Baden-Württemberg

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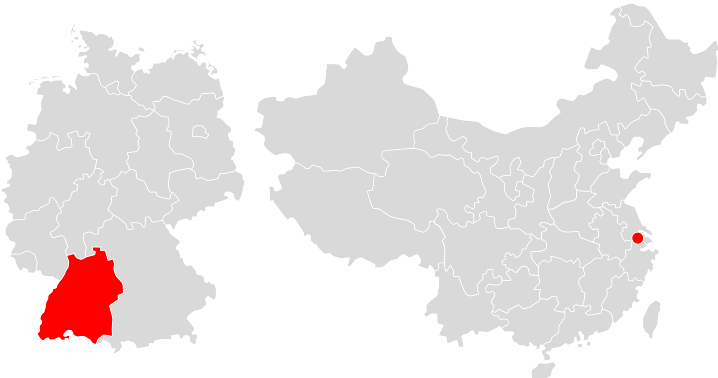
Industrial Synergies between Baden-Wuerttemberg and Suzhou Industrial Park



KIT Karlsruhe Institute of Technology

wbk Institute of Production Science

Hochschule Karlsruhe Technik und Wirtschaft UNIVERSITY OF APPLIED SCIENCES

GAMI Global Advanced Manufacturing Institute

Contents

Foreword

Although the state of Baden-Wuerttemberg in Germany may not be the richest in natural resources, it is - due to its high level of industrialization - one of the most prosperous regions within Europe and certainly one of the most innovative regions in the world.

China's shift towards becoming a promising sales market and a strong player in the manufacturing industry can be observed within the last few decades. In particular certain areas, such as Suzhou Industrial Park located in the Jiangsu province, are focusing on high-tech and knowledge-intensive industries and on highly educating its workforce.

Michael Kleiner
Director General
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The Ministry of Science, Research and the Arts (MWK) represents political key areas within the state of Baden-Wuerttemberg. We are convinced that science and research are the keys to developing innovative solutions. This is why one of our main policy goals is to create excellent conditions and support researchers and institutions.

The main objective of this research study is to systematically analyze synergies and potentials for future collaborations between industry as well as research and education institutions which are located in Suzhou Industrial Park and the state of Baden-Wuerttemberg. Strengths and weaknesses of these regions are therefore structured in a way to support decision makers such as companies and research institutions in their internationalization strategy towards Baden-Wuerttemberg and China.

The Ministry of Science, Research and the Arts highly appreciates these research results of wbk Institute of Production Science at Karlsruhe Institute of Technology, the Institute for Learning and Innovation in Networks at Karlsruhe University of Applied Sciences and the Global Advanced Manufacturing Institute in Suzhou.

Core findings

Business models and customer needs

Firms from Suzhou and B-W *focus on different international market strategies*. Surveyed B-W firms employ an average of 50% of staff abroad; whereas surveyed Suzhou firms mostly remain located in Suzhou and focus on export.

Both regions feature *highly skilled talent pools*, with high numbers of university enrollment and graduates. Tertiary education enrollment is at 55% in B-W, and at 68% in SIP. *Dual education* as it exists in B-W is missed in SIP.

Firms from B-W and SIP focus on products adapted to *customer needs, high quality and innovative solutions*. Competition in SIP is characterized more often by high cost pressure with competing firms from other regions in China.

Technology use, innovation and research

The surveyed SIP firms use innovative technologies to a similar extent, but *less e-mobility and energy efficient technologies*. For certain standard components, B-W firms' technological lead is declining or does not exist anymore.

Most of the surveyed B-W firms generate innovations in e-mobility (42%) and environmental technology (37%). Most used technologies are integrated IT systems (48%) & energy/ material efficient technologies (39% and 36%).

Both regions feature *high numbers of patent applications.* From 2012-13, the patent growth rate in B-W was 2%, in SIP 15%. Many firms in both regions regard themselves as *market (±70%) or product innovators (>75%)*.

Cooperation and competition

The surveyed B-W firms expect *strong competition* in *manufacturing technologies* (31%), *new materials* (25%) and *nanotechnology* (16%). In contrast, Suzhou firms see high potential for cooperation in these indus-tries.

Some firms already pursue *local sourcing cooperation in China*. International cooperation in R&D is not common yet. On a domestic level, 82% of B-W's and 46% of Suzhou's surveyed firms partner with research facilities.

The surveyed B-W firms expect strong potential for cooperation in fields in which China faces severe challenges, such as *environmental technology* (33%), *water systems* (30%), and renewable energy technologies. (29%)

Location factors and future challenges

Both regions feature *very high industrialization rates* (B-W: 39%, SIP: 51%), *relatively high GDP growth rates* (B-W: 1.7%, SIP: 10.7%) *and high export ratios*. Therefore, *manufacturing plays a significant role* in both regions.

The surveyed B-W firms realize 12% of their sales in China, compared to 8% of their purchasing of intermediate inputs. 49% of the surveyed firms from B-W already have manufacturing locations in China, 32% also have R&D locations.

High productivity demand and rising labor costs will push the need for *automation* in China. Increasing pollution in China will call for solutions in *environmental technology, water treatment, medical technology, and e-mobility.*

Introduction

Baden-Wuerttemberg

The federal state of Baden-Wuerttemberg (B-W) is located in the south-west of Germany and is the third largest German state in both terms of area and population. Its population consists of 10.51 million people (including 11% foreigners) as of December 2011. The state capital is Stuttgart, which is also one of the country's most important cities in the country economically and a center for the automotive industry and manufacturing. It is home to well-known manufacturers such as Daimler AG, Robert Bosch GmbH, and Dr. Ing. h.c. F. Porsche AG. (Birkner 2013)

Structurally, B-W is divided into four major administrative districts (Freiburg, Karlsruhe, Stuttgart, and Tuebingen). These again are grouped into a total of 35 sub-level administrative districts and nine independent cities [1]. Economically, it is divided into 12 cluster regions (see Table 1). (Birkner 2013)

The history of B-W in its current form dates back to the year 1951, in which it was created by a merger between Wuerttemberg-Baden, Wuerttemberg-Hohenzollern and South Baden. (Birkner 2013)

[1] Baden-Baden, Freiburg, Heidelberg, Heilbronn, Karlsruhe, Mannheim, Pforzheim, Stuttgart, Ulm.

Suzhou Industrial Park

Suzhou Industrial Park (SIP) is located in the city of Suzhou in China's Jiangsu province, with direct and fast connections to major hubs such as Nanjing, Jiangsu's capital, and Shanghai. Jiangsu is the most densely populated province of China: although it is the 2^{nd} smallest province, it has the 5^{th} largest population. (Deutsche Bank Research 2015) Suzhou has 10.58 million inhabitants, comparable to B-W. The share of expatriates in Suzhou is at 0.2% of the total population. (Crown Relo 2014)

SIP is one of eight high-tech industrial zones in Jiangsu province. Moreover, there are 16 economic and technological development zones (ETDZ), six science and technology (S&T) parks, and one bonded zone in the province. (Schuurman & He 2013) For each type of zone, the Chinese government implements different measures, special regulations, and exceptions. ETDZs are zones in which foreign direct investments [2] (FDI) are encouraged, i.e. by tax exemptions and special import regulations. There are 49 ETDZs in entire China, one third of them are located in Jiangsu. High-tech industrial zones are very similar to ETDZ, and the definitions are often used interchangeably. They are, however, more targeted towards high-tech industries, like SIP. (HKTDC 2014)

[2] Investment from one country into another (usually rather by companies than by governments, and involving a physical investment or establishing operations)

In Bonded Zones, high-level logistics services as well as tax exemptions are offered. The Chinese government also started developing S&T parks in the 1980s, based on the example of Silicon Valley in the USA. (Unesco 2014; Schuurman & He 2013)

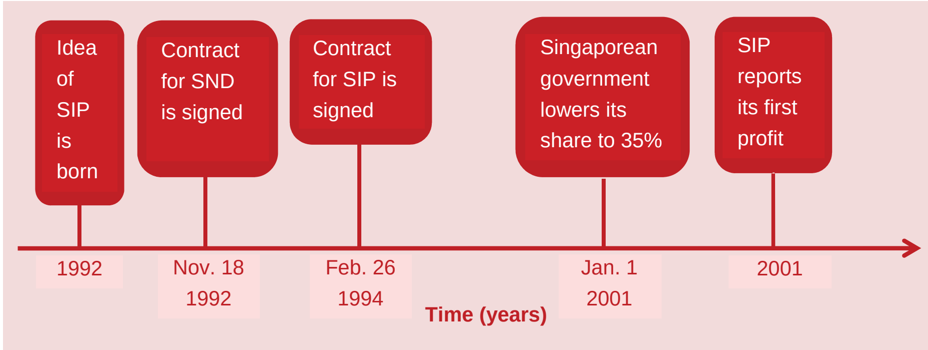

Figure 1 Timeline of the history of SIP (Han 2008)

SIP started as a joint project between the governments of Singapore and China in 1994 (see Figure 1). The Singaporean government owned a majority share of 65% at the time at which the contract was signed in 1994. The endeavor was meant to lead to crucial benefits for both parties: on the one hand for the Singaporeans to invest in China, on the other hand for the Chinese to learn from Singapore's vast knowledge and experience. (The Straits Times 2014) SIP received strong competition from neighboring Suzhou New District (SND) industrial zone in its first years and faced severe losses. In 2001, SIP started to make its first profits. (Han 2008)

SIP is divided into six zones: Dushu Lake Science Education Innovation Park, the Jinji Lake Central Business District, an Integrated Free Trade Zone, a high-tech Industrial Zone, an ecological science hub, and Yangcheng Lake Eco-Tourism Resort. (SIPAC 2011d)

Trends and strengths

The market in B-W follows a trend typical for highly-developed countries, and faces challenges with regards to rising labor costs, high quality standards, and high innovation levels. Manufacturing has a long tradition in B-W, and is supported by many high technology fields. German customers are characterized by a high spending power, and attach high value to quality and technology. (Birkner 2013)

Although B-W is not rich in natural resources, it has a skillful talent pool. On top of that, it is not only one of the most innovative German federal states but may also be seen as one of the most innovative areas in the world. Particularly due to its high industrialization percentage it is one of the most prosperous regions of Europe. (Wolf 2014)

> *“If one does not have coal or gold, one has to be innovative.”*
>
> Trans. Nicola Leibinger-Kammueller, CEO of Trumpf AG (Rehberger 2014)

Another strength of B-W is the high level of industrialization. With an industry contribution of 39% to the state’s GDP and 61% by agriculture and services, the state is highly industrialized. In comparison, 28% of GDP is created by industry in entire Germany. (Birkner 2013)

One trend among foreign investments in China is the shift from China as a low-wage manufacturing location toward a potential sales market with a strong growing middle class. Growing prosperity and higher buying power of Chinese customers make the market extremely interesting. (Fernandez et al. 2013) SIP in particular has outpaced the status of China as a low-wage manufacturing site, and focuses on high-tech, knowledge-intensive industries and a highly educated workforce. Special regulations and support by the Chinese government make the location even more attractive for foreign investors. Such policies include efficient administrative systems following the Singapore model, and exceptions on normal Chinese customs regulations in order to lower investment barriers for foreign companies. (Yao 2014) Lowering of restrictions for foreign companies has proven to be a success recipe: every second day, a foreign company settles in SIP. (SIPAC 2014b)

SIP’s excellent human resources and skilled talent pool are an important strategic advantage for which it is often praised. (SIPAC 2013c)

In SIP, the contribution of industry to GDP is even higher than in B-W. 53% of the park’s GDP is industry-generated, compared to 43% for entire China. (Shira 2014)

Moreover, SIP has received an ‘AAA’ rating[3] and several other awards and accolades, a selection of which will be listed here. One of the characteristics of SIP that is most often applauded is its administrative efficiency based on the Singapore example. Also, it is ranked the second-best industrial development zone in China in a study carried out by China’s Ministry of Commerce in 2010. Out of 90 industrial parks that were assessed, SIP ranked second, just behind Tianjin’s Economic-Technological Development Area. (Shira 2011) On top of that, it was designated as a pilot zone for eco-industrial parks and as a pilot zone for Intellectual Property Rights (IPR) protection by the Chinese government (CSSD 2014; Zhao 2012). It is also a demonstration zone for nanotechnology (YESIPO 2014). Moreover, SIP is a pilot zone on preferential policies for technologically advanced services, and China’s first services outsourcing demonstration base (Suzhou University Press 2014).

> *"If we had had to follow all the normal regulations in China we would never have had the breakthrough we did."*
>
> Barry Yang, deputy secretary and chairman of the Suzhou Industrial Park Administration Committee (Shen 2014)

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[3] An AAA-rating is the highest possible rating out of seven gradations for industrial parks in China. Parks with AAA-ratings are the most established and offer an attractive investment environment. (China Knowledge 2014)

Geography

B-W covers an area of almost 36,000 km², around 130 times the size of SIP. On a national level, B-W's neighboring states are Bavaria, Hessen, and Rhineland-Palatinate (see Figure 2). It shares international borders with France and Switzerland. It is drained by the Rhine, the upper Danube, and the Neckar. (GTAI 2014; Birkner 2013)

With an area covering three times B-W in terms of size, Jiangsu province, in which SIP is located, has a vast space to be covered (Walter-Weilan 2014). SIP itself covers a total area of 278 km² (SIPAC 2011d). The neighboring cities of Suzhou are Shanghai to the west, Zhejiang to the south, Anhui to the east, and Shandong to the north. Jiangsu has a coastline of around 1000 km² bordering the Yellow Sea and the southern part of the province is passed through by the Yangtze River. Thus, it is located at the connection of the Yangtze River Economic Delta and the Coastal Economic Belt. (SIPAC 2011c)

Figure 2 Location of B-W in Germany

Figure 3 Location of SIP in China

Transportation infrastructure

Baden-Wuerttemberg has an excellent transportation and infrastructure system. Its road network consists of over 1,500 km of highways, and an additional 5,000 km of main roads. The road network is complemented by an extensive rail network with a total length of over 4,500 km. The most important rail connections are the Rhine Valley route via Mannheim and Basel, the high-speed route from Mannheim to Stuttgart, and the Strasbourg-Stuttgart connection. Moreover, transport via water routes is possible over 550 km of waterways. Mannheim, Ludwigshafen, Karlsruhe, Heilbronn and Kehl are the 4th to 8th largest German ports. The commercial airports of Stuttgart, Karlsruhe Baden-Baden, Lahr and Friedrichshafen complemented by 18 cargo airports provide an outstanding air transportation network. (Ministerium für Finanzen und Wirtschaft 2014c)

SIP's infrastructure system enjoys good connections to surrounding airports, railway lines, highways, and seaports. The cities in Jiangsu have grown around 12% since 2000, and in order to connect them, the infrastructure system in Jiangsu had to expand accordingly. (Schuurman & He 2013) 10 civil airports can easily be reached, and 7 railway lines as well as 9 major highways connect SIP to its surroundings, such as the Beijing-Shanghai Railway and Express Railway, shortening the train ride from Suzhou to Shanghai to 20 minutes (HKTDC 2014). Suzhou is easily reached from the nearby cities of Wuxi, Shanghai, Nanjing and Hangzhou. Moreover, it is well-connected to the ports of Shanghai, Zhangjiagang (specialized in oil shipments), Taicang, Changshu (specialized in chemical transports), Nantong and Liujia. (Walter-Weilan 2014)

Figure 4 Overview of the transportation network in B-W

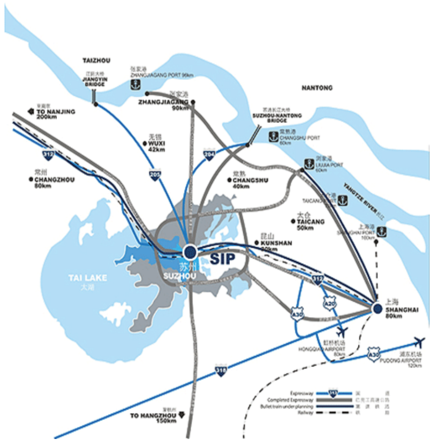


Figure 5 Overview of the transportation network connecting SIP (Focus Technology 2014)

Initial situation in Baden-Wuerttemberg and Suzhou Industrial Park

Economic indicators and business development

B-W has an above average share in the German gross domestic product: in 2012, its share was 14.7% of the German total GDP compared to a 13.15% population share. GDP growth in B-W was at 1.7% on a year-on-year basis from 2011 to 2012. (Birkner 2013) In 2013, B-W's GDP per capita was at about USD42,000. It ranked fifth of all German federal states in terms of GDP per capita, after Hamburg, Bremen, Hessen, and Bayern. The German average GDP per capita was at almost USD40,000 in 2013. (Statista 2014) B-W's total GDP was €407.24bn [4] in 2013. (Statistische Ämter des Bundes und der Länder 2014)

B-W documented low, but steady growth rates in 2013 and 2014, with a GDP growth rate of 0.9% in 2013, and of 1.7% in 2014 (Statistisches Landesamt B-W 2014c; Statistisches Landesamt B-W 2015).

[4] 486.15 billion USD, mid-market rate of 05.03.2015

Jiangsu's real GDP growth has been above the national average since the 1990s, which is triggered to a large extent by the rich south of the province, with the presence of industrial parks such as SIP and SND. Whereas Jiangsu province ranked 4th of all Chinese provinces with a GDP per capita of USD14,047 in 2013 (after Tianjin, Beijing, and Shanghai), the GDP per capita in Suzhou amounted to almost USD20,000 in 2013. (China Whisper 2014) In SIP, GDP per capita levels are even higher than in the rest of Suzhou. They were already close to those of Singapore in 2009, with Singaporean GDP per capita levels of around USD32,000 in 2009. SIP's total GDP amounts to around half the amount of B-W's GDP and rose 10.7% on a year-on-year increase in 2013. (China Daily 2009; Trading Economics 2015) Its GDP was RMB191bn [5] in 2013, and already reached RMB127.76bn [6] in the first half of 2014 (Wei 2014).

Over the past 20 years, SIP documented an impressive annual economic growth rate of 30%, although this growth rate has slowed down during recent years. In 2012, the GDP of the park grew 10.7% compared to the previous year. (HKTDC 2014) All in all, it still is one of the fastest and sustainably growing parks in the world (China-Finland Nano innovation center 2014).

[5] 31.3 billion USD, mid-market rate of 05.03.2015
[6] 20.5 billion USD, mid-market rate of 05.03.2015

Traditionally, B-W is a location of industries with high export ratios [7], such as the automotive industry and the mechanical engineering sector. In 2013, the export ratio of all industries in B-W amounted to 42.6% excluding services [8]. It thus ranked third of all federal states, after Bremen with 51.3% and Hamburg with 50.3%. The German average export ratio was 39.9% in 2013. (Statistisches Landesamt B-W 2014a)

With an unemployment level of 4.2% in 2014, B-W has the lowest unemployment rate of all German federal states, compared to a national average of 7.3%. It also reported a year-on-year decrease of 0.5% compared to 2013. (EURES 2014)

Among all German federal states, B-W attracted the most FDI projects in 2013, with 32% of all FDI projects. Runner-up North Rhine-Westphalia attracted 23% of FDI projects, and number three Hessen reported 14%. In total, 701 FDI projects were realized on German soil. According to the Ernst and Young European Investment Monitor 2013, almost 10% of these projects were undertaken by Chinese investors. (Handelsblatt 2014)

[7] The export ratio of a country is a measure to determine the importance of foreign trade and to expose interdependencies between foreign markets. It also serves as a performance indicator for the openness of an economy. High export ratios imply high dependence on other countries' economies and a very open economy. (Statistisches Landesamt B-W 2014b)

[8] Foreign trade statistics only take the exports of goods into account. Services exports are not taken into consideration.

Export & Import

SIP contributes 30% to the entire import and export volume of Suzhou (SIPAC 2014b; Deutsche Bank Research 2015).

In 2011, SIP reported an unemployment rate of 2.7%, which is clearly below the national unemployment rate of 4.1% (Trading Economics 2014).

SIP has attracted a substantial amount of FDI. Of all the FDI targeted towards Suzhou, 22% was designated for SIP. Suzhou is the top destination for FDI in China, with three times as many FDI as Shanghai. (Sin 2014) On a national level, SIP itself also ranks high with regards to utilized FDI in ETDZ rankings. It ranks third in this category, after Tianjin Economic-Technological Development Area and Dalian Economic & Technological Development Zone. (HKTDC 2014) Of these FDI, 42% stems from Europe and the USA, followed by 18% from Singapore, and 13% from Japan and Korea. The remaining 27% are contributed by Hong Kong, Macau, Taiwan, and other regions. (University of Liverpool 2014) SIP and its neighboring industrial park SND push the levels of FDI projects for entire Jiangsu: in 2009, more than 4,000 FDI projects were approved for entire Jiangsu province (Jiangsu Provincial Economic & Trade Office 2010).

Industry structure

With a manufacturing industry contribution[9] of 39% to the B-W's GDP in 2012, the state is highly industrialized (Birkner 2013).

Based on the number of employees involved in B-W's manufacturing workforce, a distinction per industry sector can be used to draw a comparison of the most important industry fields, based on a workforce of 1,073,313 employees (see Figure 6). In order to analyze the data for B-W, the workforce involved in manufacturing was analyzed based on data from the B-W Statistical Office. Employees in services were not considered to draw a comparison to the SIP manufacturing industry. (Birkner 2013)

Based on the division by number of employees in 2012, the key sectors in B-W currently are mechanical engineering, automotive engineering, and data processing devices, electronic and optical goods (see Figure 6). They are followed by chemicals, pharmaceuticals and plastics, and metal production and processing. (Birkner 2013)

[9] Includes construction and all industry fields (secondary industry)

Manufacturing industry is the most important driver for economic growth in the entire area in and around SIP. The whole Suzhou prefecture has an industrialization ratio of 53%[10], which is strongly influenced by the presence of industrial parks such as SIP. (Shira 2014)

The SIP Administrative Committee (SIPAC) keeps track of the total amount of fixed asset investments undertaken per industry. Figure 7 shows the total fixed asset investments in SIP sorted by industry field in 2012 (by both foreign and domestic firms). (SIPAC 2013a)

Data processing devices, electronic and optical goods, and mechanical engineering are designated by the government as the pillar industries of SIP's economy (see Figure 7). In the field of electronics (integrated circuits, LCD panels, communication and computers), foreign and domestic manufacturers such as Samsung, AMD, AUO and Hitachi, complete an industrial chain of integrated circuits design, wafer manufacturing, assembly, and other equipment. The industry field of chemicals, pharmaceuticals and plastics plays an important role as well, followed by automotive engineering, and metal production and processing. (SIPAC 2014a)

[10] Based on GDP calculations and respective GDP contributions to SIP's total industry of primary industry (agriculture), secondary industry (industry), and tertiary industry (services)

As can be seen in Figure 6, the industry in B-W is driven by automotive and mechanical engineering (Birkner 2013). In SIP, mechanical engineering plays a similarly large role, automotive engineering is slightly smaller. Data processing devices, electronic and optical goods are the largest industry in SIP, and also play a significant role in B-W. (SIPAC 2013a)

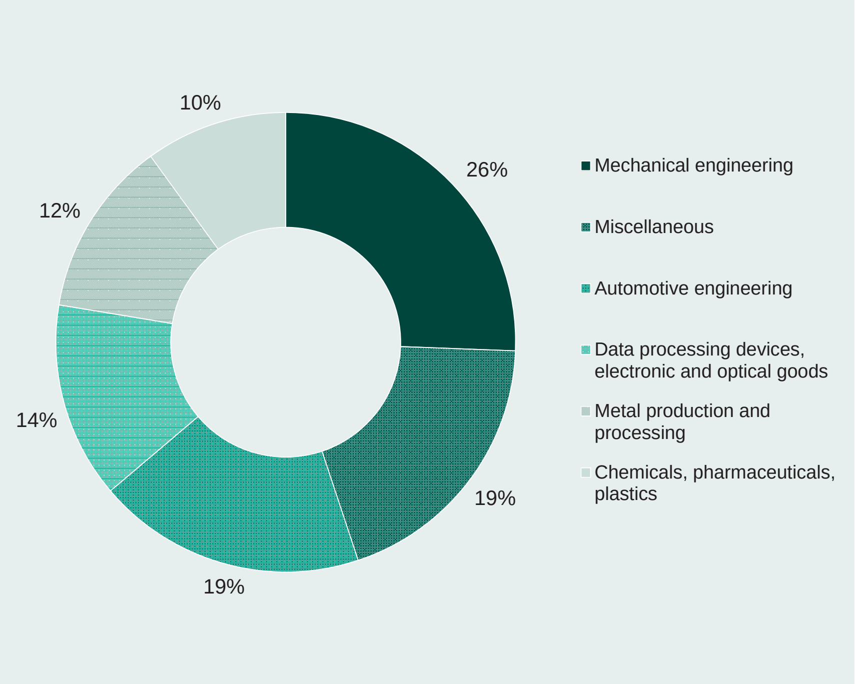


Figure 6 Industrial structure in B-W in the manufacturing industry. Data from B-W investment guide, based on share of B-W's employees involved in manufacturing industry fields in 2012 (Birkner 2013; Baden-Wuerttemberg Statistical Office 2013)

As the birthplace of the automobile, the importance of the automotive engineering industry and the mechanical engineering industry is not surprising: with 19% and 26% of all employees respectively, almost half of B-W's manufacturing workforce was active in these fields in 2012 (see Figure 6). The field of data processing devices, electronics, and optical goods occupies another 14% of B-W's manufacturing workforce, followed by metal production and processing, which employs 12% of the employees in manufacturing. The field of chemicals, pharmaceuticals, and plastics is another important industry with 9% of the manufacturing workforce. The remaining industry fields compose 19% of the total manufacturing workforce. (Birkner 2013)

Data processing devices, electronic and optical goods were the largest industry by fixed asset investments in 2012 with 43% of total fixed asset investments. In SIP, mechanical engineering plays a comparably important role as in B-W and attracted one third of fixed asset investments in 2012. It is followed by chemicals, pharmaceuticals, and plastics, which attracted 10% of investments. The fields of automotive engineering, and metal production and processing are comparably smaller with 3% of fixed asset investments respectively. The remaining industries attracted 8% of fixed asset investments. (SIPAC 2013a)

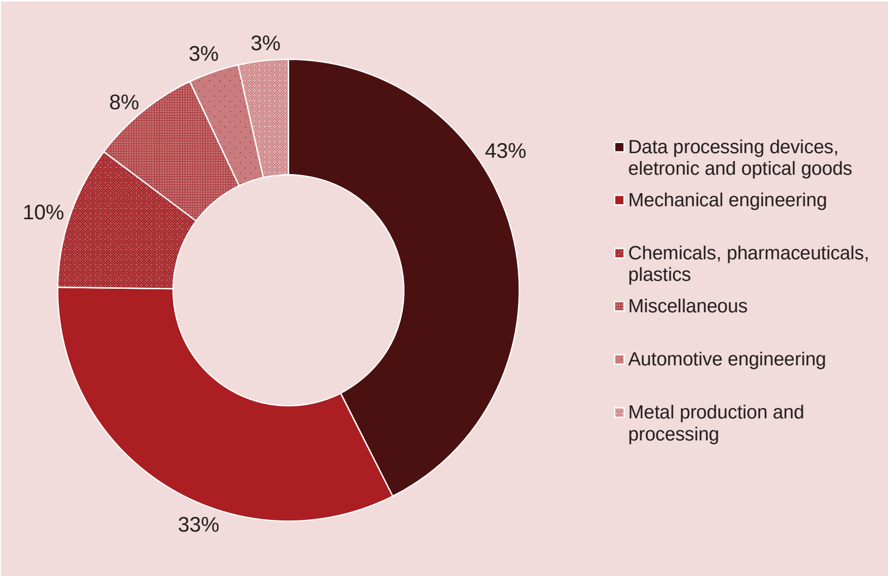


Figure 7 Fixed asset investments in manufacturing by industry field in SIP in 2012 based on SIPAC annual statistical data (SIPAC 2010; SIPAC 2013a)

Role of company size

In 2013, 484,700 companies were active in B-W, with a total turnover of €821.9 bn. Of these companies, 21% operated in the production industry field. (Statistisches Landesamt B-W 2013a) A total of 5.86 million employees were registered in 2013. Of them, 68% were employed by the services sector and 31% by the production industry. (Statistisches Landesamt B-W 2014d)

The backbone of the German economy is formed by a large amount of SMEs[11]. They constitute a significant fraction of companies with a 99.6% share in the total amount of companies, and a 60.2% share of the total workforce. Often, these SMEs are specialized and innovative companies that operate within a certain niche: so-called hidden champions. The federal state of B-W has implemented several financial incentives and support policies for SMEs. In the manufacturing industry, the share of SMEs is significantly lower with 50.5%. (EURES 2014)

Apart from SMEs, many large companies are located in B-W. Of the more than 1,500 German companies that are market leaders in their field, 26% are located in B-W. On average, twice as many market leaders reside in B-W compared to the national average, with 3.8 global market leaders per 100,000 inhabitants in B-W. (Wirtschaftswoche 2013)

In 2014, there were more than 24,000 domestic-invested companies in SIP, up 2% from 2013. In 2014, more than 3,800 foreign companies operated in SIP (SIPAC 2013a). Moreover, 130 state-owned enterprises were present in SIP in 2014. (SynTao Thinktank 2014)

Many German companies investing in SIP are highly specialized, and start with a relatively small investment. However, both small and large investments are endorsed by SIP authorities and receive favorable investment treatments. The market spectrum varies from SMEs operating in niche markets to Fortune 500 companies. There are currently 150 Fortune 500 companies in SIP, of which 30 have also set up R&D centers in SIP. (The Straits Times 2014; Crown Relo 2014) At the moment, there are 136 projects with an investment value of more than USD100m each. Of those projects, seven are worth more than USD1bn (SIPAC 2014b).

