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The Innovativeness of the German Automotive Industry as a Lever for Employment and Wealth of Nation

Abstract

Innovativeness is a prerequisite for profitable companies as well as for a sustainable economy. Innovations are the adequate response in times of rising competitive pressure and increasing rivalry on the global markets. Additionally, the shut down due to the global pandemic has hit all automotive companies extremely hard.

Currently there are unmistakable signals in evidence indicating a radical technological change coming along with an economic downturn in the automotive industry.

The research question examines the innovativeness of the German automotive industry. The answer will be given with selected figures referring to qualitative and quantitative reasoning. In summary it can be stated that the German automotive industry has an outstanding performance in terms of innovativeness. The urgent need to support this industry can easily be derived.

Keywords: automotive industry, innovation, expenditures, production units, sales figures, open innovation, research and innovation (R&I), patents.

The Innovativeness of the German Automotive Industry as a Lever of Stability for Economy and Employment

Günter Hofbauer und Anita Sangl

1 Introduction

Innovations are mandatory prerequisites for the profitability and sustainability of enterprises. The necessity for innovation is pushed by rising competitive pressure, increasing rivalry on the markets and shortened product life cycles. In this working paper a short introduction into innovation management is given. The research question deals with the innovativeness of the automotive industry, which will be demonstrated with selected facts and figures.

The justification of this topic is that there are currently strong signals noticeable indicating a radical change accompanied by a downturn in the automotive industry. Especially the German automotive industry and correspondingly the German economy seem to slide into big trouble. This working paper presents the innovative power of the German automotive industry. The importance of the German automotive industry for employment, sustainability and economic wealth in particular as well as for Germany as a location for industry in general will be explained.

Methodologically, a theoretical and an analytical approach are used. Latest literature, surveys, statistical data and logical conclusions provide justified arguments. To start with, the current situation for the automotive industry will be described. Secondly, the success factors of innovation management will be shown on a theoretical basis. Thirdly, the performance data of the German automotive industry are deployed on a statistical data basis. Last but not least the need for action to support this industry will be derived.

The contribution to academic discussion is to point out the significance and impact of the automotive industry in terms of input and output factors. The findings provide reasonable results about this special industry in comparison to others as well as effects on economies contributing to the wealth of nations.

Based on these findings this working paper intends to figure out the significance of the German automotive industry for competitiveness, employment, sustainability and economic wealth especially for Germany as a proper place of location.

It can be summarized that the German automotive industry provides a huge contribution to the economy in terms of investment and employment on the input side and innovation and prosperity on the output side. Thus, in the light of structural and technological problems this industry is worth to be supported.

2 Initial situation

All modern economies need proper innovations to convince customers to buy and to increase profitability as well as to improve competitiveness. The innovation management has the crucial task to meet all requirements from internal and external stakeholders of the enterprise. Some industries are more and others are less innovation driven. The reasoning for innovation is the attractiveness of markets (Hofbauer et al. 2009).

Especially the German automotive industry is highly innovative, but there is the fear that the automotive industry is heading into a structural and technological trouble, which could lead into a severe crisis for the German economy. There are more than early warning indicators: Worldwide sales volume of the automotive industry dropped 5% at mid-year 2019. German car manufacturers lost 20% of export in the two most important markets China and the US (Kröger 2019). As a consequence, suppliers and car manufacturers already announced layoffs on a large scale.

The current threats are diesel scandal, strict engine exhaust regulations, electrical and digital revolution and moreover a foreseeable economic downturn. Trade wars, driving bans, insufficient electrification and skepticism of customers about e-mobility worsen the situation additionally on the demand side. To make matters worse, the covid-19 pandemic caused a severe crisis in the first and second quarter 2020 by interrupted supply chains and shut downs of entire production plants, especially in Germany. The damage can be seen in the sudden drop of sales volume, which will account for about 23% in total in comparison to previous year. Estimations calculate a worldwide decrease of 1 million produced cars in total.

These are the reasons, why car manufacturers urgently need support in terms of money to invest in order to be able to keep up. R&D budgets are badly needed for alternative fuel, for optimization of conventional power drives and extension of electrical mobility as well as for the digitalization of the factory and the car up to automated driving.

Furthermore, competitors from other industries like google, amazon, apple, uber are going to penetrate the mobility market as a whole. They earned a lot of money in their initial businesses and are in search of new business opportunities in other areas. Their advantage is that they have a high capital strength to cover budgets for research and innovation (R&I) and do not have the burden of the past in terms of technology, products and plants.

From the year 2015 on the total number of registered cars worldwide exceeded the number of 1 bn units. The highest number of new car registrations was observed in China, followed by USA and Japan. In 2017 70.5 m cars and 25.1 m commercial vehicles were manufactured worldwide. In China 25.71 m cars were produced. The share of Asia in the global automotive market is 49.9 percent. The biggest manufacturer is Toyota with 10.47 m units with a corresponding sales volume of 238.53 bn EUR. The most profitable car manufacturer at these times was BMW with 10% EBIT rate.

Total sales of the top 100 global automotive suppliers reached 889 bn EUR in 2017. The biggest supplier worldwide was the German based Bosch company with sales volume of 47.6 bn EUR. The biggest supplier in Asia in terms of sales volume was Denso with 36.4 bn EUR.

The German market moved from the year 2008 with 5.53 m units to 5.12 m units in 2018, with only small ups and downs in between. The peak was in 2011 with 5.87 m units and in 2018 however a considerable amount of 525,175 units less than 2017 (-9.3%). The decrease from 2018 to 2019 was 456,660 units, which means another -8.9%. Figure 1 (own graph) shows the numbers of production units from 2005 until 2019, and estimated for the year 2020 (source: VDA 2020).

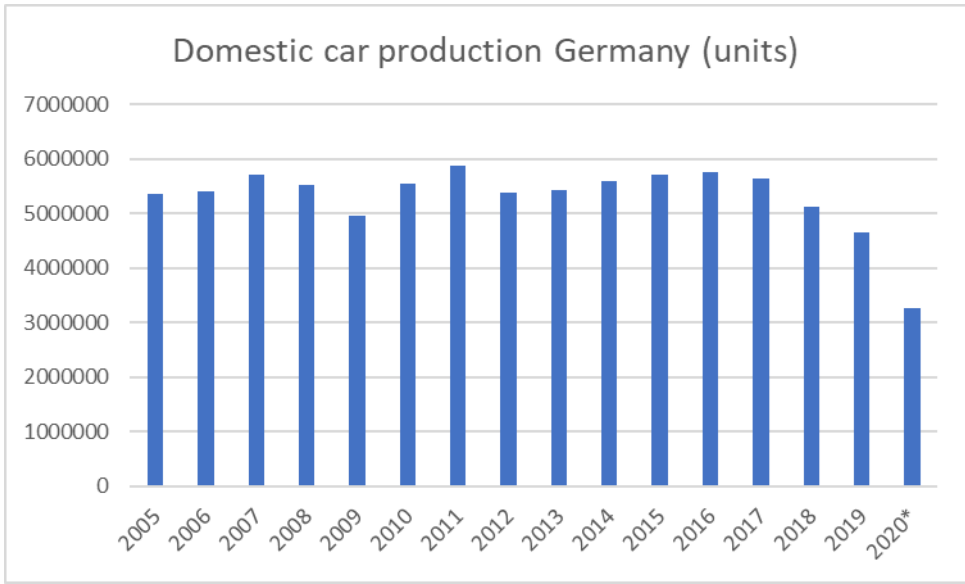


Figure 1: Domestic car production units Germany (2005 – 2020)

Figure 1 also shows that the drop in the year 2019 was higher than the decline ten years before during the worldwide financial crisis.

