



EXPLORING OPEN INNOVATION

An analysis of the influence of external search strategy
on innovation performance and its effect on employee loyalty
in the German automotive industry

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Abstract

External knowledge sources are nowadays commonly accepted to be an important element for firm's innovative performance. Therefore, this research helps to get new insights into the level of firm's openness behavior referring to its search strategy and innovation performance. Beyond, it tries to find evidence for employee loyalty between high performing and other firms. In detail, the subject here is to explore open innovation by analyzing what dimensions of firm's external search channels are affecting innovation outcomes and whether higher innovation performance could be related to employee loyalty and satisfaction in the R&D department of the German automotive industry.

In this study three dimensions of external search strategies that affect firm's innovation performance are investigated. The two concepts of external search breadth and depth that both look into the subject of "how" firm's access external knowledge are introduced. The third concept shows the relevance of interacting with a wide range of external sources during the innovation process emphasizing "with whom to interact with" (Arruda *et al.*, 2013). Quantitative research within a mail survey was used for data collection purposes. Based on the survey, I found that searching intense and deeply present a curvilinear relation (taking an inverted U-curve) between the search strategy and firm's innovation performance, and discovered the presence of a point of "over-search". Regarding external search breadth this study indicates that the diversity of different external partners possesses a positive effect on innovation performance of German automotive firms. Next, I found that the level of openness within the innovation process is an important dimension as well. Therefore, this thesis provides evidence that firm's innovation performance depends on different external actors. In particular, customers, other companies in the holding and suppliers possess a significant impact. Finally, the results indicate that open innovation positively affects innovation performance among German automotive firms and that high-innovators tend to have more satisfied and consequently loyal R&D employees than other firms.

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1. Introduction

1.1. Research Gap and Research Question

A constantly changing environment through increasing globalization, shorter time-to-market periods, intense competition, and the uprising need to win the race for talents are trends that companies can only manage if they innovate (Chen *et al.*, 2011). Companies start to realize that fully relying on its internal Research and Development (R&D) capabilities is risky and expensive in an increasingly open business world. Therefore, co-operations and interactions with external channels are receiving more and more attention. The open innovation model was framed to manage these uprising challenges by interacting with external innovation sources (Chesbrough, 2003a). In the literature is open innovation also commonly assimilated with “technology acquisition” and “technology exploitation” (Lichtenthaler, 2008). However, technological innovation has often an uncertain outcome since only a fraction of innovations lead to new products and services that make it to the market successfully (Chen *et al.*, 2011). Therefore, particularly technology-based industries have to explore new ways of innovation to escape this productivity dilemma (Ili *et al.*, 2010).

The German automotive industry is the largest industry sector in Germany and it is strongly relying on cutting-edge technologies. Nowadays, it is the most innovation-intensive German industry with a percentage of sales out of new products and services of over 50%. The budget in 2014 is estimated on 47,1bn € and innovation expenses amount about 10,2% of sales.¹ However, for decades the automotive industry was not considered to suit into the open innovation model because of its historically large investments in internal R&D (Ili *et al.*, 2010). Through the need for increasing innovation and cost pressure in the industry, the Original

¹ ZEW Innovationen Branchenreport: Ergebnisse der deutschen Innovationserhebung 2013, Jg. 21, Nr. 10, Januar 2014.

Equipment Manufacturers (OEMs) explored new ways to achieve firm success and profitability. One important method was the tendency to turn away from solely internal R&D towards external knowledge sourcing (Ili *et al.*, 2010). Even though several studies about the positive impact of external search channels on firm performance (Salomo *et al.*, 2008; Tsai and Wang, 2008) exist, it is still not clear, what the significant dimensions are in achieving superior innovation performance in the German automotive context. Therefore, this thesis explores external search breadth and depth as models of external search strategy, and identifies the relevant external innovation partners to maximize innovation performance.

When it comes to innovation and performance the focus of attention should be also shifted towards R&D employees. In a competitive and globalized industry, as the German automotive one, employees become the foundation for firm performance and productivity (Homburg *et al.*, 2009). Laborers are directly involved in innovation activities and therefore responsible for the innovation outcome. Also, it is considered that satisfied employees are more loyal and have a significant impact on firm profits (Yee *et al.*, 2010). However, employee-firm relations were barely tested in the context of innovation performance. Therefore, I want to explore whether firm's innovation performance could have a positive impact on employees in building a loyal relationship towards the company.

