



# *Tooling in Germany*

2016

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Wolfgang Boos  
Michael Salmen  
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Lars Johannsen  
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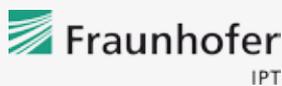
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## Laboratory for Machine Tools and Production Engineering (WZL) of the RWTH Aachen University

Across the world the Laboratory for Machine Tools and Production Engineering (WZL) of the RWTH Aachen University with its 900 employees is standing for successful, forward-thinking research and innovation in the area of production engineering. In four different fields, research activities not only relate to fundamental theories and findings, but also to the application of findings in an industrial context. Furthermore, practical solutions are developed to optimize production. The WZL covers all sub disciplines of Production Technology with its four chairs Production Engineering, Machine Tools, Metrology and Quality as well as Manufacturing Technology.



## Fraunhofer Institute for Production Technology IPT

The Fraunhofer Institute for Production Technology IPT, located in Aachen, combines knowledge and experience in all fields of production technology. In the areas of process technology, production machines, mechatronics, production metrology and quality as well as technology management, the IPT offers partners and customers tailor-made solutions and immediately actionable results for modern production. Together with WZL and WBA the IPT conducts benchmarking projects in the tooling industry focusing on the technological capabilities of tool shops.

## Imprint

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## Spotlight



Germany is one of the most important producers of tools and dies worldwide. Due to globalization, new markets and therefore new possibilities to increase the revenue arise. In the last ten years an increasing number of international tool shops has entered the market which has shaken the supremacy of German tool shops. The German tool and die industry has reacted to this development with measures designed to increase efficiency while also maintaining high quality standards. The study “Tooling in Germany” provides an overview of the German tool and die industry as well as current challenges and trends of the tool making sector. The study shows the development and status quo of German tool shops with regard to the dimensions product, process and resources.

**~ 3,800**

**... is the current  
number of German  
tool shops**

**4.8 bn. €**

**... was the total revenue  
of German tool shops in  
2014**

**1.8 bn. €**

**... revenue was  
generated through  
exports in 2015**

**72 %**

**... of German mold  
manufacturers have  
less than 50 employees**



# Excellence in Production

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The competition “Excellence in Production” for the “Toolmaker of the Year” is an institution within the tool and die industry. Since 2004, the Laboratory for Machine Tools and Production Engineering (WZL) of the RWTH Aachen University and the Fraunhofer Institute for Production Technology (IPT) are comparing the best tool shops in German-speaking countries every year in order to support the productivity and awareness level of the tool and die industry. The overall goal is to increase the competitive ability of tool shops by “learning from the best”.

In order to participate in the competition “Excellence in Production”, companies need to fill out a questionnaire as extensively as possible. The questionnaire is available to any company in the tool and die industry. The two research institutes then use the resulting information as a basis for determining key figures. Based on these key figures, the companies are ranked. For a better comparability, the evaluation is divided into four categories, each composed of the kind of market access (internal or external) and the number of employees (more or less than 50 employees). Following the evaluation, the tool making experts from WZL and IPT visit the top four companies in each category to carry out a detailed on-site audit. Based on the results from the questionnaire and the impressions gained during the audit, a judging panel with representatives from the industry, politics, associations and science nominates finalists, category winners and the overall winner for the “Toolmaker of the Year”. The award ceremony is traditionally held in the Coronation Hall of the Town Hall of Aachen on the evening of the international colloquium “Tool and Die Making for the Future”. **After the award ceremony, every**

**participant of the competition gets their individual key figures.**

In total, 295 tool shops participated in the competition of 2015. Almost half of the participants (44 %) were small, external tool shops, followed by large (24 %) and small (22 %) internal tool shops. 10 % of all participants were large external tool shops. The product range of the participating companies was very heterogeneous and included injection molds (51 %), sheet metal forming tools (30 %), massive forming tools (15 %), die casting tools (5 %), elastomer tools (2 %) and other tools (11 %) (multiple selections possible).

In 2015, 15 companies asserted themselves in the first round against the rest of the competition and were audited by a team of experts from the WZL and IPT. The visited companies distinguished themselves through high organizational and technological performance. The increasing implementation of digitization solutions, new business models and internationalization of businesses should be highlighted with regard to organizational performance. Regarding the technological aspect, the increasing realization of individual automation solutions as well as the implementation of additive manufacturing processes in the process chain should be emphasized. The 2015 competition demonstrated that the German tool and die industry is constantly evolving. In order to win the competition “Excellence in Production” for the “Toolmaker of the Year”, a company needs to convince the jury technologically along the entire process chain and be excellent with respect to finances, organization and strategy. More information about the competition can be found at [www.excellence-in-production.de/en](http://www.excellence-in-production.de/en).





# Executive Summary

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Germany is known worldwide for its seal of quality “Made in Germany”. Around the globe, German products are seen as premium quality. This understanding is not limited to products manufactured in series production, which are used daily in households; it also includes other industrial products, such as machines, equipment and tools. Among the international competition, the German tool and die industry in particular has a reputation for manufacturing high-quality, efficient tools with high production stability. However, the named aspects have their price: due to high wages, tools from Germany are some of the most expensive as compared to international standards. German tool shops are nowadays facing the challenge of selling their tools to large series manufacturers on a price-driven market and simultaneously beating national and international competitors. Furthermore, due to the increasing internationalization of producing companies, German tool shops need to compete more and more with local tool shops from low-wage countries. The goal of German tool shops should still be to distinguish themselves with higher productivity and process competence. The study “Tooling in Germany” conveys an impression of Germany as a nation of tool making as well as the development and status quo of the performance of German tool shops.

The German tool and die industry consists predominantly of small and medium-sized companies: almost 72 % of the about 3,800 tool shops have less than 50 employees. The focus lies on the manufacturing of injection molds and sheet metal forming tools. As measured by the production value, Germany was the top manufacturer of tools in Europe in 2014.

In particular, German tool shops are characterized by tools with a high surface quality. This quality leads to a reasonable, but comparatively higher tool price. The high quality can also be identified within the value creation process, which is reflected in an exact cost calculation, suitable development processes, systematic subcontracting

within all manufacturing technologies and high competencies in assembly and try-out. German tool shops are always looking for young, skilled workers due to the aging demography and invest continuously in their resources to improve productivity.

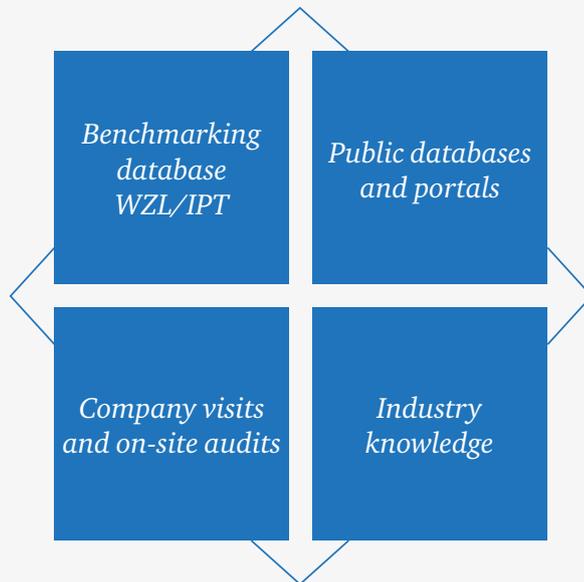
The Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University and the Fraunhofer Institute for Production Technology (IPT) have many years of experience in the tool and die industry. The joint execution of numerous industry and research projects with German tool shops provides both institutes with an insight into the status quo of the industry as well as current challenges and trends. The categorization of the productivity into the dimensions product, process and resources, developed at WZL and IPT, has established itself for evaluating the performance of tool shops and is picked up in this study.