A closer look on the last five years in figure 2 (own graph) shows a dramatic trend for the production units in Germany.

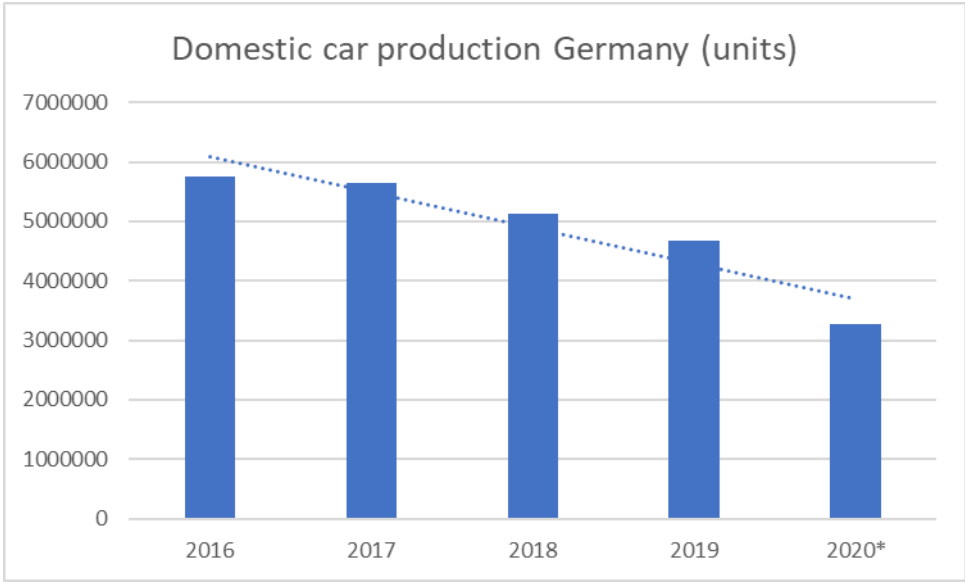


Figure 2: Car production units Germany (2016 – 2020)

The total sales volume in 2017 was about 422.8 bn EUR, therein exports with a tendency of +6% with a total number of 271.7 bn EUR which equals 64.3% of total sales. Sales volume however increased in 2018 to 426,2 bn EUR. The German suppliers in the automotive industry achieved a sales volume of 79.6 bn EUR in 2017, therein 31.6 bn EUR (39.7%) for export.

The number of employees in Germany climbed with 11,500 from 2016 to 2017 and totaled in 819,995 employees. In comparison to 2010 there were more than 118,400 jobs created by all German companies within the automotive industry.

An important relation can be shown by all generated innovations of the global automotive industry. In 2017 there were 1,223 innovations registered. The share of German automotive companies was 32%, whereas the share in terms of produced cars is only 8%. This is a single, but significant finding about innovativeness (Statista 2019). Innovativeness is a mandatory prerequisite for growth and sustainability of companies in competitive markets (Sangl/Hofbauer 2017). Innovations are not only essential for the competitiveness and profitability of companies, but also crucial for the competitiveness of countries and therefore determining the standard of living of the people and wealth of nations.

The reasoning for this article is to present the importance of the automotive industry as a significant industry, especially for German economy. All relevant decision-makers on different levels should be aware of the outstanding performance of the German automotive industry and the significant contribution to innovation, employment, economy and welfare.

The question of research is formulated as: Has the German automotive industry an outstanding innovative power? Quantitative and qualitative arguments will be deployed to answer this question. Statistical figures will show absolute scales and relative comparisons, relative to domestic industries and to competitors abroad. Depending on the result of the analysis the answer will recommend to support and save this industry or not.

The benefit of this paper is the presentation of the German automotive industry combined with the first systematic matching of innovativeness and impacts of innovation application. The purpose is to identify contributions to economy and sustainability and in the long run to competitiveness and prosperity. These potentials should become purpose of academic discussion as well as evidence for political decision making.

3 Problem formulation

The obstacles of doing successful business in industries are mostly twofold:

The first issue is about external impacts like regulation and legislation as well as negative political and economic influences. The players in a specific industry have only limited possibilities to exert influence, especially when national legislation is transferred to a transnational institution like the EU. Even though the influence is limited and the decision parameters may be contradictive. The deciders in charge should be aware of the consequences.

Scientific literature and management know-how teach us to detect weak signals and to act before problems arise. Meanwhile there are obvious strong signals to observe and everybody should have noticed and should be wide awake.

In addition to all regulative parameters, the covid-19 pandemic knocked down the whole automotive industry worldwide, too. As a result, the German car manufacturers had to suffer a complete standstill for a while and an enormous drop in sales. The production volume fell down by 36% in March, 97% in April and 66% in May 2020 compared to the respective month in previous year (VDA 2020).

Figure 3 (own graph) displays the change of production units (in %) over last 17 months compared to respective months of previous year (VDA 2020).

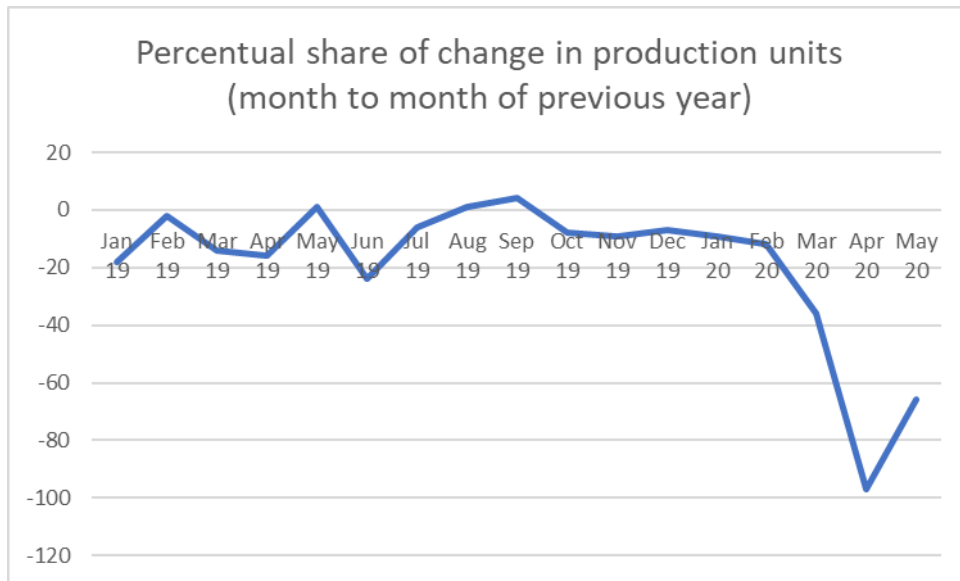


Figure 3: Relative change in production units (Germany, 2019 - May, 2020)

In figure 3 the huge impact of covid-19 pandemic is visible.

Figure 4 (own graph) displays the absolute car production units in Germany over the last 17 months, total year 2019 and year 2020 from January to May. The dotted line represents the statistical trend line.