1.2. Research Object

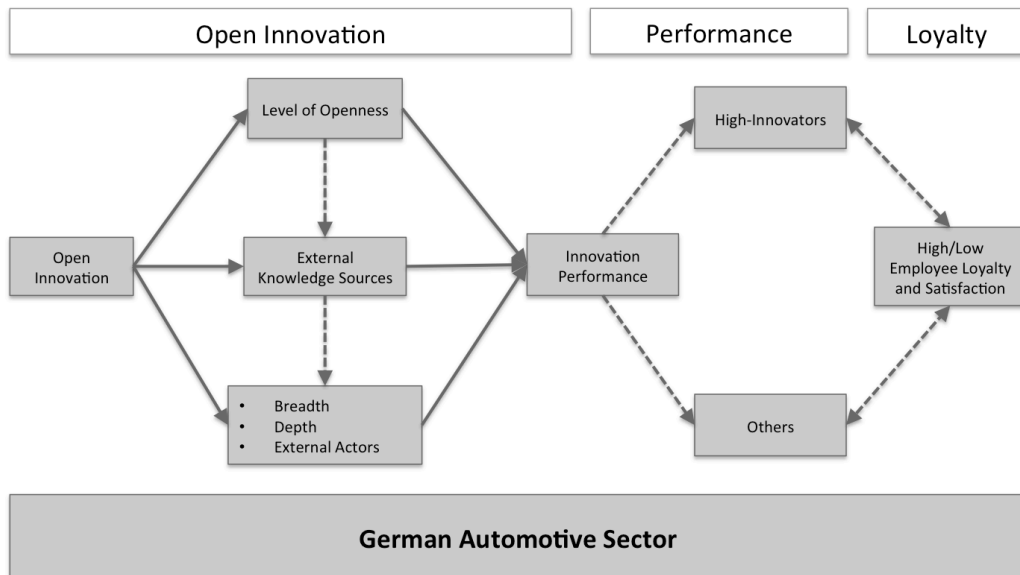
Open innovation has been introduced as a new paradigm of innovation management (Chesbrough, 2003a). The approach refers to the systematic opening of company borders for inside-out and outside-in movements of technologies and ideas. Hereby, it enhances internal innovation and expands markets for external innovation acquisition (Chesbrough, 2003a; Lichtenthaler, 2008). One main characteristic is the integration of external partners throughout the innovation process (Cheng and Huizingh, 2014). This implies that companies have to look for external sources beyond its business segment (Malik and Wei, 2011; Huizingh, 2011).

Child *et al.* (2005) identify various motivations for companies to cooperate with external partners during its innovation activity such as better market access and joint product development. Both might lead to an increase in firm's competitiveness, sales and profitability. However, implementing open innovation activities may also hold barriers that can decrease the effectiveness of the innovation process such as the asymmetry in learning and power relations, and cultural aspects (Hladik, 1988; Hamel, 1991). After showing possible opportunities and risks for cooperating during the innovation process, I want to take a deeper look at the searching strategy. To investigate the influence of the external search strategy on innovation performance I base this work on the framework of Laursen and Salter (2006) and Katila and Ahuja (2002) who advance the view that the involvement of external partners achieves and sustains innovation. Furthermore, I complement their findings by exploring whether employee loyalty can be explained by firm's innovation performance.

Laursen and Salter (2006) developed their concept of external search breadth and depth based on the investigation of Katila and Ahuja (2002) who highlight the importance of intense co-operation and interaction with external partners (external search depth) as well as the involvement of a wide range of external sources (external search breadth) throughout the innovation process. In addition, Belderbos *et al.* (2004) and Miotti and Sachwald (2003) show the relevance of choosing the right external innovation partners to cooperate with. The impact of external search strategies on innovation performance of German automotive firms will be analyzed by gathering empirical evidence in form of a questionnaire. The loyalty variable was composed of employee perceptions and beliefs to show a possible discrepancy between highly innovative companies and others. The elementary data about the German automotive sector is provided by CIS, the Community Innovation Surveys². Figure 1 provides the conceptual framework of this thesis.

² CIS surveys gather several data about activities within the German economy by carrying out questionnaires for the last 20 years.

Figure 1: Conceptual Framework



1.3. Work Structure

The thesis is structured in five chapters of theoretical review and analysis. The second chapter covers the literature review including the definition of open innovation having the focus on external search strategy, innovation performance, and the importance of loyalty. The third chapter explains the theoretical frame of reference. Here, the topics of innovation process and external knowledge sources are covered distinguishing external search breadth and depth, and external innovation partners. Later, the study looks at the relationship between employee loyalty and innovation performance. Chapter four includes the empirical by describing the methodology and the measurement of the key points affecting innovation performance of German automotive firms, as well as the measure for employee loyalty. The fifth chapter presents results and models used to analyze the research question and hypotheses. Finally, a discussion of the main results is presented in the conclusion.

2. Literature Review

2.1. Open Innovation

Henry Chesbrough introduced the idea of open innovation in his book *Open Innovation: The New Imperative for Creating and Profiting from Technology (2003a)* as the new paradigm in innovation management and described it later on as “...the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” (Chesbrough *et al.*, 2006, p.2).