**Germany was  
#1  
in tool production in  
Europe 2014**



# Study Design



The study “Tooling in Germany” describes the performance of German tool shops with regard to the dimensions product, process and resources. The study consolidates relevant key figures of the German tool and die industry from 2015 and delivers insight into future challenges and trends of the industry. The study results are based on datasets of German tool shops from the world’s largest database of the tool and die industry worldwide. The mutual database of WZL and IPT includes over 1,000 datasets of German tool shops gathered within the last 5 years and over 2,000 datasets of international tool shops. The German datasets are partially a result of the competition “Excellence in Production” for the “Toolmaker of the Year”. On the other hand, data from joint benchmarking projects of German tool shops is included in this study. Another part of the study results from published data of the tool and die industry. Sources are publicly available databases and portals, for example Comtrade, Eurostat, Hoppenstedt and data from the VDMA. Furthermore, industry knowledge from the tool making experts of WZL and IPT is also included. This knowledge is derived from company visits, on-site audits, expert discussions as well as industry

and research projects.

The study “Tooling in Germany” gives a holistic overview of the development and status quo of the German tool and die industry. Based on the three dimensions

- Product
- Process
- Resources

a qualitative and quantitative assessment of the organizational and technological performance of German tool shops is illustrated. In addition, a description of current challenges and trends and their successful addressing is included.



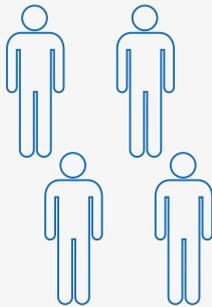
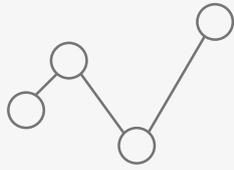
**The WZL/IPT database has gathered more than**

**1,000**

**datasets of German tool shops within the last 5 years**

## Industry and Current Trends

*[Germany is the largest economy in Europe.]*



About  
**43 million**  
employed people  
in Germany in 2015

With a gross domestic product (GDP) of around 3.0 tn. € in 2015, Germany is the largest economy in Europe. The tertiary service sector is the most important part of the GDP with 69 %, followed by the industry with 30 %. In total, 43 million people were employed in Germany in 2015. The industry is characterized by a mixture of internationally operating companies as well as small and medium-sized enterprises, in which the latter are often hidden champions in their métier.

The German economy is currently the third-largest importer and exporter worldwide. In 2015, Germany exported goods with a value of 1.2 tn. €. The most important export goods are motor vehicles and their components as well as machines and chemical products. In the same year, 948.5 bn. € worth of goods were imported, primarily data processing products, motor vehicles and their components as well as oil and natural gas. Germany's most important trading partner is the USA, exporting goods

worth 114.0 bn. € and importing goods worth 59.6 bn. €. The most important European trading partner of Germany is France. In 2015, the worth of goods exported to France was 103.0 bn. €, whereas goods with a value of 66.9 bn. € were imported into Germany. Further important trade partners are the Netherlands, China and the United Kingdom.

The economic growth of Germany has been positive since 2004, with exception of the global recession in 2009. Larger layoffs could be prevented in this time by reducing working hours. This flexibility allowed most companies to come out of the recession strengthened. Furthermore, there is a minimum wage of 8.50 € for employees in Germany since 2015. The German industry traditionally acts with a long-term perspective and hence could position itself very well in many diverse sectors. If this approach is also reliable in the fast moving electronics and software world, time will tell.



**3.03 tn. €**  
GDP of Germany in  
2015



**8.50 €**  
minimum wage per  
hour in Germany



**36,402 €**  
average yearly income in Germany

## [Three main trends will shape Germany's future.]

The development of Germany will be shaped by three main trends, which will have a lasting effect on the business activities of German tool shops.

### Globalization

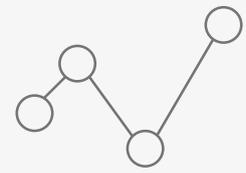
The increasing international integration of industry and the rising competition from Asia, Eastern Europe and South America with aggressive pricing strategies and competing technologies are a consequence of globalization. In the future, this will highly influence the German manufacturing industry and especially the tool and die industry. However, globalization also offers chances to open up new markets, resource availability and new customer segments. Already 45 % of the world population live in China, India, Indonesia, Pakistan and Bangladesh. Producing companies need to consider this clientele in their product design and their creation of value more and more.

### Demographic Change

The German Federal Agency for Civic Education forecasts a population decrease of 7 million by 2050 of the current 81 million people. Reasons include low birth rates in international comparison. Due to the aging working population, new concepts need to be developed to involved older work force in the production of the future. Tool making is very personnel and knowledge intensive and is therefore highly influenced by the demographic change.

### Industry 4.0

After mechanization, electrification and automation, manufacturing companies are on the verge of the fourth industrial revolution. The basis for Industry 4.0 is the close to real-time availability of all production-relevant information. By linking human, machine and object, value creation networks are created. The networking of product and machine saves resources, lowers costs and raises efficiency. Through intelligent monitoring and transparent processes, manufacturing companies can react quickly and flexibly with their production in case of market changes. Intelligent products and machines also gather production data, thus allowing the development of new solutions and the optimization of production processes. The basic requirement for a successful and sustainable implementation of Industry 4.0 applications is digitization. The entry of digital devices into daily life serves as an example for the industry to digitalize administrative and production-related tasks. Even partially automated tool shops still offer large potential for digitization. According to a study, German companies will invest about 10.9 bn. € into digitization solutions until 2020. German tool shops can only confront the rising complexity and faster interaction with an advancing digitization of the value creation process. For the tool and die industry, digitization is of special importance in order to build up value creation networks in the context of Industry 4.0.



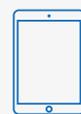
**45 %**

**of the world's population live in China, India, Indonesia, Pakistan and Bangladesh**



**8.6 %**

**is the estimated decline of Germany's population until 2050**



**10.9 bn. €**

**will German companies invest into digitization solutions until 2020**



# The Tool and Die Industry

*[72 % of all German tool shops employ less than 50 employees.]*



By international comparison, the German tool and die industry has a leading position with regard to the quality of tools. Measured by the number of companies and employees, the German tool and die industry is a small industrial sector. Around 3,800 tool shops with approximately 54,000 employees currently do business in Germany. Of these companies, 72 % employ less than 50 people and only 1 % more than 100. This emphasizes the fact that the industry is mainly composed of small and medium-sized companies and is characterized by a strong heterogeneity and fragmentation. German tool shops with a larger number of

employees are mainly internal tool shops in the automotive industry. By international comparison, this employee distribution is also representative of other countries, such as China. The share of tool shops with revenues of less than 12.5 m. € per year is 83 %. Revenue is mainly generated through the manufacturing of sheet metal forming tools, massive forming tools, injection molds and various services. The market access of German tool shops is almost equally distributed, with 47 % external and 53 % internal.



**~ 3,800**  
tool shops exist in  
Germany

## Market Access

**72 %**  
of all companies employ  
less than 50 employees



**28 %**  
of all companies employ at  
least 50 employees



**54,000**  
people work in the  
German tool and  
die industry

**83 %**  
of all companies have revenues  
of less than 12.5 m. €



**17 %**  
of all companies have revenues  
of more than 12.5 m. €

**53 %**  
of all companies are  
internal tool shops



**47 %**  
of all companies are  
external tool shops



## [The German tool and die industry is the European production champion of 2014.]

With a production volume of around 4.8 bn. € in 2014, Germany is the largest producer of tools in Europe. Approximately 1.8 bn. € worth of the produced tools was exported in 2015. Premium German tools are highly demanded abroad. Injection molds worth 890 m. €, sheet metal forming and massive forming tools worth 804 m. € and other tools worth 97 m. € were exported in 2015. Furthermore, 1.2 bn. € worth of tools were imported into Germany, the majority was injection molds worth 700 m. €. Tools for sheet metal forming and massive forming (457 m. €) as well as other tools

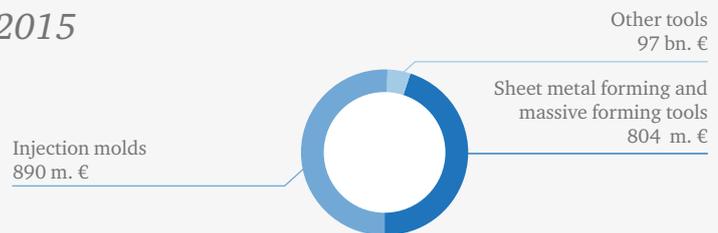
(86 m. €) were also imported. The most important trading partners for tools are China, USA, Italy and the Czech Republic.