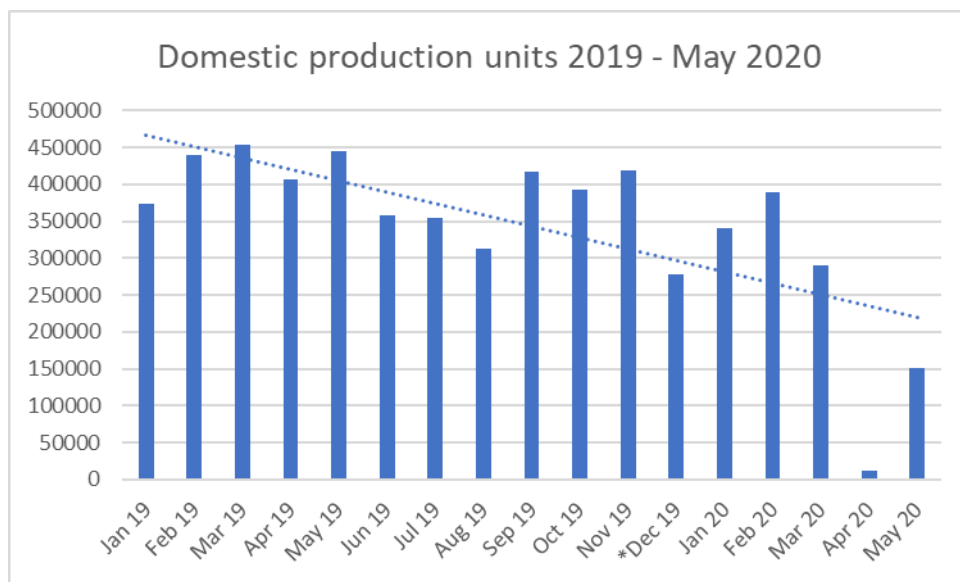


Figure 4: Absolute car production units (Germany, 2019 - May, 2020)

The general trend over years, especially the trend over the last years as well as the consequence on the year 2020 in shown in figure 5 (own graph) on a year-to-year basis (source VDA 2020).

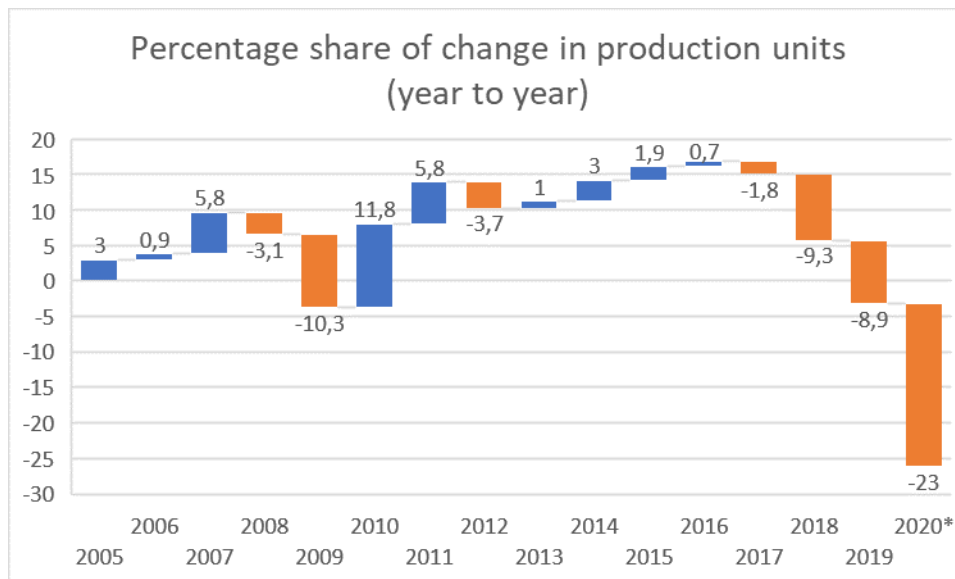


Figure 5: Change of production units in % (*estimated for 2020)

There was a peak in 2016 with 5.746.808 produced units. The decline started in 2017 and continued 2018 and 2019. This decline was mainly caused by structural economic problems and uncertainty on the demand side, which caused a reluctance to buy. The severe drop in 2020 was mainly caused by the covid-19 pandemic, but with an overlap with before mentioned reasons. The degree of this drop is estimated with -23% on average in 2020 in relation to previous year (Müller 2020).

The second issue is about the internal performance of market participants. In this context, the different companies have to develop competitive strategies and optimize their respective operations. With regard to the performance, this means mainly the ability to perfectly manage the innovation process. It is in the nature of the matter that innovations are unique and always risky when they are introduced for the first time. But innovations are the decisive prerequisite for growth and sustainability of companies in current and future markets. Therefore the innovation management processes should systematically support R&I and make it happen (Hofbauer/Sangl 2018a).

This is why a systematic innovation management process is required (Hofbauer/Wilhelm 2015). A creative environment generating a plurality of innovative and productive ideas on the one hand and a precisely managed holistic R&I process (Hofbauer/Sangl 2018a) on the other hand are essential prerequisites for the competitiveness and profitability of companies.

Figure 6 (own graph) shows that not all German companies are already well prepared. About 28% of analyzed German companies have installed a systematic innovation management yet. A bigger part of 43% have integrated at least approaches to such process management in their daily business. A small part of 3% currently have none, but plan to change this in the near future. It is remarkable that 26% of all companies do not have installed a systematic innovation management (DIHK 2015).

We will see later on that the German automotive industry belongs to the companies, which have installed a very powerful innovation process.

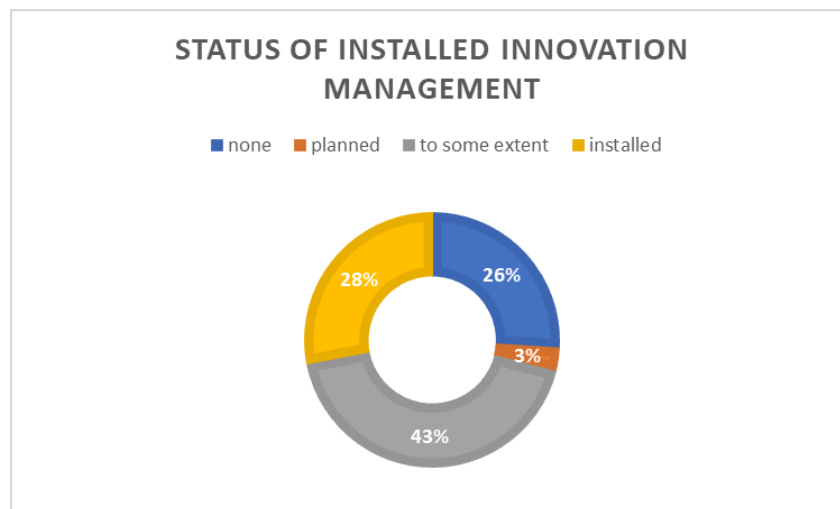


Figure 6: Current status of installed innovation management processes in German companies

Scientific studies of world market leaders show that there are some core elements of success required. Excellent process management is core amongst others (Hofbauer/Sangl 2018). They can be characterized as strategic and operational. These elements appear to be decisive for their outstanding performance (Frietsch et al. 2015):

The strategic issues are:

- Global growth as a strategic corporate goal
- Commitment to active research and innovation

The operational issues are:

- Excellent process management
- Systematic knowledge management
- Scientific cooperation
- Know-how protection through fast patent application

This article pays attention to the research question considering above mentioned key points. In case of provided evidence of innovativeness, a strong recommendation will be given to protect a leading innovation position in times of radical change, discontinuities, economic downturn and rising competition.