[11] Small- and medium-sized enterprises. The EU-wide definition applies to companies with less than 250 employees and revenue less than €50m (Birkner 2013).

Cluster similarities and differences

One way to compare different industries is by observing the synergies of industry clusters. However, the term cluster is used in different, not always consistent ways. Thus, slightly different definitions of clusters circulate. The Baden-Wuerttemberg Ministry of Finance and Economics interprets the term as follows: *"The term cluster describes a regional concentration of companies from one industry or field of technology or competence that may also compete with each other."* (Ministerium für Finanzen und Wirtschaft 2012) Clusters in B-W fall into the category of high-tech clusters, and are generally sectorial, meaning that companies from the same sector work together in order to pursue a common goal of achieving synergies and improving innovation processes (Stahlecker et al. 2012).

B-W focuses on 18 industry clusters, following a bottom-up approach to assemble already existing industry specializations into clusters. In 2008, the 18 sustainable target fields were selected based on a study carried out by the Ministry of Economic Affairs (see Table 1). The study was carried out in order to create an online cluster database, where companies can connect with others in their field of operation. The database went online in 2010. The selection of target fields was performed to determine strengths of the clusters that already exists, and to implement a sustainable support strategies for these clusters. By collecting data on a state-wide level, it could also be defined which clusters should be centralized in order to enhance state-wide synergies. The fields include both industry and services. (Buhl 2012)

Sectorial clusters, in which companies collaborate in the same industry field in order to achieve synergies, are also present in SIP. In addition, clusters in SIP are geographical due to their proximity to one another within the boundaries of the industrial park. They are high-tech oriented, similarly to the clusters in B-W. Knowledge service clusters are also present in SIP, which are clusters with an advantage of easy access to skilled employees. One example is the establishment of co-operations with local universities in order to gain access to the skills of qualified engineers. It has been shown that areas with a higher amount of clustering are generally more innovative and contribute to GDP growth. (Wear 2008; Frattini & Prodi 2013)

Whereas B-W has rather implemented a bottom-up approach, which builds upon existing companies and specialists as a foundation, China follows a top-down approach. This means that the government decides and plans which areas should be focused on beforehand, based on capacities and limiting conditions of the designated areas. The park has USD6.86bn at its disposal to support companies that decide to develop in the park, according to the director of the SIP Economic and Trade Development Bureau. It focuses on certain fields by subsidies, research grants, by building research centers and maintaining close ties with universities and research institutes for those fields. Also, polluting and low value-added companies may be forced to leave until they fulfill the park's requirements. (Wei 2014)

B-W is divided into twelve geographical economic cluster regions. The quality of the regional clusters is guaranteed by several criteria[12]. In these regions, the existing industry structure is assembled into the 18 industry clusters as defined by the Ministry of Economic Affairs, amounting to a total of around 250 cluster initiatives (industry fields can be present in one region more than once). Within these clusters, companies work together and are supported by both universities and research institutions from B-W. The collaboration in the twelve regional cluster regions is complemented by a state-wide umbrella network, which is incentivized by the federal state government through financial support measures[13]. Other support measures for instance include trainings and working groups. The state-wide initiatives work closely with cluster regions by cooperating with local agencies and transfer institutions between research and industry. At the same time, on-the-spot opportunities for cooperation and networking are provided through trade fairs and exhibitions. (BuhlÉAdditionally, working groups and qualification events are organized through the state-wide network. (Buhl 2012; Ministerium für Finanzen und Wirtschaft 2012)

[12] Cohesiveness of clusters (horizontal proximity through similar products or services, vertical proximity through similar or shared value-added chains or steps of the value-added chain); geographical proximity; sufficient amount and density of companies (critical mass); sales potential on at least a national level with high export potential.

[13] In the form of EFREs, trans. European Fund for Regional Development

In the recent past, industry clusters have increasingly gained recognition by the Chinese government as an effective policy tool, since they contribute to balanced economic development (Wear 2008). Industry clusters in China however are divided into two kinds: low-tech clusters, which follow a bottom-up approach and may be useful in order to compensate economic inequalities and especially to enhance industrial synergies. This type of clustering is generally found in low-technology, low-cost industries such as textile. (Iammarinoa & McCann 2006) In contrast to this type, there are high-tech clusters on the other hands, which follow a strict top-down approach. Due to China's rapid development, the Chinese economic policy of the past twenty years has actively focused on creating high-tech clusters in fields that are regarded as promising. The focus is mainly on future key industries. The central government issues five-year development plans in cooperation with the provincial governments in order to decide which industries should be focused on in which area, and to ensure that industry clusters from different regions remain competitive and do not compete with one another. Not only do the governments decide upon future focus areas, but also on which incentives should be implemented in order to support these industries. (Frattini & Prodi 2013) As such, SIP receives strong government support for its key clusters (SIPAC 2014b). According to the government's 5-year-plan for SIP, the fields that are targeted include new materials, renewable energies, electronics, optics and photonics, and nanotechnology (see Table 2) (SIPAC 2012).

In B-W, the industry clusters that have the largest presence in the cluster regions and on a state-wide level correspond to a large extent with the industries that play the most important role in the industry structure (see Figure 6 and Table 1). This means that large industries are represented proportionally by the presence of industry clusters. The automotive and healthcare industry cluster fields are represented in almost every of the twelve cluster regions. IT, logistics, nanotechnology, and production technology also have a strong presence in the twelve regions (see Table 1). (Buhl 2012) A 2011 survey among 1,751 companies from all industry fields in B-W by the Fraunhofer ISI and the Chamber of Industry of Commerce in Karlsruhe revealed that companies themselves view IT as the most promising growth field. The interview partners also mentioned other promising future technology fields, such as production technologies, renewable energies and environmental technology, new materials and surface technologies, and e-mobility. In the state's coalition agreement, mobility, healthcare, and energy- and resource efficiency are targeted as important future fields. (Stahlecker et al. 2011)

SIP has been designated for competitive clusters in renewable energies, bio-medical technology, environmental technology, and nanotechnology. Moreover, the industry fields of IC, LCD, auto and aeronautical parts, software are supported and promoted, as well as services outsourcing (see Table 2). (SIPAC 2014a) This cluster strategy is in accordance with SIP's '3+5'-strategy, which focuses on three pillar industries in SIP that are already large, and supports five important rising industries (see Figure 8). The three pillar fields are machinery manufacturing, electronics and IT, and modern services industry. The five rising industries are bio-medical technology; nanotechnology, optoelectronics, and renewable energies (targeted as one industry field); environmental technology and protection; integrated telecommunications; and software, animation and games. It also shows that transformation is a continuous process in SIP, and that it remains to focus on high-tech industry specializations. (SIPAC 2014b; Shen 2014)

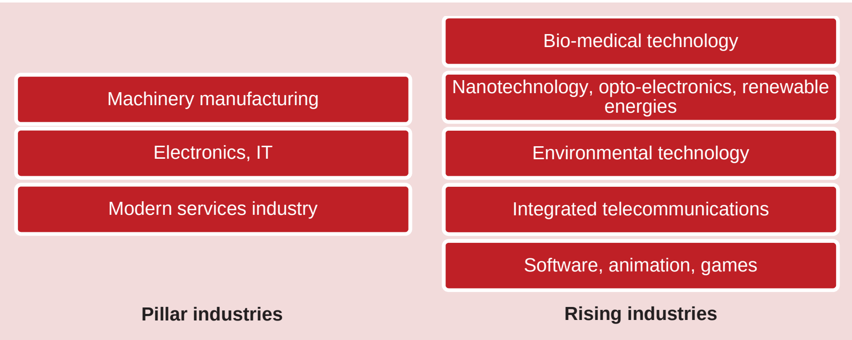


Figure 8 Overview of pillar industries and rising industries in SIP (SIPAC 2014b; SIPAC 2014a)

Table 1 Cluster overview by regional presence in the nine most important industry clusters in B-W. These are the industry clusters that have the strongest presence in the geographical economic cluster regions (Buhl 2012)[14]

Cluster designation (most important industry clusters)	Stuttgart	Heilbronn-Franken	East Wuerttemberg	Middle Upper Rhine	Rhine-Neckar	Northern Black Forest	Southern Upper Rhine	Black Forest-Baar-Heuberg	High Rhine – Lake Constance	Neckar-Alb	Danube-Iller	Lake Constance – Upper Swabia	Total
Automotive	■	■	■	■	■		■	■	■	■	■	■	*11*
Healthcare industry & medical technology	■	■	■		■	■	■	■		■	■	■	*10*
Information technology	■			■	■		■			■			*5*
Logistics	■		■		■						■		*4*
Nanotechnology	■			■	■				■				*4*
Production technology	■		■		■		■	■		■	■	■	*8*
Environmental technology	■	■		■	■		■		■				*6*
Micro systems technology							■	■					*2*
Photonics			■										*1*

[14] The twelve fields not mentioned in the table are: biotechnology, energy, aerospace and aviation, mechatronics, pharmaceuticals, satellite navigation, safety technology, telecommunications, economic sciences and services

Table 2 High-tech industrial zones in China with similar specializations (CND 2014; JNDZ 2014; NJHTZ 2014; Xuzhou Development Zone 2014; SND 2012)

Industrial zones	Changzhou	Jiangning	Nantong	**Suzhou Industrial Park**	Suzhou New District	Xuzhou
Renewable energies	■	■	■	■	■	■
Bio-medical technologies	■			■		
Environmental technologies				■		
Nanotechnologies				■		

Detailed description of most important industry clusters

The main emphasis in B-W is on the automotive industry, healthcare industry and medical technology, IT, logistics, nanotechnology, production technology, environmental technology, micro systems technology, and photonics (see Table 1). These are the clusters that have the strongest presence by number of regions in which they are present, or because they have a large number of state-wide cluster initiatives. (Buhl 2012) The clusters will be described in the following section. Photonics and MST are also included: although they are not the largest clusters in terms of size, they are extremely important for other industry clusters and are more important than is expressed by numbers only. MST and nanotechnology are described in one section below, since both have many synergies. The services industry is also described, even though it is not a manufacturing industry cluster like the others, but it has an important cross-sectional function in supporting the other industry clusters.

1. Automotive engineering

B-W is well-known for its automotive engineering, but offers more than large car manufacturers: the mobility branch consists of more than 2000 companies and research partners that cooperate closely. There are more than 100 production sites of vehicle producers, which are supported by more than 200 direct suppliers. (Ministerium für Finanzen und Wirtschaft 2011)

According to the ‘3+5’ plan, the fields that are the most fundamental for SIP (pillar industries) are machinery manufacturing, services, and electronics and IT. The most promising and most heavily supported future rising industries are nanotechnology, bio-medical technology, environmental technology and protection, renewable energies, optoelectronics, and integrated telecommunications (see Figure 8). Apart from the ‘3+5’ plan, pharmaceutics and fine chemicals will also be enlisted in the detailed description, since it is also an important and promising industry, despite not being specifically targeted as one of the rising industries. Software and animation will be regarded together with IT under the section IT and electronics due to lack of available data. (SIPAC 2014a; SIPAC 2014b; HKTDC 2014)

1. Machinery manufacturing

Machinery manufacturing, together with electronics and IT, is one of the strongest industries that have supported SIP’s growth over the past 20 years. Especially in automotive parts, aviation parts, precision machinery and engineering machine sectors, numerous foreign and domestic companies contribute to the large output of this industry field. (China-Finland Nano innovation center 2014) Big players include Bosch, ZF, GM, MTU, SEW, Amtek, Emerson, Flowserve, Schneider, Black & Decker, Siemens, Zeiss, Kybota, GE, Caterpillar, and many more. (China-Finland Nano innovation center 2014) SIP has an outstanding reputation for precision engineering. (HKTDC 2014)

Suppliers from the upstream and supporting fields of electronics, IT, plastics, optics and metal industries in particular profit from the thriving automotive industry. Innovative solutions in the area of sustainable mobility are gaining more and more attention, such as e-mobility. The greater Stuttgart area is the geographic center of the automotive industry and particularly targets the upper end car production. Especially in the automotive industry, 'Made in Germany' stands for high quality and enjoys an outstanding reputation (Ministerium für Finanzen und Wirtschaft 2011) One of the major competitive advantages of B-W as the most important automotive location in Germany is its densely knit network of suppliers and producers. Important car manufacturers include Audi, Mercedes-Benz, and Porsche. Major manufacturers of heavy vehicles are also present, as well as manufacturers of special vehicles. In total, the 2000-company-network achieves export ratios of more than 50%. (EMC 2004) One third of the entire German turnover in this field is generated by B-W, and around one sixth of automotive jobs in the EU-28 is located in B-W, with almost 350,000 jobs in the automotive industry in B-W (bw-fairs 2014b).

2. Healthcare industry & medical technology

Synergies between companies from biotechnology, pharmacy, medical technology, optics, and electronics are present in research and product development in this broad industry, including both SMEs and large companies. The prerequisites are promising given the presence of a developed research infrastructure, high-level education and a large talent pool. (Ministerium für Finanzen und Wirtschaft 2011)

2. Services

Although not a manufacturing industry field, services play an important supportive role in SIP. Especially compared to other industrial parks in China, services are an upper priority in SIP. These services include efficient administrative services, support offices for foreign investors, patent offices to offer advice on patenting strategies and procedures, and many more services. Moreover, there are more than 50 HR services, offering recruiting services and many more. All in all, SIP implements a service-oriented policy and offers whole-day, whole-process support and services for investors. (China-Finland Nano innovation center 2014) In 2013, the services sector generated 39.7% of the park's GDP (Wei 2014).

3. Electronics and IT

Complementing the machinery manufacturing industry, electronics and IT likewise have contributed to SIP's economic growth over the past 20 years. Big players in electronics include Philips, Hitachi, Samsung, and others. In IT, companies such as Microsoft, IBM, Oracle, HP, and others are represented in SIP. In total, more than 500 IT companies are active in SIP, with an access to a talent pool of 20,000 IT specialists. (China-Finland Nano innovation center 2014) SIP contributes significantly to China's manufacturing of LCD panels and IC: in 2008, the output value of SIP's LCD and IC contributed to the total output of these fields in China with 3% and 16% respectively. Mechanical-electronic integration is another core business of SIP. (HKTDC 2014)

Companies such as Carl Zeiss, Aesculap, and Paul Hartmann are present in the healthcare industry in B-W. (Ministerium für Finanzen und Wirtschaft 2011) Cluster initiatives being present in various regions of B-W demonstrate the importance of cooperation between biotechnology and medical technology, with clusters that guarantee the pursuit of pharmaceutical projects from the beginning until the successful implementation on an industrial scale. (Ministerium für Finanzen und Wirtschaft 2011) Several of the healthcare regional clusters include STERN (Stuttgart-Tuebingen-Esslingen-Reutlingen-Neckar-Alb) and the Rhein-Neckar triangle near Heidelberg. BioLago in Tuttlingen, close to Lake Constance, is an example of successful clustering: more than 450 medical technology firms are present in this small municipality, the global center for medical technology, among them global players such as Aesculap. On a state-wide level, Biopro looks after the interests of biotechnology and life sciences in B-W. (Handelsblatt 2013) In national comparison, B-W is the largest location for medicine and pharmaceutics in Germany, with 159 companies in biotechnology, 635 in medical technology, and 136 in pharmaceutics as of 2013. The export ratio is high, at 65%. (Biopro 2013) More than 90% of the companies in this field are SMEs (Ministerium für Finanzen und Wirtschaft 2014b).

4. Nanotechnology

Nanotechnology is designated to become one of the most important growth drivers for SIP, and SIP is well on its way to become China's nanotech hub. By the end of 2012, more than 100 nanotech companies were present in SIP, with more than 5,500 nanotech experts and more than 20 research institutions with a nanotech specialization. Until the end of 2015, SIP intends to attract additional 100 nanotech companies from over the world, as well as 5,000 more experts and thus become China's most internationally-oriented and important hub for nanotechnology. By building up and supporting entire value chains, SIP helps companies in the industry to take their products from prototyping through research and development to commercialization. (YESIPO 2014; SINANO 2014) As part of the nanotechnology cluster, Nanopolis was started as a geographical cluster project in 2010. Here, R&D, pilot and mass production, trainings, headquarters, and exhibitions in the field of nanotechnology can all take place in one location. (China-Finland Nano innovation center 2014) The most important industry areas of focus for nanotechnology in SIP are nano-manufacturing technologies (such as printed electronics, MEMs and nano-carbon), energy and green technologies (photovoltaics, battery technology, and others), and nano-medicine (for instance drug delivery and nano-diagnostics) (NanoGlobe 2011). Each year, Nanopolis attracts around 50 new firms. Nanopolis director Dr. Zhang Xijun expects Nanopolis to have 300 tenants and 25,000 to 30,000 employees by 2019 (Shen 2014).

3. Information technology/TIME

The TIME cluster is the consolidation of telecommunication, IT, media, and electronics. In this industry cluster, global players and SMEs offer solutions to support both manufacturing and services industries. Because of its presence in all levels of the production chain, the TIME cluster is an important driver for innovation and value creation in almost any industry in B-W. Particularly in the IT cluster, many companies are present. In the greater Karlsruhe region for instance, the IT cluster is the cluster with the highest development potential. Focus lies on B2B [15] and technical software solutions, and there are numerous cluster initiatives, e.g. to support IT start-ups. (Staatsministerium B-W 2010) Many global players, such as IBM, Hewlett-Packard, SAP, Alcatel, and others, have chosen B-W as their location due to its promising conditions and large talent pool (Ministerium für Finanzen und Wirtschaft 2011).

4. Logistics

Logistics is one of the core business areas of B-W and belongs to the services field, with 17,000 companies active in logistics services. If all jobs in trade and logistics are counted, the number of employees amounts to around 400,000. The logistics business is mainly driven by medium-sized companies. B-W is important as an east-west connection in the heart of Europe and due to major transportation hubs such as Mannheim, Karlsruhe, Stuttgart, Heilbronn, and Ulm. (bw-invest 2014b)

In the first half of 2014, nanotechnology applications generated 8% of SIP's total output value (Wei 2014). Cooperating closely with nanotechnology innovators, the new materials also play an important role in SIP (HKTDC 2014).

5. Bio-medical technology

In this industry, entrepreneurs with overseas education and work background have been targeted and attracted to relocate to SIP. Likewise, independent intellectual property owners and domestic investors with competitive technologies and an international background are invited. (SIPAC 2014b) Surroundings for geographical clustering have been constructed with the implementation of the Biobay project, which started operation in June 2007 and is located in Dushu Lake Science District. Biobay is a key driver of life science innovation, drug discovery, diagnostics, and medical devices. It offers start-up support services through offices and trainings, and has invited research institutes such as the Chinese Academy of Sciences (CAS) and the Suzhou Institute of Nano-tech and Nano-bionics. There are platforms for knowledge exchange and support, such as support in patent filing, and platforms for testing, such as drug testing. Biobay also facilitates networking events among companies, and provides connections to regional manufacturing industries. In total, around 400 companies currently are located in Biobay. Most of them are specialized in medical devices (24%), drug discovery (22%), and followed by nanotechnology (14%) and other fields of biotechnology (11%). (Biobay 2015)

[15] Business-to-business

5. Nanotechnology & micro systems technology

Micro systems technology (MST) and nanotechnology are cross-sectional technologies, which create value for industries such as the automotive industry, mechanical engineering, optics, medical technology, measurement and control technology, and biotechnology: industries, in which B-W also remains strong. Research institutions in the industry of nanotechnology play an important role, for instance in the MicroTEC cluster in Karlsruhe, Villingen-Schwenningen, Stuttgart, and Freiburg, where especially the universities of Freiburg and Karlsruhe are world-wide renowned for their research in this field. Around 14% of the patents filed in MST world-wide stem from this cluster. Around 3,600 companies in B-W are active in MST, which is around one quarter of all MST companies in Germany. Among them, 750 companies are specialized in nanotechnology. The industry of micro systems technology creates around 75,000 jobs in B-W. (Ministerium für Finanzen und Wirtschaft 2014a; bw-invest 2014a)

6. Production technology

This industry cluster is an important partner for many other industries in B-W, especially automotive engineering (Buhl 2012). Its core industries mechanical and construction engineering have close ties with electronics, optics, IT, metal processing and automation.

The rest of the companies located in Biobay operate in support services and clinic research organizations (Biobay 2015). By 2012, companies in Biobay had applied for 2,171 patents within five years. Almost 20% of these patents were granted. (SIPAC 2013b) In the first half of 2014, biomedicine generated 11% of the SIP's output (Wei 2014).

6. Environmental technology & protection

Not only does SIP implement advanced environmental protection measures within its boundaries, it also seeks for environmental certifications from companies present in SIP. Thus, it is one of the most eco-friendly parks in China and has achieved the status of eco-industrial zone. (CSSD 2014)

7. Renewable energies

The goal for the new energy sector is to create a 100 billion RMB output by the end of 2015 (SIPAC 2011b). The implementation of smart city concepts, such as energy saving concepts and green energy is endorsed (CSSD 2014). SIP is one of the pioneers in smart city building as one of 190 smart city pilot projects in China (Tan, Gim & Aw 2013).

8. Optoelectronics

To support this rising industry, the Suzhou Industrial Park Optical Communication Industrial Alliance Associates (SIPOCIA) was established in 2009. Members can actively participate in networking and other activities. (SIPAC 2011a) SIPOCIA's main goal is to promote technological exchanges, in order to help SIP become an important international base for optoelectronic innovation and production. (SIPOCIA 2014)

Since B-W is not rich in natural resources, production technology clusters are more targeted towards innovative solutions than production of raw materials to achieve optimal material efficiency, e.g. by energy and material efficiency technologies, e-mobility production technologies, and new materials processing technologies (Birkner 2013). A good example is the machinery production regional cluster in Black Forest-Baar-Heuberg, where the technology transfer among approx. 5,000 specialized niche machinery firms ensures their leadership on global niche markets (Staatsministerium B-W 2010). In total, production technology offered around 300,000 jobs in B-W in 2013 (Statista 2015).

7. Environmental technology

A dynamic interaction takes place in this cluster among companies from IT, chemistry, optics, electronics, mechanical engineering, and biotechnology. With an eye on the future, close ties with the automotive industry are nurtured to develop e-mobility and connected vehicle concepts. Due to B-W's presence in automotive, IT, and energy, this will be an important future growth driver. (Staatsministerium B-W 2010) In addition, many firms in the Karlsruhe area work together on energy efficiency concepts, through combination of IT and new energy generation solutions such as geothermal and biomass. 600 companies and research institutes participate in the environmental technology state-wide cluster. (Ministerium für Finanzen und Wirtschaft 2014d)

SIPOCIA was initially founded by 16 companies. It covers optics upstream firms (suppliers of optical devices), midstream firms (design manufacturers of optoelectronics systems), and downstream firms (manufacturers of optoelectronics devices). It thus actively pursues the goal of supporting the entire optoelectronics value chain. Domestic cluster members include Innolight, AltaElectronics, and others. (Chinese Association of Science and Technology 2013) Foreign firms that manufacture optoelectronic products and are active in SIP are, among others, Schneider Electric and Honeywell (NanoGlobe 2011).

9. Integrated telecommunications

Similarly to bio-medical technology, Chinese entrepreneurs with an international background are being attracted as workforce in SIP for this field, especially for unified communication, software, and integrated circuit design. Building on the pillar industry of electronics and IT, SIP is moving in the direction of smart city building. In collaboration with Singapore, SIP is implementing smart city initiatives, such as intelligent transport; cloud computing; and smart environment management since 2013. SIP is one of China's 190 smart city pilot areas. (SIPAC 2014b; Infocomm 2013; Tan, Gim & Aw 2013) In the first half of 2014, cloud computing generated 6.2% of SIP's output value (Wei 2014).

8. Photonics/optics

Optical technology as an industry cluster is a hidden champion in itself: in terms of number, only 300 companies are active in this field, but the industry is extremely important for other industries such as automotive, mechanical engineering, medical technology, and process and control engineering are highly dependent on optics. (bw-fairs 2014a)

Global players such as Zeiss, Trumpf, and Sick are based in B-W and are regarded as market leaders in their field. Almost 9,000 employees are occupied in this branch, thus making B-W one of the most important optics locations in Germany. (bw-fairs 2014a)

9. Services

The manufacturing industry in B-W is supported by a broad range of services, such as financial services in Stuttgart: Germany's second largest stock exchange is located here, as well as many insurance firms and home loan banks. In order to support the numerous high-tech fields, high-quality and technology-oriented services are offered to support these companies in the increase of productivity and to help strengthen their competitive position, such as IT solutions for the planning and simulation of manufacturing processes or consulting services. (Stuttgart financial 2014) The services sector employs almost two thirds of the work force in B-W, with almost four million employees (Statistisches Landesamt B-W 2014d).