Although it is a new coined term, open innovation was formed out of various ongoing developments from the past. Some included concepts were the Not Invented Here (NIH) syndrome of Katz and Allen (1982), the lead user approach of von Hippel (1986), the consideration of complementary assets of Teece (1986), and the absorptive capacity concept of Cohen and Levinthal (1990). Beyond, also present challenges had formed the open innovation term. Changes in the business environment characterized by changing customer requirements, new technologies and the mobility of skilled labor made it difficult for companies to keep its strategic advantage from internal R&D (Chesbrough, 2003a; 2006). This means that companies need to acquire external knowledge, ideas and technologies to accelerate its internal innovation process. In addition, unused internal knowledge should be monetized through external paths to market (Chesbrough, 2003a; 2003b).

Therefore, the open innovation model implies several internal and external search channels (West and Gallagher, 2006). Firms can open up its innovation process in two directions, either inbound or outbound (Lichtenthaler and Ernst, 2009; Lichtenthaler, 2009). Inbound open innovation activities correspond to firms' ability of acquiring and exploiting external knowledge from cooperating partners and sources such as suppliers, customers, competitors, research institutes, universities and governments (Faems *et al.*, 2005; Tether and Tajar, 2008; Cheng and

Huizingh, 2014). Furthermore, it describes the ability of leveraging external discoveries since firms do not need to rely solely on their own R&D capabilities anymore (Chesbrough and Crowther, 2006). Previous research in this area has covered networking with external actors (Dittrich and Duysters, 2007; Enkel, 2010) and the integration of new innovative ideas (Piller and Fredberg, 2009).

Outbound open innovation activities imply external exploitation of firms' internal knowledge. It includes patents, licensing out, outsourcing of internal knowledge, and firm spin-offs (Lichtenthaler and Ernst, 2009; Cheng and Huizingh, 2014). Studies on outbound innovation activities include co-operation, partnerships, licensing and alliances (Lichtenthaler and Frishammer, 2011), and commercialization of unused internal knowledge and technologies in new and uprising markets (Enkel and Gassmann, 2010; Chesbrough and Crowther, 2006). As open innovation encompasses a wide part of activities (Cheng and Huizingh, 2014) with different openness levels (Huizingh, 2011), this work is focusing mainly on the inbound concept by acquiring external knowledge from different sources to explore its effect on firm's innovation performance.

2.2. External Search Strategy

According to Chesbrough (2003a) plenty of innovative firms shifted to a more open business approach using external partners to innovate. An important part of opening the innovation process plays the search strategy used to acquire new technologies and ideas. Research shows that search strategies have a significant impact on innovation performance (Katila, 2002; Katila and Ahuja, 2002). Cohen and Levinthal (1990) highlight that the ability to exploit knowledge from external sources is a crucial part of innovation performance. Companies were also adopting open search strategies that imply deeper or wider search to achieve a more sustainable innovation (Laursen and Salter, 2006). Over the years uprising models of innovation identified that successful innovators heavily rely on their interaction with external players throughout the innovation process,

including lead users, suppliers, and many different institutions (von Hippel, 1988; Ludvall, 1992; Szulanski, 1996). Chesbrough (2003a, 2003b) suggests that innovative firms do not need to spend high investments in internal R&D but rather have to develop the ability to successfully innovate through exploitation of knowledge available from a wide range of external sources through the utilization of an effective external search strategy.

2.3. Innovation Performance

Innovation performance is a very fragmented research area. The term originally refers to how successful firms were in introducing new products or services to the market (Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994). Many research studies about measuring innovation performance were conducted, using new product or service innovativeness (Atuahene-Gima and Wei, 2011), the degree of success of new products and services (Blazevic and Lievens, 2004; Baker and Sinkula, 2007), or even the percentage of sales (Im and Workman, 2004). Other research studies imply various different performance measures to analyze innovation performance from different perspectives (Henard and Szymanski, 2001; Im and Workman, 2004). Out of this overall collection the following four dimensions are selected to demonstrate innovation performance (Cheng and Huizingh, 2014; Arruda *et al.*, 2013):

- New product or service innovativeness
- New product or service success
- Better customer performance
- Better firm's financial performance

The first dimension is new product or service innovativeness. It refers to the novelty level of the innovation introduced to the market (Garcia and Calantone, 2002; Salomo *et al.*, 2008). The second one, success of new products or services in the market, is measured by firms' ability to compete (Baker and Sinkula, 1999). The third dimension is customer performance that covers the large area of customer satisfaction and loyalty (Blazevic and Lievens, 2004). Finally, the last dimension is financial performance of firms

in the market. This can be analyzed through financial success of new products and services referred to firm's profitability (Im and Workman, 2004). The measurement of innovation performance must not only be based on financial measures but also on different cycle time measures (Griffin, 1993; Knudsen and Mortensen, 2011). This method allows a comparison of unequal innovation activities, even if the firms are not active in the same sector. So, additional three dimensions will be added to complete the measures for innovation performance (Arruda *et al.*, 2013):