4 Literature review and problem solution

Innovativeness is inevitable for the sustainability of companies. Thus, R&I management is one of the most important entrepreneurial functions (Hofbauer/Gandhi 2016). The outcome in terms of new products or applications is the essential requirement for prosperous enterprises. An innovative enterprise may be characterized by means of: new product introduction, development of additional benefits, entering new markets, targeting global growth, increase of market share as well as enlargement of sales and profit (Hofbauer/Sangl 2018a). Innovations substantiate competitive advantage (Hofbauer et al. 2009).

In the past, new products were mainly generated in internal research and development departments within a closed loop in the respective company. An increasing number of innovations is nowadays created in innovation networks, where the creative potential from inside and outside the company is used (Engelhardt/Hofbauer 2017). This is the beginning of a new kind of competition for all industries. This means that networking capability is postulated in order to orchestrate the network of co-innovators towards the joint purpose.

The own core competencies are not any more that critical as it was on a stand-alone intention. Companies with the highest R&D budgets and largest departments are not any longer automatically in a leading position. Companies know that they have to exploit their existing knowledge and resources to achieve competitiveness. The internal R&D mostly focuses on exploitation, whereas the exploration is more and more done by external sources (Hofbauer/Hofbauer 2016). In fact, those companies will succeed, which have the capability to utilize the worldwide creative potential from outside. Open innovation (Brening/Hofbauer 2017) is appropriate to get innovations done within a shorter time frame and lower cost. Crowdsourcing and open innovation are proper to harness the external know-how (Borchardt 2012).

4.1 Open innovation as a means to broaden creative potential

The necessity for new innovation approaches is pushed by rising competitive pressure, increasing rivalry on the markets and shortened product life cycles. Companies are forced to speed up innovation and to allocate higher budgets. In addition to that, new technologies as well as cost and time pressure have changed the practice of innovation enforcement. Internal innovation has changed into open innovation.

Open innovation (Brening/Hofbauer 2017) means to open the internal innovation process and integrate innovative ideas, solutions and technologies coming from external co-innovators. This makes it possible for companies to employ a huge creative potential from outside, explore various new ideas in a shorter period of time, exploit different applications, save money and reduce flop rates. Open innovation is a significant possibility to collect new ideas and know-how on demand and the feeding is quickly done. These arguments strongly suggest that there is a high potential for value added. The principle of open innovation is shown in figure 7 (own graph according to Chesbrough 2003, p. 43). Valuable ideas may come from inside and outside the company and can be marketed from inside and outside as well (Chesbrough 2003).

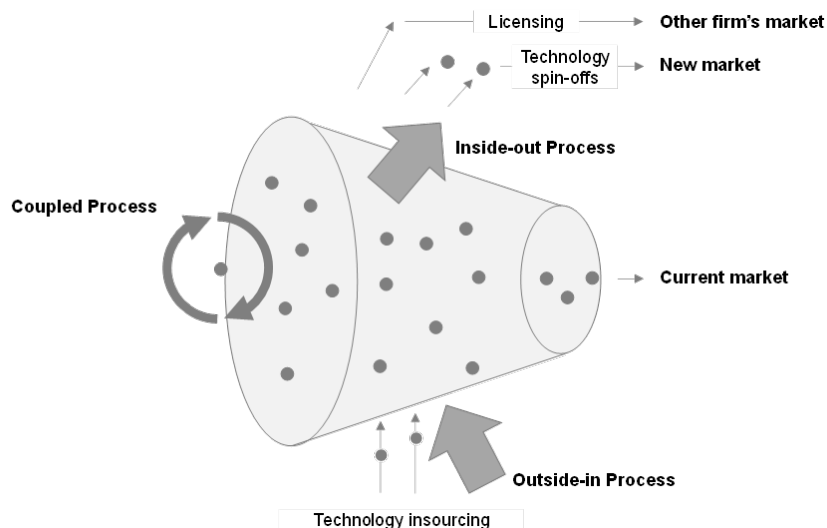


Figure 7: Principle of open innovation

This proceeding provides new possibilities to take advantage of using new potentials outside the own company. The principle of open innovation shows that ideas can be integrated from outside (outside-in process). Ideas also can be taken out of the internal innovation process (inside-out process) to be marketed in another way. Even a combination is possible in terms

of a coupled process (Chesbrough 2003). The most advantageous approach for a company to create competitive advantage in its current market is the outside-in process. Here the knowledge base of a company is boosted by contributions of external co-innovators.

There are various sources for the generation of new product ideas from outside the company. External sources like experts, technology consultants, suppliers and even customers initiate ideas and elaborate solutions for the respective assignment of tasks. Scientific surveys of the Centre for European Economic Research (CEER) documenting their Innovation Survey (2019) show with which partners companies prefer to enter into cooperation agreements for innovation projects.

Figure 8 (own graph according to CEER 2019) shows different providers of ideas and solutions from outside the company. This figure shows the share of German enterprises active in generating innovations on the one hand (dark bar) and the share of all cooperating and innovating companies on the other hand (light bar). The most popular partners for cooperation partnerships in terms of innovation are universities and universities of applied sciences with 63%, which means a share of 11% of all enterprises active in generating innovations. The second most frequent partners are suppliers (35%), followed by customers from the private sector with 33% ranking third.

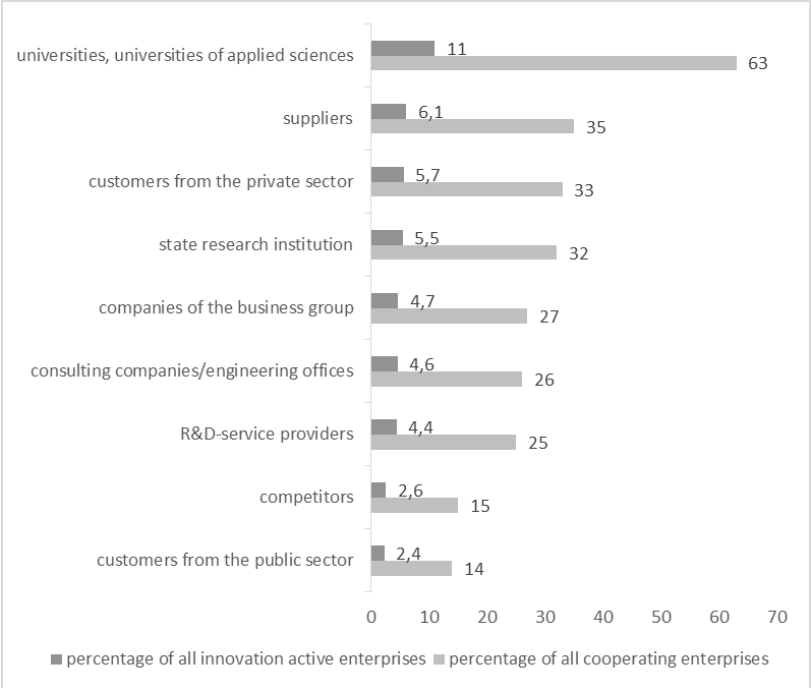


Figure 8: Preferred partners for innovation cooperation in Germany

In order to create suitable value by the use of open innovation, the management needs to have specific capabilities. Absorptive capability is the most important precondition (Reichwald/Piller 2009, p. 99). Companies in search of new ideas need the ability and competence to identify and absorb know-how from outside. This absorbed know-how is useful for the own innovation activities and value shall be created by commercial exploitation (Engelhardt/Hofbauer 2017). Multiplicative capability is also a major issue, because the inside-out process refers to value creation by marketing internal know-how outside the company. The motivation for this advancement is to market the innovation faster than through the internal standard procedure. This shift of business activities offers added value through licensing, spin-offs, start-ups and multiplying technology use. The so-called coupled process describes the combination of the outside-in and the inside-out process. The consolidated activities may be realized in alliances, strategic networks, joint ventures and cooperations. In order to establish competitive advantages, the members try to develop technical standards and dominant designs of their products. To have the right balance between absorb and provide is the most important precondition in these partnerships. In this case relational capability is needed, which refers to balance the efforts and wins within a network, otherwise the network would not be successful. Following this, all partners are able to establish competitive advantages and create value accordingly.