10. Pharmaceuticals, fine chemicals

Although not explicitly listed in SIP's '3+5' plan, these two industries have also been important growth drivers for SIP (HKTDC 2014). In combination with the currently rising industries, they will remain important, especially in collaboration with companies from the fields of nano- and biotechnology. Large companies such as BASF, Johnson & Johnson, Pfizer, and GSK, are present in SIP. (NanoGlobe 2011)

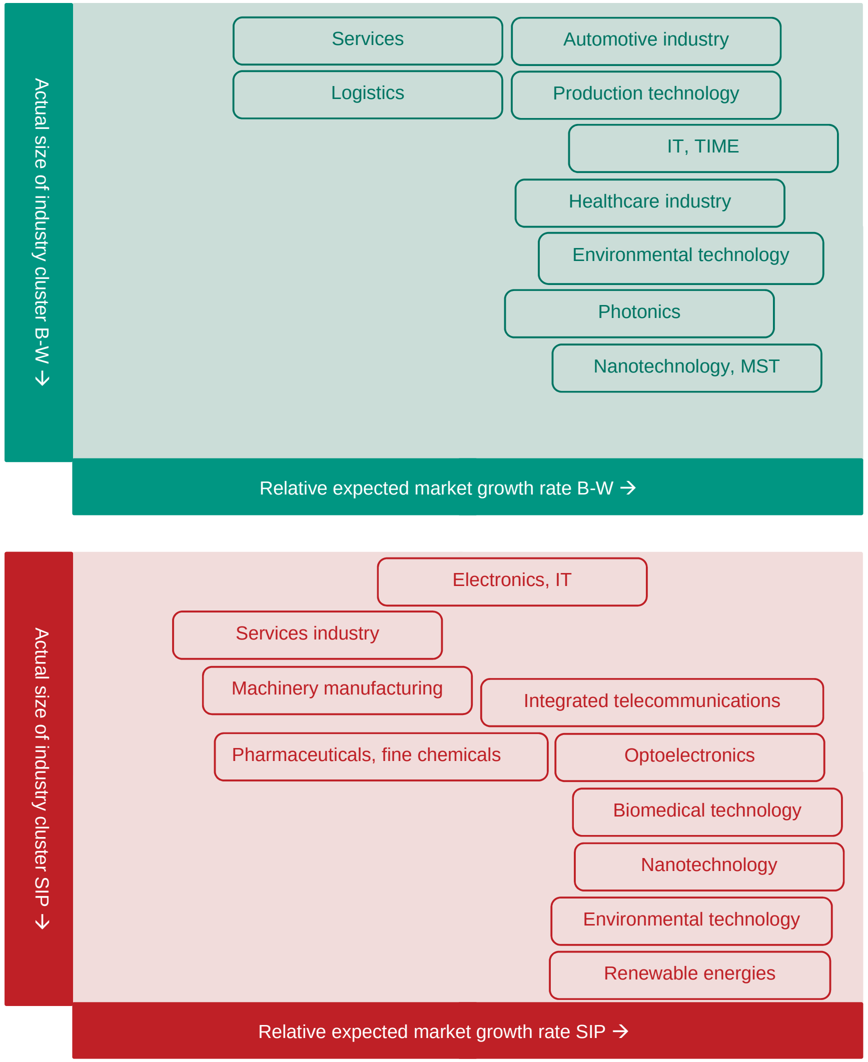
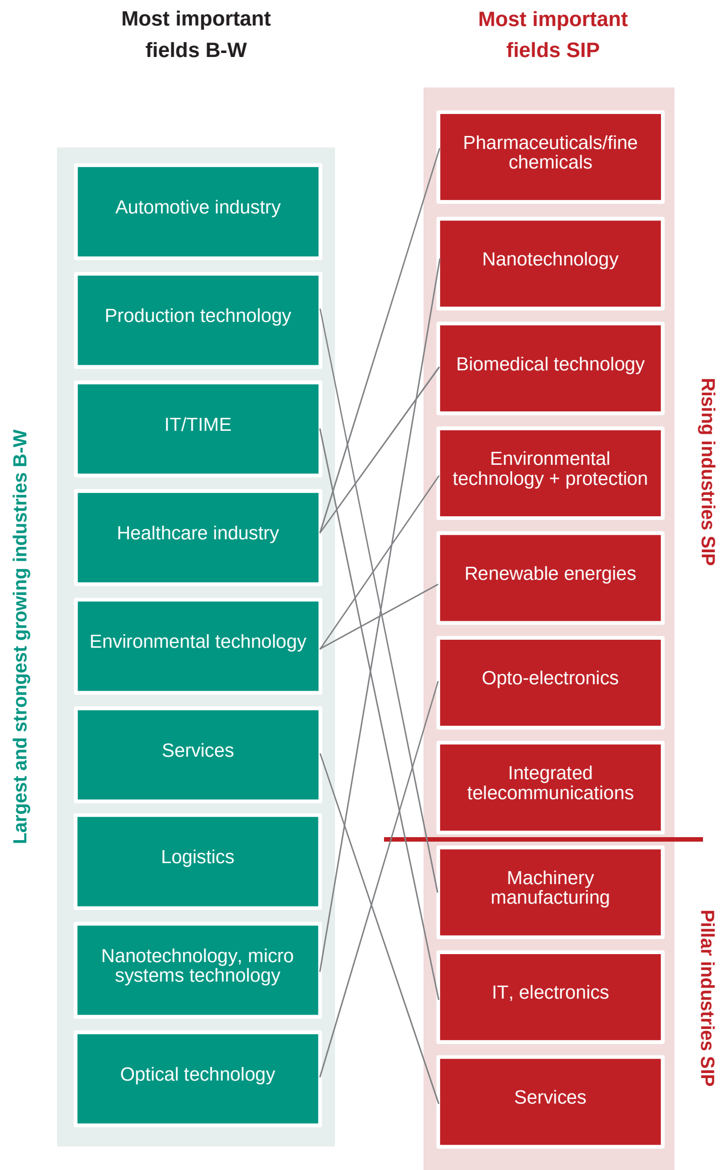


Figure 9 Comparison of relative market growth rates vs. actual size of industry cluster in order to assess the future growth potential of selected industry fields based on BCG matrix principle. Growth and actual size refer to markets in B-W and SIP respectively. Market size based on own calculations and estimations derived from quantitative data on number of companies and number of employees. Market growth estimations based on qualitative data through respective government strategic growth plans, targeted key industries, funding plans and expert expectations with regards to future key industries. SIP industry clusters are depicted in red, B-W industry clusters are portrayed in green (Birkner 2013; Buhl 2012; SIPAC 2014b)



Knowledge infrastructure

Education system

Baden-Wuerttemberg has a comprehensive education system. Different types of secondary education characterize its high school system. After completion of primary school, children attend one of three levels of secondary education: *Hauptschule, Realschule* or *Gymnasium*. After finishing the practically oriented *Hauptschule*, students will usually enroll in practical vocational training or start work in public service at a basic level. *Hauptschule* graduates with good grades may also enroll in further education in *Realschule* or *Gymnasium. Realschule* is ranked between the other two school types, and graduates from this type of school will usually start an apprenticeship or enroll in *Gymnasium* for further education. *Gymnasium* is the most academically oriented school type and prepares students for tertiary education. The core of further education is formed by numerous apprenticeships and vocational trainings, which have traditionally always played a strong role in bringing forth a strong work force of practically oriented trainees and apprentices in Germany. In total, there are 70 institutions of higher learning, including world-famous universities that produce influential research institutions. Nine universities, 23 universities of applied sciences, eight art and music schools, and six colleges of education are present in B-W. Previously, only a small percentage of high school graduates attended university. This has been changing, as more and more university students start their education every year, leading to a 55% gross enrolment rate in tertiary education in 2011. (GTAI 2014; (Brugger & Wolters; Ministerium für Wissenschaft, Forschung und Kunst 2014)

China has a vast education system. After a 9-year compulsory primary and junior middle school enrollment, students may attend a vocational school or a senior high school. For senior high school, an entrance test needs to be absolved. Senior high school gross enrollment rate is at 44%, and is lower than in developed countries. The SIP senior high school enrollment rate is at 99.8%, far above the national average. Tertiary education enrollment rate in China is at 27%. In SIP, the enrollment rate for undergraduate programs is at 68%, and thus is higher than the country average. (China Education Center 2014; SIPAC 2013c) In 2002, Suzhou Dushu Lake Science-Education Innovation District was founded in order to integrate education, research and residential living. For the development of this area, Silicon Valley was chosen as a key reference model. (Tang 2012) The SIP administration invited key universities to open sub-departments or research institutions in SIP, which was done by several of them, such as Nanjing University, Southeast University, Xi'an Jiaotong University, University of Science and Technology of China (USTC), and Renmin University of China. Moreover, some universities moved their entire campus there, such as Suzhou University and Xi'an Jiaotong Liverpool University. Currently, there are 24 higher education institutions and one national research institute at Dushu Lake. Of these 24 higher education institutions, ten are universities. (SIPAC 2013c; China-Finland Nano innovation center 2014)

To support universities, Germany has implemented the concept of elite universities (EI). These universities receive additional funding for excellent research. In the first phase of the initiative, from 2007 to 2012, nine universities received additional funding. In the second round, which started in 2012, eleven universities receive the support. In B-W, KIT and Freiburg used to be elite universities; Heidelberg, Konstanz, and Tuebingen currently are. (Ministerium für Wissenschaft, Forschung und Kunst 2014)

One highly praised feature of the German education system is its dual education, where theoretical knowledge transfer in classrooms is complemented by practical vocational training in and by companies. The concept is widely spread, and many companies rely on the high quality of these graduates to fill their practical positions. German university enrollment rates therefore are lower than in most other EU countries, with the dual vocational system offering a good alternative. The quality is guaranteed by several national criteria and standards. However, several challenges have arisen in recent years. 2013 was the first year in which more high school graduates chose to attend university or college instead of a vocational school. Due to this, 40% of companies had difficulties finding students for their vocational training positions. (Bundesministerium für Bildung und Forschung 2014)

On a college level, dual university programs implement the combination of practical trainings with theoretical lectures in a similar way. After completion, students will receive a college diploma. (Bundesministerium für Bildung und Forschung 2014)

In China, the prestigious C9 league exists, which is comparable to the US Ivy League. It is an alliance of nine Chinese universities. These nine universities receive 10% of government funds for only 3% of the China's researchers. Together, these researchers are responsible for 20% of publications from China, and 30% of citations. (Yue & Zhu 2009) Three of them, namely Xi'an Jiao Tong, Nanjing University and USTC, have locations in SIP. (Tang 2012)

Originally, vocational education plays an important role in traditional trades, e.g. Chinese medicine and martial arts. From the 1950s onwards, the vocational system was used to train skilled workers for the planned economy. At the end of the 1980s, the system was transformed to a more school-based system. However, vocational schools are not very popular nowadays. In 2013, less than half of the students who were admitted to higher secondary education chose to attend a vocational school as an alternative to senior high school. (Wang 2014) Other problems are quality-based. Due to limited funds of vocational schools, many companies complain about quality and implement own vocational training programs instead, such as Robert Bosch GmbH. (SIPAC 2014c) Inspired by the success of vocational school systems in other countries, the system is being implemented more and more in SIP. Currently, there are five vocational schools in Dushu Lake District, which have set up a coordinating council. Among the schools are the SIP Institute of Vocational Technology in cooperation with Samsung, the Singapore Institute of Safety Officers, and the HKU Space Global College Suzhou. (SIPAC 2013c; Wang 2014; SIPAC 2014c; SIPAC 2011e)

Table 3 Universities in B-W and SIP. (SIPAC 2013c; China-Finland Nano innovation center 2014; Ministerium für Wissenschaft, Forschung und Kunst 2014)

B-W			SIP		
University	EI[16]	Specializations	University	C9[17]	Specializations
University of Freiburg		Humanities, social sciences, natural sciences	*China University of Science and Technology*	x	Scientific and technological research, engineering, humanities and management
Heidelberg University	x	Humanities, social sciences, natural sciences, specialty in law, medicine	*Fudan University*		Politics, humanities and social sciences, natural sciences & mathematics, medicine, business
University of Hohenheim		Agricultural and natural sciences; business and economics	*Nanjing University*	x	Humanities, social sciences, natural sciences
Karlsruhe Institute of Technology (KIT)		Engineering, computer science, physics, natural sciences	*Southeast University*		Engineering, architecture, art history
University of Konstanz	x	Sciences, humanities, law, economics, politics	*Suzhou University*		Humanities, Textile Engineering, Chemistry, Materials Science, Medicine
University of Mannheim		Business administration, economics, law, social sciences, humanities, mathematics, computer science	*Xi'an Jiaotong University*	x	Engineering, technology
University of Stuttgart		Civil, mechanical, automotive, industrial & electrical engineering	*Xi'an Jiaotong Liverpool University*		Engineering, architecture, business, international business
University of Tuebingen	x	Medicine, natural sciences, humanities			
Ulm University		Natural sciences, medicine, engineering sciences, mathematics, economics, computer science			

[16] EI: elite universities receives additional funding for excellent research

[17] C9: C9 league universities receive 10% of government funds for only 3% of the China's researchers

Talent pool

In total, almost 350,000 students were enrolled in tertiary education in Baden-Wuerttemberg in 2014, including around 10% foreign students (Ministerium für Wissenschaft, Forschung und Kunst 2014). In B-W, students may attend university, university of applied sciences, college of education or college of art. The latter one will not be analyzed in this section due to the small amount of students in this area.

Both SIP and B-W have highly educated employees as one of the keys to their success and their status of innovation driver. In total, 170,000 students were enrolled in universities in B-W in 2013. Almost 40% of them were enrolled in engineering, mathematics, or natural sciences on a university level in 2013, which corresponds to more than 69,000 students. On top of that, 144,000 students were enrolled in these subjects in universities of applied sciences, corresponding to 44% of the total number of students at universities of applied sciences (see Figure 10). The largest number of students in B-W is enrolled in universities of applied sciences. Here, law, economics and social science have the most students, followed by engineering, mathematics and sciences, and linguistics and cultural sciences. On a university level, the fields of mathematics and sciences, economics and social sciences, and linguistics and cultural sciences draw the most students. Engineering is chosen by less university students, but still ranks ahead of medical and health sciences, and agricultural, forestry and nutrition sciences. In colleges of education, linguistics and cultural sciences, and mathematics and sciences are the most-chosen subjects by students from B-W. (Statistisches Bundesamt 2014)

In entire Jiangsu province, incl. Suzhou, there were more than 1,400,000 students currently enrolled in universities and colleges in 2013. Of them, around 5% studied in SIP. (China-Finland Nano innovation center 2014; SIPAC 2013c) Every year, around 43,000 people start working at SIP as new employees. More than 40,000 students leave the universities in Suzhou as fresh graduates annually. (China-Finland Nano innovation center 2014)

SIP offers education on the level of junior college, bachelor, and master. Pursuing a PhD in SIP is also possible. The implementation of the junior college program is Singapore-inspired and offers students a two-year fast-track preparation for university. In Singapore, it was originally intended as an alternative to a regular bachelor's degree, but instead has become the norm to pursue a bachelor's degree. In SIP, this degree is not necessary to attend university. (Su 2002) SIP ranks first among other national economic and technological development zones in terms of talent pool size, which contains more than 190,000 persons with a junior college education level degree or higher (see Figure 10). Especially in the fields of services and bio-medicine, the number of bachelor degrees is high. The services field also ranks first in the number of master degrees, followed by the software and animation field. All in all, these three fields have the most students in total, when adding all levels. (GAMI 2014b)

Returning talents that were educated abroad or have overseas work experience form an important innovation driver. Especially in biotechnology and IT; these groups are specifically targeted and welcomed. (SIPAC 2014a)

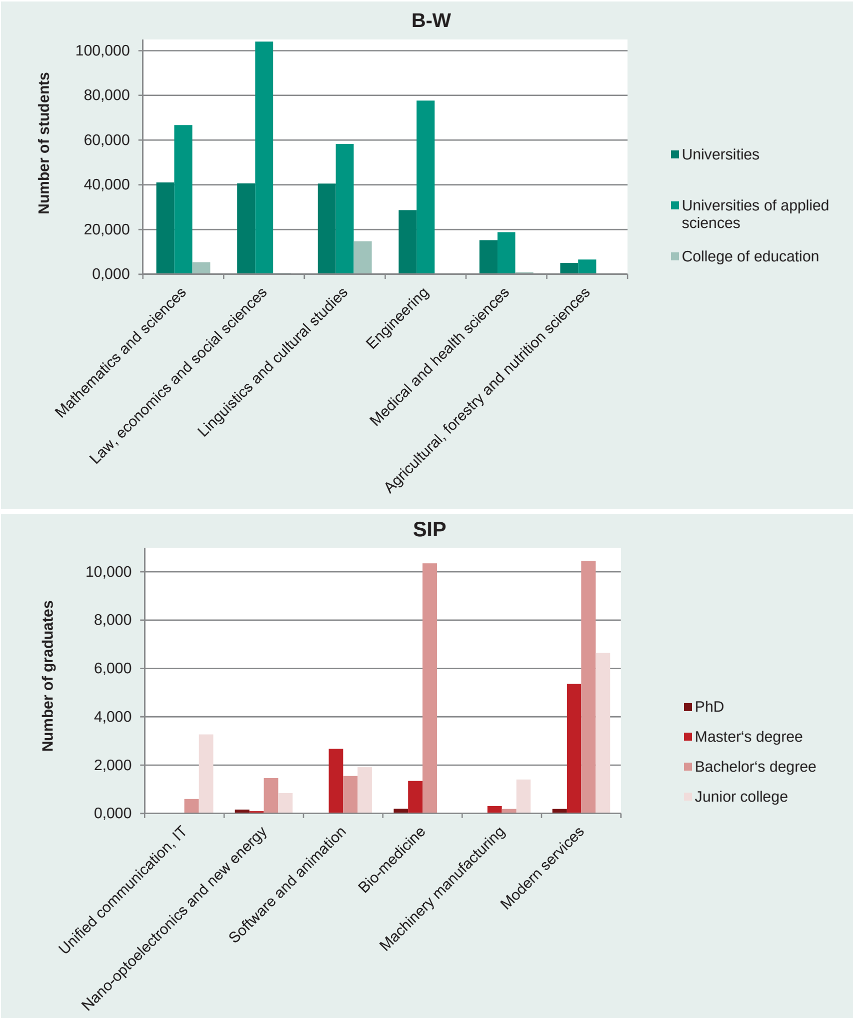


Figure 10 Education levels and subjects in B-W (top) and SIP (below). Due to lack of available data, tertiary education types were assessed for B-W, and types of college degrees for SIP. Also, the scale is different. (Statistisches Bundesamt 2014; SIPAC 2014a; based on GAMI own research)

Innovation and R&D investment

Based on the division into 12 economic cluster regions, an innovation index is calculated for the regions. It consists of the two sub-indexes level and dynamics. The level index portrays the current innovation situation based on 6 indicators, whereas the dynamics index provides information on the year-on-year development of these indicators[18]. The two sub-indexes enter into the total value of the innovation index in a 3:1 ratio. The value of the innovation index for B-W is the highest in Europe, which is mostly due to the highly innovative mechanical engineering, electrical engineering and automotive industries, and the high number of B-W patent applications. B-W received a total innovation index value of 71.3%, compared to 50.2% for Germany and 36.8% for the EU-28. (Statistisches Landesamt B-W 2014b; Buhl 2012)

Chinese companies are using innovation to adapt to globalization, and implement new services and products to conquer new markets. Whereas innovation is a top strategic priority for 21% of MNCs[19] in China, it is the number one priority for 42% of Chinese companies in China, which implies that Chinese companies put a higher priority on innovation. Foreign companies have recognized the role of the Chinese companies as innovators (see Figure 11). (Veldhoen et al. 2014) Chinese companies are more likely to partner with organizations to achieve innovation: 77% cooperate with universities, 68% with suppliers. However, they are less likely to partner with customers by vertical integration than MNCs in China are. (Veldhoen et al. 2014)

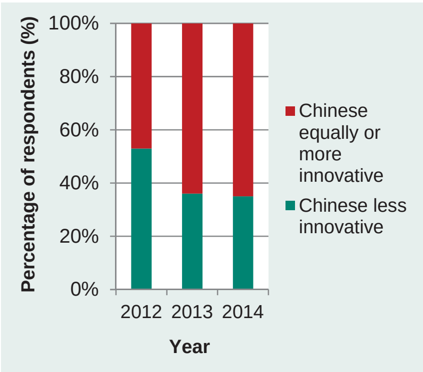


Figure 11 Results from China Innovation Survey 2012, 2013, 2014. MNCs that operate in China (WFOEs and JVs) were asked whether they would rate themselves more or less innovative than Chinese companies. (Veldhoen et al. 2014)

[18] The indicators are: (1) R&D expenses relative to GDP; (2) Amount of R&D employees compared to total number of employees; (3) Amount of employees in knowledge intensive high technology industries compared to total; (4) Amount of employees in knowledge intensive service industries compared to total; (5) Employees in scientific and technological fields compared to total; (6) Number of European patent applications per one million inhabitants

[19] Multinational companies

The German research landscape exhibits a dense structure of public and private funding, both for basic and applied research. In B-W twelve of the 80 German Max Planck institutes are based in B-W, as well as 14 of the 60 Fraunhofer Institutes and 25% of the Helmholtz Association research facilities (European Commission 2014). The main investors in R&D in B-W are industry, universities, and the public sector. The largest contributor is the industrial sector through its numerous in-house research facilities. This knowledge and funding infrastructure, combined with highly educated, skilled employees, both in SIP and B-W, are keys for representing potent innovation regions.

The amount of GDP spent on R&D by the federal government in B-W is high compared to the rest of Germany: in the year 2011, it was at 5.1%. 4.1% was contributed by the commercial sector, 0.4% by the government, and 0.6% by the universities. (Statistisches Landesamt B-W 2013b)

At the end of 2013, there were 51 national research institutions, 147 R&D institutions set up by foreign enterprises, and 253 R&D institutions set up by domestic enterprises in SIP (SIPAC 2011d; SIPAC 2014b).

As stated by Chinese vice premier Wu Yi at the 9th Suzhou Industrial Park Joint Steering Council meeting 2007, GDP spending on R&D should be up to 5% by 2014. In the year 2013, the R&D investment of SIP was at 3.3% of GDP. (SIPAC 2014b)

Publication activity

Publication activity is one of the measures which are used in this study to compare research intensity and innovation capacity in B-W and SIP. Publication activity is a good measure to document the research intensity of public research institutions, such as universities. A significant part of research, however, is not conducted by public institutions, but by companies. Therefore, the publication activity analysis will be complemented by a patent analysis to fully cover both aspects of research intensity. (Frietsch, Neuhäusler & Rothengatter 2013)

> *"Innovation is a cross-cutting way of equipping all sectors of our economy to be more competitive. […].It is indeed about turning new ideas into growth, prosperity, jobs and well-being."*
>
> José Manuel Durão Barroso, President of the European Commission, at the Innovation Convention 2011 on the Europe 2020 Innovation Strategy (Barroso 2011)

In order to analyse the relationship between publication activity in B-W and SIP, university publications in B-W and Jiangsu were examined to draw a comparison. For B-W, solely university research was analyzed, given the fact that almost all publications stem from universities and research institutes. For the analysis of publication activity in Jiangsu, solely the releases by national universities were taken into account.[20] [21] In order to retrieve the total amount of publications, four main subject areas were examined: life sciences, physical sciences, health sciences and social sciences & humanities. These are the subject areas into which the publication database Scopus divides all research papers, which means that all papers belong to at least one of these categories. For the research by category, physical sciences are the most important for both SIP and B-W. The physical sciences are divided into eleven further research fields[22]. We consider the five research fields of computer science, engineering, materials science, chemistry, and physics and astronomy, since these are the research fields with the highest publication activity of the physical sciences. In addition, these are the fields in which both B-W and SIP are the most active, based on the number of clusters and employees per branch.

[20] The Chinese universities considered are national universities: Nanjing University, Southeast University, Hohai University, Nanjing University of Science and Technology, Nanjing Agricultural University, Nanjing University of Aeronautics and Astronautics, China Pharmaceutical University, China University of Mining and Technology and Jiangnan University. For B-W, we consider the universities of Freiburg, Heidelberg, Hohenheim, Karlsruhe (KIT), Konstanz, Mannheim, Stuttgart, Tuebingen and Ulm.

[21] The data were retrieved with the database query system Scopus. Scopus has around 20% more coverage than all Science Citation Index studies, meaning that it reaches even more scientifically significant papers than covered by the SCI.

[22] Chemical Engineering; Chemistry; Computer Science; Earth and Planetary Sciences; Energy; Engineering; Environmental Science; Material Science; Mathematics; Physics and Astronomy; Multidisciplinary

Comparison of publication numbers and growth rates

In B-W, the number of publications has been increasing steadily over the past ten years. All subject areas reported an average CAGR[23] of 3.8% from 2003 until 2013. Of the five sectors that were taken into further examination, the sector leading in growth is the field of computer science with a CAGR of 10.7%, followed by materials science (7.2%), chemistry (6.1%) and engineering (6.0%). The research field of physics and astronomy closes the sequence with a CAGR of 5.7%. (Elsevier - Scopus 2015) Although computer science reported the highest CAGR, it came from a lower starting level. Physics and astronomy still reported most of the publications in 2013 despite having the lowest CAGR. All in all, physics and astronomy registered almost 3,000 publications in 2013, followed by engineering and chemistry as a shared runner-up, both with around 1,300 publications. Computer science and materials science follow closely, both registering more than 1,000 publications in 2013. Remarkably, KIT in Karlsruhe reported around 50% or more of the publications in B-W in all five sectors, and even more than 70% in engineering and computer science. (Elsevier - Scopus 2015)

The first matter that stands out is the staggering publication growth rate of the five categories over the past ten years by the Jiangsu universities. They reported an average CAGR of 25.9% from 2003 to 2013. (Elsevier - Scopus 2015) Likewise, Jiangsu universities have overhauled their counterparts in B-W in publication activity by category. The engineering field was the fastest growing sector with a CAGR of 43.5%, followed by computer science (34.6%), materials science (28.5%) and chemistry (22.8%). Physics and astronomy remained overall second in number of publications in 2013, despite having the slowest annual growth rate of 20.1%. (Elsevier - Scopus 2015) With regards to the overall amounts in 2013, the engineering field is a distant first in Jiangsu with around 11,500 publications in 2013 alone. The chemistry research field registered around 5,000 publications. The other sectors follow at a clear distance to the engineering field as well, with approximately 4,000 publications each. Taking the number of publications per institution into consideration, Southeast University leads in computer science and engineering with around 25% of publications in 2013. Southeast and Nanjing University compete in materials science, both with approximately 20% of publications. China Pharmaceutical University takes a clear lead in chemistry with 43% of publications, whereas Nanjing is first in physics and astronomy (30%). (Elsevier - Scopus 2015)

[23] CAGR: Cumulated average growth rate

Table 4, Table 5 Growth in number of publications from universities in B-W and Jiangsu, 2003-2013 (Elsevier - Scopus 2015)

B-W	Computer Science	Engineering	Materials Science	Physics and Astronomy	Chemistry	Physical sciences total
2003	372	757	593	1,566	757	5,474
2004	407	946	561	1,706	809	5,869
2005	523	1,149	573	1,862	864	6,736
2006	606	1,108	602	2,074	921	6,814
2007	734	1,181	665	2,146	924	7,262
2008	1,021	1,259	784	2,116	1,021	7,440
2009	1,008	1,411	1,140	2,443	1,187	7,401
2010	1,134	1,306	1,145	2,560	1,164	7,602
2011	1,154	1,430	1,307	2,769	1,267	7,959
2012	1,063	1,276	1,159	2,949	1,265	8,043
2013	1,027	1,349	1,185	2,724	1,367	7,942
CAGR (%)	10.7%	6.0%	7.2%	5.7%	6.1%	3.8%

Jiangsu	Computer Science	Engineering	Materials Science	Physics and Astronomy	Chemistry	Physical sciences total
2003	203	306	342	677	684	2,988
2004	258	698	378	694	783	3,952
2005	724	2,702	945	1,474	1,145	8,704
2006	1,214	3,603	1,189	1,716	1,490	11,375
2007	1,639	4,318	1,337	1,919	1,878	13,448
2008	2,663	6,091	2,029	2,486	2,525	16,751
2009	3,917	7,282	3,003	3,272	3,467	20,318
2010	4,366	8,274	2,965	3,117	3,628	21,794
2011	4,238	9,684	3,607	3,723	4,110	25,149
2012	4,028	10,340	3,733	4,035	4,720	26,986
2013	3,968	11,351	4,202	4,239	5,313	29,931
CAGR (%)	34.6%	43.5%	28.5%	20.1%	22.8%	25.9%

The number of publications from Germany started to grow rapidly from the 1990s onwards (Elsevier - Scopus 2015). One of the reasons for this was the increased scientific potential in the beginning of the 1990s due to the German reunification. Over almost 40 years, the CAGR amounted to 4.4%. From 1976 until 1989, this was only 2.8%, from 1990 until 2014 the CAGR was 4.8%. (Braun & Glänzel. W. 2005) Reasons for the stronger growth include increased government support and improved access to knowledge sharing networks. Although various German scientific magazines do exist, it is more common to publish in English, which raises the impact of German articles. (Sarchet 2012)

All in all, China's publication activity has been growing exponentially since the late 1990s, both in terms of citations as well as in total amount of published papers. The Fraunhofer ISI found that China's CAGR in publication of papers amounted 18.4% from 1980 until 2011. The CAGR for citations was even higher, at 27.3%. There are several reasons for this: not only has the government steadily kept increasing R&D spending, business expenditures have also started to play and more significant role in Chinas development towards a knowledge economy. On top of that, the potential of the Chinese talent pool is basically unlimited in terms of quantity, which may also lead to increased publication quantity. (Zhou & Leydesdorff 2006; Fu, Frietsch & Tagscherer 2013) Many Chinese publications are published in one of the thousands of Chinese scientific magazines. In 2001, already more than half a million papers were published in these magazines annually, and the number continued to grow ever since. Many publications are cited among each other in these magazines, a fact which explains both the large number of publications as well as the growth in citations. Zhou and Leydesdorff also found that many of these Chinese journals remained fairly isolated from the rest of the world, even when the articles were published in English. Despite the large number of Chinese papers and citations, the question remains how big the impact of these papers is. (Zhou & Leydesdorff 2006; B. Jin, R. Rousseau 2004)

In general, an increase in the number of publications implies an increase in quantity of papers; whereas an increase in the number of citations refers to an increase in quality of research papers, thus reflecting the actual impact that these papers had. In 2013, the Fraunhofer ISI published a study to compare these two numbers, with some significant findings as a result. The German quality-to-quantity ratio has been increasing steadily over the past three decades. This means that the impact of German papers has grown, due to a faster increase of their quality than quantity. (Stahlecker, Meyborg & Schnabl 2013)

Table 6, Table 7 Number of publications and citations by country from 01/2001 to 08/2011(Scimago 2015; Thomson Reuters 2011)

#	Country	Number of scientific citation index publications
1	USA	3,049,662
2	China	836,255
3	**Germany**	**784,316**
4	Japan	771,548
5	England	697,763

#	Country	Number of scientific citation index citations	Citations per paper
1	USA	48,862,100	16.02
2	**Germany**	**10,518,133**	**13.41**
3	England	10,508,202	15.06
4	Japan	8,084,145	10.48
7	China	5,191,358	6.21

The Ministry of Science and Technology offers financial incentives for promising scientific magazines to raise them to an international level. Due to these incentives, it is not surprising that China's share of SCI included papers grew to 8.5% from 2002 to 2012, thus achieving a second rank after the US [24]. The Fraunhofer ISI found that the impact ratio of Chinese papers decreased until 2006, meaning that more focus was put on quantity than on quality. This ratio has been improving steadily since 2007. As can be seen in Table 6 and Table 7, the number of Chinese publications has a larger impact than Chinese citations, which implies higher quantity than quality. (Hvistendahl 2013) Although the quality of research papers is rising, it remains an actual problem: many research grants and promotions are granted based on the number of papers published, thus eroding the quality of those papers and encouraging plagiarism and invented journals. In a study conducted by the Chinese government, one third of more than 6,000 researchers at six leading institutions admitted to having plagiarized or copied papers at some point during their academic career. (The Economist 2013) The key driver for both the growth in quantity and quality has been government spending on science and technology. Since the 1990s, the government has started to focus on supporting quality by developing and endorsing world-class universities and supporting education as a whole. Therefore, the government emphasized the importance of quality as a key priority in the 2006 national scientific development plan. (Fu, Frietsch & Tagscherer 2013)