- Greater speed of the innovation process
- Superior quality of the product or service
- Less costs of the innovation process

2.4. Power of Loyalty and Satisfaction

The power of loyalty is an essential element in the business world with significant impact on company's performance (Harter *et al.*, 2002). Moreover, it became an indicator to identify innovative companies that possess the ability to serve uprising customer needs in the markets (Reichheld and Teal, 1996). In this sense, achieving loyalty must be a central objective in every company.

Plenty of articles, forums, conventions and best practice examples exist on how to enhance loyalty efforts (Reichheld, 2003). According to Foster *et al.* (2008) and Reichheld (2001) companies with more loyal customers, employees or shareholders generate even higher sales and profits. Hence, from a company's perspective, it is very important to increase the number of loyal customers or at least maintain them to stay competitive in the market. However, companies cannot earn customer loyalty before earning employee loyalty first (Reichheld, 2003; Reichheld 2006).

In the literature, employee satisfaction is often linked to customer satisfaction, and therefore causally related to firm and industry performance (Schneider *et al.*, 2003; Homburg *et al.*, 2009). Employee satisfaction can be described as the result of a person's positive

perceptions to his or her work or company (Homburg and Stock, 2004). Further research studies show a positive and significant relation of employee satisfaction with employee loyalty towards their company, as well as a negative relation with their purpose to leave (Griffeth *et al.*, 2000; Hom and Kinicki, 2001; Martensen and Gronholdt, 2001). Michlitsch (2000) concludes in his research on employee loyalty that high-performing employees are the key for a successful business model. Yee *et al.* (2010) explore a significant impact of loyal employees on firm's financial performance. Accordingly, satisfied and therefore loyal employees are the key of any successful performing company. Several studies already analyze loyalty among different performance dimensions (Yee *et al.*, 2010; Reichheld and Teal, 1996; Michlitsch, 2000; Homburg *et al.*, 2009), however, the influence of innovation performance on employee loyalty and satisfaction was barely tested. Therefore, this research is exploring whether higher firm's innovation performance could be decisive for greater employee loyalty.

3. Theoretical Frame of Reference

3.1. Innovation Process and External Knowledge Sources

Innovation can be seen as a process with sequential and interconnected activities (Van de Ven *et al.*, 1999; Svetina and Prodan, 2008). The first Schumpeterian innovation model proposed a non-integrated model of innovation where firms develop and commercialize new technologies on their own (Schumpeter, 1942). In this model innovation was treated as a linear progression of processes performed by firms internally. The complete development of an innovation from basic research to product launch in the market was following a formal and inflexible internal process (Godin, 2006; Svetina and Prodan, 2008).

More recently this non-linear and more “closed” innovation model has changed. Many firms now cooperate across industries with external sources (Cohen and Levinthal, 1990; Tsai and Wang, 2008). Chesbrough (2003a, 2003b) emphasizes the benefit of using external knowledge sources through increasing inter-firm technology transfer to manage a successful innovation process. He states that this concept enables companies to discover new ideas, lower its innovation risk and increase the speed to market. Accordingly, firm’s searching behavior and external search strategy assume great importance when analyzing innovation performance (Katila and Ahuja, 2002). An external search strategy may be defined as a company’s decision to select the best possible way to acquire and exploit external knowledge (Laursen and Salter, 2006). A company’s external search strategy is widely shaped through external environmental factors such as the availability of technology, the framework of the innovation system and the degree of complexity and turbulence (Cohen and Levinthal, 1990; Klevorick *et al.*, 1995). On the other hand, Laursen and Salter (2006) propose another important characteristic. They claim that manager’s past experiences and future expectations influence the external search strategy as well. Nevertheless, the most crucial part of an external search strategy is its level of effectiveness, which is affected by how the

company manages its search processes of exploiting new ideas, external knowledge and technologies (Arruda *et al.*, 2013). Although, organizations possess these capabilities it is still difficult for them to determine a leading search strategy (Levinthal and March, 1993). Empirical research shows that to develop the best strategy it is important to focus on the industry the company operates in, the type of knowledge explored and the novelty of innovation (Criscuolo *et al.*, 2011; Garcia and Calantone, 2002). These are reasons why it is worthwhile investigating the development of an effective external search strategy. Therefore, it becomes more important to dig deeper into the dimensions that affect company's search strategy and its effectiveness.