A distinguishing feature of the tool manufacturing in Germany is the precise production of highly complex and expensive sheet metal forming and massive forming tools for the automotive industry. This precision is secured by the excellent quality and reliability of machine tools produced in Germany as well as the spatial proximity to corresponding manufacturers.

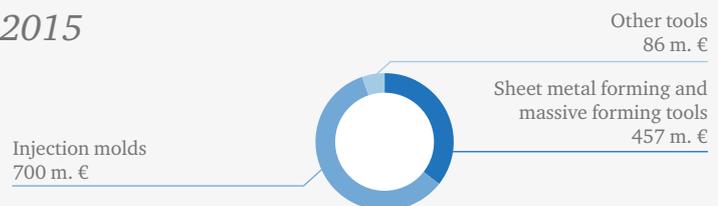
### Top 5 tool and die producers in Europe 2014



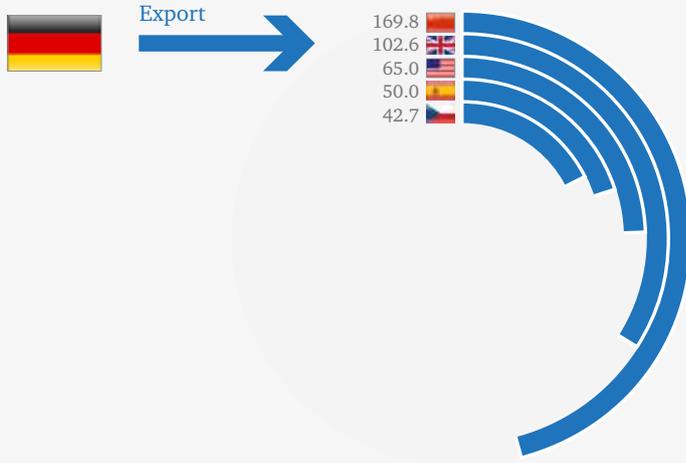
### Tool exports 2015



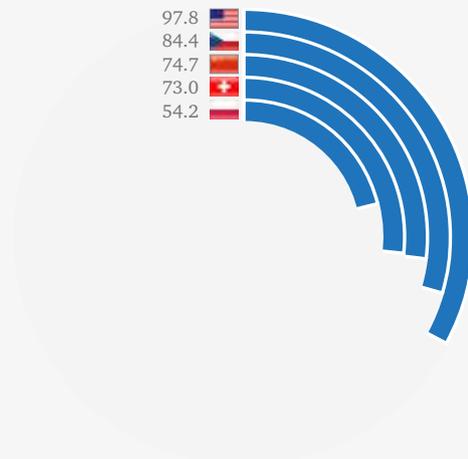
### Tool imports 2015



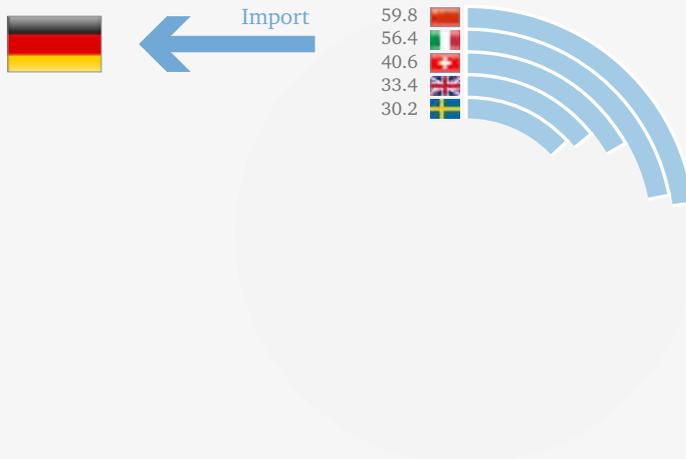
*Export sheet metal forming and massive forming tools in m. €*



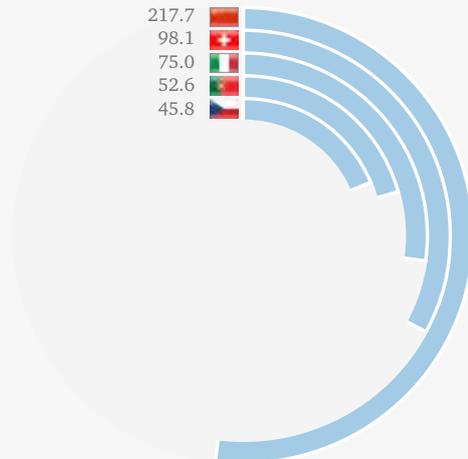
*Export injection molds in m. €*



*Import sheet metal forming and massive forming tools in m. €*



*Import injection molds in m. €*



With 169.8 m. € and 102.6 m. € respectively, the majority of exports of sheet metal forming and massive forming tools goes to China and Great Britain. Next are the exports to the USA (65.0 m. €), Spain (50.0 m. €) and the Czech Republic (42.7 m. €). The majority of exports of injection molds goes to the US and the Czech Republic with respective export volumes of 97.7 m. € and 84.4 m. € China (74.7 m. €), Switzerland (73.0 m. €) and Poland (54.2 m. €) have the next largest imports of German injection molds. The main share of sheet metal

forming and massive forming tool imports are from China (59.8 m. €) and European countries like Italy (56.4 m. €), Switzerland (40.6 m. €) and Sweden (30.2 m. €). The import volume of injection molds is mainly from China (217.7 m. €). Another 98.1 m. € and 75.0 m. € worth of injection molds are imported from Switzerland and Italy. Portugal (52.6 m. €) and the Czech Republic (45.8 m. €) are the next largest sources of injection molds for Germany.



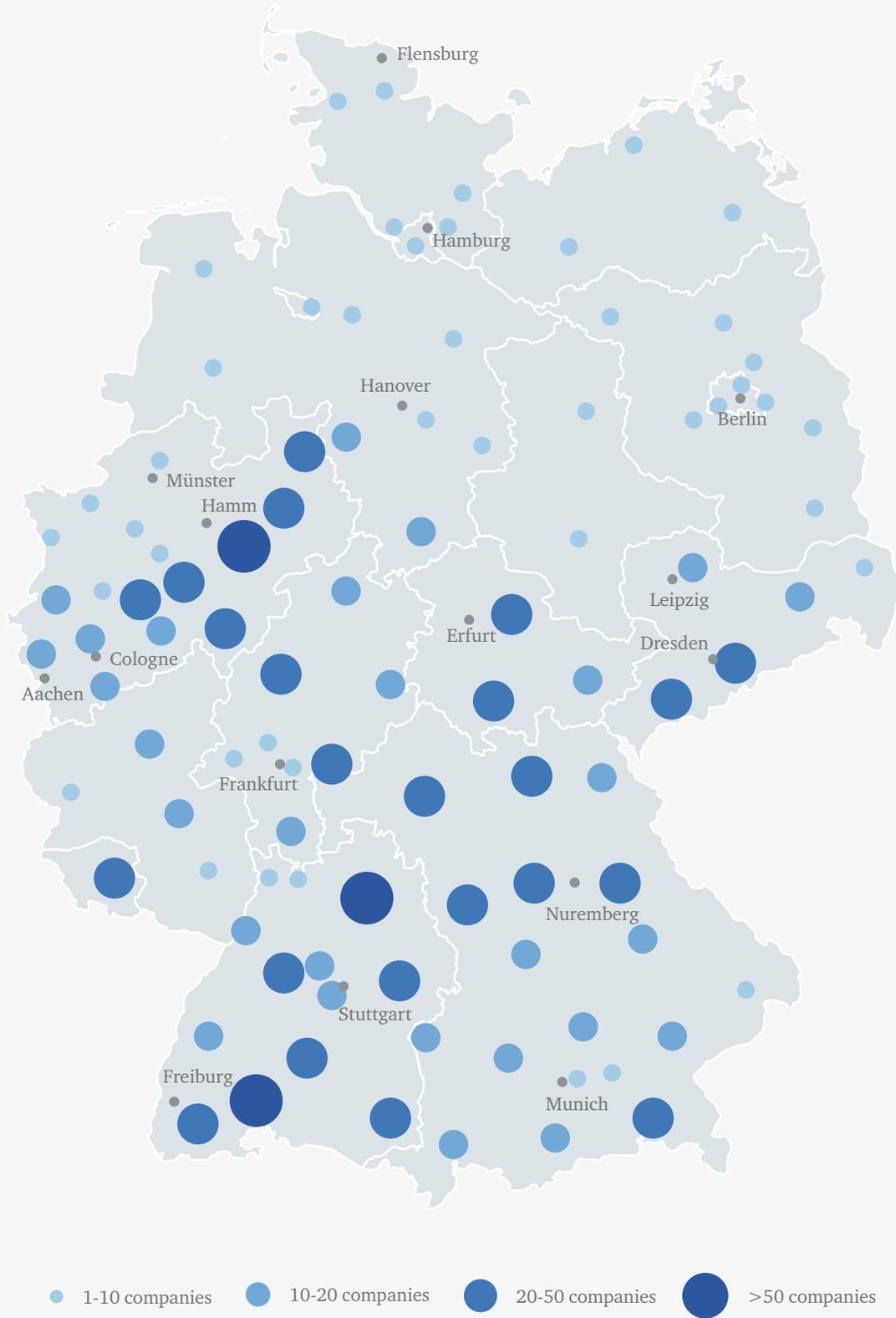
**47.2 %**  
**of German tool shops**  
**are in Bavaria and Ba-**  
**den-Württemberg**