[24] Science Citation Index, maintained by Thomson Reuters

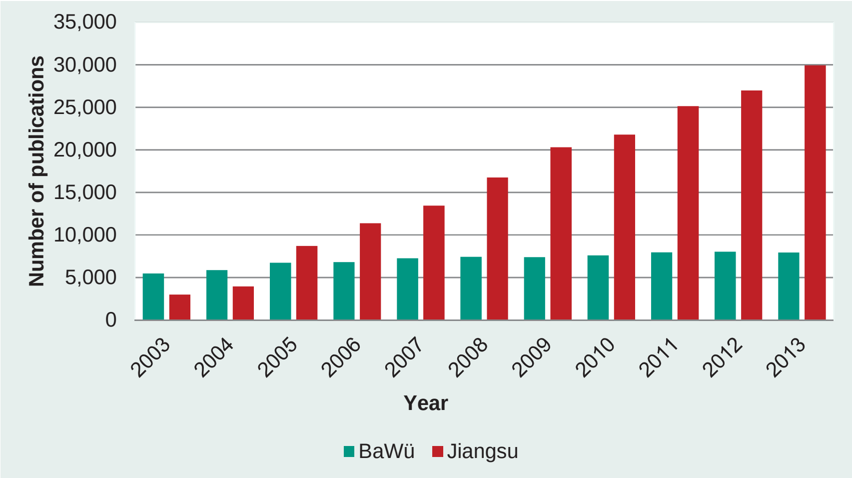


Figure 12 Comparison in publication activity in the five categories with the most publications that were selected from the subject of physical sciences: computer science, engineering, materials science, chemistry, and physics and astronomy (Elsevier - Scopus 2015)

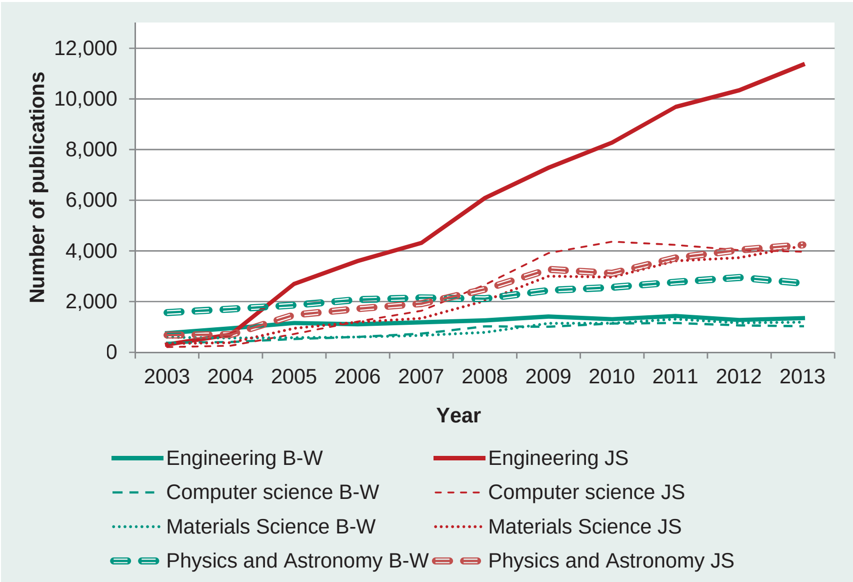


Figure 13 Comparison of B-W and Jiangsu in the fields of computer science, engineering, materials science, and physics and astronomy (Elsevier - Scopus 2015)

Patent practice and comparison

With the first patent being granted in 1877, the German patent system nowadays is one of the most advanced globally, together with Japan and the United States. Germany, Japan, and the US are also leading countries by number of publications (see Table 6). (Buhl 2012) Patents are filed with the German Patent and Trademark Office (DPMA) in Munich. It is possible to apply for a German national patent, or for a patent under the Patent Cooperation Treaty (PCT) at the DPMA. Applicants can also file a European patent directly at the European Patent Office (EPO), which usually happens if the economic expectations for the patent pay-off are higher. (Dornbusch et al. 2013) Germany joined the worldwide PCT in 1970, and has been a member of the European Patent Convention since 1977. Global PCT filings are usually based on location-based expectations for certain products: if an invention is expected to be of strategic benefit for a certain market abroad, it may be useful to apply for an international PCT patent for this invention. If the pay-off of the patent is expected to take place in Germany, filing a patent at the DPMA may be a better option. (World Intellectual Property Organization 1995)

In comparison to Germany, patenting is still relatively new for many Chinese companies. In 1984, the promulgation of the first patent law took place and marked the start of a patenting upraise. Due to the destruction of intellectual property during the Cultural Revolution, little importance was attached to its protection. Before the Cultural Revolution, which started in 1966 and lasted until 1976, there were no significant patent laws in the PRC. (Deng & Treiman 1997) The number of patents initially grew slowly from 1984 until the 1990s, and started to increase exponentially after several law adjustments were made and international treaties were signed. In 1994, 24 for years later than Germany, China joined the international PCT. In 2001, it took another important step toward better IPR protection by a patent law amendment, endorsing legal changes in accordance with WTO agreements to comply with international standards. (Sorell 2002; Embassy of the United States Beijing 2014) Chinese patents are territorial, and are filed at the State Intellectual Property Office (SIPO) in Beijing. In addition, the China Patent Protection Association (CPPA) serves as a supervisor for copyright infringements. CPPA is formed voluntarily by several companies and patent experts if they wish to join the organization. Foreign organizations have the possibility to file their patents through registered patent agents. In this case, the agent will deal with legal and administrative procedures. (Embassy of the United States Beijing 2014)

Criteria for invention patents in Germany are the following: inventions from all fields of technology are patentable, under the restriction that it must be possible to repeat the invention, meaning that it should not simply be a lucky try which succeeds only once. A patent is mainly granted on the basis of the following three criteria: novelty, an innovative inventive step and the possibility to apply the invention on an industrial scale. (Deutsches Patent- und Markenamt 2014)

Furthermore, it is possible to apply for *utility models*, *trademarks* and *registered designs* in Germany. The *utility model* is very similar to an invention patent. However, it is only checked on compliance with application criteria and thus can be granted a lot faster. It is regarded by many applicants as an easier, quicker way to apply for a patent and is granted after several days, compared to up to one year for an invention patent. Another important difference is that it is only valid for ten years, compared to 20 years for an invention patent. Only processes and biotechnological inventions are not eligible for utility model patents. It is also possible to apply for a *registered design*, which protects the visual appearance of a product. Therefore the design has to play a role in the purchasing decision of the product in particular. Registering it prevents third parties from copying the design. Registered designs are valid for 25 years. The DPMA also issues *trademarks*, which are usually slogans, logos, or images. For the comparison to China, trademarks have no counterpart and therefore will be left out of the rest of this study. (Deutsches Patent- und Markenamt 2014)

The Chinese criteria for invention patents are comparable to the German criteria. An invention patent should be characterized by novelty, inventiveness and practical applicability. (Sorell 2002)

In China, apart from invention patents, it is possible to apply for *utility model patents* and *design patents*. Principally, the patent categories are comparable to the German ones. A *utility model patent* is comparable to its German counterpart. They are not granted for processes, but for products which are fit for practical use, and only for the shape and structure of a product. In both countries, utility models are not examined regarding the content, but checked on compliance with the application procedure. This leads to much shorter handling times than for invention patents. In China, it may take three to five years for an invention patent to be granted. For a utility model only one year is needed. Whereas an invention patent is valid for 20 years, the protection of utility models lasts for ten years. A *design patent* is comparable to a German registered design, and guarantees protection for the shape and appearance of a product. Moreover, the design should be original and inventive. It should also be ensured that the design does not copy any content from prior design patents, and thus does not cause any conflict to prior design patents. After issuance, it is valid for ten years. (Sorell 2002) Contrarily to B-W, trademarks in China are not monitored by the same office that registers patents but by the China Trademark Office (CTMO). Therefore, issued statistics by SIPO do not include trademarks and are not included in this study. (Bosworth & Yang 2000)

At this point, it should be pointed out that in SIP, the processing of patent applications takes a considerably longer period of time than in B-W. For an invention patent, the processing time can take from three to five years in SIP, compared to less than one year in 85% of the cases in B-W. (Deutsches Patent- und Markenamt 2014) In entire China, the grant lag for invention patents was 4.71 years from 1990 until 2002 (Liegsalz, J., & Wagner, S. 2011). For utility model patents and registered designs, the differences are even more substantial: in Germany, applicants need to wait for several days after applying for a registered design or utility model. In SIP, this takes one year on average. (China IPR Helpdesk 2014) When querying patent statistics, it should be noted that patent applications are filed in the year of application, and patent grants in the year in which the grant is received. This should generally be taken into account when consulting patent statistics. Especially in the case of comparing B-W with SIP in China, where the differences are significant, the difference in patent grant lags between the two regions should be noted. (Fink & Maskus 2005) Liegsalz and Wagner found that companies with little experience in China in particular may benefit from support through patent offices with the filing of invention patents in order to reduce the grant lag (Liegsalz, J., & Wagner, S. 2011).

Table 8 Comparison of the aforementioned patent criteria in Germany and China. Utility model patents have less stringent patentability requirements than invention patents, which is depicted in the figure below. The first criterion applies to all types of patents and encloses the fulfillment of application requirements, which means that applications should comply with a certain form, language, and other criteria in order to be assessed by the responsible patent office. (DPMA 2014; Kraßer & Bernhardt 2009; China IPR Helpdesk; Embassy of the United States Beijing 2014; Sorell 2002; Schieber 2011)

		Filing forms fulfill requirements	Novelty	Inventive step	Industrial applicability	Practical applicability	Visual appearance	Role in purchasing decisions	No conflict to prior rights
Invention patent	DE	■	■	■	■				
	CN	■	■	■		■			
Utility model patent	DE	■	(■)	(■)	(■)				
	CN	■	(■)	(■)		(■)			
Registered design/design patent	DE	■					■	■	
	CN	■		■			■		■

Table 9 Detailed overview of patent criteria (Deutsches Patent- und Markenamt 2014; Kraßer & Bernhardt 2009; China IPR Helpdesk; Embassy of the United States Beijing 2014; Sorell 2002; Schieber 2011)

		Protection duration	Time to be granted	Criteria	Other characteristics
Invention patent	DE	20 years	Usually less than a year (in 85% of the cases)	Technical invention, form of appearance, novelty, inventive step, industrial applicability	Application fee €350 Additional annual fees due beginning from the third year
	CN	20 years	Three to five years	Novelty, level of inventiveness, practical applicability; granted for a new technical solution or improvement of a product/method	Application fee RMB950 Additional fees due annually
Utility model patent	DE	Ten years	Within a few days	Proven on substance, not on novelty, inventive step or industrial applicability	Application fee €40 Additional fees due after three, six and eight years; not for processes and biotechnological inventions
	CN	Ten years	One year	New practical solution rather than brand new; covering the shape or structure of a product; lower level of inventiveness than invention patent	Application fee RMB500 Additional fees due annually; not for chemical compounds, methods or processes
Registered design/ design patent	DE	25 years	Within a few days	Visual appearance (color and shape); role on purchasing decisions	Application fee €60 Additional fees due for the 6th, 11th, 16th and 21st year
	CN	Ten years	One year	Original, innovative design relating to shape, color, pattern or combination thereof; 'aesthetically pleasing' product and industrial applicability; no conflict of prior rights	Application fee RMB500 Additional fees due annually

The following figure draws a comparison between the patenting categories in B-W and SIP. In this context, it has to be emphasized that there are no trademarks included in patent statistics in the case of SIP, whereas trademarks represent a significant portion of patents in B-W. Moreover, there is no distinction between all patent types for SIP like for B-W due to a lack of available data.

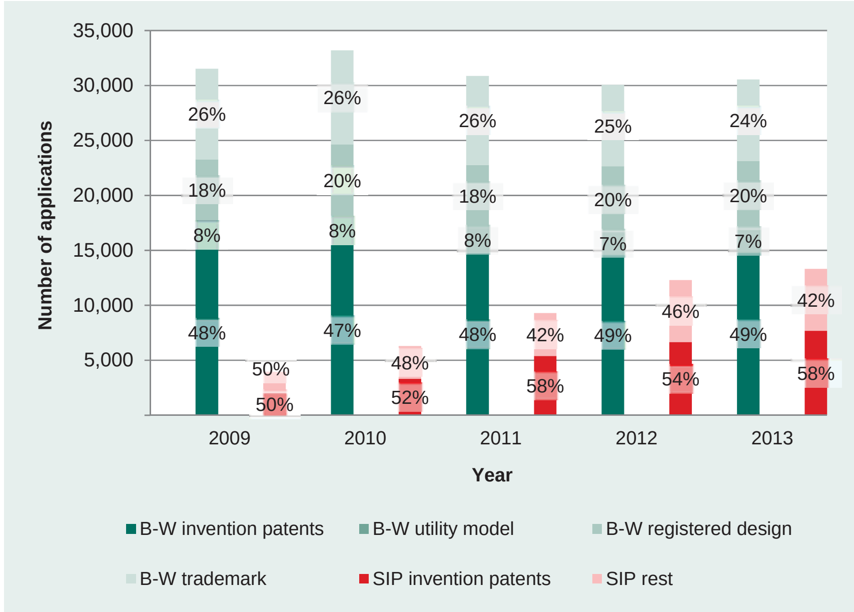


Figure 14 Comparison of the different patent types (invention patent, utility model, registered design, and trademark (B-W only)) from 2009 to 2013 in B-W and SIP. The percentage of invention patents compared to the total amount of patents is displayed for every year for both SIP and B-W. (SIPO 2015; Deutsches Patent- und Markenamt 2014)

In both countries, it is also possible to file an international patent through the PCT. PCT enables applicants to file a patent only once in order to receive patent protection for different countries simultaneously. The applicant can choose in which and how many of the 148 member countries the patent should be filed. The PCT procedure works as follows: firstly, a single filing of a patent application is submitted in one language, and hereby enters the PCT international database. It then stays in the international phase for approximately 30 months, which also provides the applicant with more time to decide upon the countries in which the patent should come into effect. During the international phase, an International Searching Authority (ISA) checks whether the application is patentable and if it fulfills the novelty criterion, based on previous literature and research on the subject. Moreover, the patent is checked on an inventive step and industrial applicability, comparably to the national requirements in both Germany and China. After a period of 18 months, the patent is published to the world and remains in the international database to be double-checked by a second searching authority. Finally, the application enters the national phase. As a consequence, the patent applicant needs to conquer less local procedures once it enters the national phase, since PCT applications already have to meet several requirements that generally reduce the hurdle to comply with national requirements. Also, the application needs to be filed only once at a participating PCT office in one language, whereas otherwise the applicant would need to file single applications at patent offices in every of the targeted countries. (WIPO 2014b) Worldwide, the number of PCT applications follows a growing trend. In 2012, more than half of all the applications that patent offices around the world received from non-residents were filed through PCT, up 7% from the previous year. (WIPO 2013)

Likewise, PCT applications are gaining in popularity in SIP and B-W. However, they are still not very common compared to the global average. Although the amount of PCT applications is increasing in SIP and B-W, it is still significantly lower than the number of national patents. Especially in SIP, the filing of PCT patents is still not very common. Here, only 114 PCT applications were submitted from 2003 until the end of 2011, implying that the local market is still the main battlefield for companies here. (Liu et al. 2012; Zhao Z. 2012) The numbers for B-W are much higher, at a cumulated amount of 2000 patents from 2000 until 2010, but also still significantly lower than the number of national patents. (Liu et al. 2012; Frietsch, Neuhäusler & Rothengatter 2013) To draw a comparison, almost 200,000 PCT applications were filed worldwide in 2012 (WIPO 2013). PCT applications are more expensive than national applications. Similarly to EPO applications, a possible explanation may be that PCT applications are merely filed for patents with higher expected pay-offs. (Dornbusch et al. 2013) Therefore, only PCT applications that have entered the national phase in China or Germany will be taken into account for this study, since they are included in the national level data upon entering the national phase. Outbound PCT applications filed at the respective offices will not be considered and are not part of the gathered data. Instead, the focus will be on invention patents to compare the regions' levels of innovation and put industrial synergies into relation.

Invention patents are a measure of a region's innovativeness, and reflect research intensity by both public institutions and companies. They offer an insight into R&D numbers that registered designs and utility model patents provide to a lesser extent due to the lower level of innovation compared to invention patents.

Also, since most companies do not publish R&D numbers, invention patents provide a good insight into information that is not revealed to the public by companies. (Frietsch, Neuhäusler & Rothengatter 2013)

Comparison to national average

With 138 patent applications per 100,000 inhabitants, B-W was well above the German average of 59 applications per 100,000 inhabitants in 2013. 14,829 invention patent applications were filed by organizations from B-W in 2013, which implies a proportional share of 23.5% in all German invention patent applications. The number of invention patent applications from B-W increased by 2.3% compared to the previous year. (Deutsches Patent- und Markenamt 2014)

The concentration of patent applications in SIP is high compared to the rest of the country: in SIP, 640 invention patent applications were filed per 100,000 inhabitants, compared to 61 per 100,000 in the rest of China in 2013. (SIPO 2015; China IP News 2014) The number of invention patent applications has increased impressively since 1999 (Liu et al. 2012). This can be attributed to various reasons, such as the pro-patent changes in the legal environment, especially an amendment to the patent law in 2001. These introduced changes following international standards in preparation of China's entry to the WTO in 2001. (Guangzhou Hu & Jefferson 2009; Liegsalz, J., & Wagner, S. 2011)

Amount of invention patent applications

From 2009 until 2013, the share of invention patent applications compared to all applications (including invention patents, utility models, designs and trademarks) was very stable and varied from 47 to 49% (see Figure 14). In 2013, invention patent applications contributed to 48% of the total amount of applications. (Deutsches Patent- und Markenamt 2014)

From 2009 until 2013, the amount of invention patent application compared to the total (invention patents, utility models, and registered designs) varied from 50 to 60% (see Figure 14). In 2013, the share of invention patent applications amounted to 58%. (SIPO 2015)

Amount of invention patent grants

From 2009 until 2013, the B-W invention patent grant rates varied from 10 to 13%, leading to an average grant rate of 12% (see Figure 15). (Deutsches Patent- und Markenamt 2014)

The invention patent grant rate varied from 9% to a maximum of 16% in from 2009 until 2013 with an average grant rate of 13% (see Figure 15). (SIPO 2015)

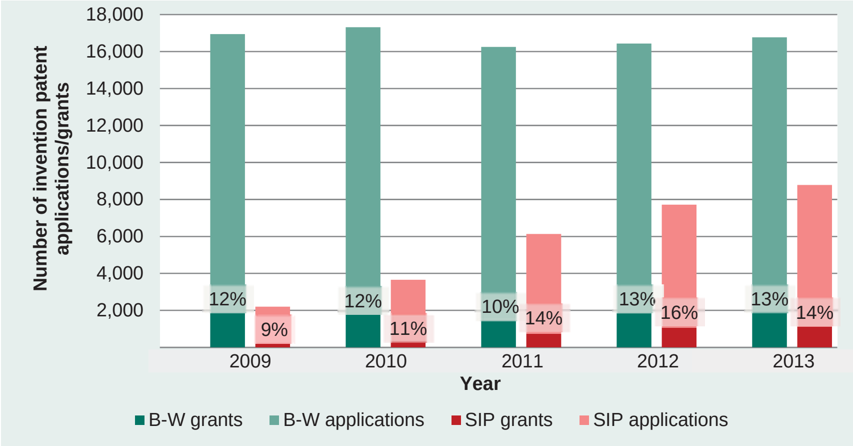


Figure 15 Trends in the number of patent applications in B-W and SIP. The patent acceptance rates in B-W and SIP are comparable, although SIP rates deviate more strongly. The displayed percentages are the annual grant rates for B-W and SIP (DPMA 2014; SIPO 2015)

In B-W, the share of invention patents granted is lower than in the rest of Germany, with 12% granted on average in B-W from 2009 until 2013. 13% of invention patent applications were granted in B-W in 2013, compared to 22% in entire Germany (see Figure 16) (Deutsches Patent- und Markenamt 2014).

In SIP, average patent grant rates are also lower than in the rest of the country. From 2009 until 2013, the average grant rate in SIP was at 13% on average. In 2013, 14% of invention patent applications were granted in SIP, compared to 25% in the rest of the country (see Figure 17) (SIPO 2015).

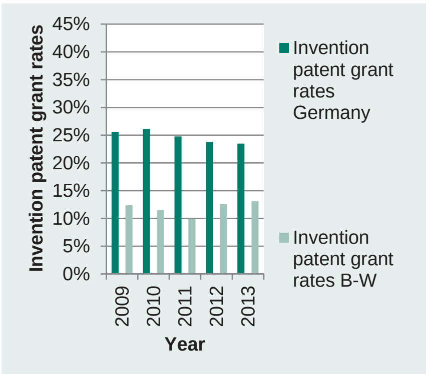


Figure 16 Invention patent grant rates in Germany and B-W (Deutsches Patent- und Markenamt 2014)

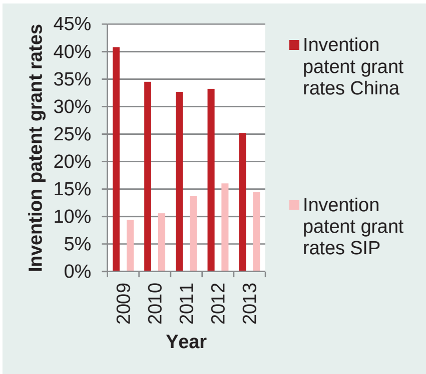


Figure 17 Invention patent grant rates in China and SIP (SIPO 2015)

In B-W and in SIP, patent grant rates are lower than in the rest of the country. Various reasons for low invention patent grant rates may exist. In this section, the most common theories are listed and summarized. In 1990, Griliches addressed the variability of invention patent acceptance rates among Germany, France, UK and USA, and found that this was due to differences in the average granted patent's quality. He also found that this difference in quality is mainly due to differences in national procedures and resources. (Griliches 1990) Firstly, low grant rates may refer to lower quality of patent applications, or may imply that a patent shows too many similarities to prior inventions. Especially in high-technology fields with large numbers of innovations, other companies may file patents on the same matter, particularly if innovative solutions are of strategic advantage for many companies operating in the same field. Many product designing and developing companies worldwide also feel that the quality of invention patents is decreasing at the expense of increased patent quantity, which leads to a decreased inventive step and thus causes lesser quality. (Philipp 2006) Secondly, it could also mean that quality is being assessed more critically, and therefore the quality of accepted patents is higher (China IP News 2014). Finally, withdrawing patents also leads to lower grant rates. Some applicants only need the patent for a very short period of time, for instance to block competitors. After that, they may drop the application or are not willing to pay the fees. (Liegsalz, J., & Wagner, S. 2011; Guangzhou Hu & Jefferson 2009) The latter reason is in accordance with DPMA statements, which confirm that a significant amount of invention patent applicants withdrew or failed to pay. Also, some applications were rejected on grounds of lack of technical novelty during and after the application procedure. (Deutsches Patent- und Markenamt 2014)

Worldwide, the invention patent grant rates have been following an increasing trend. In general, the number of invention patents accepted globally shows higher rates than both Germany and China. In 2006, 41% of invention patent applications were granted, including both national level as well as PCT patents. (WIPO 2008)

Patent analysis by patent categories

The International Patent Classification (IPC) operates a hierarchical top-down patent classification system consisting of categories and related sub-categories that are marked by patent codes. The code exists of several building blocks, which describe the exact field to which a patent belongs. First of all, a section symbol is used to determine the eight main sections: **A** Human Necessities; **B** Performing Operations, Transporting; **C** Chemistry, Metallurgy; **D** Textiles, Paper; **E** Fixed Constructions; **F** Mechanical Engineering, Lighting, Heating, Weapons; **G** Physics; **H** Electricity. Subsequently, a two digit code provides information about the class symbol, followed by a final letter for the subclass. The class symbol thus is the second hierarchical level of the system. The subclass subsequently provides further details as precisely as possible. Following the final letters, the patent subclasses can be further divided into groups. The group level is the lowest level, and can finally be divided into main groups and subgroups. Thus, with sections, classes, subclasses, main groups and subgroups, five levels exist. (Griliches 1990; Thomson Reuters 2014) In the example below, the structure of the patent system is portrayed. In the example below, the selected main section is H: electricity. The selected class is 01, leading to H01: basic electric elements. Subsequently, the selected subclass L completes the classification. H01L stands for semiconductor devices. (WIPO 2014a) For this study, a comparison between classes and subclasses will be drawn, due to the different levels of granularity of the available data for both countries. Therefore, the example below only shows the classification for the first three levels (main sections, classes, subclasses).

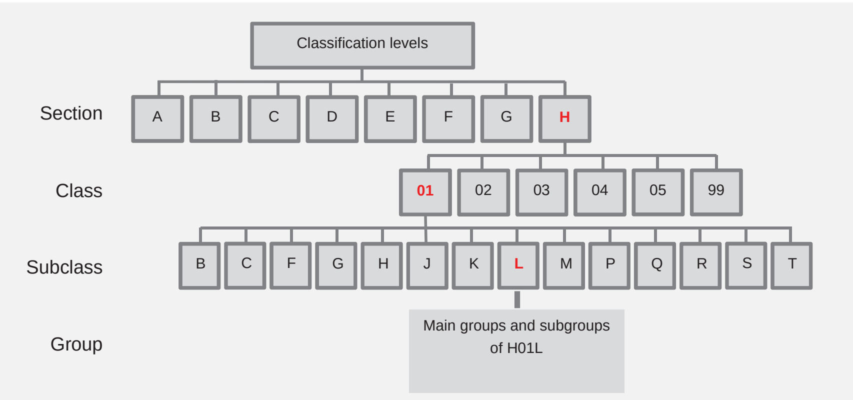


Figure 18 Example of the patent classification system with main sections, classes, subclasses, and groups (WIPO 2014a)

In B-W, the field with the most patent applicants from 2003 to 2013 was B60: vehicles in general, reporting a total of 5,000 applications. It is followed by F16 (engineering elements or units) with almost 4,000 applications, and G01 (measuring and testing) with almost 3,000 (see Figure 19). With more than 2,000 applications, H01 (basic electric elements) also plays a significant role in B-W. (Deutsches Patent- und Markenamt 2014)

From 1999 until 2011, the most patent applications in SIP stemmed from the fields G01N (investigating or analyzing materials by determining their chemical or physical properties) and C12Q (measuring or testing processes involving enzymes or micro-organisms; compositions or papers therefor; processes of preparing such compositions; condition-responsive control in micro-biological or enzymological processes). Both reported more than 1,000 patent applications until 2011 (see Figure 19). H01L (semiconductor devices) ranks third, with almost 400 applications. (Liu et al. 2012)

In B-W, most patent applications are from vehicle engineering, as well as measuring, testing, and basic electric elements. In SIP, patent applications mainly stem from the fields of materials investigation, measuring and testing, and semiconductor devices. As can be seen from Figure 19, the main synergies in patent categories occur in the patent areas G01, H01, and H04. These are measuring and testing (G01), basic electric elements (H01), and electric communication techniques (H04). However, some differences in scale can be observed: whereas in B-W the largest category B60 reported almost 5,000 applications, the largest category in SIP was G01N with 1,200 applications. It should be noted that the difference in magnitude is partly due to the different levels of granularity of the information available, showing more detailed categories for SIP. Moreover, the time frames are slightly different.