The authors Katila and Ahuja (2002) suggest to concentrate on two dimensions throughout the development process of an external search strategy. The first dimension implies deep and intense interaction with external sources. The second one consists of the broad diversity of interaction with external actors. In the German automotive context broader and deeper search might enable companies to develop greater abilities to adapt changes and hence to innovate successfully. A third dimension is proposed by Miotti and Sachwald (2003) and Belderbos *et al.* (2004) that contains the free selection of which external actors to interact with.

3.2. External Search Breadth

Laursen and Salter (2006) developed the concept of Katila and Ahuja (2002) in order to analyze the consequence of broader and deeper searching on innovation performance. The first concept is external search breadth that is related to the variety of external actors the company interacts with, which the authors define as "*the number of external sources and search channels that firms rely upon in their innovative activities.*" (Laursen and Salter, 2006, p.134). Katila and Ahuja (2002) stress that companies that explore and acquire new knowledge and solutions use mainly breadth as their external search strategy. Prior research has demonstrated that the more external partners the company interacts with

the higher the innovation performance gets (Katila and Ahuja, 2002). In the German automotive context the interaction with various external partners became an indispensable part in developing new technologies and products, accelerating time-to-market and meeting market expectations (Ili *et al.*, 2010).

However, Katila and Ahuja (2002) also argue that external search breadth can cause a negative impact on the search process. The authors state that the scanning process of a wide range of sources and the heavy involvement of external actors becomes the more intense it gets less beneficial, rather than the contrary. They argue that a cost of integration of knowledge exists which may overrun the benefits of new knowledge discoveries. Taking positive and negative effects into account, empirical studies (Laursen and Salter, 2006; Leiponen and Helfat, 2010) come to the conclusion that the number of different external actors the company interacts with is curvilinearly (taking an inverted U-curve) related to innovation performance. Based on this, the first hypothesis has been framed as followed:

Hypothesis 1. *External search breadth has a positive effect on innovation performance of German automotive firms.*

3.3. External Search Depth

As seen above, the variety of external actors presents the importance of a broader search process. However, regarding the external search strategy not only a wide range of external actors is relevant but also the intensity of interacting with them. In this sense, the second concept refers to external search depth. Here, the relevant perspective lies in the analysis of deep interactions with external sources and defines how deeply to draw from different external search channels (Laursen and Salter, 2006). This is the dimension where the company exploits valuable knowledge of external actors it interacts with, according to Katila and Ahuja (2002). Levinthal and March (1981) conclude that through iterative processes and the usage of same knowledge elements the possibility of emerging errors is reduced

significantly, and routines are developed and strengthened. All these activities add reliability to the innovation process and trust in the mutual co-operation. In this sense, the iterative application of knowledge acquired from external partners may help the company to assimilate and even expand its innovation competencies (Katila and Ahuja, 2002). Therefore, the integration of external technology and strong co-operation with other industry actors are crucial for increasing innovation power, and indicate the importance of increasing technology intensity (Ili *et al.*, 2010).

However, Dosi (1988) claims that sooner or later there is a limitation to the process of drawing deeply from external sources. As regards that, Katila and Ahuja (2002) discover two criteria. At first the authors point out the existence of a cost where after a certain point the innovation activity of the same source becomes more costly, while at the same time the solution becomes far too complex. They named it the point of “over-search”. The second criterion is related to the fact that the deeper the interaction with a single external partner goes the less flexible and more rigid the innovation process becomes (Argyris and Schön, 1978).

Hence, Katila and Ahuja (2002) and Laursen and Salter (2006) suggest that in principle greater reliance on a single external knowledge sources has a positive outcome until it reaches the point of “over-searching” where deeper digging becomes disadvantageous in terms of firm’s innovation performance. Therefore, the second hypothesis can be stated followed:

Hypothesis 2. *External search depth is curvilinearly (taking an inverted U-curve) related to innovation performance of German automotive firms.*

3.4. External Innovation Partners

The degree of interaction and the diversity of external sources are essential dimensions of the external search strategy. The German automotive industry is a fast-paced and highly competitive environment that heavily invests in R&D and new product development (NPD). The industry players depend on the most and best idea creation. Therefore, interaction with

external actors is shifting into their focus of innovation developments (Ili *et al.*, 2010). The OEMs are surrounded by external knowledge sources with whom they could interact. Under many possible external innovation partners, I decided to use the selection of Arruda *et al.* (2013) which was also conducted and analyzed by ZEW, the Centre of European Economic Research, relative to the period 2012, and published in Community Innovation Surveys (CIS)³ most recent in 2013. The selected actors are:

- Customers
- Competitors
- Other Companies in the Holding
- Suppliers
- Universities and Research Institutes