*[Almost half of the tool shops are situated in South Germany.]*

The German tool and die industry has a tendency to accumulate in regional hot spots. In particular, there are many tool shops in Baden-Württemberg around Stuttgart and other locations, east Westphalia, south Westphalia, and the High Rhine area. The region around Franconia and the Upper Palatinate are also highly influenced by the tool and die industry. It can be determined that clusters are often close to the automotive OEMs or their suppliers. About

47.2 % of all tool shops are based in Bavaria and Baden-Württemberg, which means almost half of the tool shops are located in the south of Germany. Although less than in southern Germany, the Ruhr area and the Rhineland have a relatively high density of tool shops with an overall share of 13,8 %. Northern Germany, Brandenburg and Thuringia feature a comparatively low number of tool shops.

*Local distribution of tool shops in Germany*



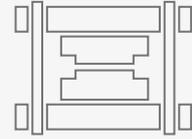


# Product

*[Large product diversity despite the high focus.]*

The tool and die industry in Germany has a diverse product range. While the industry focusses the production of tools for injection molding (53 %) and sheet metal forming tools (28 %), there are also companies that specialize in warm (9.5 %) or cold (7.5 %) massive forming tools. The internal focus on few or only one tool type leads to a high degree of focus in German tool shops. By comparison, Chinese companies often produce many different tools and are thus significantly less specialized. This focus cannot only be found in the product itself, but also within the manufacturing and administrative processes as tool shops concentrate

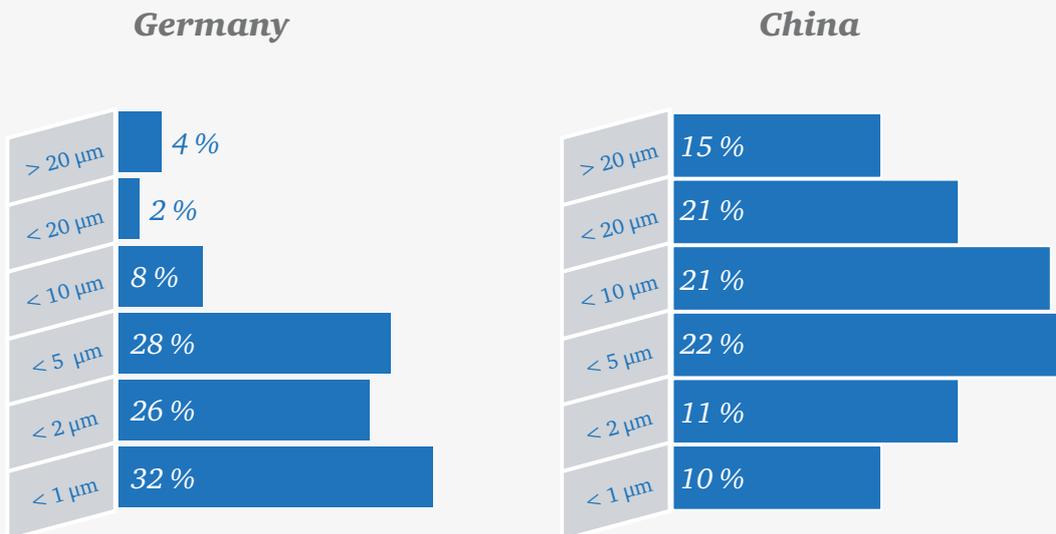
on core competencies in tool manufacturing and purchase other components and services from strategic partners. The diversity of tools can also be seen in the typical tool dimensions and weights. While injection molds are usually smaller than 1,000 mm x 1,000 mm and weigh less than 1,000 kg, sheet metal forming tools are larger and heavier on average. Regardless of dimension and weight, the surface quality achieved is largely below 1 µm. This is a definite difference to Chinese tool shops, which often only have an exactness of 5 µm on free-form surfaces.



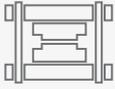
**32 %**

**of German tool shops manufacture tools with a surface quality less than 1 µm – in China it is only 10 % of all tool shops**

## Achieved Surface Quality in Comparison



Explanation: x % of all companies achieve surface quality of ...



## [Premium tools for reasonable prices.]

German tools have the reputation of being of very high quality but also very expensive. The average price of a sheet metal forming tool produced in Germany is around 22 % higher than in China. In the field of injection molds, Chinese tools are 36 % cheaper. This discrepancy cannot only be explained by a higher tool quality, which is why German tool shops are increasingly offering additional services to differentiate themselves from competition. They are often

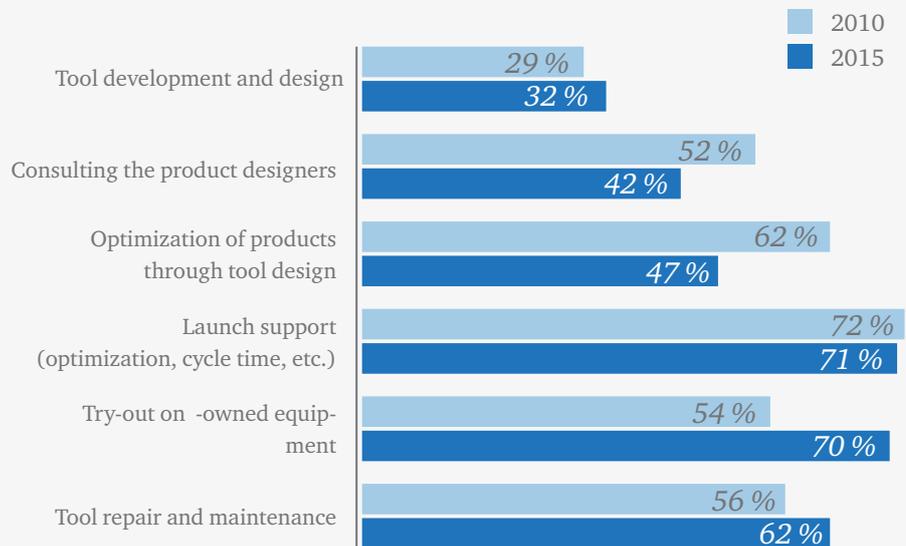
combined to so-called product-service systems, in which the tool as the core product is sold in combination with supplemental and life-cycle-accompanying services. The services offered by German tool shops have changed over the last few years. Nowadays, tool shops are less active as consultants and instead take over value creation processes from customers, especially downstream after the manufacturing of tools.