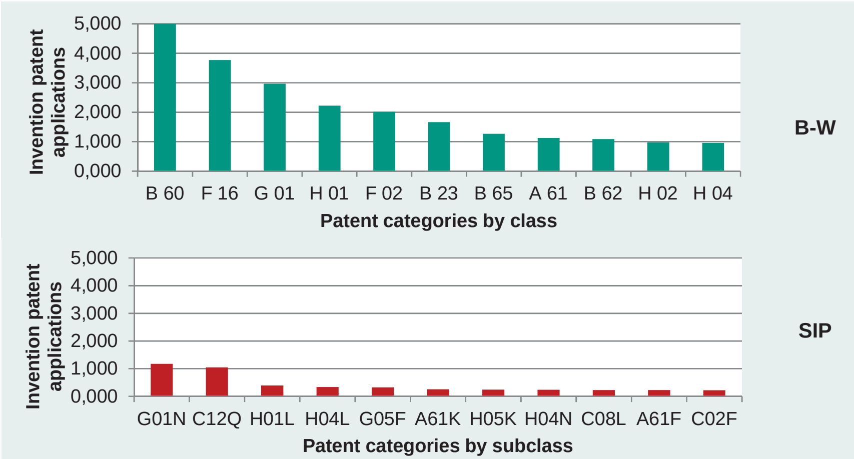


Figure 19 Invention patent applications by class in B-W from 2003 to 2013 (top), by subclass in SIP from 1999 to 2011 (below) (Deutsches Patent- und Markenamt 2014; Liu et al. 2012)

Table 10 The following table provides a detailed description of the most important categories of filed invention patent applications in B-W and SIP (Deutsches Patent- und Markenamt 2014)

	Most important categories B-W		Most important categories SIP	
1	B60	Vehicles in general	G01N	Investigating or analyzing materials by determining their chemical or physical properties (measuring or testing processes other than immunoassay, involving enzymes or micro-organisms C12M, C12Q)
2	F16	Engineering elements or units; general measures for producing and maintaining effective functioning of machines or installations; thermal insulation in general	C12Q	Measuring or testing processes involving enzymes or micro-organisms (immunoassay G01N 33/53); compositions or test papers therefor; processes of preparing such compositions; condition-responsive control in microbiological or enzymological processes
3	G01	Measuring and testing	H01L	Semiconductor devices; electric solid state devices not otherwise provided for
4	H01	Basic electric elements	H04L	Transmission of digital information, e.g. telegraphic communication
5	F02	Combustion engines; hot-gas or combustion-product engine plants	G05F	Systems for regulating electric or magnetic variables
6	B23	Machine tools; metal-working not otherwise provided for	A61K	Preparations for medical, dental, or toilet purposes

	Most important categories B-W		Most important categories SIP	
7	B65	Conveying; packing; storing; handling thin or filamentary material	H05K	Printed circuits; casings or constructional details of electric apparatus; manufacture of assemblages of electrical components
8	A61	Medical or veterinary science; hygiene	H04N	Pictorial communication, e.g. television
9	B62	Land vehicles for travelling otherwise than on rails	C08L	Cements; concrete; artificial stones; ceramics; refractories
10	H02	Generation, conversion, or distribution of electric power	A61F	Filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. stents; orthopaedic, nursing or contraceptive devices; fomentation; treatment or protection of eyes or ears; bandages, dressings, or absorbent pads; first-aid kits
11	H04	Electric communication technique	C02F	Treatment of water, waste water, sewage, or sludge

In B-W, most invention patents from 2003 until 2012 were applied for by large companies, such as Robert Bosch GmbH and Daimler AG. Large companies, such as Bosch and Daimler file significantly more patents than SMEs in B-W (see Figure 20). A study by Blind et. al. (2006) has shown that large enterprises rank the importance of patents as a protection strategy higher than SMEs. Also, blocking competitors as an incentive is more important for the larger companies. Patenting due to strategic motives especially increases with company size and R&D intensity. Moreover, many SMEs lack the funds and capacity to invest into patents as much as large companies do, due to the high costs that generally come with patent applications. (Blind et al. 2006) A study by the Fraunhofer ISI in 2011 also found that especially SMEs may need support for the filing of patents. (Stahlecker et al. 2012)

The vast share of applications is filed by the commercial sector, with universities only filing 0.5% of all patent applications (Deutsches Patent- und Markenamt 2014). In Europe, too, university patenting is not that common, contrarily to China, where university patenting supports the industry sector. In the past, various measures were introduced to trigger university patenting. Several studies have shown that the effect on university patenting by these policies was modest, or even triggered an increase in quantity paired with a decrease in quality. (Henderson et. al. 1998; Mowery, D., & Ziedonis, A. 2002; Sampat et. al. 2003)

In SIP, the company that filed the most patents from 1999 to 2011 was Suzhou Ang Biotech Co. Ltd. It was followed by Suzhou University (Suzhou University), Suzhou Positec Powertools Co. Ltd., and Avision Precision Industry Co. Ltd. (see Figure 21). A main difference between B-W and SIP is the fact that university patenting plays a more important role in SIP. In SIP, Suzhou University alone filed around 10% of patent applications from 1999 to 2011. (Liu et al. 2012) The main reason for the strong presence of Suzhou University among the top applicants and recipients are the numerous government subsidies for universities. The government has foreseen a role for universities and research institutes to serve the industry, requiring them to solve practical problems for the industry. (Hong 2008)

There are mainly two kinds of subsidies. Firstly, there are incentives that reward excellent achievements in academic research and are merit-based. Secondly, financial stimuli that pay the costs of patent applications for university researchers exist. However, these financial incentives have limitations: research has shown that subsidy programs to promote research excellence are more effective to enhance patent quality than those decreasing the cost of patent applications. The latter ones trigger patent quantity rather than quality. (Fisch, Block & Sandner 2013)

A 2013 study by the Fraunhofer Institute has shown the correlation between universities' knowledge profile and the local economic profile of the region. If the technical knowledge of universities and industry matches with regards to the specialization of companies and company clusters, the local economy profits from this. Particularly SMEs profit from this knowledge exchange. A correlation can be observed: the gains for SMEs are higher when there is an accurate technology fit with surrounding universities. The proximity to universities does not necessarily need to be geographical, but is beneficial. If sufficient communication structures are present, SMEs may also benefit from networks with universities that are located further away. Large firms tend to act rather independently of the knowledge fit with universities, contrarily to SMEs. Regarding the large amount of SMEs in B-W, this is a crucial point to further support the innovativeness of these SMEs. (Dornbusch & Brenner 2013)

Another European trend has been characterized by the fact that R&D processes have become more efficient and are increasingly adapting new technologies. This can be observed from the fact that private R&D expenditures have not grown as fast as the amount of patents, indicating a higher efficiency ratio. (Blind et. al. 2005; Janz et. al. 2001)

The two different subsidy types were not implemented in every region in China at the same time and to the same extent. Jiangsu was one of the first provinces to start with the cost reimbursement subsidy in 2000, one year after its first implementation in Shanghai. (Li 2012) Suzhou University for instance pays application and maintenance fees that are required to file and update the patent until three years after the patent authorization. If the patent is not authorized, the university will stop paying. (Suzhou University 2010) Whereas these types of subsidies are mostly implemented on a regional level, the government also implemented a central program to monitor quality and to enhance Chinese universities to become excellent universities: the 863-plan or State High-Tech Development Plan. The plan is meant to contribute to China's importance as an important research nation. (Zhang et. al. 2013) Moreover, the Chinese government has stated that its goal is to quadruple the national amount of patent applications until 2020 (State Intellectual Property Office 2011).

Also compared to other East Asian markets, universities play a more important role in China than for instance in Taiwan or Korea. The industry cooperates closely with universities and public research institutions – a mechanism which is actively endorsed by the Chinese government. (Hong 2008) Small companies on the other hand tend to apply for utility model patents that require a lower level of innovation and research. They are more likely to focus on short-term R&D projects. (Cheung & Lin 2004) Utility model patents can be important to focus on future invention patent applications. (Kim et al. 2012)

Once firms reach higher levels of technological capabilities, they will tend more towards invention patents. (Li 2009; Hong 2008; Huang, C., & Wu, Y. 2012; Hu, M., & Mathews, J. 2008; Kim et al. 2012)

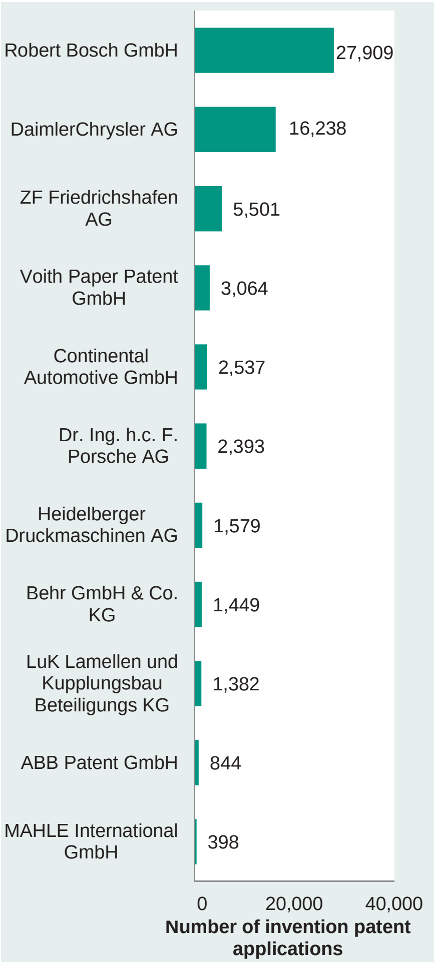


Figure 20 Overview of invention patent applications by major applicants in B-W from 2003 to 2012 (Deutsches Patent- und Markenamt 2014)

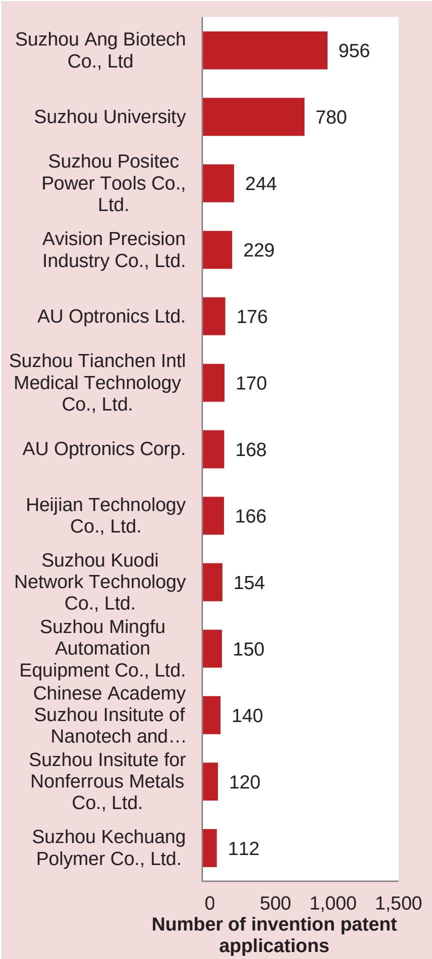


Figure 21 Overview of invention patent applications by major applicants in SIP from 1999 to 2011 (Liu et al. 2012)

Online survey results

Introduction

The allocation and relocation of production activities in the fast-growing emerging countries in Asia has become more and more important in recent years for firms of all sizes. Due to the limited economic growth in Europe in the current crisis, many managers dedicate their attention to the growth potential in BRIC countries even more than before (Gunasekaran and Ngai, 2012). In particular China has an outstanding position, as it has developed to the world´s second largest economy, leading export nation, and largest recipient of foreign direct investment during the last decade (UNCTAD, 2015).

Different frameworks try to explain why firms produce internationally (e.g. Buckley and Casson, 1976; Dunning, 1980, 1988). In the past, the China strategy of many manufacturing companies focused on the quest for cost reduction possibilities in addition to the tapping of market potential (Kinkel and Maloca, 2010; Nassimbeni and Sartor, 2007). Nowadays, German companies in China are not only interested in (1) the size of the market and its dynamic growth in many of their core industries, (2) local labour cost advantages, but recently also in (3) local knowledge augmentation potentials and highly qualified personnel (Lewin et al., 2009), as China has developed into one of the most important R&D locations worldwide (Frietsch and Schueller, 2010). Consequently, China has developed into the most attractive (re-)location destination of German companies (Kinkel, 2012; Kinkel and Maloca, 2009). It is remarkable that China has not only become an attractive destination for large companies, but equally for small and medium-sized companies (SME) (Kinkel and Maloca, 2010).

Since China does not only provide new market opportunities, but also increased local competition, Western companies nowadays face the challenge of choosing appropriate competitive and collaboration strategies (Gunasekaran and Ngai, 2012; Kinkel et al. 2014). Robb and Xie (2001) found that local Chinese manufacturing companies still appear to focus on quality, reliability and costs. In contrast, foreign companies have realized that a clear focus on customer value, delivery performance and reliability may yield some competitive advantage. Consequently, German companies need to improve the competences of their local factories from pure offshore production and market serving modes towards more customer value and innovation-oriented strategies (Ferdows, 1997).

Thus, an online-survey was conducted among industrial companies with locations in B-W and Suzhou. In the following not only companies located in SIP, but in the Suzhou region were taken into account. The following lead questions on operation and collaboration strategies were posed and broken down into operative parts:

1. What competitive, collaboration, technology and innovation strategies are leading industrial companies performing in B-W and Suzhou?
2. What are the main areas for future collaboration between industrial companies from B-W and Suzhou, and in which areas is competition still the driving force?
3. What general company characteristics are important prerequisites for successful production and R&D activities of industrial companies from B-W in China?

Data and methodology

To investigate the operation and collaboration strategies of industrial companies in B-W, an online questionnaire in German language was developed and implemented from July to September 2014. Overall, 273 manufacturing companies from B-W were participating in the survey. The individual questions in the online-survey were answered by 68 to 201 companies, depending on the content and complexity of the question and its order in the online-survey.

In parallel, the online questionnaire was translated into Chinese language and send out to a qualitative control sample of industrial companies with operations in the Suzhou Industrial Park (SIP) from August to December 2014. In this control survey, 70 industrial companies with operations in the SIP where participating. The individual questions in the online-survey were answered by 11 to 36 companies, again depending on the content and complexity of the question and its order in the online-survey.

In the qualitative control sample of companies operating in Suzhou, more than 60% belong to the group of small and medium-sized enterprises (SME) and only around 10% to the group of large companies with 10,000 and more employees. The largest sector represented is mechanical engineering with more than 40% of the participating companies, followed by the automotive industry with around 20% and electrical engineering with around 15%. Overall, compared to the industry structure of the Suzhou Industrial Park (SIP) as presented in Chapter 2, the Suzhou control sample is skewed towards SMEs and mechanical engineering companies, whereas electronics manufacturing is underrepresented. But again, the survey approach was not designed to obtain a representative quantitative sample of Suzhou companies.

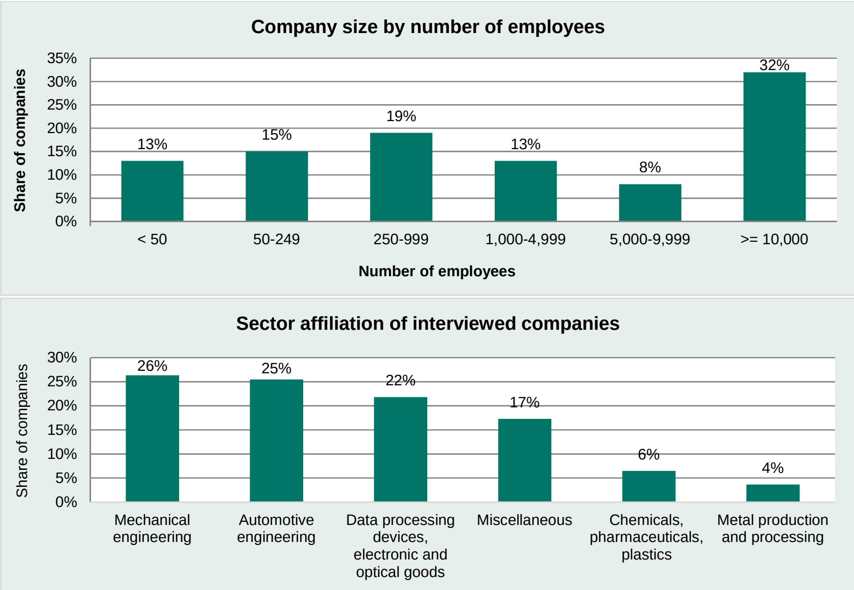


Figure 22 Size and sector distribution of the participating companies from B-W (N=108; N=110)

On average, the surveyed industrial companies from B-W have 1275 employees. One quarter of the companies have 200 employees or less, one quarter 14,500 or more. Most of the participating companies belong to the largest group of 10,000 and more employees (32%), whereas less than 30% are small and medium-sized enterprises (SME) with less than 250 employees. Thus, the participating firms represent a selected sample of rather large industrial companies from B-W.

The sample also covers in particular leading companies with a high level of innovativeness, mainly from the lead sectors in B-W, the automotive industry, mechanical and electrical engineering.

Of the surveyed companies, one quarter belongs to the field of mechanical engineering, and one quarter to the field of automotive engineering. The third largest sector is the field of data processing devices, electronic and optical goods with more than 20%. Two other important industry fields that are represented in the interview results are chemicals, plastics and pharmaceuticals, as well as the metal production and processing sector, both with approximately 5%. Compared to the industry structure of B-W as presented in Chapter 2, electrical engineering companies and automotive industry are overrepresented in our sample, whereas metal production is underrepresented. But given the limited approach that was not designed for representativeness, the sample provides a nice snapshot of the industry structure in B-W.

Production facility

Business model

The surveyed companies from B-W generated a yearly turnover of €180m or more, ranging from €40,000 to €120bn. A quarter obtained a turnover of less than €26.5m, a quarter generated €2.4bn or more.

With this turnover performance, half of the surveyed firms were able to create a value added of €100,000 or more per employee. A quarter reported a value creation of less than €75,000 per employee; a quarter reported €146,000 or more. When analyzing companies with manufacturing locations abroad, it is striking that companies with manufacturing locations in China were able to achieve on average a significantly higher (sig. = 0.021) value added per employee of €122,000 per employee compared to €103,000 without manufacturing operations in China.

In contrast, the companies of the qualitative control sample in Suzhou show a significantly lower depth of value added of 40%, meaning that they source 60% of their turnover as inputs from suppliers and service providers. This indicates that the companies in Suzhou seem to prefer or are forced to operate with a lower vertical integration level of value-added activities than their counterparts in B-W. From this it can also be concluded that the development of sustainable networks of suppliers and local sourcing options in Suzhou poses a strategic challenge for companies trying to operate there successfully.

This can be interpreted in a way that successful manufacturing operations in China might be able to help industrial companies to realize additional productivity gains in terms of value added per employee.

The surveyed companies from B-W procured intermediate inputs ranging from 3% to 80% of their turnover. Half of them spent less than 35% of their annual turnover for inputs. The 35% input ratio at turnover corresponds to a 65% depth of value added of the companies from B-W, meaning that they on average integrated almost two thirds of value-adding operations internally. For a quarter, less than 20% of their annual turnover was spent for inputs, for a quarter it was more than 50%.

Competitive factors

In this section, firms were asked to rate the importance of several competitive factors for the success of their business, using a closed-ended question from ‘not important at all’ to ‘very important’.

Among the surveyed enterprises from B-W, quality was generally seen as the most important competitive factor (78% of companies rank it very important), followed by innovative products with 61%. The price of the product was stated to be the least important competitive factor, with only 24% of the B-W companies ranking it as very important. This shows clearly that, as one could have expected, qualitative differentiation strategies seem to be much more important for the economic success of industrial companies from the high-wage, but also high-performance location B-W, than strategies focusing on a price or cost leadership.

For the companies of the qualitative control sample in Suzhou, quality (83% rank it very important) and innovative products (63% very important) are equally important as competitive factors as for the companies operating in B-W, whereas the price as competitive factor (40% very important) plays a significantly more important role for operations in Suzhou. This shows that a qualitative differentiation to competitors is also a main success factor for business operations in Suzhou, but the more important role of the price as accompanying selling point cannot be neglected.

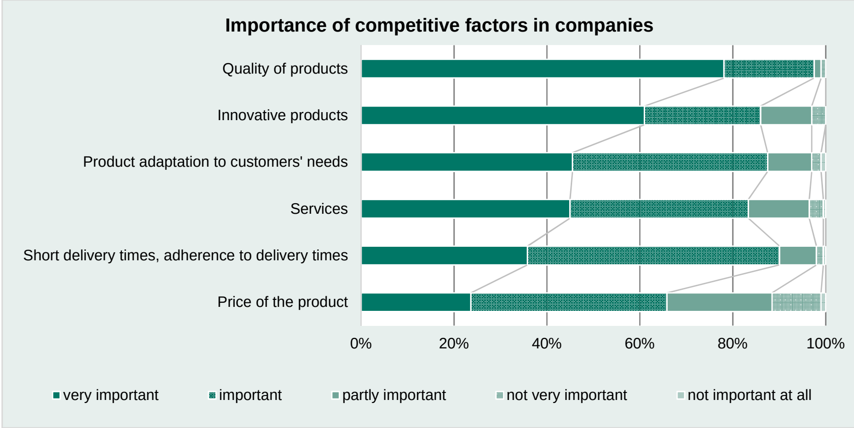


Figure 23 Ranking of primary competitive factors of the participating companies from B-W (N=198)

Implemented technologies

In order to find out which innovative technologies are the most used and economically most important among the surveyed companies, several dichotomous questions were posed to find out which technologies have been implemented in first place. Subsequently, survey participants were asked to estimate the percentage share of the use of the respective technologies at their total production capacity to be able to assess the internal utilization intensity of these technologies in the surveyed companies.

Among the top technologies that are being applied most frequently are energy efficient technologies and integrated IT systems for production planning and simulation, both being used in 56% of the surveyed companies from B-W. Material efficiency technologies also achieve a high user rate at 53%. Quite amazing 37% of the surveyed companies use production technologies for e-mobility, and equally astonishing 35% already make use of additive manufacturing technologies, e.g. 3D printers, in their manufacturing processes.

The most significant differences in the use of modern production technologies by companies operating in Suzhou, compared to those operating in B-W, can be observed in the user rates of production technologies for e-mobility (16%) and energy efficient technologies (36%), which are both used to considerably lower degree than in the B-W industry. All other of the surveyed technologies are used to a similar extent in the companies operating in Suzhou. This might be interpreted as slight evidence that sustainable and economically friendly production processes are so far not the main focus of production modernization in the Suzhou location. However, this hypothesis needs further evidence to be verified.

Also 35% of the surveyed companies use cooperative robots or other technologies to support human-machine interaction, and 31% use innovative procedures for processing new materials, e.g. composites or renewable resources. Overall, new production technologies are diffused to a really considerable extent, which can be interpreted as evidence of a strong focus on continuous production modernization in the surveyed industrial companies from B-W.

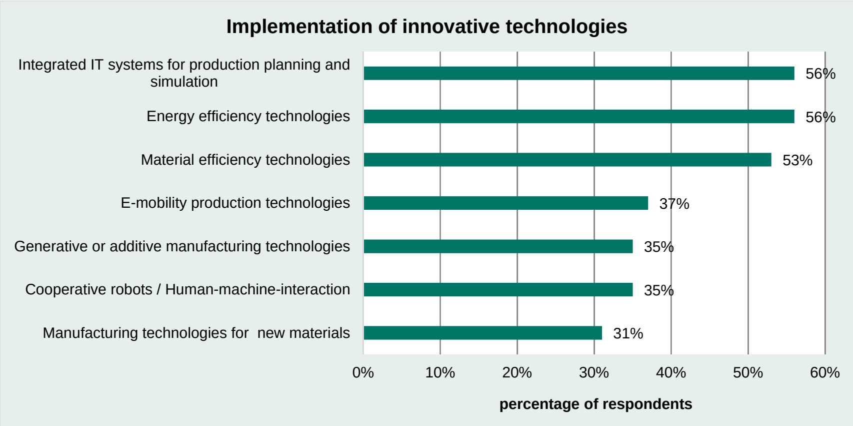


Figure 24 Share of companies from B-W using selected innovative production technologies (N=177)

The top 3 innovative technologies are also those that are used most intensively in the surveyed companies from B-W and are implemented in the largest share of their production activities, compared to other of the selected technologies. Integrated IT systems are the leading technology in terms of internal use intensity once more, being installed in 48% of the production activities in those companies in which they have been implemented.

Material and energy efficiency technologies continue the list, with 39% and 36% internal utilization intensity, respectively. In contrast, the intensity of internal use of generative manufacturing technologies and e-mobility manufacturing technologies is clearly lower, at 19% and 16%.

However, these internal utilization intensities are again surprisingly high, considering that the latter two technologies are largely discussed as niche technologies, being so far predominantly used in pilot production areas of pioneering companies.

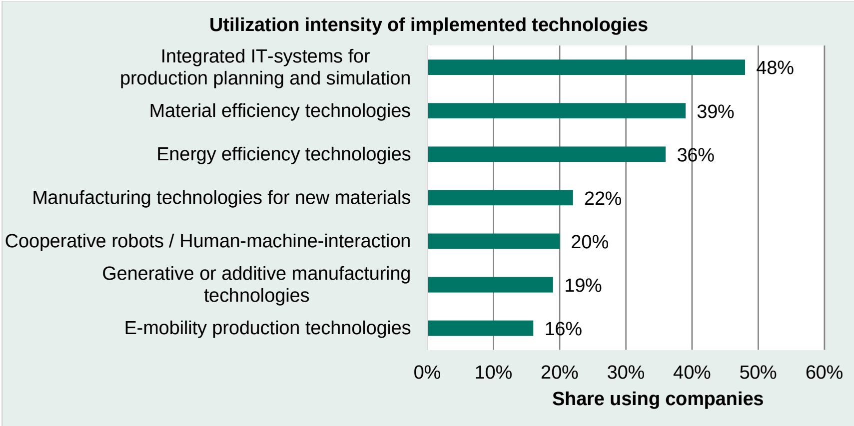


Figure 25 Internal utilization intensities of innovative production technologies in the participating companies from B-W (N = 53)

R&D activity and product innovations

In this section, the companies' tendency towards innovation and new product development was examined, combined with an inquiry about the R&D activity of the firms. Respondents were asked whether they developed new products within the last three years; and if yes, in which fields. They were also asked whether the company was the first entrant for a new product, and whether it performs R&D. These questions were followed up by percentage share estimations to find out about the new products' contribution to the firm's total turnover, and about the amount spent on R&D by the respective firms. By posing these questions, a distinction between market innovators and product innovators comes forward.

Product innovators are those, who develop new products, but are not the first to enter the world market with this product; whereas market innovators develop products that are not only new for themselves but for the world market.

A very high share of 90% of the surveyed companies from B-W conducts R&D activities, with average R&D expenditures accounting for 13% of total sales. The sample of firms surveyed thus includes mostly pioneering companies with a high level of innovation. Remarkably, larger firms in the B-W sample tend to have a lesser R&D intensity than smaller companies. Stating this we need to have in mind that the sample of the participating companies consists mostly of rather large firms, denying the verification of a potential positive SME effect. Of the surveyed companies from B-W, 85% stated to have developed new products within the last three years, which were new for their firm and/or implied significant improvements compared to older versions. The average contribution to turnover of these new products amounts to 23%. The majority of product innovators stem from the field of e-mobility with 42%, followed by 37% product innovators in environmental technologies and 36% in energy technologies. New materials follow close behind at 33%, whereas biotechnology and nanotechnology follow at a significant distance (only 10% and 8%, respectively). 73% of the firms answered that they are market innovators, with an average contribution of these innovations of 15% to the total turnover. As expected, the propensity of a company to be a product or market innovator is positively correlated with its R&D intensity, measured as the share of R&D expenditures at total turnover.

Considering the high innovation level of the surveyed companies from B-W, it is noteworthy that the average level of innovation of the qualitative control sample of companies operating in Suzhou is not inferior to this high level in any way. Almost 80% of the surveyed companies in Suzhou are performing R&D activities, with an average R&D intensity of 13% of total turnover. 77% are product innovators, realizing 19% of their total turnover with sales from new products that are not older than three years. 67% of the surveyed firms are market innovators with an average share of 15% of their turnover coming from sales with products new to the global market. However, the technological domains in which product innovations take place are different in companies from Suzhou compared to their counterparts from B-W.

Only 10% reported product innovations in the fields of e-mobility or energy technologies, and less than a quarter are active in environmental technologies. The level of product innovators in the field of new materials is similar to B-W (38%) and even higher in the field of nanotechnologies (14%). Again, as already seen in the use of new production technologies for process innovations, there does not seem to be a main focus of innovations in the Suzhou region on sustainable and economically friendly solutions. However, the interpretations drawn from such an analysis should be treated cautiously, given the small number of companies in the qualitative control sample from Suzhou.

Overall, most of the reported product innovations originate from technology fields with a close relation to the core areas of the B-W industry, namely automotive technologies, mechanical and electrical engineering. Cross-sectional technologies like new materials also play an important role, whereas key enabling technologies with application fields that are limited to specific industries and niches, like bio- and nanotechnology, seem to be only relevant for companies that are active in these specific fields. It is also striking that companies which are active in these fields report a subpar R&D intensity, suggesting that the random sample of surveyed companies might not be well representative for these technology segments.

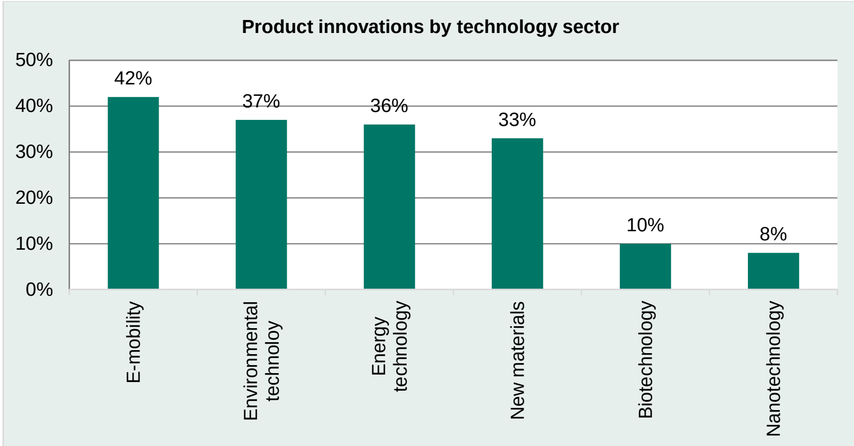


Figure 26 Main technological domains of product innovations of the participating companies from B-W (N = 121)

IPR protection

In this part of the survey, firms were asked on whether they implement IPR protection in the form of patents, followed by a question on the primary motives for patenting.