In order to show how to integrate the open innovation approach, the whole innovation process will be displayed. The Integrated Product Management Process (IPMP) by Hofbauer & Sangl (2018a, p. 341) observes and includes all relevant and necessary issues and covers a wide range of innovation management, starting with the identification of innovation fields and ending up with lifecycle management. This basic model can be opened for co-innovators in order use external potential by open innovation (Brening/Hofbauer 2017).

The IPMP makes use of internal and external sources for the generation of innovations as well as internal and external ways of utilizing ideas and thus has extensive opportunities to create value for the company (Hofbauer/Gandhi 2016). In addition to that, important influencing stake holders are displayed with their corresponding sphere of action. Exemplarily shown are trend insight enablers, lead users, expertise providers and concept validators (Brening/Hofbauer 2017). With the opening up of the innovation system, the company is able to cope with increased competition and innovation pressures by sharing the necessary investments and risks.

Figure 9 (own graph) shows the opened innovation process IPMP.

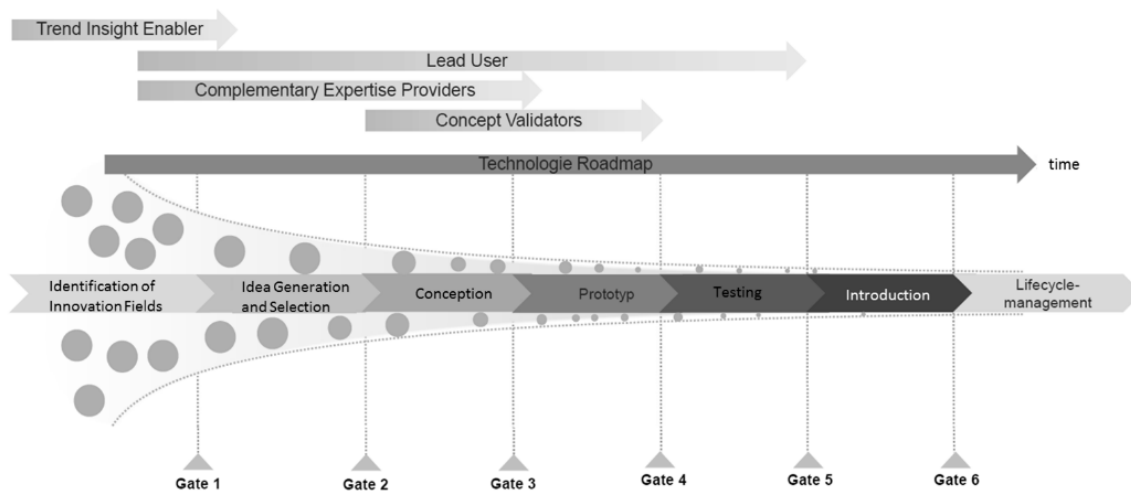


Figure 9: Opening the innovation process

In this opened process external potential and know-how can be used, which are ought to be used and transformed in the respective phase of the progress of the ongoing process.

Considering the remarks mentioned above in this chapter, the requirements to manage innovation processes have changed (Hofbauer/Sangl 2018a). Companies have to face the challenges by adapting their business activities to the changed conditions in order to remain competitive in an uncertain, volatile and complex market environment.

4.2 Summing up arguments for innovation activities of automakers

As already pointed out, innovation activities are vital for successful companies and prerequisites for establishing competitive advantage and value added. These principles also apply to the German automotive industry. The most important advantages of open innovation are reduction of time-to-market and cost-to-market and an enhancement of fit-to-market and new-to-market. The first two issues referring to time and cost are related to improved access to information about solutions of problems (Reichwald/Piller 2009). This information is about technical knowledge how to solve specific problems. Further on how to use efficiently existing resources while finding solutions. Fit and new refer to the access of information about needs and wants of customers. The knowledge about the preferences of customers is essential to

meet their needs. This helps to improve the effectivity, because the products will meet the needs of the customers and thus the flop rate will be reduced.

The opening of the innovation process represents an important additional strategic factor (Brening/Hofbauer 2017). The implementation of open innovation processes provides supplementary business potentials. In collaboration with co-innovators the most important issue is to detect and utilize innovations and innovative potential for the company. Therefore, an extensive market research is necessary. Especially suppliers play an important role in providing innovative solutions into automaker companies. Once suppliers are identified, they should be closely involved into the pre-serial and serial development process of the company (Engelhardt/Hofbauer 2017). Further on, products will only be designed best for subsequent manufacturing at supplier's site, if their manufacturing know-how is considered prematurely during the product development process. Far too often products were designed and physically developed before the production feasibility is checked, which is necessarily the next step (Hofbauer 2017). The use of digital twins throughout the entire development process on supplier's as well as on automaker's side helps additionally to save time and money (Hofbauer/Sangl/Engelhardt 2019). In order to support value creation in terms of the return of the products, the procurement management has to look for innovations and solutions to reduce complexity and optimize the product for the whole value chain (Hofbauer/Sangl 2018b).

5 Reasoning for innovativeness of the German automotive industry

In this chapter the argumentation for the research question will be provided with selected facts and figures including comparisons with German industry on average or on detailed basis with other industries.

Regarding quantitative reasoning about output factors (innovative products, sales and share of sales, patents) and input factors (investment, intensity of innovation) as well as treading new paths with opening the innovation process the outstanding performance of the German automotive industry will be justified.

One of the most convincing facts is that the sales structure of the German automotive industry accounts for nearly 50% of innovative products. Exactly 49.6% of total sales with roundabout 426 bn EUR was achieved with innovations in 2018. This is a considerable output of invested innovation input. For comparison: In Germany sales is generated with 84.5% on industry average with established products, only 15.5% with innovations.

Figure 10 (own graph) shows the noteworthy relations on sales volume of the automotive industry vs. German industry on average (ZEW 2019a).

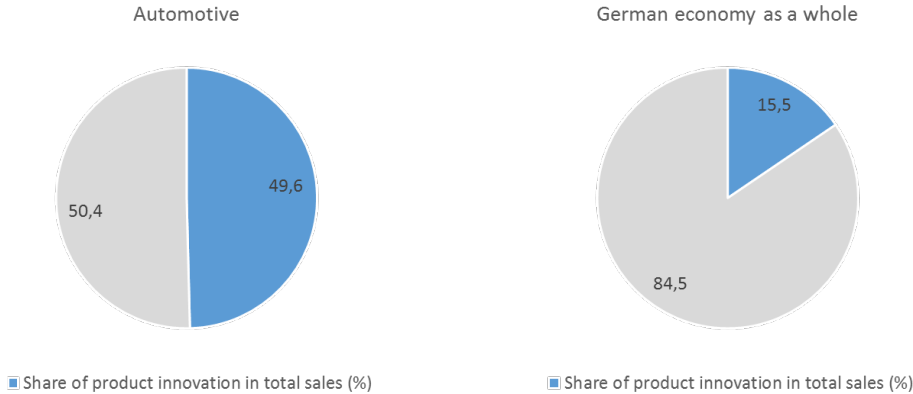


Figure 10: Share of product innovation in total sales

Figure 11 (own graph) shows significant indicators in comparison to other industries in Germany. The innovation rate displays the percentage of innovative companies within the respective industry. One can see, that the automotive industry is among the three leading innovative industries, namely automotive, chemicals/pharmaceuticals and electrical industry. The next comparison shows the share of sales with innovative products. As already depicted the automotive industry has a share of nearly 50%. Here the automotive industry is in the lead with a big gap to the second one. The intensity of innovation shows the portion of sales allocated for innovation activities.