**36 %**

is the average price difference between Chinese and German injection molds

### Services offered by German tool shops\*



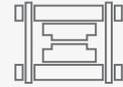
\*multiple selection possible

In the context of Industry 4.0, services for producing companies are getting smarter and smarter. In this sense, smart means data based. An increasing number of tool shops integrate sensor systems into their

tools. The overall goal is to monitor the tool's status during series production and thus being able to offer more process reliability to the customer to guarantee less downtime.

This can be achieved, for example, with a preventive maintenance of tools or by transmitting the information of a potential failure to the operator. The digitization of tools and tool components is a necessary requirement for the tool and die industry. But it has just begun and will gain importance

in the next years, also due to new information and communication technologies. In the future, this will be one of the central distinguishing criteria of German tool shops compared to foreign competitors.



## [Global is the new regional in tool making.]

While tool shops used to be part of smaller regional networks and produced almost exclusively for national customers, this strategy has changed significantly. In particular the international orientation of German tool shops has increased significantly in the last few years. A comparison of the revenue shares in 2010 and 2015 shows that Germany's share sank by 11.4 points while

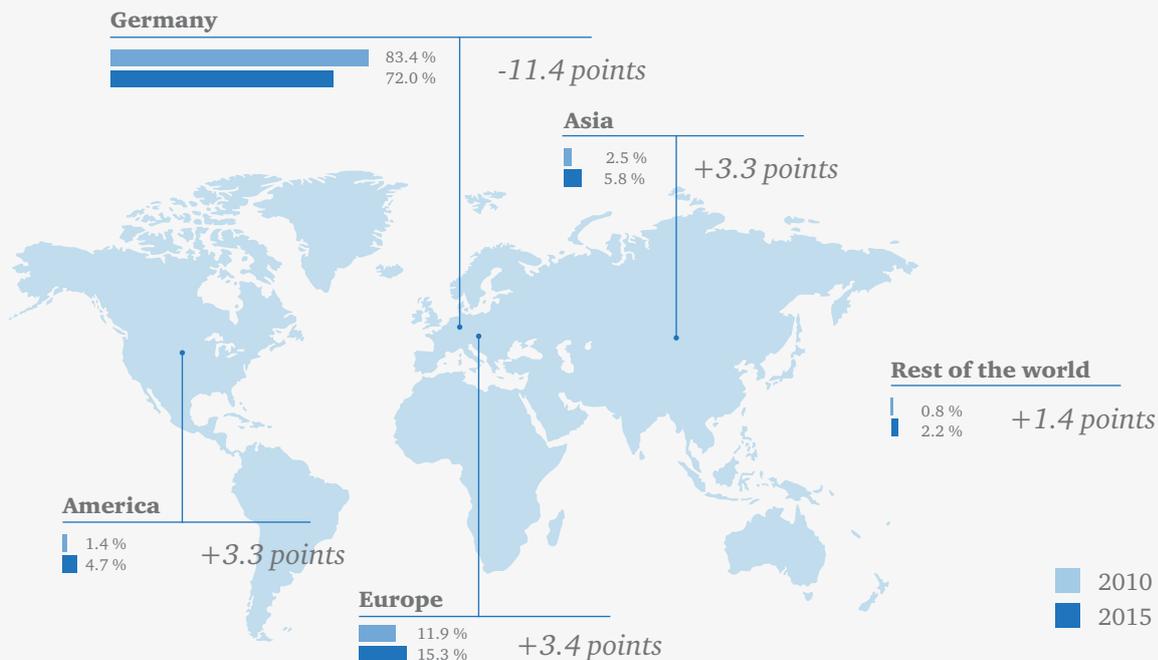
revenue generated in other European countries rose by 3.4 points. Also, the revenue share in Asian (+3.3 points) and North and South American (+3.3 points) countries as well as the rest of the world (+1.4 points) rose, meaning these markets are gaining in importance for German tool shops.

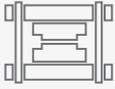


**29 %**

**is the increase of the revenue share that German tool shops generate in other European countries**

### Change of the global revenue share for tool shops





The increasingly global business activities of German tool shops demonstrate the worldwide demand for their products. However, this means that tool shops need to cooperate and network with international value creation partners in order to be able to offer services globally. For example, the international support for series production through maintenance and repairs is only possible if strategic partnerships with foreign value creation partners are

established or if tools in the series production can be monitored real-time from Germany. These challenges also result from the fact that many globally acting, German customers require tools and downstream services for all production facilities from one reliable partner. In order to guarantee quality. Therefore, many tool shops monitor their tools from Germany and have them serviced by local partners.

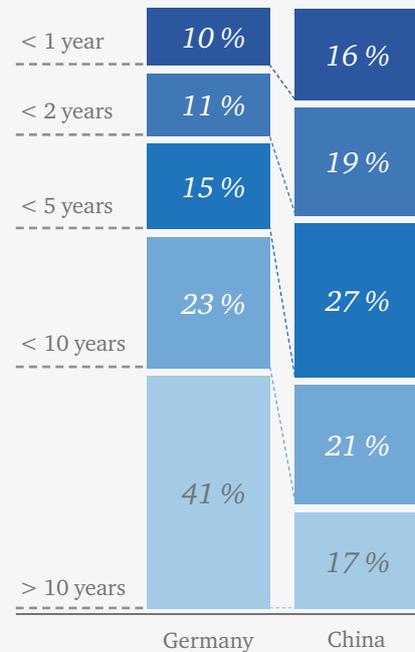
*[The tool and die industry as a loyal companion of the manufacturing industry.]*

Despite the strong internationalization of both customers of German tool shops and new competitors from other countries, it appears that products of the German tool and die industry are still in demand - locally and globally. Among other indicators, this can be seen in the duration of business relationships. 41 % of all business relationships

of German tool shops last longer than ten years. In China it is less than half that amount. At the same time German tool shops are focussing on acquiring new customers, with every fifth business relationship existing for maximum two years.

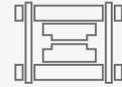
It can be seen that, next to establishing

*Duration of business relationships in Germany in comparison to China*

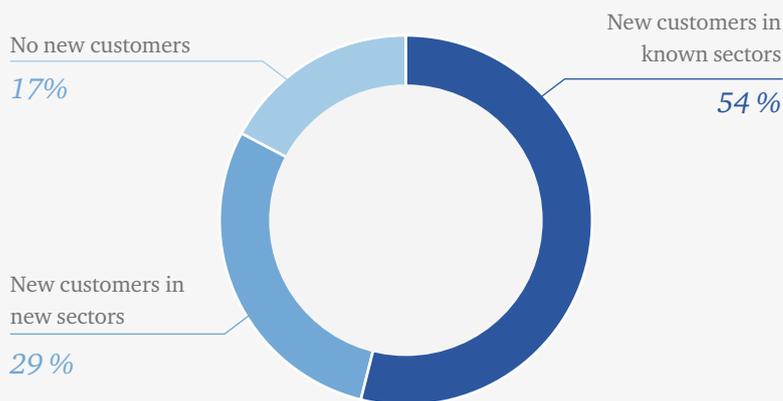


long-term business relationships, German tool shops are also managing to get new customers. The percentage of companies that were able to acquire new customers in new sectors was 17 %, while it was even higher in known sectors with 54 %. This continuous acquisition of new customers is an important process with regard to the diversification of

the customer portfolio and thereby decreasing dependency on individual customers. Furthermore, new customers boost the innovative ability of tool shops, since the product and process demands can clearly differ from customer to customer.



### *Percentage of tool shops with customers gained in 2015*





## Process

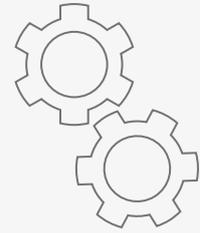
*[A high adherence to deadlines as an indicator for the process performance in the German tool and die industry.]*

The performance of tool shops is primarily shown by the mastery of the tools' manufacturing processes. The evaluation of the process performance is mainly based on the criteria cycle time and adherence to production deadlines. The average cycle time of a tool in German tool shops is 75 days. Of course, the cycle time highly depends on the type and complexity of the tools to be manufactured. Due to an accurate and dynamic planning, requirement-suited coordination of production capacities as well as a strategic integration of suppliers, the German tool and die industry reaches a deadline adherence of 76 %. This means

three of every four tools are completed on schedule.