Of the surveyed companies from B-W, 83% have patent applications in Germany. 77% have European patents, 61% own PCT patents targeting the global market, and a noteworthy share of 47% of the companies owns one or more patents in China. This can be interpreted as a clear sign that the ability to develop and adapt products for the local market needs and to protect the underlying IPR seems to be quite important for being successful in the Chinese market and being able to safeguard the potential economic benefits from new products and solutions for their own ends. A tendency that can be seen is that large companies such as automotive companies register for patents in China and for PCT patents more often. Also, innovation leaders are more likely to apply for patents in China and for PCT patents.

The results of the qualitative control sample of companies operating in Suzhou sows opposing motives. Here, the blocking of competitors is stated by most companies (74%) as the main reason for patenting, whereas the securing of the companies' own ability to act is of prior importance to a significantly lower share of companies (16%). The generation of license revenues shows a similar value (11%) as in B-W. This shows the importance for companies operating in Suzhou of being able to bring innovations in the form of new or suitably adapted products or solutions to the local market and to block potential competitors to copy it and protect the relevant IPR for securing their ability to exploit their innovative knowledge. Innovation oriented competition and customer strategies seem to be already really important in Suzhou, as price and quality might be no sufficient singular selling arguments any more.

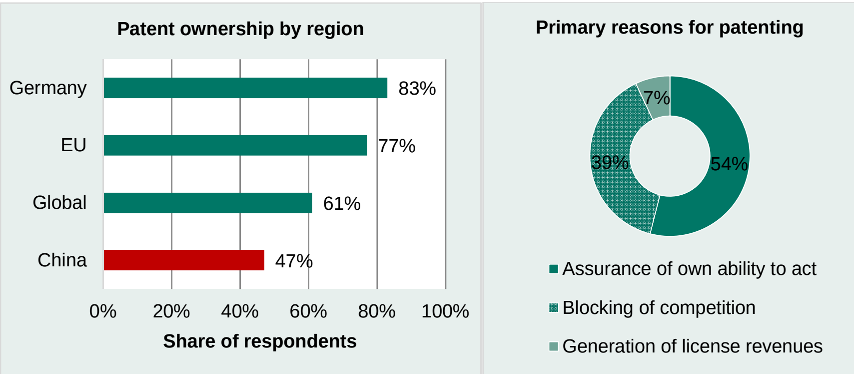


Figure 27 Patenting strategies of the participating companies from B-W (N = 141; N = 124)

The most important motive to patenting is the assurance of their own ability to act, stated by 54% of the surveyed companies from B-W. It is followed by the motive of blocking competitors in order to protect one's own products and services (39%). Few enterprises state that one reason for patenting is the generation of license revenues (7%). For small enterprises, this reason is more important than for large firms. It is less important for those that have global and/or Chinese patents. The main reason for patents, the assurance of own acting ability, is even more important for companies with Chinese patents.

Cooperation activities and future cooperation potential

Companies were first asked whether they have any of the following cooperation: R&D cooperation with research facilities or with other companies, manufacturing cooperation (for example in order to balance capacity), procurement cooperation (through joint purchases) or sales and services cooperation. Further, the surveyed companies could state in which regions they practice cooperation (B-W, Suzhou, rest of Germany, rest of China, and rest of the world). Subsequently, the respondents were asked to share their views on future potential cooperation fields for companies from B-W with companies from Suzhou.

82% of the surveyed companies from B-W practice R&D cooperation with research facilities. Overall, 73% partner with research facilities from B-W, 61% with the rest of Germany, whereas only 17% of these firms are collaborating with partners from China, and a mere 4% with partners from Suzhou.

The collaboration intensity in the qualitative control sample from Suzhou is significantly lower than in the B-W sample. Of the companies operating in Suzhou, 46% are performing R&D cooperation with research institutions, and 61% are active in R&D collaborations with other companies. These levels must not be regarded as weak, as B-W is a very strong and traditional industrial region with long-lasting collaborations and relationships in many different fields. However, despite the variety of activities to stimulate collaborative behavior in the Suzhou Industrial Park (SIP), the results show that there is still some potential for further intensification and improvement of collaboration in R&D activities.

This shows that companies from B-W are still reserved to operate collaborations in knowledge intensive fields like R&D with companies from China, as trust and the possibility to protect IPR are major prerequisites for joint activities in this field.

Noticeably, mechanical engineering companies are more likely to have R&D cooperation with research institutions from B-W. This might serve as evidence that research institutions in B-W are still deemed by industrial companies as the global benchmark in the field of mechanical engineering. Very large companies, with more than 10,000 employees, are more likely to pursue cooperation with research institutions from China. Also, automotive companies and R&D intensive firms establish the latter kind of relationships more frequently. This reflects the broader scope of R&D activities and higher amount of potential interfaces of larger and R&D intensive companies, as well as the need for closer interaction with local actors in the field of automotive engineering to be able to tailor the developed solutions as good as possible to local requirements.

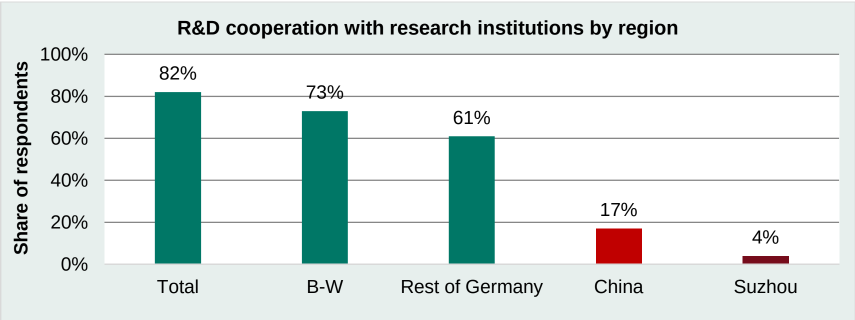


Figure 28 Regional patterns of R&D cooperation of the participating companies from B-W (N = 148)

Interfirm R&D cooperation is used on a similar level as R&D cooperation with research institutions, as 78% of the surveyed companies from B-W perform R&D relationships with other companies. Here, cooperation with partners from B-W (54%) are less frequent than in the field of cooperation with research institutions, whereas collaborations with partners from the rest of Germany (56%) are on a similar level. This reflects the need for searching excellent partners in a larger regional area, as not all desired capabilities of potential industrial partners might be found within the borders of B-W. The frequency of R&D cooperation with companies in Suzhou (5%) and China (19%) is slightly higher than in the field of collaborations with research institutions. Again, large companies and automotive companies are more likely to establish and maintain this type of relationship also with companies in China. Moreover, automotive companies also cooperate with companies in Suzhou more frequently than others when it comes to R&D. This mirrors again the broad scope of potential R&D interfaces of these companies, but also the nationally and regionally forced obligations to partner in this strategic industrial field with local companies from the respective area.

The numbers for the other types of cooperation in Suzhou and China are even lower: 5% of the companies perform sales and services collaborations in Suzhou (China: 16%), 4% maintain local production cooperation (China: 11%), and 3% are engaged in local procurement cooperation (China: 8%).

Overall, the companies from B-W still seem to be rather reluctant to horizontal collaborations with partners from Suzhou and the rest of China, particularly in the establishment of local procurement networks. In these areas, further potentials for the increase of local relationships and improvement of business activities might be unconsciously neglected.

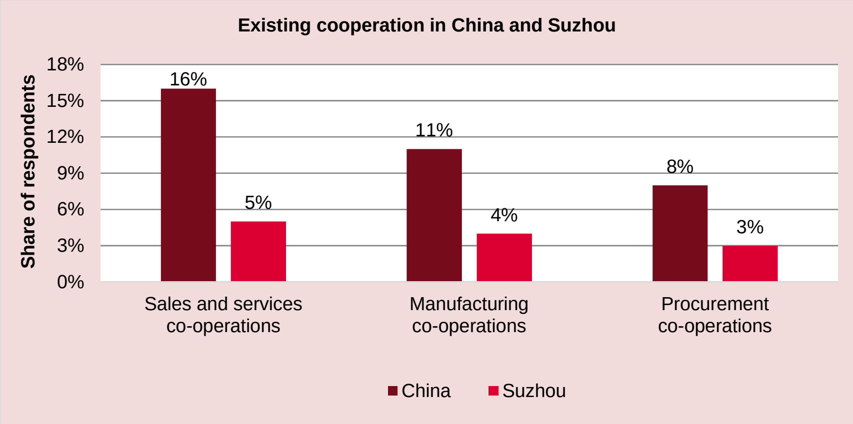


Figure 29 Further fields of cooperation of the participating companies from B-W in China and Suzhou (N=40, 54, 68)

Future cooperation potential

Subsequently, the respondents were asked to share their views on future potential cooperation fields for companies from B-W with companies from Suzhou.

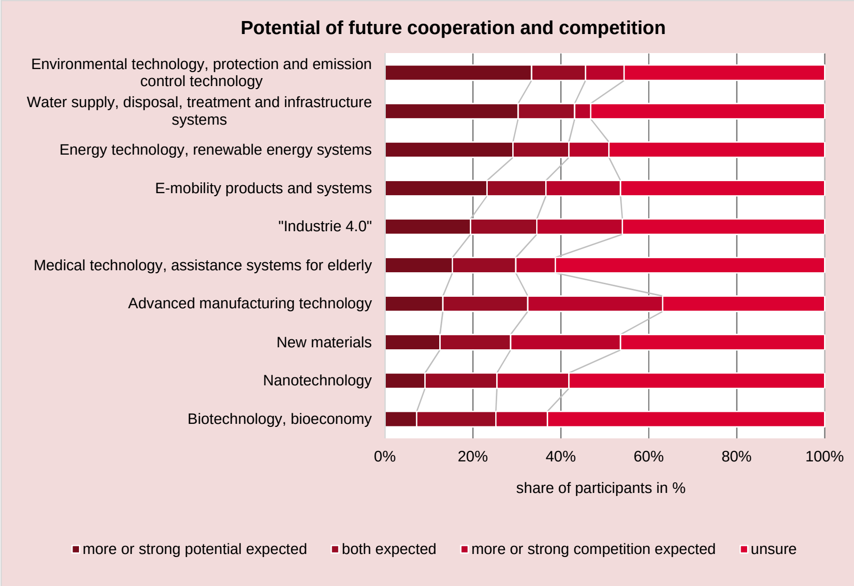


Figure 30 Technological fields with potential for future collaboration or competition between companies from B-W and Suzhou according to participating companies from B-W (N = 110)

When asked for the largest potential for future cooperation with companies from Suzhou, the surveyed companies from B-W were the most confident about environmental technology (33% of the respondents stating strong potential for collaboration or rather collaboration potentials than competition threats), water systems (30%), energy technologies (29%) and e-mobility (23%). The rest of the respondents were unsure, neutral, or negative about potential collaborations with partners from Suzhou in these technological fields.

In the qualitative control sample of companies operating in Suzhou, the tendency to collaboration activities instead of competitive behavior is noticeably higher in almost all of the surveyed technological fields. 55% of the surveyed companies from Suzhou see a strong potential for collaboration or rather collaboration potentials than competition threats in advanced manufacturing technologies, followed by energy technologies (50%), new materials (50%), e-mobility (48%), environmental technologies (43%), water systems (38%), and “Industrie 4.0” (36%).

Analogously, the field in which the strongest competition is expected are advanced manufacturing technologies (31% of the respondents stating strong competition or rather competition than collaboration activities), new materials (25%) and nanotechnology (16%). Again, the remaining respondents were unsure, neutral or felt the opposite way. A few technology fields are rather viewed in a neutral way, as neither processing relevant cooperation potentials nor posing a noticeable competition threat. These fields are “Industrie 4.0”, medical technology and assistance systems for the elderly, and biotechnology.

Overall, a pattern seems to emerge that the surveyed companies from B-W see the largest potential for future collaborations in technology fields related to crucial application areas, where China envisages huge technical and societal challenges in establishing sustainable solutions and infrastructural systems.

All other technology areas were also named by a quarter to a third of the responding companies as potential field for future collaborations (nanotechnology 32%, medical technology and assistance systems for elderly people 29%, biotechnology 24%), and thus significantly more frequently than as fields of strong potential competition. The surveyed companies from Suzhou particularly rated future collaboration potentials in advanced manufacturing technologies, new materials and e-mobility significantly more positive than their counterparts from B-W. In contrast to the latter ones, the surveyed companies from Suzhou seem to value the potentials of future collaborations not only in application areas with large challenges in China, and thus opportunities for huge market potentials, but also in cross-sectional technologies where they might hope to learn and benefit from close cooperation with companies from B-W.

Globalization of manufacturing and R&D activities and location factors in B-W

The last section can be divided into the following subclasses: global manufacturing and R&D activities of the surveyed companies, and location factors of B-W and Suzhou. Firstly, companies were asked whether they have set up a manufacturing or R&D location abroad. Then, the respondents could estimate the share of the manufacturing and/or R&D capacities at the various locations (Germany, rest of Europe, China, rest of Asia, North America, South America, rest of world). The views on location factors of B-W and Suzhou were surveyed.

Of the surveyed companies from B-W, 65% reported to have set up manufacturing locations abroad. Almost half of the surveyed companies are running manufacturing sites in China. Regarding the number of employees spread across those different manufacturing sites, on average 44% of the employees are reported to be located in Germany, followed by 16% in the rest of Europe, 12% in North America and 11% in China. The list is closed by the rest of Asia (5%), South America (4%) and the rest of the world (8%).

Large enterprises have production sites located in China significantly more frequently, as large companies are in general running more international operations than small and medium-sized enterprises. Also, mechanical engineering firms from the B-W sample tend to have production sites in China more often than others, as they want to be close to their local customers with their machinery and equipment. The fact that overall nearly half of the surveyed companies have production locations in China and already more than one tenth of the employees are engaged over there shows the outstanding importance of China as a lead market and strategic production base for many companies.

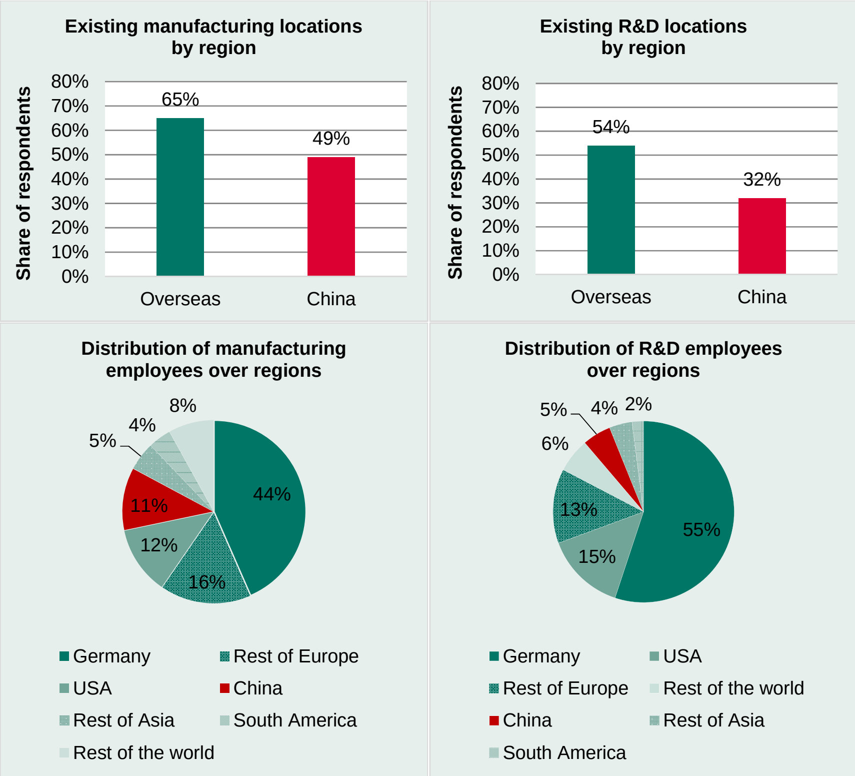


Figure 31 Global distribution of manufacturing and R&D employees of the surveyed companies from B-W (N = 129, 83, 124, 66)

Moreover, 54% of the surveyed companies from B-W have R&D locations in foreign countries. A tendency towards building up R&D locations in China can also be observed, given the fact that 32% of the respondents already practice R&D in China. Of the enterprises with R&D locations abroad, most R&D employees remain located in Europe and North America, with 55% in Germany, 15% in North America and 13% in the rest of Europe, amounting to a total share of 83% of all R&D employees in the western countries.

However, of the R&D employees in other countries, the majority is located in China (5%), followed by 4% in the rest of Asia, 2% in South America and 6% in the rest of the world. Similarly to the internationalization of manufacturing, large enterprises are significantly more likely to set up R&D activities in China. Also, research intensive companies relocate R&D to China more frequently than other companies with manufacturing sites abroad, as a result of the large variety and broader scope of engineering activities in R&D intensive firms. Companies from the automotive sector likewise tend to practice R&D in China more frequently, as they might feel a higher need than other industries to sufficiently adapt and develop their products and solutions specifically for the local market needs.

On average, the surveyed companies from B-W realize 41% of their product sales in Germany, 20% in the rest of Europe, 12% in China, 7% in the rest of Asia and 19% in the rest of the world (including the Americas). The regions, in which the largest shares of sales are realized, are also those from which the highest amount of supplies are sourced. On average, the surveyed companies sourced 53% of their inputs from Germany, 15% from the rest of Europe, 8% from China, 5% from the rest of Asia and 12% from the rest of the world (including the Americas).

Regarding the resulting patterns of international trade in general, an orientation towards more global sales than global purchasing can be noticed. Globally, the global sales-to-purchasing ratio of the surveyed companies from B-W amounts to a 26% export surplus.

Manufacturing site

For the Chinese market, the net export surplus even equals 50%.[1] Overall, this can be interpreted as a clear sign that China in the meantime plays a more important role as a large and still significantly growing market for many of the core industries from B-W then as a crucial source base for the surveyed companies' global supply chain.

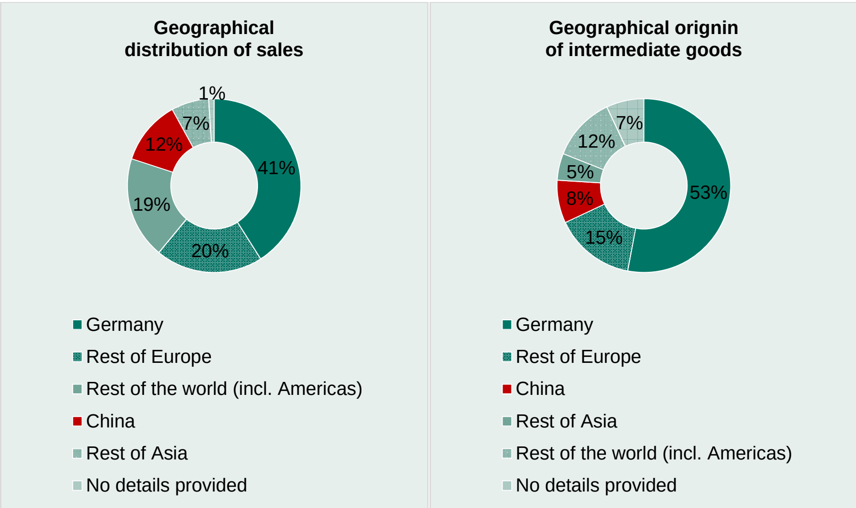


Figure 32 Global distribution of sales and inputs of the surveyed companies from B-W (N = 120, 131)

[1] Calculation of sales-to-purchasing ratio world:

$$\frac{Sales\ to\ world\ (all\ categories\ minus\ Germany)}{Purchasing\ from\ world\ (all\ categories\ minus\ Germany)} = \frac{100-41}{100-53} \approx 1.26$$

Calculation of sales-to-purchasing ratio China:

$$\frac{Sales\ to\ China}{Purchasing\ from\ China} = \frac{12}{8} = 1.5$$

Location factors in B-W and Suzhou

Location factors in B-W that are praised by the surveyed companies from B-W are its excellent IT and communication infrastructure (54% of the surveyed companies estimate it as excellent), its reliable political and legal frameworks (54% excellent), as well as the access to new knowledge and technical know-how (47% excellent), the proximity to key customers (44% excellent), and the strong cooperation with universities and research institutes (44% excellent), and the local transport infrastructure (39% excellent). Companies are also satisfied with the access to qualified suppliers (34% excellent), the attractiveness of the local market (34% excellent), the access to clusters (32% excellent), the possibilities for IPR protection (31% excellent), and the access to qualified employees (27% excellent) – although the latter factor already mirrors some problems of finding key people with specific qualifications due to the changing demographic environment.

The factors that are regarded as the most critical are the sometimes difficult access to raw materials (17% excellent), the procurement and contracting practices for public and private projects (15% excellent), as well as of course the personnel costs (3% excellent), which are always named as negative location factor when it comes to the evaluation of high wage regions like B-W.

Companies participating in the qualitative Suzhou control sample are rather positive about the quality of Suzhou as an industrial location. In particular the infrastructural framework conditions in transport (35% excellent) and IT (32% excellent), the access to industrial clusters (33% excellent) and the reliability of the political and legal framework conditions (29% excellent) were assessed quite positive by firms of the qualitative Suzhou control sample. On a lower level of quality, they also rated the potential for cooperation with local universities (18% excellent), the access to know-how (18% excellent), to raw materials (16% excellent), to qualified employees (15% excellent), and to qualified suppliers (15% excellent) relatively positive, as well as the most critical factors of IPR protection (12% excellent), and the local procurement and contracting practices for public and private projects (14% excellent).

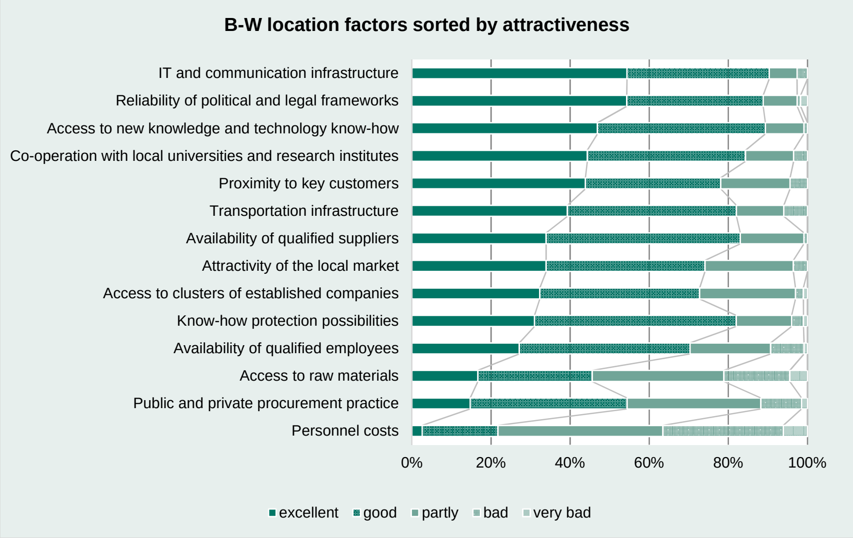


Figure 33 Location factors in B-W, assessed by the surveyed companies from B-W (N = 68)

The discrepancies in the assessment of the location factors in B-W and Suzhou by companies from Suzhou and B-W might also serve as an indication that the quality of location factors may not be assessed realistically by companies which are not operating locally.

There are only three location factors that were not assessed more positive from the companies operating in Suzhou than from the companies in the B-W sample: Labor costs (15% excellent compared to 33% in the B-W sample), the high attractiveness of the local market (33% excellent in both samples), and the proximity to key clients (18% excellent compared to 16%). It becomes apparent that the companies operating in Suzhou regard the local level of labor costs even worse than the companies located in B-W, as they are more directly affected by the already high and still rising wages in the region, particularly compared to other low-cost locations in China or other Asian countries.

The picture for the differences (between companies from Suzhou and companies from B-W) in the assessment of the quality of the location factors in B-W also interesting. Companies operating in Suzhou particularly assessed the possibilities for IPR protection (69% excellent compared to 31% excellent in the BW sample), the access to qualified employees (47% excellent compared to 27%), and the procurement and contracting practices for public and private projects (46% excellent compared to 15%) in B-W significantly more positive than companies operating directly in B-W. Also, the local level of labor costs was regarded as slightly more positive by the companies from the Suzhou sample (13% excellent compared to only 3% in the B-W sample), whereas the proximity to key customers (14% excellent compared to 44%), the attractiveness of the local market (7% excellent compared to 34%), the local transport infrastructure (19% excellent compared to 39%), and partly also the access to clusters (19% excellent compared to 32%) were assessed significantly worse than from the companies located in B-W themselves. This might be an indication that the marketing and communication activities of B-W regarding the quality of these location factors do not seem to be sufficient to convince firms from geographically and culturally distant countries of the possible advantages in this area.

Expert interview results

This chapter presents the results of expert interviews conducted within this study whereby it is to be noted that the main statements listed in this chapter do not claim to represent universal validity. The results should be interpreted with knowledge of the following context:

The qualitative expert interviews were carried out on the basis of central questions with the objective to obtain both evidence-based and evidence-expanding perspectives from practitioners concerning the innovative capability and cooperation potentials of industrial companies in the German federal state of Baden-Wuerttemberg and the city of Suzhou. Most interviews were conducted locally and in person at the particitoners' company facilities in China or in Germany. All in all, 25 expert interviews were carried out. Nine of them were conducted in terms of telephone interviews with experienced company representatives or consultants that are either self-employed or closely connected with China within a scientific context. In the following, the organizations associated with these interview partners will also be refered to as companies for readability purposes. Five of the telephone interview partners are currently based in China. Six companies at which personal interviews took place are located in Baden-Wuerttemberg, the other ten live interview partners are located in Jiangsu. The duration of the interviews varied from one to two hours. The focus of the conducted interviews was on obtaining a comprehensive insight and assessment from the point of view of manufacturing companies in Jiangsu and Baden-Wuerttemberg considering their innovation capability and cooperation potential: customer structures on a national and international level, competitive strategy, product portfolios, technology in terms of their use and development, production techniques and quality standards, research and development activities, competence networking, cooperation between industrial companies and research institutions, advantageous locational factors as well as obstacles and barriers for the internationalization in Baden-Wuerttemberg and Suzhou.

A catalogue of central questions was developed, refined by pre-tests and used as guidance throughout the interviews. The question catalogue was used as an orientation so that experts could explain their point of view extensively whereby they prevalently used examples.

After the expert interviews the recorded statements were evaluated by means of structured statement analysis, then classified and summarized in terms of key statements. If these statements strongly differed or were only made by interview partners located in one country, they were considered separately. For each subject area an informative box has been outlined, in which the key statements are presented in a well-arranged way. On the left you find the replies from practitioners in Germany, on the right from practitioners in China. The references for the replies have been abbreviated as illustrated by the following examples:

- (de1): Statement of interview partner 1, being located in Germany
- (cn5, cn7): Statements of interview partners 5 and 7, both being located in China

The companies associated with the interview partners differ greatly in terms of size, turnover, number of employees, and degree of internationalization. Table 11 and Table 12 will provide an overview of the companies. It is noted that not all of the interviewed companies in China have Chinese roots. The companies from interviews cn2, cn3, cn4, cn5, cn9, cn11, cn12, cn13, cn14 and cn15 are located in China, but originate from Germany or another European country. The focus of the main statements is on the Chinese market and on business relations with companies in China, since only one of the interviewed Chinese company representatives holds experience in the field of business relationships with Germany. Therefore overall, the German perspective is partly represented in the statements of interview partners in China. In addition to the background of the interview partners, the general market situation also explains the interview sample bias: As mentioned by one of the Chinese interview partners, the Chinese market is large enough for allowing Chinese small- and medium-sized enterprises (SMEs) to grow. Therefore, the interest of Chinese SMEs in expanding its business activities to the German market is currently limited. Beyond that, the rather low attractivity of the German market can be justified by its relatively low GDP growth rate. Taking these factors into account, it seems to be understandable that the German presence on the Chinese market is more pronounced than the opposite direction. Some of the Chinese companies in this study stated that they are principally interested in cooperations with Germany or Baden-Wuerttemberg, but were not able to take the step yet due to limited capacities. Therefore, many of them could not make statements on collaboration potentials in Germany.

Table 11 Companies interviewed in Germany

Company (interview number)	Industrial sector / product	Facility location in China / Suzhou	Size[1]
Anonymous (de1)	Drive Engineering, Drive Automation	Several, also in Suzhou	Large corporation
Anonymous (de2)	Industry Sieves	None	Small corporation
Robert Bosch GmbH (de3)	Mobility Solutions, Industrial Technology, Consumer Goods, Energy and Building Technology	Several, also in Suzhou	~ 281,000 employees ~ €46bn turnover (2013)
Anonymous (de4)	Automatic electrical couplings and hand plugs	Suzhou	Large corporation
HKR Seuffer Automotive GmbH & Co. KG (de5)	Electronics for electric motors in the automotive sector	Shanghai	~ 150 employees ~ €52m turnover (2013/14)
Pilz GmbH & Co. KG (de6)	Automation, Safety and Control Technology	Shanghai	~ 1,650 employees ~ €227m turnover (2012)
Anonymous (de7)	Machine tools	Several, none in Suzhou	Large corporation
Anonymous (de8)	Club	None	-
Anonymous (de9)	University	None	-
Anonymous (de10)	International Community	Beijing	-

[1] Due to the demand for anonymity, the classification of the size of the company is done here according to § 267 HGB (law that governs the primary commercial code for companies in Germany) in small, medium and large corporations.