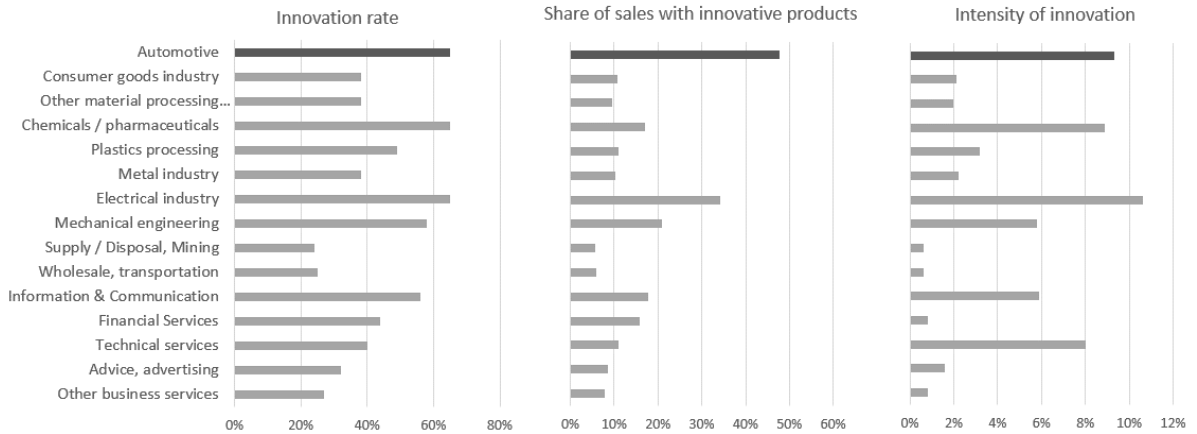


Figure 11: Comparison of innovation indicators across different industries (ZEW 2019b)

The comparison pinpoints that there is a wide range between the different sectors, but this is quite normal and the innovation intensity represents the degree of competition and even the profitability of the business.

Table 1 illustrates exemplarily the range between the automotive industry and the average of all sectors.

Table 1: Range of innovation measures for automotive sector and average of all sectors in Germany (ZEW 2019b)

	share of innovative companies	of intensity of innovation as expenses in % of sales	share of sales with innovative products
Automotive industry	62.3%	9.39%	49.6%
Average all industries	36.0%	3.14%	15.5%

The empirical data show that innovation activities and corresponding budgets on the input side as well as sales figures of innovation on the output side have a huge impact on companies and economies. Innovations in terms of products and services are essential for competitiveness and profitability.

The overall expenditures of the German automotive industry for innovation is displayed in figure 12 (own graph). On the left scale we see the absolute figures of the German automotive industry and on the right scale the absolute figures of the overall economy in bn EUR. After the crisis in 2009 one can see a steady increase of the expenditures. After 2011

the progression of the automotive industry (bars) was higher than the German industry on average (line).

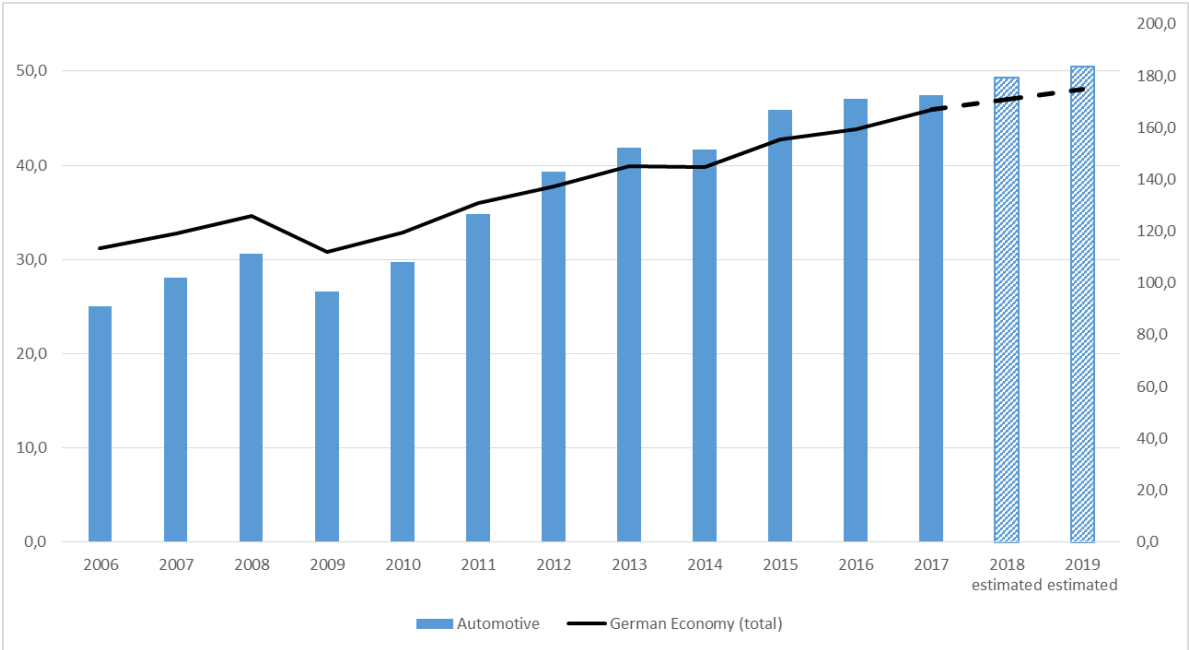


Figure 12: Innovation expenditure in € billion (ZEW 2019a)

All companies have to watch out for their cost position in order to stay competitive. Figure 13 (own graph) shows the comparison of the proportions of German automotive industry versus German economy on average with process innovation-related cost reductions over time. This means that innovation activities are not only important for new products, but also to impact the cost position of a company. In this context the German automotive industry has also a leading position far above average in process related innovation.