These five external actors are likely to lead to positive innovation outcomes for German automotive firms, according to CIS. Customers compose in general an external information source of knowledge about technologies, market characteristics and customer needs (Arruda *et al.*, 2013). In the innovation phase an involvement or collaboration with customers tends to accelerate this process. Furthermore, it may reduce market risks associated with new product or service introductions (von Hippel, 1988), making customers an important co-developer or inventor when offering new ideas, concepts for prototype developments, or complex products during the initial project phase of innovations (Tether, 2002; Lettl *et al.*, 2006). Moreover, von Hippel (1986) shows the importance of interacting with customers whose needs represent the market and form future market needs, which he defined as lead users. Further actors that can reduce costs, improve product or service quality, and, as a consequence, speed up the innovation process are competitors and suppliers (Clark, 1989; Dyer, 1996; Ragatz *et al.*, 1997). Supplier involvement in the early stages of the innovation process, for example in the conceptualization or design stage, can be beneficial according to Bidault *et al.* (1998). On the other hand, it

³ Webpage: <http://www.zew.de/en/publikationen/innovationserhebungen/innovationserhebungen.php3>

poses the risk that sensitive knowledge could leak out of the company (Mikkola and Larson, 2006). Competitor involvement makes sense in some limited cases mainly to reduce costs and create synergies in R&D (Tether, 2002; Miotti and Sachwald, 2003). Universities and research institutes are also treated as important external actors enabling access to new scientific technologies and knowledge (Klevorick *et al.*, 1995; Belderbos *et al.*, 2004). According to Belderbos *et al.* (2004) an interaction with universities and research institutes is having a positive effect on the development process of radical innovations. The last actor defined are other companies in the holding. Chesbrough (2003a) holds the opinion that new ideas, hidden knowledge and pioneering technologies can be found everywhere in the company regardless of its size. In this regard, it is important to interact with companies within the holding and access the whole range of the organization to achieve superior performance throughout the innovation process.

As seen on the foregoing, interaction with any external actor above may have a positive outcome on company's innovation process. To make further estimations a heterogenic impact of different external actors on innovation performance is proposed (Belderbos *et al.*, 2004). Therefore, the following hypothesis is stated as followed:

Hypothesis 3. *Interacting with a) customers, b) competitors, c) other companies in the holding, d) suppliers, and e) universities and research institutes positively affect innovation performance of German automotive firms.*

3.5. Employee Loyalty in Matters of Innovation Performance

OEMs are always searching for new ways to add more value to its innovation activity and improve the quality of products or services. One of the most important factors in achieving this objective is human resource, which is directly involved in the innovation activity and outcome. Prior research indicates a mutual relation between employee job satisfaction and firm productivity (Yee *et al.*, 2008; Appelbaum *et al.*, 2005). Further

research points out that employee satisfaction has a positive impact on customer satisfaction and, therefore, also on firm sales and profitability (Yee *et al.*, 2010). Accordingly, happy and satisfied employees enable the firm to possess also happy customers. On the other hand, unhappy and unsatisfied employees, and weak employee-firm relations could prevent the firm of achieving greater customer satisfaction (Bhattacharya and Sen, 2003; Dwyer *et al.*, 1987; Hughes and Ahearne, 2010). Moreover, permanent employee loyalty might lead to cost reductions of employee turnover (Hoon and Phelps, 1992). In this sense, keeping employees can enable firms to keep its strategic advantage from new technologies developed internally and, consequently, its innovations (Chesbrough, 2003a; 2006). In addition, employee promoters stimulate business performance and enhance productivity through better provision of customers experience and better involvement in new idea findings of products, innovation processes and improvements (Reichheld and Markey, 2011). Therefore, if companies successfully bind loyal R&D employees they will consequently achieve better employee-firm relations that could result in higher firm innovation performance.

However, in this thesis I want take the opposite approach and analyze if innovation performance may be decisive for superior employee loyalty. This prediction also includes the assumption that high-innovators may have a more positive impact on employee loyalty and satisfaction than other companies in the industry. Hence, the last hypothesis is framed as followed:

Hypothesis 4. *Higher innovation performance positively affects employee loyalty and satisfaction.*

4. Empirical Study

4.1. Data and Methodology

Analytical data was gathered in form of a questionnaire. Before the survey was sent to German automotive firms, I conducted an interview with two industry experts who are specialized in the field of innovation management to verify the concept and applied models in this research. The survey was released for a two-month period from November 2014 to January 2015. It was applied through the online survey platform “Qualtrics” and sent to a database of 82 German automotive companies. Finally, 35 out of 82 surveys from German automotive companies were collected, filled in from senior, lower and assistant management employees out of the R&D area and its sub-departments.