Table 12 Companies interviewed in China

Company (interview number)	Industrial sector / product	Facility location in China / Suzhou	Size[2]
Bao Li Nonwoven Co., Ltd. (cn1)	Non-woven fabrics supplier	Kunshan	~ 150 employees
Anonymous (cn2)	Automotive supplier	Several, also in Suzhou	Large corporation
Dorma Door Control (Suzhou) Co. Ltd. (cn3)	Door closer, Automatic door systems, Access control	Suzhou	~ 210 employees in Suzhou
Eolane Technology (Suzhou) Co., Ltd (cn4)	Electronic manufacturing service	Suzhou	~ 3,600 employees ~ €400m turnover (2013)
aichele GROUP GmbH & Co. KG (era-contact GmbH) (cn5)	Automotive supplier, Medical technology, Construction machinery	Suzhou	~ 710 employees ~ €75m turnover
Zhangjiagang Feichi Machinery Manufacturing Co., Ltd. (cn6)	Cleaning Boats	Several, also in Suzhou	~ 120 employees ~ RMB20m assets
Suzhou Hengzhisheng Accessory Co.,Ltd (cn7)	Textile industry	Several, also in Suzhou	~ 200 employees ~ €200,000 turnover
Anonymous (cn8)	Medical technology	Several, also in Suzhou	Large corporation
Lauterbach (Suzhou) Technologies Co., Ltd (cn9)	Hardware-Software	Suzhou	~ 120 employees (2013) ~ €100m turnover (2013)
Suzhou LZY Technology Co., Ltd. (cn10)	Wiring harness, Electric wires and cables	Several, also in Suzhou	~ 1,400 employees in SIP ~ RMB2bn turnover (2013)
Anonymous (cn11)	Machine tools	Jintan	Large corporation
Anonymous (cn12)	Supplier for automotive, electronics and home appliances industry	Shanghai	Large corporation
Anonymous (cn13)	Testing-service provider in the automotive industry	Suzhou	Large corporation
Anonymous (cn14)	Electronics	Several	Large corporation
Anonymous (cn15)	Automation technology	Several	Large corporation

[2] Due to the demand for anonymity, the classification of the size of the company is done here according to § 267 HGB (law that governs the primary commercial code for companies in Germany) in small, medium and large corporations.

Customers
• Mainly B2B relationships *(de1, de3, de5), (cn3, cn7, cn9, cn10)* • Internationally oriented customer base *(de3, de6), (cn7, cn10)* • Adapting to individual customer preferences is unproblematic for most companies, but nonetheless proves to be challenging *(de1, de5), (cn2, cn7)*
Challenges concerning customer acquisition (B2B) • Lack of technical knowledge *(de5, de6)* and lack of German and European technical processes *(cn13)* on the side of Chinese customers • Identification of the right distributor *(cn1)* and the right products for the mass market *(cn3)*

According to the statements of the interview partners, most of their customers are businesses and not end-consumers. Thus, their customer structure is characterized in particular by business-to-business (B2B) relationships, reflecting the significant clustering of companies along the value chain both in B-W and SIP.

Whereas German companies with a location in China mainly focus on the local market; Chinese companies such as Hengzhisheng (cn7) act as distributors for clients all over the world. Nearly all companies in this study have an internationally oriented customer structure, although SMEs such as Feichi (cn6), HKR Seuffer Automotive GmbH & Co. KG (de5) and Pilz GmbH & Co. KG (de6) mainly operate in their country of origin.

The adaptation to individual customer preferences is an important core competence, according to several interview partners. For the majority of the companies participating in this study, this poses little to no problems. Partially, their business models are even characterized to a large extent by customer focus as a part of their core business. Nevertheless, tailored manufacturing may be particularly challenging. Some of the especially challenging factors mentioned here include keeping up with short transaction times as well as the manufacturing of custom-made products. These factors prove to be more challenging for SMEs due to capacity constraints. Global players often produce standard products, but handle product changes and custom-made orders locally in order to react to specific market conditions. The fast pace in particular is the biggest challenge for the surveyed companies in order to meet customer requirements. The manufacturer of premium doors Dorma (cn3), for example, implements application engineering for this purpose in terms of sizes, security applications and costs.

In their answer to what the most important challenges in the process of customer acquisition in China are, respondents often mentioned the lack of technical knowledge on the side of Chinese firms. Moreover, many Chinese clients are not acquainted with German and European technical processes yet. In Germany and Europe on the other hand, the required cost-benefit ratio may be difficult to achieve, according to HKR Seuffer Automotive GmbH & Co. KG (de5).

The contact with the right partner and the identification of the products for the mass market , as well as the quality requirements of customers, were mentioned as challenges.

Competition	
• The Chinese market is highly competitive in the majority of industry sectors *(de1, de5, de6), (cn1, cn.4, cn7, cn10)*	
Important competitive advantages: • Product quality *(de1, de2, de4), (cn2, cn3, cn5, cn7)* • Technological competence of German companies *(de1, de4, de5), (cn2, cn3)* • High level of service and cooperation with customers *(de1, de2), (cn7, cn8)*	
• Good reputation *(de1, de7)*	• Short delivery times *(cn2, cn10)*
• Average Salaries in China are lower than in Germany *(de10)*	• Competition characterized by high cost pressure *(cn5, cn7)*

All respondents describe their market in China as highly competitive, independent of the industry field in which they operate. Small companies that are active in niche markets or distinguish themselves from the competition as premium providers, form an exception, because no other competitor can provide similar quality.

The most important competitive advantages that differentiate participating companies from their competitors – both in the high-tech and low-tech segment – are good product quality, technological competence, a high service level, intense and good cooperation with customers.

> *"The development of the Chinese economy has led China to become a serious competitor in many advanced technologies and not anymore the extended workbench of German companies."*
>
> Peter Löscher, former CEO of Siemens

Some of the interview partners even regard their company as quality leader in the respective market sector, for example the Chinese scarf manufacturer Hengzhisheng (cn7). In order to maintain these competitive advantages, frequent innovations and active collaboration with clients are necessary. Especially for Chinese companies, maintaining close ties to the customer is gaining more and more importance. These companies are leaving behind the status of being an “extended workbench” for low-price end products and are rather becoming customer-oriented innovation drivers. By doing so, they react to the changing market, where the demand for quality is starting to outweigh the importance of favourable prices.

According to several German interview partners in China and in Germany, German enterprises enjoy an outstanding reputation according to Chinese customers.

When comparing the average wages paid in China and Germany, the Chinese ones are lower although this does not apply to all areas and regions. On China’s east coast, the wages have increased notably fast. The salaries of high-qualified employees are already at almost the same level as in Germany.

Reliability and short delivery times were mentioned by two Chinese companies as two of their most important competitive advantages, and thus demonstrate the growing importance of customer orientation.

A large amount of competitors and so-called “garage companies” have created high cost pressure in various sectors of the Chinese market. One respondent illustrated this with the extreme example of some competitors who offer unrealistic prices on the market, which do not even cover material costs. A Chinese scarf manufacturer confirms the price competition from rivals from other provinces.

Products and technology

- New products added to company portfolio during the past three years *(de5, de6), (cn1, cn2, cn3, cn5, cn9)*

- Product portfolio features high quality *(de1), (cn3)* and continuous development *(de1), (c1)*
- Quality standards are achieved quickly *(de1, de6)*
- Adaptation to customer preferences is important *(cn6, cn9)*

- Production technology is subject to continuous improvement processes *(de5, de6), (cn8)*
- Technological lead of German companies to Chinese companies is diminishing; in some sectors it does not even exist anymore *(de7, de10), (cn11, cn12)*
- In China, the same machines and production technologies as in Germany are used *(de4)*

The majority of companies in this study stated that they added new products to their product portfolio during the past three years, especially those in the high-tech segment that distinguish themselves through innovative products. A global player from Germany gave rise to the particular concern of market launches of new products, which are dependent on local laws, thus causing delays in some situations. The products of the interviewed companies excel in consistent high quality. Additionally, high standardization levels help to ensure the quality of these products.

German companies pursue the goal of quickly achieving quality standards after the implementation of new products. One method to rapidly achieve quality standards is the detailed planning of the start of production. In some Chinese plants, a full audit of purchased parts may be necessary before production, due to large variations in the quality of parts from domestic suppliers.

The ability to adapt products to customer preferences was rated as extremely important by the respondents. China forms a large, inhomogeneous market, which can lead to strongly differing conditions. Therefore, customizing is an important competence for customer acquisition and retention. Products should generally be adjusted to match local markets, independent of whether the development took place in Germany or in China.

To obtain constant progress in production technologies, companies such as HKR Seuffer Automotive GmbH & Co. KG (de5) and Pilz GmbH (de6) implement continuous improvement processes. During the production start-up phase, quality gates are defined in order to be able to recognize development risks in time.

Companies from Germany frequently stand out through their use of excellent technologies. In this regard, they are ahead of their Chinese counterpart. In the automotive industry, for instance, the lead is currently estimated at two to three years. For many standard products however, for example for electric switches, the lead to Chinese companies no longer exists.The answers of the respondents clearly indicate that the same machines, systems, and production technologies that are used in Germany are frequently used in China as well.

A German company standardizes core processes globally, although handling processes need to be designed differently. In China, for instance, manufacturing should be executed in an easier manner, apart form core processes, because there is no training concept which is similar to that of a German master craftsman (Meister). Also, the interview partner emphasized that good boundary conditions for “Industrie 4.0” are provided due to the technology-friendly culture and curiosity about new technologies in China.

“The German mechanical engineering industry has an excellent reputation in China. The technology leadership of German companies is undisputed in the Chinese market. Chinese customers as well as competitors recognize a clear lead of German companies in terms of precision, productivity, durability and energy efficiency.”

Alixpartners (2014)

Research and development

- Many companies nowadays employ R&D staff members in China *(de3, de9), (cn1, cn2, cn4, cn5, cn6, cn8, cn10, cn12, cn13, cn14)*
- R&D centers are usually located in the country of origin, especially for SMEs *(de1, de2, de4, de5), (cn1, cn5, cn6, cn7, cn9, cn11)*
- The generation of ideas takes place all around the world *(de1, de3)*
- German companies in China mainly concentrate on customization and tailoring *(cn5)*

- The risk of product piracy in China is present for many companies *(de3), (cn2, cn3, cn5, cn6, cn7, cn11, cn12, cn13, cn14)*, but not for all of them *(de1, de5, de7), (cn2, cn6)*
- Continuous innovations as protection against product imitation *(de3, de5, de7), (cn2, cn14)*

- Patents and design property rights as prevailing protection measure *(de1, de3, de5), (cn1, cn2, cn3, cn5, cn6, cn8, cn9, cn10, cn12, cn13)*.
- In addition to global patents, some companies also apply for local patents in china *(de3), (cn3)*

All interviewed companies stated that they actively pursue research and development activities. Many of them have these activities embedded in their Chinese locations as well. However, there are significant differences with regards to the size and capacity of those R&D departments: the largest part of R&D activities still takes place in the countries of origin of the respective companies. A French company forms an exception: according to the answer of the respective interview partner, a full-function R&D department with all operations is situated at the Chinese location. German companies mainly focus on customization and tailoring abroad, but the products manufactured in Suzhou are still developed in Europe. However, various interview partners mentioned plans to relocate parts of their R&D activities to China in the long term.

Whereas most of the R&D activities of the companies were mainly limited to Germany and Europe; the generation of ideas, which can provide impulses for new developments, already takes place on a global scale. Regarding this matter, the interview partner of Robert Bosch GmbH (de3) mentioned that special requirements and preferences from customers can only be identified locally. Therefore, cross-border development systems are needed to consolidate ideas so that they can be elaborated in the R&D headquarters.

The fear of product imitation and loss of know-how is regarded as an important issue in China. However, both, Chinese and foreign companies can be victims of such plagiarism cases, although the risk in the high-tech segment is lower than for low-tech products. The production technologies for high-tech products complicate the manufacturing of imitations substantially.

Success story: Lauterbach's fight against fake products

Three years after their arrival in China, Lauterbach's leaders realised their flagship product, as well as their website, and even their business cards had been copied and sold by someone else on the Chinese market.

"We started registering our logo, our name, the copyright for the hardware, and the copyright for the software," said Tom Meyer, the company's General Manager in China. They managed to stop the copies with the help of a lawyer.

"To me, the key to success is registrations – rather more than too few. Registrations here in China are relatively inexpensive and easy to achieve."

http://www.euronews.com/2013/05/17/how-to-protect-your-ipr-in-china/ (07.03.2015)

Although the technology of very complex products may often be difficult to copy, their hardware (appearance, shape) can mostly be imitated easily. One German interview partner regarded this as an immense problem, whereas others had experienced product imitations, but reported that no real damage was inflicted upon them.

In order to protect their own innovations, most companies make use of patents that have a global reach, or at least are valid in the most relevant countries.

Since the protection of know-how is not completely secured by patents only, companies such as Robert Bosch GmbH (de3) and HKR Seuffer Automotive GmbH & Co. KG (de5) strive towards a technology and innovation leadership in their field, by continuously increasing their know-how. A Chinese scarf producer on the other hand feels powerless against imitations, since his products can easily be copied by competitors.

The interview partner from Lauterbach (Suzhou) Technologies Co., Ltd (cn9) mentioned successful approaches against plagiarism in the past, and especially praised the cooperation with the Chinese authorities in SIP.

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(Euronews 2013)

Another interview partner mentioned that the risk of product piracy does not only occur on the Chinese market, but also European companies experience this problem with competitors located in their respective country of origin.

Competencies	
• Employee fluctuation in China has declined over the past few years, but still poses a major challenge *(de1, de3, de4, de9), (cn5, cn7, cn13)* • The employee fluctuation is significantly higher for blue-collar workers than for white-collar workers *(de7), (cn5, cn13, cn14)*	
• Continious internal transfer of experience-related knowledge *(de1, de5), (cn2, cn3, cn4, cn8, cn9, cn12)* • Development opportunities for employees are offered *(de4, de6), (cn2, cn8, cn10, cn14)*	
• Commitment of individual companies for better education, for example by implementing an own dual education system in China *(de8), (cn2)*	
• It is often challenging to find qualified employees in China *(de3, de4, de7), (cn12)* • On average, education levels in China are lower than in Germany *(de7), (cn13)*	

• The dual education system in Germany is praised, and missed in China at the same time *(de3, de4, de6)*	• Experience of employees is important for companies *(cn3, cn5, cn6)*
	• Qualifications expected from employees:
	  • Innovation affinity *(cn6)* and research ability *(cn1)*
	  • Open-mindedness towards new concepts and ideas *(cn2)*

Keeping internal competencies and know-how within the company proves to be a considerable challenge in China, given the fact that employee fluctuation is still relatively high. Even though the situation has improved according to the statements of several interview partners, the fluctuation is still significantly higher than in many other countries. A fluctuation rate of approximately 20% in the beginning of the Chinese industrialization was estimated. Nowadays, this value is at 5 to 15%, depending on the company. High fluctuation rates can be observed especially at manufacturing employees who receive offers from competitors, in order to be able to profit from the rivals' know-how. Fluctuation in the white-collar sector is partially perceived as substantially lower than in the blue-collar sector. However, fluctuation in both sectors can lead to big problems. If a key employee leaves the company, important know-how can get lost. A Chinese scarf producer does not require exceptional employee qualities; and mentions that employee fluctuation is very high. On the other hand, a German high-tech company in China, which needs high-qualified employees, nowadays barely observes any fluctuation. This is reasoned by their specialized area of operation and good corporate culture with family-like relationships. A Chinese company mentioned their own welfare system with free trainings, team activities, and team rooms.

The majority of interview partners enables a transfer of know-how for existing and new employees through internal training and further education opportunities. One company representative mentioned that many investments are made in the area of education, and that external trainers from Germany are employed. Another proposed option is that Chinese employees receive on-site trainings at the German location which includes a stay of several weeks at the German location.

Many companies offer their employees opportunities for further education, in order to further develop the competencies within the company. In Germany, for instance, cooperations with the Steinbeis center[3] exist, through which employees can pursue an external MBA. Often, companies also offer 'classical' internal on-the-job trainings for their employees.

Some of the companies also mentioned their good corporate culture and internal collaboration as success factor. One Chinese company called it 'their own welfare system' with cost-free training, expenses for team activities, and employee accommondations.

Some interview partner mentioned, that most of the Chinese students are, form their point of view, educated too theoretically. To solve this problem they cooperate for example with the German Chamber of Commerce and build their own vocational schools. A German company established, for example, their own training centers at its production sites to ensure the quality of education.

All in all, several companies mentioned challenges in searching for qualified employees in China. According to the answers of one interview partner this includes all company areas, but especially manufacturing. Another interview partner mentioned the difficulties concerning the search for qualified R&D employees in particular.

The dual education system in Germany is both praised and missed in China by numerous interview partners. In this context, the interview partner of Robert Bosch GmbH (de3) mentioned that employees with low or very high qualification levels are generally sufficient. However, there is a structural lack of employees with a mid-level technical education which is comparable to the German industrial trainings. Several companies also state that a dual education on a bachelor or master level would be useful.

Especially companies that are driven by innovation expect open-mindedness towards new concepts and ideas from their employees in order to maintain a competitive advantage through innovation leadership. Additionally, more and more Chinese companies expect innovation and R&D competencies from their employees to avoid falling behind foreign companies.

[3] The Steinbeis Center of Management and Technology offers career-integrated bachelor's and master's programs, where employees work on their company projects while completing an officially recognized degree (SCMT 2015)

<table>
<tr><th colspan="2">Cooperations</th></tr>
<tr><td colspan="2">• Local sourcing is implemented by many companies in China (de2, de4, de5, de6), (cn4, cn8, cn12)</td></tr>
<tr><td colspan="2">• Cooperations by German companies with universities or research institutions in China are not common yet (de1, de4, de6), (cn3)
• Only large[4] German corporations are cross-linked with universities and research institutions in China (de3), (cn11, cn12, cn13, cn14)</td></tr>
<tr><td colspan="2">Differing expectations from cooperation partners:</td></tr>
<tr><td>(de5, de6):
• Reliability
• Technological competence
• Product quality
• Low logistic costs
• Certifications in the quality management field</td><td>• Right size (cn4)
• Actively pursuing R&D (cn1)
• Manufacturing experience (cn6)
• Compliance with international standards (cn1)</td></tr>
<tr><td colspan="2">• Strong cooperation of domestic companies with universities and research institutions in their own country (de1, de4, de5, de6), (cn1, cn4, cn7, cn8, cn9, cn13)</td></tr>
</table>

All the interviewed companies with manufacturing sites or trade departments in China maintain supplier relations with companies located in China. Pilz GmbH & Co. KG (de6) pursues a strict local-for-local strategy if possible. According to them, this turns out to be a success, because Chinese companies already are able to produce good and constant quality. In the automotive industry, this can be attributed to the prevailing quality standards. Other companies in this study express a different view. For instance, one interview partner mentions that the product quality of Chinese suppliers ‘fluctuates strongly’. In his opinion, this can be explained by instable processes on the one hand, and by the high employee fluctuation in Chinese companies on the other hand. One stated the advantage of local sourcing as the possibility to reduce costs.

According to four German companies, cooperations with universities and research institutes in China are not the norm yet, at least not for the majority of companies. Especially for smaller companies, the necessary infrastructure to cooperate with foreign researchers is needed. Only the large enterprises interviewed in this study, such as Robert Bosch GmbH (de3), have an international network at their disposal and cooperate with universities in Shanghai or Beijng. Other German companies, such as Lauterbach (cn9) conduct German-Chinese education cooperations with, for instance, Tongji University located in Shanghai or with Chinese universities through industry internships or scholarships. In one case, mutual application development in cooperation with Chinese research institutes was mentioned.

[4] Classification according to § 267 HGB (law that governs the primary commercial code for companies in Germany)

Requirements for cooperation partners differ between German and Chinese companies, and may have their origin in diverse self-perceptions of the companies: German companies emphazise know-how to be their highest valued asset, protect it from the others, and build up their success on a know-how lead. They prefer that partners along the value chain meet their needs as precisely as possible, so that they can conduct clearly defined assigned tasks well by themselves. The interviewed Chinese enterprises, however, value the possibility of growing together with partners through learning from them.

Apart from a good quality of purchased goods, German company representatives expect business properties such as reliability, technological competence, and low logistics costs from their suppliers. Some of them even request quality management certifications. All in all, the German companies are mainly interested in smooth procedures and product quality comparable to their own.

Chinese companies expect their cooperation partners to have the right size to promote the companies’ activities, e.g. in terms of increasing the customer base and supporting networking activites. Additionally, cooperating partners should have experience in manufacturing, in conducting R&D, and to comply with international standards such as ISO standards. The short-term goals of such partnerships vary from mutual R&D activities to accelerated market growth.

Already, cooperations with research institutes and universities in the country of origin are the norm for most of the interviewed companies. These cooperations include almost all subject areas, including product design, software, material science, and other research projects. In China, some of these projects are supported by the Chinese government through the „863 program – State High-Tech Development Plan“[5]. In Germany, a vast landscape of research support measures exists, varying from state resources to country-wide support initiatives, and even Europe-wide support programs.

[5] The “863 program“ or “State High-Tech Development Plan“ is a project which was initiated by the Chinese government to support the development of R&D (MOST 2015).

Collaboration and innovation drivers	
• Building up a foundation of trust, especially through personal contacts, are important for successful collaborations *(de1, de5, de6)* and can be forged, for instance, via the „Productivity Promotion Center“ located in Suzhou *(cn1, cn7)*	
• Innovation impulses in China are often cost-driven *(de3)*	• Innovations on a local level are important to quickly adapt to customer preferences in China *(cn3, cn9)*
• Management positions are generally occupied by German managers *(de4)*	• Good management and professional employees are the most important success factor for collaboration *(cn10)*

An important factor for successful collaboration in China undoubtedly is the personal contact to colleagues, customers, and suppliers. The creation of a foundation of trust is the most important element for successful collaboration in China, both within the Chinese management, and on the Chinese market as a whole, according to HKR Seuffer Automotive GmbH & Co. KG (de5).

In Suzhou, the „Productivity Promotion Center“ is the facility which helps to establish personal contacts according to several companies.

Pilz GmbH & Co. KG (de6) for instance identifies China and South-East Asia as regions which play a main role in driving innovation. According to Robert Bosch GmbH (de3) though, these innovations are mainly cost-driven.

One important success factor for the collaboration with China that was mentioned frequently is the occupation of top management positions with General Managers from Germany. Only one company stated it had been successful in finding domestic managers for the management of their Chinese location.

The companies in this study regard local innovation impulses as important, since these build the foundation to adapt to customer preferences and changing market conditions.

The interview partners responded differently to the question of what the biggest success factors for collaboration in China are: cultural experience and lingual commonalities were mentioned by one German company, research capacity by a Chinese company. Moreover, good management and professional employees were mentioned as a potential success factor.

Location factors	
Location advantages Suzhou • Located on the east coast of China and proximity to customer clusters and Shanghai harbor *(de1, de4), (cn2, cn3, cn4, cn5, cn6)* • Relatively high level of education and good access to qualified employees *(de1, de4), (cn2, cn3, cn6)* • High quality of life *(de1, de4), (cn2, cn9)* • Good transportation possibilities, infrastructure, and logistics *(de1, de4), (cn1, cn3, cn4, cn5, cn7)*	
• The choice of a location is often determined by a partner or an important customer *(de4, de5), (cn5)*	
• Due to strong price increases on the Chinese east coast, manufacturing is being relocated to the west or to other low-income countries *(de3)*	• Good collaboration with and support by the local government *(cn4, cn6, cn8, cn9)*

Suzhou is designated to be a technology cluster by the Chinese government. Therefore, it is not surprising that the location factors which are supported by the government especially benefit the region. This is confirmed by the answers of the interview partners. Suzhou Industrial Park offers a range of attractive location factors, according to the respondents with sites located in the area. The location in Jiangsu province, on the east coast of China, where by far the most industrial companies are located, offers easy access to numerous potential customers and suppliers. Suzhou is situated close to the harbor and customer clusters of Shanghai (see chapter 1), and thus enjoys well-established connections to international trade routes. Another important location factor which distinguishes Suzhou from other cities is the high level of education in the region, making it significantly easier to find qualified employees. Moreover, Suzhou offers employees a high standard of living and a good infrastructure – factors that make it easier for companies to retain their employees or to win over foreign employees for deployment in China.

In some cases, the location selection is restricted by requirements from partners or important customers. This led to the formation of clusters from certain industrial sectors – a differenciation trend that was even more reinfored by government initiated programs.

Whereas the exploitation of the Chinese market was mostly restricted to the east coast in the beginning, relocation towards the west is currently taking place, according to various interview partners. Possible reasons for this are the rising labor costs in the east, making this region too expensive for low-cost manufacturing. Therefore, purely cost-driven relocation motives rather lead some companies to go further low-wage countries such as Bangladesh, Malaysia, Vietnam, and Indonesia. Moreover, industry is being relocated from central inner city locations to the outside due to environmental restrictions, according to Robert Bosch GmbH (de3).

The good and uncomplicated cooperation with the local government and authorities in SIP is highly praised by several interview partners. Since authorities in China work in a manner which may be not fully transparent to foreigners, it can be challenging for foreign companies to assess important processes from the outside. Therefore, dealing with Chinese authorities is one of the big challenges when conducting business in China. The respective authorities in SIP are tackling this problem actively, and therefore have received a very positive feedback, as the interview partner from Lauterbach (cn9) mentioned.

Review and international outlook

- Hurdles with regards to internationalization, especially concerning expansion to China:
  - Bureaucratic hurdles *(de1, de6, de10)*
  - Search for qualified personnel *(de4, de6, de8, de9)*
  - Staffing of management *(de2), (cn12)*
  - Cultural, linguistic barriers *(de1, de2, de9), (cn3, cn4)*
- Wishes regarding improvements:
  - Accelerate imports to China *(cn3, cn5)*
  - Stronger collaboration regarding economic policies in China is desired *(cn2, cn3, cn4, cn10)*
  - Set-up of a „China-Desk“ with all involved and interested parties *(de10)*
  - Easier access to China for German students *(de8)*
- Opportunities
  - Expansion of the market segment *(de7)*
- Future challenges:
  - Increase of productivity *(de4), (cn11)*
  - Increase of labor costs *(de4), (cn11, cn12, cn13)*
  - Environmental issues *(cn11, cn13)*
  - Structural change in the economy *(cn11)*
  - High import taxes on high-tech components *(de7)*
  - Political power struggles *(cn11, cn13)*
- Future technology fields (especially on the Chinese market):
  - Automation technology *(de7), (cn14)*
  - Environmental technology and renewable energies *(de7, de8, de10), (cn11, cn14, cn15)*
  - Water purification and treatment *(de8, de10), (cn15)*
  - Medical technology *(de8, de10), (cn11, cn14)*
  - Service industry *(cn11)*
  - Automotive growth in China *(cn12, cn13)*
  - Electric mobility *(cn12, cn13)*

Bureaucratic hurdles in general were mainly stated as a large barrier with regard to internationalization and building up a location in China. This hurdle had to be overcome for several companies. Some of the problems mentioned include trouble with the needed certifications for products, customs offices which do not operate following consistent standards, and the Chinese legislation as a whole. In this context, it was pointed out that authorities in Suzhou work more efficiently than their counterparts in other regions, so that bureaucratic burdens are perceived as being significantly lower than in other parts of China.

Another challenge concerns the employees at Chinese sites. Pilz GmbH & Co. KG (de6) for instance planned to staff the Chinese location with Chinese employees directly from the beginning, but has encountered difficulties in doing so. Another company in this study offered German employees the possibility to work in China, but has to deal with the challenge that German employees show relatively little flexibility and that the majority wants to return to Germany. The staffing of management in China poses a special challenge. One of the respondents has tried to build up a business in China and failed, allocating this mainly to the local management of the Chinese site.

Both German and Chinese companies regard cultural differences as a challenge for mutual activities. A German company in China mentioned that German policies and thinking do not fit into the Chinese reality. In order to overcome these difficulties, several strategies are applied. Most of the interviewed companies staff top management positions with German or at least European employees, which allows them to gain better control and facilitate easier communication to the company's headquarter. Simultaneously, deployed expats should get acquainted with Chinese culture in order to deal with clients and employees. Several companies see opportunities for improvement in the standardizatrion and acceleration of the import process to China, which may currently take twice as long as in other countries.

One possible approach to solve problems on these matters could be formed by stronger cooperation on a political and economical level in China. Formalities such as visa requirements, customs, and other local official regulations could be conducted more efficiently from the respondents' point of view. An improvement of these matters may improve and simplify cooperations and foreign involvement. One interview partner mentioned that this could help to compensate the current lack of trust, especially concerning plagiarism and loss of know-how, or the different taxation regulations for domestic companies.