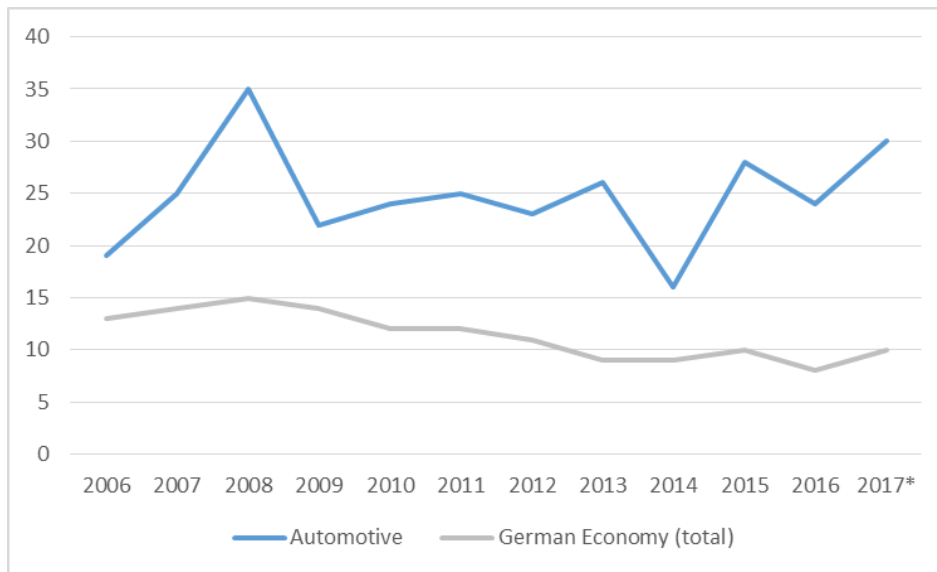


Figure 13: Proportions of process innovation-related cost reductions (in %) (ZEW 2019a)

With regard on innovativeness it is also important to analyze the openness of companies or industries in general. This is an important issue to take advantage in competitive markets. Increasing competition faces companies with pressure to innovate and force them to push innovation activities with higher budgets. Innovations are drivers for profitable growth, competitiveness and sustainability.

New technologies as well as cost and time pressure have changed the practice of innovation activities. Closed innovation has evolved into open innovation. The basic idea of open innovation is to open the internal innovation process to integrate innovative ideas, solutions and technologies coming from outside. Open innovation (Brening/Hofbauer 2017) is a major opportunity to get new ideas and know how on demand and tasks quickly done, without limitations in thinking and problems coming up with a slow-acting and sometimes calcified internal organizations.

Figure 14 (own graph) shows the way of operating product innovations within the automotive industry, answering the question who is involved in the process. The figures display that there are as much innovation projects done together with third parties as on a stand-alone basis (multiple choices possible). In comparison to total industry on average the automotive industry in Germany is about one third ahead of the other sectors with regard to open innovation.

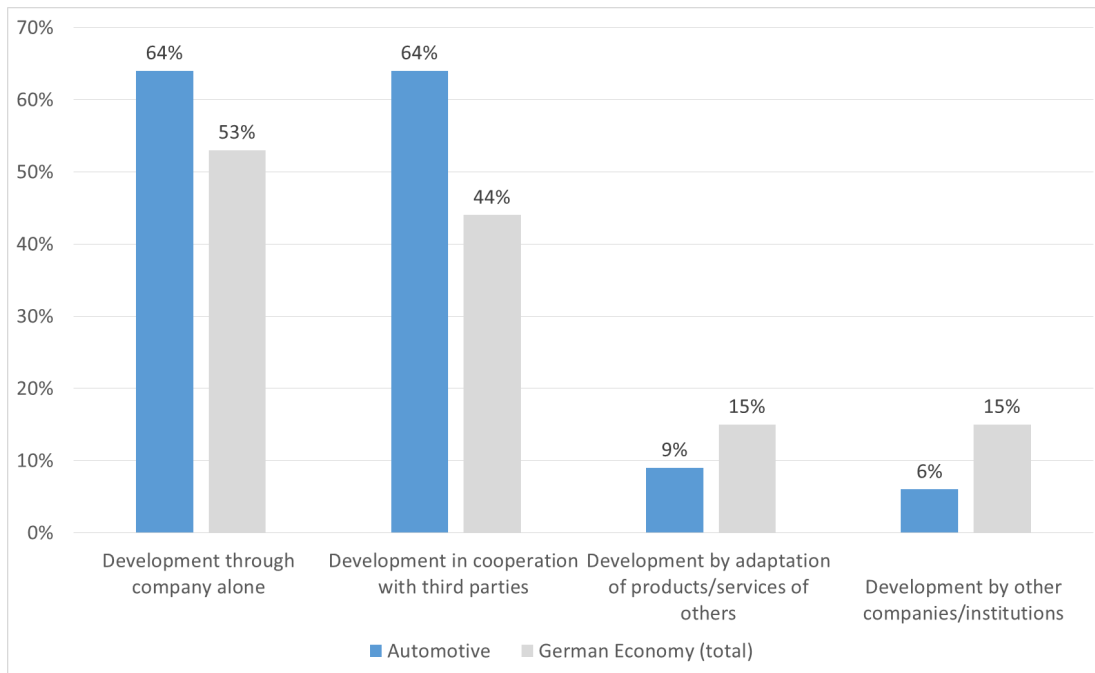


Figure 14: Developers of Product Innovations 2014-2016 (ZEW 2018a)

With regard to open innovation and inclusion of ideas from outside there are many ways to execute. Figure 15 (own graph) shows four different ways to collect ideas. Workshops with experts from own industry, experts from other industries, online/crowd-based generation and joint ventures.

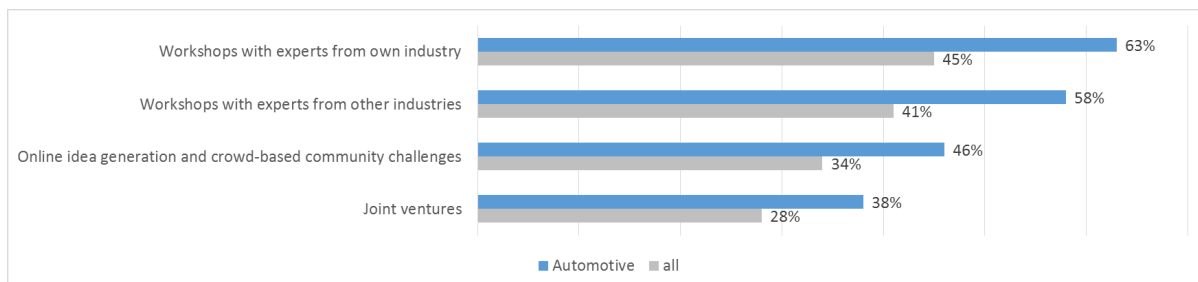


Figure 15 Innovation sources from outside the company (Deloitte 2019)

In comparison to total industry on average the automotive industry in Germany is about one third ahead of the other sectors with regard to open innovation.

Figure 16 (own graph) shows various cooperation partners from outside for automotive industry versus German economy in total. One can derive that the German automotive industry has already opened to external sources of innovation.