The survey consists of four parts. The first part covers general company information, such as company size and firm’s investments in innovation. The second part provides a detailed insight about innovation efforts of the company and, on the other hand, of the German automotive industry. The next part is the essential part focusing on the research topic of this thesis by covering the diversity of external innovation partners, external search breadth and depth, innovation performance and employee loyalty and satisfaction. The fourth part asks general information about respondents. Detail information about the measures is given in the next chapter. After data collection the analysis was conducted in SPSS (Statistical Package for the Social Sciences) that was partly integrated on the “Qualtrics” platform. Out of the sample 45% indicated revenues over 1bn €, 24% between 1bn € and 500 mil € and 26% below 500 mil €. Considering the estimated amount of investments in R&D the average investment was about 8,5% out of the revenues from previous years.

4.2. Measures

4.2.1. Types of External Innovation Partners

The different types of external sources were covered in the survey by answering questions about the intensity level and importance of the interaction with external partners within the innovation process. Each of the five external actors from chapter 3.4 were analyzed separately. For analysis purposes a 7 points Likert scale from 1 “strongly disagree” to 7 “strongly agree” was chosen to evaluate the intensity of the relationship. Higher scores indicate a closer relationship with the partners within the innovation activity. In contrast, lower scores indicate the opposite. Cronbach’s alpha is used to measure internal consistency and reliability of scales in the survey. For these five indicators the coefficient is 0,825, which verifies a high level of consistency of the survey. In terms of the following regression analysis a binary scale according to Leiponen and Helfat (2010) was used by coding values from 1 to 4 as 0 and values from 5 to 7 as 1.

4.2.2. Measures for External Search Breadth

Two dimensions measure the degree of openness of innovative companies and are part of the external search strategy. One dimension is the breadth variable that refers to the diversity of external partners the company cooperates with. The measures for external search breadth were based on the publications of Laursen and Salter (2006) and Chen *et al.* (2011). Accordingly, the values for the five external actors were codified as 0 and 1 after the same scheme as above. Thereon, the results of each of the five indicators were summed up so that breadth close to 0 indicates no or a weak relation and breadth equal to 5 indicates a strong relation with the five external partners. According to this, the higher the measured value of the parameter the greater the variety of partners the company interacts with during its innovation activity. Cronbach’s alpha equals 0,756.

4.2.3. Measures for External Search Depth

The other dimension is the depth variable. This dimension analyses how intense firms draw on each of the external partners during the innovation

process. As Chen *et al.* (2011) state, the depth variable can be calculated by using the average of the interaction rate of all external actors displayed on a Likert scale from 1 “strongly disagree” to 7 “strongly agree”. Companies with greater depth exploit external knowledge from a wide range of external actors intensively. Hence, higher scores indicate a more intense relation with the innovation partners. Lower scores mean the opposite. In this case Cronbach’s alpha for the five factors is 0,867 representing again a high level of internal consistency.

4.2.4. Measures for Innovation Performance

Innovation performance is the dependent variable in the analysis. The theoretical part of the measurement of innovation performance was based on the work of different authors from chapter 2.3 and is quantified by seven factors:

- New product or service innovativeness
- New product or service success
- Better customer performance
- Better financial performance
- Greater speed of the innovation process
- Superior quality of the product or service generated
- Less cost of the innovation process

The Likert scale was used in the questionnaire to measure the importance of each factor. The points on the scale are allocated from 1 “strongly disagree” to 7 “strongly agree”. Higher scores on the Likert scale mean a strong firm innovation performance compared to its competitors and lower scores indicate a weak innovation performance. Cronbach’s alpha coefficient is 0,798. In terms of the regression analysis the average of this seven variables was used to measure overall innovation performance of German automotive firms.

4.2.5. Measures for Employee Loyalty

The tool used to evaluate employee loyalty is the employee Net Promoter Score (eNPS). The eNPS is deviated from the original Net Promoter Score (NPS)⁴ developed by Fred Reichheld, Bain & Company, and Satmetrix (Reichheld, 2003). The eNPS approach seeks for the best measureable attributes of employee engagement that might have an impact on customer satisfaction and growth opportunity. The data of this score is based on two survey questions, stating “Q1: How likely would you recommend this company as a place to work to a friend or colleague?” and “Q2: How likely is it that you would recommend your company’s products or services to a friend or colleague?” (Reichheld and Markey, 2011; Official Net Promoter website⁵).

The answers are distributed on a scale from 0 to 10. Employees are sorted into Promoters, Passives and Detractors. Promoters are those employees considered as loyal enthusiasts who answered the question with a score of 9 or 10. Detractors are the opposite, they answers are located between the score of 0 to 6 and they are considered as unhappy employees. Employees who answered between the scores of 7 and 8 are called Passives, which means, their answers will only count towards the total number of respondents with no influence on the formula (Official Net Promoter Website). At the end, the eNPS and the average of innovation performance were used for the correlation determination and the regression analysis. Moreover, the relation of employee loyalty between high-performers and others was also illustrated based on this data.