A „China-Desk“ for all involved and interested parties could serve as an information and coordination platform for the topics mentioned above, but also as a networking desk where business relationships may arise and be developed. For such a "China-Desk" in Baden-Wuerttemberg it would be important to bring together strategic thought leaders from forerunning companies in different industrial sectors, research institutions, policy and from all cluster initiatives in Baden-Wuerttemberg. Such an approach would allow to develop a coordinated strategy for crucial future topics that are independent from different regional cluster interests.

At present, official permissions rarely exist allowing German students to conduct their bachelor thesis about an industry topic within China. Internships for foreign students are also difficult to organize. Reducing and simplifying these rules could help to better prepare German students for the Chinese market.

As described, German companies in China rather focus on high-tech products in the premium segments at higher prices. Developing products on a slightly lower level promises a large market, and thus can be used to distinguish and protect the own premium segment. On the other hand, entering the standard product segment may be danger ous since it may spoil the company's reputation as a provider of premium quality.

Another significant challenge for German companies in China is caused by the rapid rise of salaries, especially at the east coast. Until date, wages of managers and employees with special qualifications have increased to a level comparable to the German one. The wages of other employees are rising with approximately 15% per year. This development urges companies to increase their productivity in order to keep company-wide productivity on a stable level.

Many companies see great opportunities in automation to increase productivity. According to a study, the use of robots will help the automotive industry, electrical industry and mechanical and plant engineering the most. China still has to increase their efforts for automation technology. For example there are 30 robots per 10,000 employees in China (2013), while in Germany there are still almost ten times as many (282 robots per 10,000 employees).

(Fiducia Management Consultants, 2014)

One interview partner mentioned structural changes in the Chinese economy as a further challenge. Whereas the Chinese economy is currently shaped by investments and manufacturing industry, the services industry is expected to experience a strong upswing in the future. Here, the challenge is to find suitable growth niches.

Other future challenges in China include the growing problem of environmental pollution due to high emission levels in Chinese cities. Another challenge may be the emerging taxation on the import of high-tech components to China, which could lead to uneconomical manufacturing of these parts in China.

The Chinese market offers diverse strategic growth fields in technology to invest and expand. Within this context, automation technology was regarded as a technology which will become increasingly important due to rising labor costs in China. Further future technology fields that were pointed out by experts entail environmental technology and renewable energies, water treatment and purification, medical technology, the entire services industry, the automotive industry, and the electric mobility sector.

In particular, the sectors that are protecting the environment are important for German companies, which can provide the necessary know-how. In their 12th five-year plan, the Chinese government set high goals to improve the use of natural resources, reduce CO_2 emissions and invest in renewable energies.

According to one German company, water purification was stated to be a "gold mine" for German companies. China features both water-rich and water-poor regions, and is starting to take the environmental awareness of its citizens into account more carefully. The Chinese government classifies environmental protection and especially water resources as an extremely important topic.

Summary

Business models, competencies and human resources

Several of the companies that participated in this study can be associated with the fields of automotive and mechanical engineering, as well as with electronics, chemicals, and metals. Many of the surveyed companies from B-W already target China as an *important sales market*, or have set up *manufacturing or even R&D activities in China* in the meanwhile. The Chinese companies in this study thus far primarily remain located in China. Many of them do not sense a strong need for local engagement abroad yet, although they do target the international markets in order to export their products. However, they state that the Chinese market still offers sufficient growth potential. Another difference is that companies from Suzhou have lower levels of vertical integration of value-added processes than their counterparts in B-W. Therefore, it can be concluded that developing a network of suppliers and local sourcing in Suzhou is of strategic importance.

A challenge that was stated by companies in China in general, regardless of size, was *employee recruitment and retention*. In China, employee fluctuation still is a major challenge since staff members are willing to change companies for slightly higher salaries. Competitors actively recruit key personnel from both, blue- and the white-collar sector, to profit from company-internal knowledge that was passed on to these employees. Therefore, staff retention measures such as development opportunities in the form of free trainings as well as team building activities are being implemented by several companies to prevent this. Additionally, building up a foundation of trust by transferring responsibilities to key employees is seen as effective countervailing measure. Finally, sufficient payment proves to be another important incentive, leading to wage levels comparable to the German ones for management and highly-specialized staff positions.

The German *dual education system* is highly praised, but missed in China at the same time. German businesses in China report a structural lack of employees with a mid-level practical technical education or a dual education on a university level.

In Chinese locations of Germany companies, *management positions* are mainly occupied by German expatriates, thus facilitating easier communication and close cultural ties with the foreign location site for the headquarters in Germany. However, attention should be paid to different leadership styles and the management of cultural differences. Therefore, employees with experience in Chinese culture may deal with these differences more easily.

> *"The risk of missing out on China is greater than the risk of being part of it."*
>
> Heinrich von Pierer, former CEO Siemens AG, 2006.

The *lack of employees with a mid-level practical technical education* is being addressed through several measures in SIP. Firstly, several vocational schools have set up a coordinating council for vocational schools in Dushu Lake Education District in 2006, thus supporting and assisting existing as well as new vocational institutes. Secondly, several foreign companies have implemented their own vocational education in their Chinese locations, such as Robert Bosch GmbH. (SIPAC 2014c)

Good management practices and motivated employees are regarded as an essential success factor by Chinese companies. On top of that, more and more Chinese companies and MNCs in China expect their employees to show *technology affinity and research ability* in order to keep up with the international pace in their field of technology. In the past, many Chinese employees already showed a high technology affinity, but often lacked creativity and the ability to work independently. (Weldon & Vanhonacker 1999) In some industries, such as biotechnology and IT, high-qualified employees that were educated abroad are specifically targeted with attractive job offers to return to SIP (SIPAC 2014a).

Customers

Companies from both, B-W and SIP state high importance to *maintaining solid and stable customer relationships*, but often do so in different ways. The majority of companies are paying attention to fulfill individual customer solutions, and state that *tailored manufacturing* is important to adapt to customer requirements. Nonetheless, this may sometimes prove to be challenging, particularly due to the fast pace at which the Chinese market is moving.

A major challenge for German companies which operate in China is formed by the *lack of technical knowledge on the customer side*. Furthermore, German and European technical processes are sometimes not sufficiently understood by Chinese customers.

The German companies in SIP mainly operate in the regional market. The attractiveness of the Chinese market as a sales destination can be explained by its growing GDP rates and the increasing spending power of Chinese customers (Farrell, Gersch & Stephenson 2006). Due to the stagnating economic growth in Europe, countries with high GDP growth rates such as China are seen as attractive alternatives to generate turnover. A competitive advantage for the German companies in SIP stems from the *excellent reputation* which ‘Made in Germany’ enjoys among Chinese customers.

For Chinese companies, quickly reacting to customer preferences is becoming increasingly important. A shift *from low-end, mass market products toward high-quality, high-tech, and individual solutions* can be observed. Customer focus and product tailoring are becoming more and more relevant in the process of product development.

Several Chinese companies in SIP already broadened their horizon to the international market, and specifically *target the international export market* for their products.

Competition and competitive factors

The Chinese market is already *highly competitive* in most industry sectors, with the exception of specific *niche markets and premium market segments*. Several highly specialized German companies operating in China may be seen as market leaders in certain niche markets. The *lower level of labor costs* may still be seen as competitive advantage for companies operating in China. However, the level of labor costs is rising fast on the Chinese east coast, with wages for highly-qualified and management personnel already having reached European levels. Therefore, companies operating in the low-cost manufacturing industry are already considering relocating to China’s west or to other countries such as Bangladesh, Indonesia, and Vietnam. The Chinese government’s ‘Go-west-strategy’, which was launched in 2001, actively encourages companies to expand to China’s west by building up sufficient infrastructure and offering tax benefits. (Moody, Hu & Ma 2011)

Companies from B-W have a good reputation, especially with regards to *product quality and adaptation to customer needs, technological know-how, innovation affinity, and high customer service levels*. These competences are seen as competitive advantages for companies from B-W. Most of the interviewed companies target the *premium market segment*, where there is a large demand for high-quality and highly innovative products. The technological lead in certain industry sectors, however, is diminishing. In the automotive industry for instance, the lead is currently estimated at two to three years. For certain standard products, it does not even exist anymore.

Chinese companies stand out by their ability to achieve *short delivery times and lower prices* than their competitors, especially for standard products. The surveyed companies from Suzhou attach more value to achieving low price levels than their counterparts from B-W. This may be due to the reason that the competition is oftentimes characterized by *high cost pressure* at sometimes unrealistically low prices, especially from other regions in China. One example of an industry with such heavy price competition is the textile industry. Foreign companies usually avoid these highly-contested industries with low profit margins, and focus on high-tech industries where they can excel by specialization and high quality instead. Yet, a *changeover can be observed* among the surveyed companies in Suzhou, by whom product quality and innovative products are already being regarded just as important as by their counterparts in B-W.

Implemented technologies

Companies in both SIP and B-W pursue *continuous innovation strategies* through the progressive development of new products for their portfolio. To maintain this innovation progress, not only the products themselves are subjected to continuous improvement, the technologies with which they are produced are as well. Exemplary *production technology improvements* are technologies for energy and material efficiency as well as the implementation of integrated IT systems. Especially in sectors with high production standardization such as the automotive industry, Chinese and German companies mostly use the same machines and production technologies already.

The *technologies that are implemented the most* by companies from B-W include *energy efficient technologies and integrated IT systems* for production planning and simulation, both of them being used in more than half of the surveyed companies from B-W. *Material efficiency technologies* are also implemented by more than half of the surveyed companies; followed by production technologies for *e-mobility and additive manufacturing technologies*, which are both being implemented by more than a third of the surveyed companies. The list is concluded by *cooperative robots* or other technologies to support human-machine interaction, and the use of *innovative procedures for processing new materials.*

Most of the *technologies are used to a similar extent* by the companies in Suzhou as by the B-W companies, except for e-mobility and energy efficient technologies, which are both used to a considerably lower degree by the surveyed companies in Suzhou than by their counterparts in B-W.

"If this was school, Suzhou Industrial Park would be top of the class."

Lim King Boon, vice president of the China Singapore Suzhou Industrial Park Development Group Co. Ltd (CSSD) regarding the economic performance of SIP (Shen 2014)

R&D activity and product innovations

Many German companies already perform R&D in China, as *the creation of new ideas also takes place globally* for companies which serve global markets. In this context, China is already regarded as source of innovation in important strategic growth fields, rather than a location where new ideas are merely absorbed and executed. Developing innovative content in China, however, often goes hand in hand with the *risk of product piracy*. In China, this risk is not only present for German companies; Chinese companies state to suffer from product piracy as well. However, product piracy also forms a threat in Germany, yet less than in China. Even though some high-tech products are very difficult to copy, cases where only the appearance of the hardware of a product was imitated in China have been reported, thus still harming the reputation of the respective original manufacturer. The scope of impact of the imitations ranges from being very damaging for a company to not posing any real threat at all, depending on the industry field and the specific situation. IPR protection is called upon to protect companies against product imitation.

Also, companies try to make it harder for competitors to copy their products by working on continuous innovations, thus remaining one step ahead of the competition. Therefore, it is not surprising that China experienced a boom in patenting and publication activity over the past 25 years (Guangzhou Hu & Jefferson 2009). Considering the total number of publications in the time period from 2001 until the mid of 2011, China was already ranked second in the world, after the USA; Germany ranked third (Scimago 2015). In patenting activity from 2012 to 2013, SIP reported a growth rate of around 15%. In comparison, the same number for B-W amounted to 2.3%. (DPMA 2014; SIPO 2015)

With 90%, a *very high amount of the surveyed companies in B-W actively pursue R&D*, and almost one third of them operate R&D locations in China. The average rate of turnover spent on R&D by the surveyed companies in B-W is 13%. From the German point-of-view, many innovations in China are still *cost-driven*. China and South-East Asia are regarded as important innovation drivers since the customer requirements differ from those in western countries. B-W itself can be regarded as *one of the most innovative regions in Europe*, and one of the most innovative regions globally (Statistisches Landesamt B-W 2014b).

The amount of R&D spending as a percentage of GDP is high in B-W, at 5.1% of GDP in 2011. Thereby, 80% of R&D spending was contributed by the commercial sector. (Statistisches Landesamt B-W 2013)

More than three quarters of the surveyed firms from B-W considered themselves product innovators, a little less than three quarters even consider themselves market innovators. Most of the product innovations stem from the fields of e-mobility, environmental technology, and new materials. In comparison, bio- and nanotechnology are named to a lesser extent, but are nonetheless mentioned by a remarkably high amount of surveyed companies, given the fact that these are specific niche technologies.

Likewise, the *R&D intensity among the companies in Suzhou is high*, with almost 80% of the surveyed companies actively pursuing R&D. Like their counterparts in B-W, the surveyed companies in Suzhou spend on average 13% of sales on R&D. For Chinese companies, innovations are mainly driven by the *increased need to adapt to customer requirements*. Innovation is becoming an important core component of business models, and is starting to overtake low-cost manufacturing as the prevailing paradigm.

In SIP, 3.3% of GDP was spent on R&D in 2013. As stated by Chinese vice premier Wu Yi at the 9th Suzhou Industrial Park Joint Steering Council meeting 2007, GDP spending on R&D should be up to 5% by 2014. (SIPAC 2014b)

The companies from Suzhou are comparably innovative, with *more than three quarters referring to themselves as product innovators, and more than two thirds considering themselves as market innovators*. The fields from which most product innovations stem are generally similar to those in B-W. Notable exceptions are formed by e-mobility, which provides for less product innovations by the companies in Suzhou, and nanotechnology, which achieves a remarkably high rate within the Suzhou companies.

However, companies from nanotechnology and biotechnology rated themselves as product and market innovators less often than those from other industries.

German companies excel at achieving quality standards quickly and establishing high standardization levels to maintain high quality. This is necessary though, due to high innovation pressure from the Chinese side as in many technology fields the innovation lead of western based companies is diminishing or does not even exist anymore. Continuously launching new products has become essential due to strong competition and fast-changing market conditions. However, product launches may be impeded by local legislation. As one possible solution, MNCs generalize products and processes on a global level out of efficiency reasons, building on economies of scale. They then adapt to local requirements on the spot, thus standardizing when possible, and tailoring when adequate.

Other differences occur in environmental technology, which is also less important for product innovations in Suzhou, and the field of new materials, which is mentioned slightly more often as a field where product innovations come from.

The large Chinese sales market is characterized by many changes that are currently taking place. Firstly, it offers *many options for tailoring and customization*, since customer requirements partly differ from those in western markets. A shift in focus from low-end, low-cost segments toward higher-end product segments can be observed, which is also reflected in the process of product development: more high-end, tailored products are being developed instead of low-end mass products. Secondly, another shift is taking place from a technological perspective, and future technologies such as those used for “Industrie 4.0” purposes are gaining increased recognition. They find wide appeal in China due to the technology affinity of the Chinese market.

IPR protection

83% of the surveyed companies in B-W hold patents registered in Germany. In comparison, *a little less than half of them own patents in China,* which is a surprisingly high number since not every surveyed German company is competing on the Chinese market. Primary reasons for patenting are the *assurance of the own ability to act*, as mentioned by more than half of the participants from B-W. A little less than half of the participants from B-W implement patenting strategies to block competitors; however, this motive is more common for large companies. Patenting to generate license revenues as a primary reason is less important.

After Bavaria, B-W is the *federal state with the second largest number of invention patent applications* in Germany. Although patenting and publication activity are not increasing as fast as in Jiangsu, they continue to grow steadily at a stable pace. *Major patent applicants are large companies* such as Daimler AG, Dr. Ing. h.c. F. Porsche AG, and Robert Bosch GmbH. (Deutsches Patent- und Markenamt 2014)

The companies in Suzhou mention that the *blocking of competitors is the most important primary reason* for patenting. This reason is significantly more distinctive among these companies, with almost three quarters of the surveyed companies in Suzhou mentioning it as their primary reason for patenting. The *assurance of the own ability to act* and the generation of license revenues are less important as primary reasons. This shows the importance for companies operating in Suzhou of being able to bring innovations in the form of new or suitably adapted products to the local market and to block potential competitors and protect the relevant IPR for safeguarding their innovative knowledge.

The patenting activity in Jiangsu province is characterized by a *large surge in the number of patent applications* in the recent past. Contrarily to B-W, *universities*, such as Suzhou University (SuDa), *contribute a significant amount to patenting activity* in the province (Liu et al. 2012). Chinese economic policy has specified that universities should support the industry with their research (Hong 2008). In order to actively support IPR protection, SIP was designated as an IPR protection pilot zone by the Chinese government (CSSD 2014).

Patent analysis reveals that similarities exist in some of the fields in which patents are applied for in B-W and SIP. *Synergies occur especially in the industry fields of measuring and testing, basic electric elements, and electric communication technique* (Deutsches Patent- und Markenamt 2014; Liu et al. 2012).

Cooperation activities and future cooperation potential

Cooperation activities between firms and research institutions already take place locally and internationally. Although some challenges exist, there are several *promising future cooperation industry fields*. Additionally, support measures to connect companies, such as help desks, already exist. Difficulties within cooperation in China may arise due to *differing expectations from cooperation partners*, such as the fact that Chinese companies expect to learn from their partner through shared knowledge, which might be seen as a threat by foreign companies. Also, *challenges in supplier relations may emerge* due to quality and delivery time deviations that arise over time. A possible solution can be intensive supplier development, which on the downside may be resource- and time-consuming. Nonetheless, supplier relations on a local sourcing level remain attractive due to their cost saving potentials. Particularly in the automotive industry, high quality levels can already be guaranteed by Chinese suppliers at present due to high quality management and standardization levels in this industry.

When doing business in China, *personal connections are essential for success*. One way to forge these connections in the Suzhou areas is through the „Productivity Promotion Center", which is located in Suzhou. For SMEs in particular, entering the Chinese market may be challenging due to a lack of capacity. Therefore, entering a Joint Venture with a Chinese partner is a solid entry strategy for this type of company. In B-W especially, cooperation is supported through extensive vertical cluster networks with companies from the same industry (Buhl 2012). In SIP, clusters are also starting to emerge, and are already present in some industries, such as nanotechnology and biomedical technology (Biobay 2015; NanoGlobe 2011). *Cultural awareness problems* may influence the relationship with suppliers, clients, and employees. Managers should be acquainted with Chinese culture and be aware of the differences in leadership styles. Another important point is the importance of being able to cooperate on a *basis of trust*. Different perceptions, such as business activities which from a German point of view may be seen as corruption, should be dealt with carefully. Chinese authorities have more rigidly intervened in these activities in the recent past than before (Branigan 2015).

In B-W, clustering takes place on a vertical and horizontal scale, following a bottom-up approach. Existing industries are assembled into industry clusters. On top of this, state-wide coordinative cluster initiatives exist (Buhl 2012; Porter 1998). Contrarily to B-W, the Chinese cluster approach rather follows a top-down structure, meaning that clusters are specifically targeted and addressed to become a specialized cluster in one or more specific industries. Usually, they are also geographical, meaning that the cluster activities are concentrated in one location. The selection of geographical locations for a cluster takes place on the basis of a detailed assessment of the prevailing boundary conditions of the cluster area in order to assure that the area offers the right surroundings for the designated cluster industry, such as ports, infrastructure, and human resources (Porter 1998).

German companies expect their partner to be *reliable and to offer low logistics costs* when there is a geographical distance between the cooperating sites. *High product quality and technological competence* are also highly valued, and may be assessed by certifications in the field of quality management. Only large German enterprises are already cross-linked with Chinese universities and research institutions. For SMEs, this is not the case yet due to a lack of capacity and connections (Liegsalz, J., & Wagner, S. 2013).

Local sourcing cooperation is already pursued by the majority of German companies operating in China, but research cooperation has not become the norm yet. In contrast, *strong research networks with institutions in the country of origin do exist* for the companies from B-W. 82% of the surveyed companies in B-W maintain cooperation with research institutions, and a similar number applies to the cooperation with companies. Most of this cooperation takes place with companies in B-W or the rest of Germany. Around one fifth of the surveyed companies have established research cooperation with companies and research facilities in China; for Suzhou, of course, this number is lower, since Suzhou is just one city. Automotive companies, very large companies, and R&D intensive firms are more likely to maintain R&D cooperation to China. Production, procurement, and sales cooperation are not that common yet.

Cooperation potential

For Chinese companies, the most important qualities to look for in a cooperation partner include having the *right company size* to promote the companies' activities, e.g. in terms of increasing the customer base and supporting networking activities, and having *manufacturing experience*. Preferably, a partner should also *pursue R&D and comply with international standards*. Also, Chinese companies expect to *learn from a partner when entering a collaboration*, which can cause difficulties for non-Chinese partners due to know-how protection mechanisms.

In Suzhou, *research cooperation is not yet as common as in B-W*. Almost half of the surveyed companies partner with research institutions and more than 60% feature cooperation with other companies. These numbers are by no means low, despite being lower than in B-W, as one should keep in mind that B-W is a very strong and traditional industrial region with long-lasting collaborations and relationships in many different fields.

All in all, the greatest cooperation potential is expected by the companies from B-W in the fields of *environmental technology, water purification treatment and infrastructure systems, energy technologies* and *electric mobility*. Analogously, the fields in which the strongest competition is expected include *advanced manufacturing technologies, new materials* and *nanotechnology*. Overall, a pattern seems to emerge that the surveyed companies from Baden-Wuerttemberg see the *largest potential for future cooperation in technology fields related to crucial application areas*, namely those in which China envisages huge technical and societal challenges in establishing sustainable solutions. In contrast, *strongest competition behavior might persist in cross-sectional technologies* like advanced manufacturing or new materials, where the companies from B-W do not want to risk losing their competitive edge.

Among the Suzhou companies, the tendency to cooperation activities is noticeably higher in almost all of the surveyed technological fields. Likewise, the number of fields that are seen as a threat is considerably lower. More than half of the surveyed companies from Suzhou see a strong potential for collaboration or rather collaboration potentials than competition threats in *advanced manufacturing technologies,* followed by *energy technologies and new materials*. Also *e-mobility, environmental technologies, water systems, and "Industrie 4.0"* are mentioned as future fields for cooperation by one third to half of the surveyed companies. Several other technology areas were named by a quarter to a third of the responding companies as potential fields for future collaborations (*nanotechnology, medical technology, and biotechnology*). The surveyed companies from Suzhou particularly rated future collaboration potentials in *advanced manufacturing technologies, new materials and e-mobility significantly more positive* than their counterparts from B-W.

Globalization of manufacturing and R&D activities

Most of the companies – both German and Chinese – are *internationally-oriented*, except for several SMEs, which mainly operate in their country of origin. This is also shown by the fact that B-W is the German federal state with the third-highest export ratio of Germany, and that SIP contributes 30% to the entire import-export volume of Suzhou (Statistisches Landesamt B-W 2014a; SIPAC 2014b; Deutsche Bank Research 2014).

Of the surveyed companies from B-W, almost two thirds already have manufacturing locations abroad. *Almost half of the surveyed companies have manufacturing locations in China*. R&D locations abroad are also on the rise: with more than half of the surveyed companies having R&D locations abroad, and almost a third in China, a *tendency towards increased global innovation* can be observed. One tenth of the manufacturing employees of the surveyed companies is already employed in China, stressing the importance of the Chinese market.

Among the surveyed companies from B-W, more sales to China than purchasing from China can be observed, underlining the *importance of China as a potential sales market* and not primary a manufacturing or sourcing hub.

Location factors in Baden-Wuerttemberg and Suzhou

The companies from B-W which have manufacturing locations in China stated that the choice of a location is only partly influenced by key customers or important partners. Several advantages of SIP in particular were pointed out, including its *strategic geographic location* close to Shanghai and Nanjing, its *high level of education and high quality of life*, which also makes it attractive for expatriates. In addition, its *good transportation and infrastructure possibilities* are praised. These factors are partly similar to the strategic location factors of B-W, where *education, infrastructure and high quality of life* are also valued. Both regions also feature *high levels of industrialization and innovation as dominant growth drivers* (SIPAC 2011; Birkner 2013). Both areas can rely on *high university enrollment rates*, and have a large number of students and graduates (SIPAC 2013; Brugger & Wolters 2012). Whereas SIP targets geographic clustering of knowledge and innovation, these are spread more across the state in B-W. The bundling of advantageous location factors in SIP can be partly attributed to the targeting of SIP as a specific development zone by the government for certain specializations, such as environmental technology, nanotechnology, and biotechnology (Buhl 2012; Frattini & Prodi 2013).

The *most attractive location factors in B-W as viewed by the surveyed companies from B-W* include its excellent IT and communication infrastructure, its proximity to key customers, and its reliable political and legal frameworks. Also, the access to new knowledge and technical know-how as well as the strong cooperation with universities and research institutes are valued highly, in addition to the local transport infrastructure. Companies are also satisfied with the access to qualified suppliers, the attractiveness of the local market, the access to clusters, the possibilities for IPR protection, and the access to qualified employees – although the latter factor is already becoming increasingly difficult due to changing demographics. Location factors that form a challenge include the difficult access to raw materials, high personnel costs, as well as the public and private procurement practices for the allocation of projects, which may be due to stagnating economic growth.

Companies operating in Suzhou especially value the possibilities for IPR protection, the access to qualified employees and procurement practices in B-W more positively than companies from B-W. Also, the local level of labor costs in B-W was regarded slightly more positive by SIP companies. Factors in B-W that were rated significantly worse by Suzhou companies than by their counterparts from B-W include the proximity to key customers, the attractiveness of the local market, the local transport infrastructure, and partly also the access to clusters.

German companies operating in Suzhou state that the high attractiveness of the regional consumer market can be seen as the most important factor. Especially the region's high economic growth rate and its proximity to major hubs such as Shanghai provide for an excellent market environment. Other factors that are seen positively are the personnel costs and the proximity to key customers. A remarkable advantage of Suzhou is the fact that *cooperation with local authorities* works more easily and faster than in other parts of China. Partly opaque legal-political frameworks and bureaucratic hurdles, the complicated search for qualified suppliers and access to clusters are still seen as challenging. The *search for qualified employees* may still be seen as challenging despite SIP's excellent education system.

Companies surveyed in Suzhou are rather positive about the quality of Suzhou as an industrial location. In particular, they rate the infrastructural framework conditions in transport and IT, the access to industrial clusters and the reliability of the political and legal framework conditions quite positive. On a lower level of quality, they also rated the potential for cooperation with local universities, the access to know-how, raw materials, qualified employees, and qualified suppliers relatively positive, as well as the most critical factors of IPR protection, and the local procurement and contracting practices for public and private projects. The location factors that were viewed more negatively form the surveyed firms in Suzhou than from the surveyed companies in B-W were those regarded as most positive by the companies from B-W: labor costs, the high attractiveness of the local market, and the proximity to key clients.

Review and general outlook

Although there are challenges paired with doing business in China, the *general outlook is a very positive one* – as well for China in general as more specifically for SIP. The numbers alone speak volumes: every second day, a foreign company commences business within the boundaries of SIP (SIPAC 2014b). Whereas German GDP growth rates follow a slow, but stable pattern, the strong GDP growth rate of China over the past decade alone has attracted many investors to the Middle Kingdom. China has become a leading export nation, and was the largest recipient of FDI during the last decade (UNCTAD 2015). In the end of 2014, the Economist predicted that China will overtake the USA as the world's largest economy by 2021 (The Economist 2014).

Notwithstanding, there is more beyond the surface than just success stories and projections of virtually unlimited growth. Companies dealing with China are also facing challenges. Many of the challenges that emerge, however, can be dealt with accordingly by sufficient preparation and awareness with regards to important cultural and economic differences. Some of the challenging factors for German companies in China include *bureaucratic hurdles*, the search for *qualified personnel*, as well as *cultural obstacles*. German companies also stress that aspects requiring improvement include the *acceleration of import processes*, and *easier access to China* for German students, e.g. to absolve internships. Also, further options for business contacts and *networking opportunities* could be improved.

Due to the fast speed at which the Chinese market is moving, some challenges are yet to arise or to diminish – it remains a certainty, however, that the Chinese market will encounter changes due to the transformations which are currently taking place and yet to come in the near future. Several factors that may become even more challenging are caused by the *increase in labor costs*, as well as by the related *need for an increase in productivity*. Due to strong labor cost increases in the east of China, several foreign companies are already considering to relocate to the west of China or to other low-income countries to decrease the operation cost level (Moody, Hu & Ma 2011). Increased use of automation and production technologies as well as "Industrie 4.0" related technologies may also pose a solution. This may also provide new opportunities for the German and B-W machinery and equipment industry as a provider of productivity solutions. Secondly, the expected *increase of import taxes on high-tech components* could create a market environment in which relocation to China becomes more attractive for high-tech companies that are reliant on such components. Finally, the *high pollution levels* will trigger a much-needed increase of environmental awareness. This will create possibilities in environmental technology on the one hand, but will make it more difficult to find expatriates that are willing to work in such an environment. Other industries that will be "positively" influenced by the local pollution issues are water treatment and purification, medical technology and renewable energies. Due to the increasing spending power of Chinese consumers, the automotive industry will continue to grow and especially electric mobility will pursue a spot in the limelight of the automotive field.

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