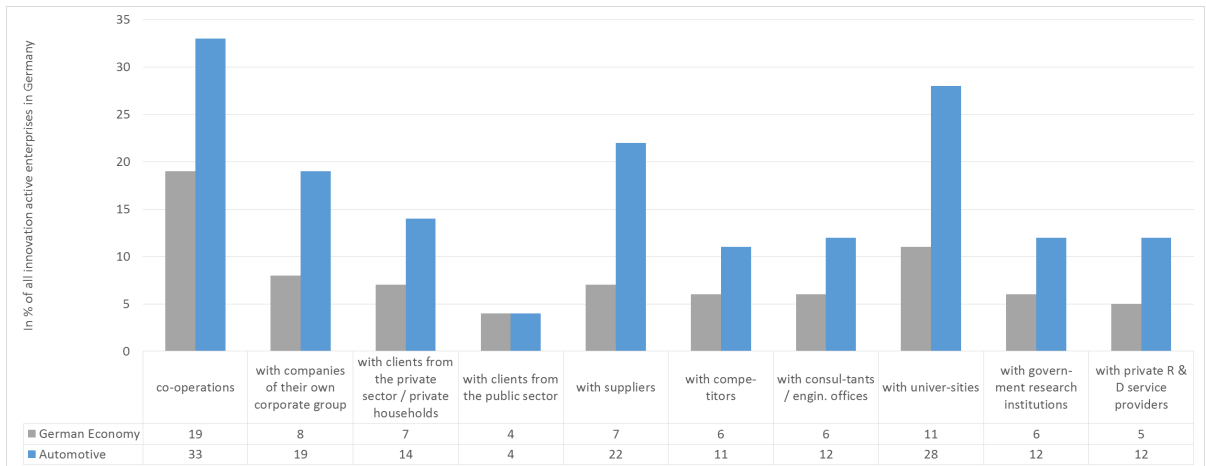


Figure 16 Cooperation modes in R&D in Germany 2014-2016 (ZEW 2018b)

Figure 17 (own graph) provides information about the geographical distribution of innovation partners. This gives strong advice that the German automotive industry is ahead in this respect, too.

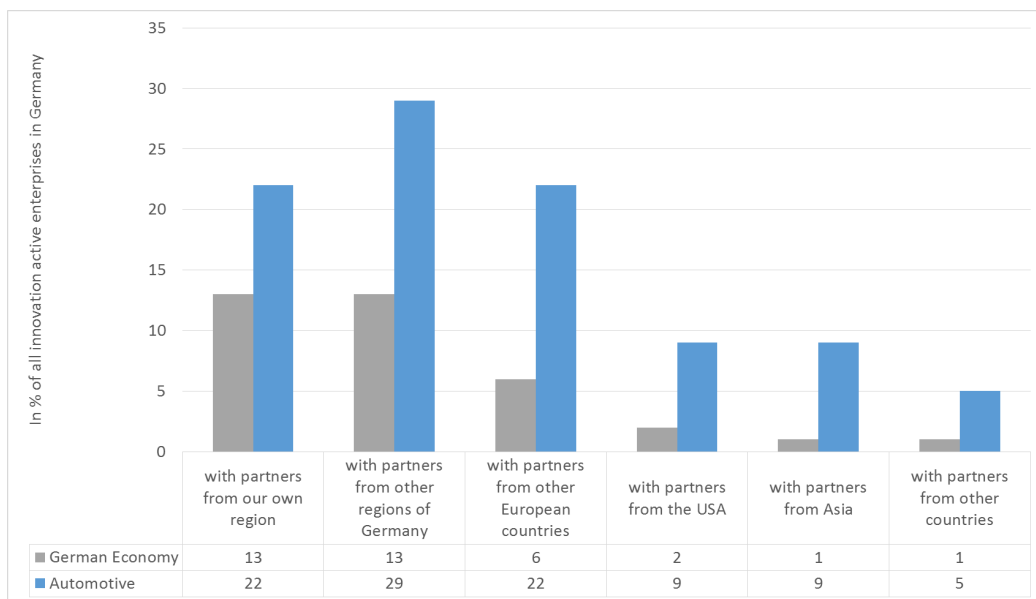


Figure 17: Origin of cooperation partners for German companies 2014-2016 (ZEW 2018b)

An interesting output of investment in innovation is the volume of patents in order to protect intellectual property and secure competitive advantage. In 2018 the number of patent applications amounted to a total of 67,895 patents, thereof 12,273 from the transport sector, which was a plus of 5.8% in comparison to 2017. The top 3 applicants were (DPMA 2019):

- Robert Bosch GmbH: 4,230
- Schaeffler Technologies AG & Co. KG: 2,417
- Ford Global Technologies, LLC: 1,921

Figure 18 (own graph) shows the innovation index (CAM 2018) of the top 5 automotive companies worldwide. The index value is a composite of degree of innovation, originality, customer value and level of maturity.

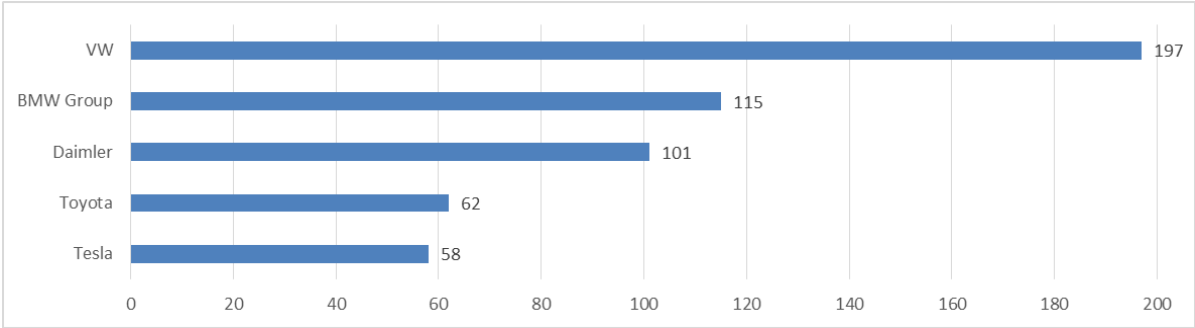


Figure 18 Innovation Index of selected automotive companies in 2017 (CAM 2018)

All the qualitative and quantitative arguments demonstrate a high degree of innovativeness for the German automotive industry, far ahead of all other industry sectors in Germany. The reasoning also presents that the German automotive is prepared for global growth and definitely committed to active research and innovation. The key point of success are perfectly managed innovation processes, executed in cooperation with external innovation partners and to apply immediately for patents to protect intellectual property.

6 Summary and conclusions

This working paper deals with the significance of innovation in general and the accomplishment of the German automotive industry in particular. The indication of a disruptive change especially for the German automotive industry is in evidence. A variety of influencing factors merge to a situation of radical change. Big trouble seems to be inescapable.

In addition to the technological and structural changes another threat emerged in the beginning of the year 2020. The covid-19 pandemic threatens the automotive industry on the input, as well as on the output side. On the input side supply chains are interrupted and on the output side, production and sales activities lie down. In the end this means a severe decline in financial power. The financial power however is a necessary prerequisite to overcome all the described threats through innovation management.

The factors of success for innovation management have been outlined on a theoretical basis. These factors also apply to the German automotive industry. Remarkable issues are a strictly managed innovation process and the targeted appliance of open innovation techniques. The evaluation indicates that the German automotive industry is well positioned.

The current situation with regard to structural and technological change accompanied by the covid-19 pandemic shows currently a bad picture of this business and a challenging murky outlook as well.

In the empirical part the situation of the German automotive industry was pointed out in several dimensions. Statistical evidence was given with absolute and relative figures. The overall assessment shows an outstanding performance of the German automotive industry, in comparison to domestic industries as well as in comparison to car manufacturers abroad.

The key points are the excellence in executing process management, including internal and external knowledge management with the support of cooperations and protecting quickly the outcome in terms of intellectual property.

In consideration of the formulated research question and careful assessment of arguments, it can be stated that the German automotive industry has an outstanding innovation power. Summing up, it can be concluded that this innovation power is key for the German economy in regard to innovation, employment, prosperity, competitiveness and in the end for the welfare of the nation.

Consequently, it can easily be derived that there is a huge and instant need for action to support this industry:

short-term: to overcome the current crisis due to covid-19 pandemic

mid-term: to solve structural problems and impact of economic downturn

long-term: to manage strategic transition to alternative drives and mobility

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