengthen the location further and intensify the collaboration between different actors within the region. The start-up network SAXEED (2014), for instance, offers students, academics, and entrepreneurs at the four universities in

Chemnitz, Freiberg, Zwickau and Mittweida free support to found start-ups. Two M&E associations in Chemnitz (Institut Chemnitzer Maschinen- und Anlagenbau e.V. (ICM, 2014) and Kompetenzzentrum Maschinenbau Chemnitz / Sachsen e.V. (KMC, 2014)) support their member companies in the field of research and development and cooperation projects with local universities and research institutions. For more than 20 years, the Fraunhofer Institute for Machine Tools and Forming Technology (Fraunhofer IWU, 2014a) has existed in Chemnitz. It provides application-oriented research and development in the field of production technology for the automotive and mechanical engineering sectors. Since 2010, the M&E Innovation Cluster for Mechatronic Machine Systems has been located in Chemnitz. It is a joint research project of the Fraunhofer Institute, Chemnitz University of Technology, and a number of industrial firms. The purpose of this innovation cluster is to concentrate the available technical and organizational resources and make them available to all parties involved (Fraunhofer IWU, 2014b).

The analysis of the M&E industry in the region of Chemnitz shows that an industry sector rooted in a long tradition and a sustaining network can have the power to overcome massive structural changes. It depends on the ability and willingness of people acting at different levels to engage in a long-term development of the region and contribute to goal-oriented collaboration in innovation processes.

Conclusion and future trends in the German M&E sector

The M&E industry is a very important pillar for the German Economy. It is dominated by SMEs and characterized by a concentration on export markets and a high degree of collaboration along the value chain. Highly skilled workers, trained in the dual education system, produce sophisticated machines. They are in demand in industrialized countries as well as in emerging markets that wish to develop their own manufacturing capabilities.

Innovation processes, their outcomes and their driving factors differ in many regards from other industries. The analysis of the German M&E industry in the context of innovation reveals the important role of the customer in the innovation process of M&E companies. Through close producer-customer interaction and learning by producing, high-quality products are created. The numerical balance of engineers and technicians in Germany can be regarded as a prerequisite for the high innovation performance of M&E companies. These companies need both the ideas of engineers and the practical skills of technicians to implement innovative ideas. Policy initiatives at all levels attempt to support the industry by practically applying the theoretical knowledge of cluster theory and RIS and fostering interactive learning in innovation networks.

The industry has also faced many challenges in recent years, such as the rise of competitors from emerging markets and the shortage of skilled personnel as a result of demographic change. As a consequence, the collaboration in R&D and innovation networks becomes crucial. SMEs in particular, which often lack financial and human resources, need the knowledge exchange to ensure their international competitiveness in the long term.

The example of Chemnitz shows how huge economic, social and demographic changes have affected the local M&E industry. The long history and local embeddedness of companies as well as the collaboration of actors at different levels have helped to

overcome the massive structural changes and made it possible to reinvent the location as a center of the German M&E industry.

Altogether, the German M&E industry benefits from its long tradition. Efficient and sustaining supply structures and R&D networks were built up over a long time period. They provide the basis for the future evolution and innovation strength of the German M&E industry that cannot be easily imitated by other countries.

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德国装备工业创新

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摘要： 本文致力于德国装备制造业创新状况的研究。本文首先评述了创新过程研究中的核心概念，即生产者-客户关系、生产过程学习和互动学习；接着，基于二手数据总结了德国装备制造业的主要特征；最后，根据开姆尼茨地区装备制造业的案例研究深入探讨了影响制造企业创新能力提升的因素。

关键词： 装备制造业；德国；创新；开姆尼茨地区