The process begins with the draft of a quotation based on the customer request. On average, German tool shops require five days to react to the customer's request and send a quotation. The process of generating a quotation suitable to the request takes 4.8 hours on average. Therefore, German tool shops manage to answer requests from their average 5.4 main customers and potential new customers quickly and efficiently.

See study > Successful Calculation



**5 days**  
are needed to draft  
a quotation

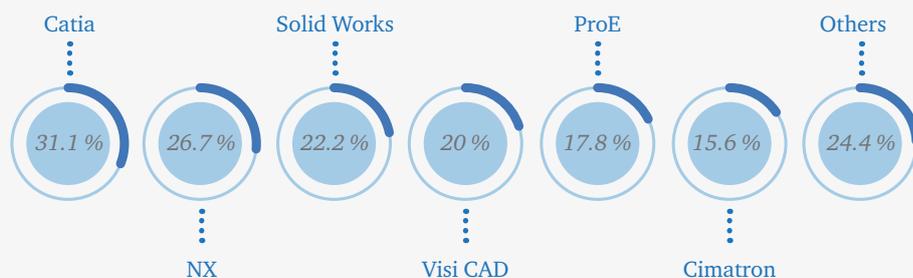
*[Development and design as competence entities in companies.]*

The German tool and die industry knows about its competencies in the upstream processes. Since 2004, between 10 % and 11 % of all employees are employed in the development and design departments. Various CAD systems are used for the design, even within the same company. Catia is the most common software (31.1 %), followed by NX (26.7 %) and Solid Works (22.2 %). Potential reasons for the simultaneous use of different

CAD systems can be the varying demands of customers or the different experiences of employees with each system. In total, 34.4 % of all project volume in development and design is being outsourced. This is done partially because of capacity shortages, but also to get new stimuli from external design engineers and use them in the company.



**11 %**  
of the employees work  
in development and  
design



\*multiple selection possible



*[On average, three days of training per year for employees in production planning and work preparation.]*

German tool shops have recognized the importance of a production planning in tool making which is suitable for their demands. In the areas of production planning and work preparation the German tool and die industry has successively built up employee capacities: Whereas the share of employees tasked with production planning or work preparation was at 6.0 % in 2004, it rose up to 10.6 % in 2015. That is an increase of 77 %. German tool shops have realized that production planning and CAM programming have increasingly gained in

relevance to manage the heterogeneous order spectrum of projectable new tools and unplanned repairs and change requests. The German tool and die industry is also aware of the complexity of production planning and work preparation in small batch production: On average, employees in production planning and work preparation have three days of internal and external training per year.

See study > Successful Planning



**77 %**

**increase in the share of employees in production planning and work preparation from 2004 to 2015**



**39 %**

**reduction of rush orders from 2004 to 2015**

*[13.3 different manufacturing technologies used by tool shops on average.]*

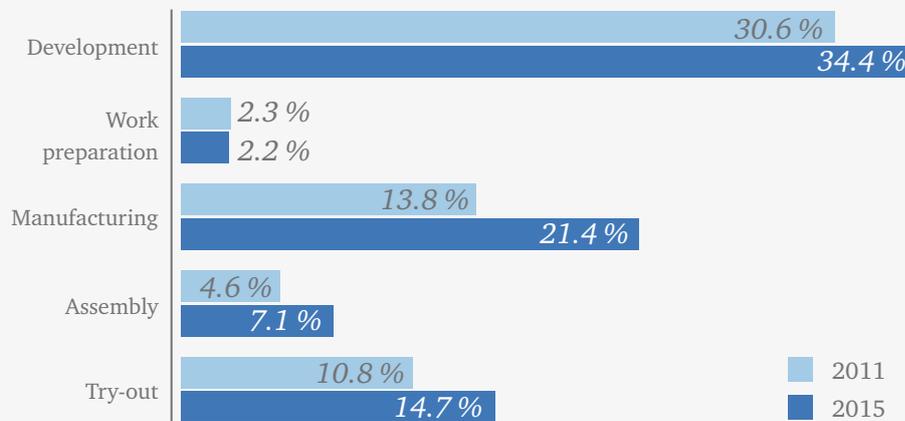
An important part of the performance of the German tool and die industry lies in the mechanical manufacturing department. The previously described, positive development of tool shops in recent years in production planning and work preparation can especially be seen there. The share of internal rush orders, which often result from static and inefficient planning, have been reduced from 32.4 % in 2004 to 19.9 % in 2015. This is a decrease of 39 %.

The German tool and die industry needs to compare itself constantly to Chinese competitors. There are large differences in the area of mechanical manufacturing. In Chinese companies, 8.2 different manufacturing technologies are utilized on average, contrasting to 13.3 in Germany. Hence,

German tool shops make use of a wide range of technologies in the manufacturing process. More differences between German and Chinese tool shops will be highlighted in the chapter focusing resources.

German tool shops increasingly use external value added partners along the entire process chain. Particularly, an order volume of 34.3 % in development and design work is placed externally. In manufacturing and machining the volume of external value creation is 21.4 % and in try-out 14.7 %. The share is even lower in assembly (7.1 %) and work preparation (2.2 %). With respect to the increasing integration of external value creation partners, German tool shops have reduced the number of main suppliers. While German tool shops had 21 main

## External value creation alongside the process chain



suppliers on average in 2009, the figure was continuously reduced to 16 main suppliers in 2015. The smaller amount of main suppliers leads to the conclusion that the tool shops developed a stronger focus on strategic suppliers as well as high-quality products and adherence to schedules of suppliers. This is seen by the data about correctness and punctuality of deliveries: In 2015, 92 % of all deliveries were correct while

88 % were on time. Nevertheless, German tool shops still have the potential to continuously increase the correctness and timeliness of deliveries throughout an intensive monitoring, auditing and further development of their suppliers.

## [Tripling of customer complaints in assembly and try-out.]

The departments assembly and try-out are knowledge intensive parts of the tool manufacturing process. The experience gained from numerous tool projects and the understanding of the employees for the tool's try-out are essential for a timely production and customer delivery. To achieve this goal, German tool shops employed every fifth worker in assembly and try-out (20.5 %) in 2015, which represents only a slight increase since 2009 (18.2 %). By increasingly integrating experienced

employees from production, German tool shops try to use their existing know-how to minimize the number of try-out loops. Currently there is potential among German tool shops to raise the customer satisfaction as the number of customer complaints nearly tripled between 2009 and 2015 from 5.6 % to 15.0 %. Possible reasons could be the rising number of customer demands as well as more complex tools with lower tolerance limits.



**15 %**

**of tools have customer complaints after the second try-out loop**



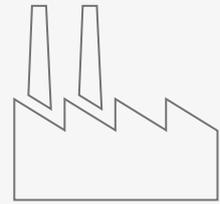
## Resources

### [High average age and only few trainees and young workers.]

One of the most important resources in the German tool and die industry are the employees. Their know-how about products and processes as well as their experiences are key success factors for the financial results of German tool shops. In particular, the large share of employees in manufacturing (about 45 %) has a large influence on the quality of tools.

In the last ten years, two trends have clearly developed. First of all, the average age of

employees rose from 37.7 years (2004) to 40.3 years (2015). Furthermore, the share of trainees sank continuously from 15.7 % (2004) to 8.9 % (2015). The combination of these two trends is a threat for the sustainability of the tool and die industry in Germany. A positive trend is that employees tended to work longer for their companies, rising from average 13.8 years (2004) to 16.9 years (2015), which is a result of low fluctuation.



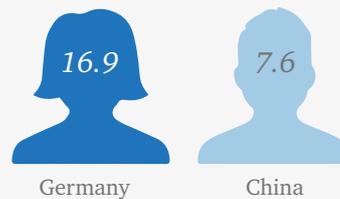
**45 %**

**of employees work in manufacturing department**

#### Average age in years



#### Company affiliation in years



### [Steady investment to secure future competitiveness.]

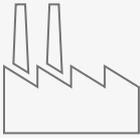
Apart from the employees, technological resources are a deciding factor in the tool and die industry. The developments and innovations of the past few years have given German tool shops many opportunities to modernize their machinery. Apart from a short-term decline in 2008 due to the global recession, investments measured by percentage of total sales revenue steadily increased. Particularly, the core technologies of the tool and die industry, milling and spark erosion, underwent many technical innovations and improvements in the last few years. Furthermore, the possibilities for automating single or combined manu-

facturing processes increased, e.g. in linear production lines. This significantly increases the potential to reduce the cycle time and the possibility for unmanned machining. Nowadays, the importance of technological resources as a distinguishing characteristic has risen higher than ever before due to increased competition from Asia and Eastern Europe. Especially the industries for small electronic appliances and medicine technology demand high accuracy, which requires maximum precision from the technological resources. Thus, the machinery together with the well-trained employees in German tool shops are important characteristics.



**9.3 %**

**of sales revenue was invested in 2015 by the EIP finalists**



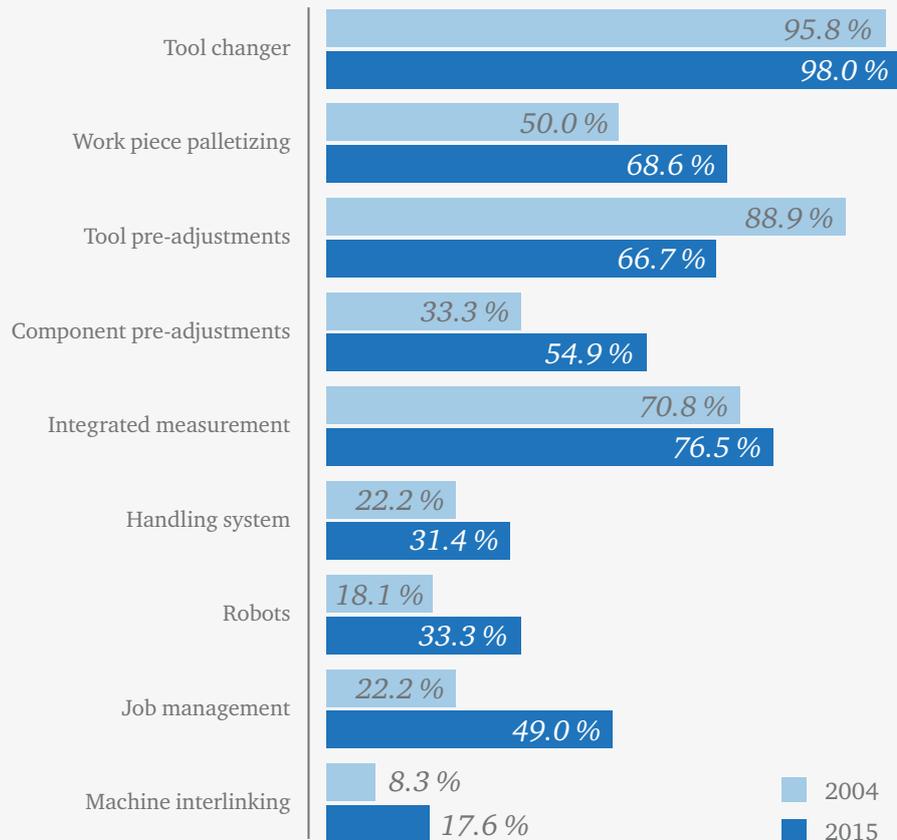
**6.7 years**  
is the average age  
of milling machines  
among the EIP finalists  
in 2015

**Milling**

The most important technology in tool making is milling, with an average production share of 48.0 %. Most German tool shops rely on new and modern machines, resulting in an average age of 9.8 years for the existing resources. The average age of milling machines of the finalists of the competition “Excellence in Production” in 2015 was only 6.8 years. New, modern HSC milling machines are especially suited for a near-net shape finish as well as manufacturing of electrodes for die sinking. These advantages are increasingly being used by German tool shops, with the share of HSC milling machines almost doubling from 22.2 % to 44.1 % since 2004. The produc-

tivity in milling, measured by using the average run-time per year, rose by 25.0 % in to 3,445 hours per year and machine the same time span. A main cause for the rise in productivity is the implementation and extension of automation concepts: In 2004 the degree of automation was at 53.0 %, but rose to 58.8 % in 2009 and 61.9 % in 2015. In particular, the share of work piece palletizing, the use of industrial robots and machine interlinking almost doubled in the last years. Modern 5 axis milling machines also contribute to the ability of producing near-net shapes with exact surfaces without any rework.

*Automation measures for manufacturing technology milling*

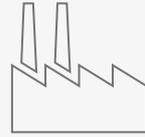


Explanation: x % of all machines are equipped with the automation measure x.

### Sink-EDM

After milling, sink-EDM is the second most important technology in tool making, especially for the production of tools with multiple cavities. This fact is emphasized by the high share of the manufacturing time of about 25 % (2015) in tool shops with a focus on injection molds. It is noteworthy that the average run-time per year has stagnated at around 2,900 hours. Also, there was only a small increase in the degree of automation from 41.8 % in 2004 to 50.2 % in 2015. Reasons for this are long-established

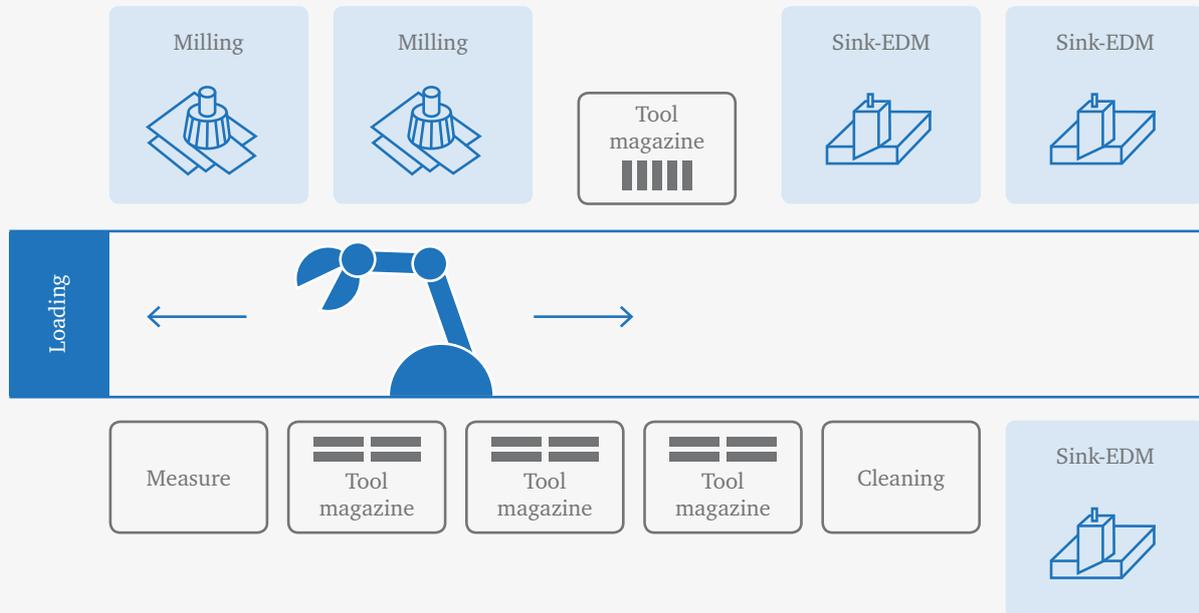
methods for automating sink-EDM as well as the fact that a CAM interface has not really established itself yet. Only two thirds of companies have a CAM interface for sink-EDM. However, there was a clear increase in the use of industrial robots from 20.7 % (2004) to 39,0 % (2015). Further, sink-EDM can be implemented ideally in production lines, where the electrode milling via HSC milling machine and tool and work piece equipping can run autonomously.

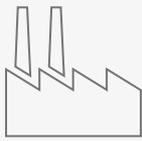


**39 %**

**of companies use industrial robots for sink-EDM**

### Example of a linear manufacturing line in tool and die making





**3,805  
hours**

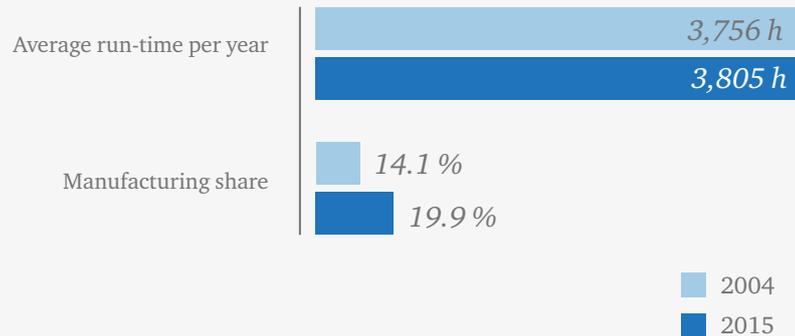
**is the average run-time  
of a wire-EDM machine  
per year**

### Wire-EDM

In 2004, the majority of tool shops already had new wire-EDM machines with an average age of 6.2 years. The reason for that are the technological advances that resulted out of substituting the fast-wire technology with newer, more efficient and precise CAM interfaces. Additionally, wire-EDM is an important technology for the tool and die industry due to its precision, with a positioning accuracy of 1 µm, and long run-time per year with an average of 3,805 manufacturing hours. Nevertheless, the use of wire-EDM entails process challenges that still are not solved. Palletizing is difficult to implement due to the wire handling, often

resulting in different palletizing systems being used for wire-EDM and other manufacturing technologies. This is why the degree of automation stagnated at 30.0 % between 2004 and 2015. Moreover, the downtime rose considerably in the last few years, despite the use of CAM programming in 60.0 % (2015) of the cases. Therefore, apart from the implementation of further automation measures for wire-EDM, the reduction of downtime is also a challenge for the future. Wire-EDM generally remains a core technology for manufacturing injection molds, together with milling and sink-EDM.

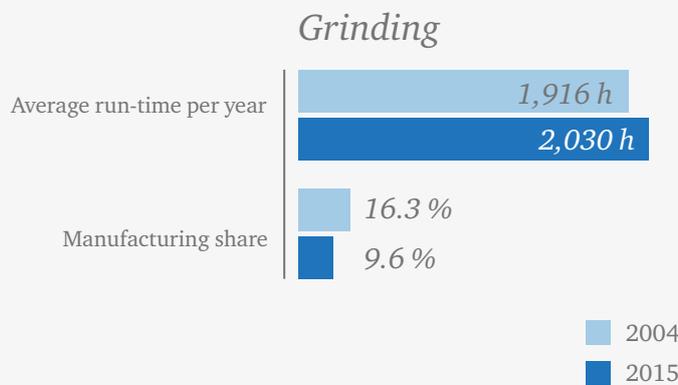
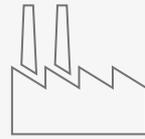
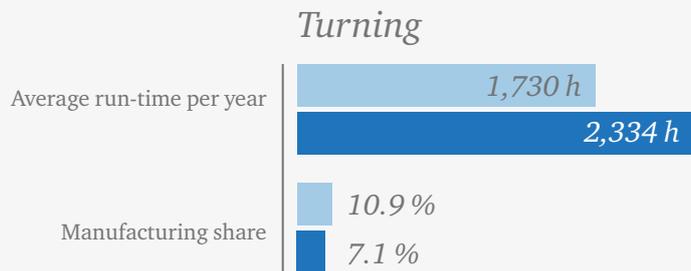
### Wire-EDM



### Turning & grinding

Both turning and grinding are regarded as demand technologies in the tool and die industry. This description applies to machines that run fewer than 750 hours per year. The use of turning or grinding depends on the type of tool being manufactured. In the production of warm and cold massive forming tools, turning is almost as important as milling, while it plays a small role for other tool types, such as injection molding and die casting tools. Grinding is used for all types of tools, but this technology is most important for the

manufacturing of forming, pressing and injection molds. It is noticeable that in the last ten years, turning and grinding have lost importance in production, despite an increase of the run-time by 26,0 % for turning and stagnation for grinding. This can be seen in the decreased production share (turning 7.1 % and grinding 9.6 %). A cause for this is the technological productivity of modern 5 axis HSC milling, which makes it possible to create exact final contours and eliminates fine finishing.



### Try-out

The try-out process has increasingly gained importance over the past few years in the German tool and die industry. This is clearly demonstrated by the fact that companies set up 4.6 try-out facilities on average in 2015, which is more than double compared to 2.1 in 2004. The necessity of higher try-out capacities illustrates the importance of this process step. The quality of the try-out process has a significant influence on the lead time of the tool as the try-out phase highly accounts to the total lead time. Sufficient capacities in the try-out department directly help to optimize the lead time. With the help of extensive simulations, the number of necessary try-out loops may be reduced in the future. First positive effects were already reported. However, looking at the entire tool and die industry, the number

of required try-out loops has not changed much in the last ten years. Consequently, there is much potential for optimization.



**4.6**  
is the average number  
of try-out facilities  
of a tool shop



# Summary & Outlook

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## **Industry**

Germany is one of the largest economies in the world and needs to address several different trends in the future to assert its position. The pivotal role of Germany can also be seen in its tool and die industry. Germany produces the most tools in Europe, of which about 40 % are exported. There are several tool making areas, primarily in the south and western parts of Germany.

## **Product**

German tool shops are highly focused on a certain tool range, leading to a high degree of specialization. The individual tool types are distinguished by their measurements and weight. Another characteristic of German tools is the high surface quality. Regardless of the size of the tool, the finish usually measures below 1  $\mu\text{m}$ . This is a major difference to Chinese competitors, which often only achieve a surface finish of 5  $\mu\text{m}$ . The high quality is also reflected in the price. For both sheet metal forming tools and injection molds, the average price is significantly higher compared to Chinese tools. This price difference cannot only be justified with a higher quality, which is why many tool shops increasingly offer various services.

## **Process**

The performance of German tool shops is characterized by the mastery of the processes along the entire process chain. In particular, low cycle times and high adherence to production deadlines are typical of the German tool and die industry. The tool development and design are given special importance by German tool shops, as seen by the relatively high employee share. Furthermore, there is a focus on production planning and work preparation, highlighting their significance. Also, German tool shops utilize far more manufacturing technologies than Chinese companies.

## **Resources**

The average age of an employee in the tool and die industry continuously rose in recent years and currently is at 40.3 years, meaning that more employees will leave the labor force due to retirement. Unfortunately, the number of trainees in the tool and die industry is decreasing at the same time. Thus, German tool shops need to implement a systematic knowledge transfer in order to prevent loss of know-how. A positive is that company affiliation has increased due to low fluctuation. With regard to technology, German tool shops have very advanced, innovative and modern machinery. This can be explained by the fact that there have recently been many technological innovations for the core technologies of milling and sink-EDM.

The German tool and die industry belongs to the best of its craft worldwide. German tool shops distinguish themselves with their premium products, efficient processes and productive resources. To secure business in the long-term, especially internationally, German tool shops need to continuously develop. In particular, digitization and Industry 4.0 offer great possibilities to exploit further potential. In the sense of “stagnation means falling behind”, German tool shops need to work on retaining their advantage over competitors through systematic improvements in all areas.

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# Our Studies

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**Erfolgreich  
Performance Messen**  
2017



**Erfolgreich Fertigungstechnologien Einsetzen**  
2017



**Erfolgreich Finanzieren**  
2016



**Smart Tooling**  
2016



**Tooling in Turkey**  
2016



**Tooling in China**  
2016



**Erfolgreich Digital Vernetzen**  
2016



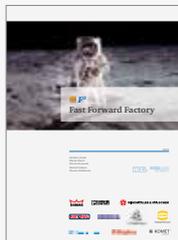
**Tooling in Germany**  
2016



**Erfolgreich Mitarbeiter Motivieren**  
2016



**Fast Forward Tooling**  
2015



**F<sup>3</sup> Fast Forward Factory**  
2015



**World of Tooling**  
2015



**Erfolgreich Kalkulieren**  
2015



**Erfolgreich Planen**  
2015



**Getaktete Fertigung**  
2015



**Tooling in China**  
2015



**Tooling in South Africa**  
2014



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