⁴ NPS is a method to measure loyalty of firm’s relationships to e.g. customers. NPS is calculated by subtracting the relative number (%) of Detractors from the relative number (%) of Promoters. The range within the score can vary from -100 to +100. Generally, positive NPS is considered as good and NPS over +50 as excellent.

⁵ Website: <http://netpromotersystem.com>

5. Results

5.1. Descriptive Statistics

The descriptive statistics are based on the sample of 35 respondents from the German automotive industry. Table 1 presents descriptive statistics including variables of breadth and depth as well as each variable of the five external actors that are impacting innovation performance of German automotive firms. At this point it should be mentioned that the research sample was checked on errors before the analysis to avoid any sort of bias.

Table 1: Descriptive Statistics

	N	Mean	S.D.	Minimum	Maximum
Breadth	35	2,91	1,62	0	5
Depth	35	4,58	1,26	1	6,2
Innovation Performance	35	4,91	0,89	2,57	6,4
Customers	35	5,37	1,52	1	7
Competitors	35	4,63	1,65	1	7
Other Companies in the Holding	35	4,11	1,81	1	7
Suppliers	35	4,43	1,42	1	7
Universities and Research Institutes	35	4,37	1,77	1	7

As regards the breadth variable it can be seen that German automotive companies have on average a more intense and deeper relation with roughly 3 external partners within their innovation activity. In the survey only 6 companies stated that they had a relationship with all five partners and 10 companies specified their interaction with 4. The average of the depth variable is 4,58, which means that German automotive companies in general tend to have a sufficient and more intense relationship with external partners. After all, it is observed that German companies interact

intensively with customers, competitors and suppliers. Other companies in the holding and universities and research institutes play a moderate role concerning the intensity of the relationship. With respect to the innovation performance variable, it is observed, that on average the innovation level of German automotive companies is satisfying.

The dimensions of loyalty and satisfaction of employees were based on the two questions from chapter 4.2.5. Table 2 presents the overall eNPS scores, which are indicating positive employee loyalty.

Table 2: Overall Employee Net Promoter Score

Q1: eNPS	N	%	Q2: eNPS	N	%
Promoters	14	40,00%	Promoters	16	45,71%
Passives	8	22,86%	Passives	6	17,14%
Detractors	13	37,14%	Detractors	13	37,14%
Sample	35	100%	Sample	35	100%
Score		+2,86%	Score		+8,57%

According to table 2 the overall employee mood of the respondents seems positive, even though the first value of *Q1* is comparatively low. However, the positive percentage rates indicate that on average employees in the German automotive sector tend to have good employee-firm relations.

5.2. Results of the Regression Analysis for Innovation Performance

The regression analysis is examining correlations between variables and the previous hypotheses. The correlations of the core variables breadth, depth and innovation performance are given in Table 3. All three variables have a positive and strong correlation. Nevertheless, the breadth and depth variable present a very strong correlation that could possibly cause multicollinearity problems in the regression analysis. Therefore, the impact of each variable on innovation performance will be analyzed separately in different models.

Table 3: Correlations of Key Variables

	1	2	3
1. Breadth	1		
2. Depth	0,846*	1	
3. Innovation Performance	0,631*	0,754*	1

**Correlation is significant at the 0.01 level (2-tailed)*

The focus of this thesis implies not only the analysis of external search breadth and depth but also the exploration of an effective external search strategy referring to superior innovation performance. In this sense, I want to find out which external innovation partners have a beneficial effect on innovation performance. Therefore, five different models were constructed in Table 4. Model 1 and 3 show the linear relationship of breadth and depth variables in relation to innovation performance and endorse hypothesis 1. In model 2 and 4 these variables were tested whether or not a curvilinear relationship (taking an inverted U-curve) exists and thereby supports hypothesis 2 in proving the existence of a point of “over-search”. The last model tests hypothesis 3 and explores which external innovation partners are significantly affecting innovation performance of German automotive firms.

Table 4: Determinants of Innovation Performance in German automotive Industry

	Model 1	Model 2	Model 3	Model 4	Model 5
Breadth	0,334*** (4,676)	0,621* (1,710)			
Breadth ²		-0,063 (0,841)			
Depth			0,532*** (6,596)	1,182*** (4,614)	
Depth ²				-0,152* (1,782)	
Customers					0,703* (1,988)
Competitors					0,345 (1,667)
Other Companies in the Holding					0,611*** (3,921)
Suppliers					0,478* (1,975)
Universities and Research Institutes					0,309 (1,251)
Number of observations	35	35	35	35	35
R ² (R-squared)	0,398	0,403	0,569	0,601	0,416

Note: t-Statistics between brackets.

*** $p < 0.001$, ** $p < 0.05$, * $p < 0.10$

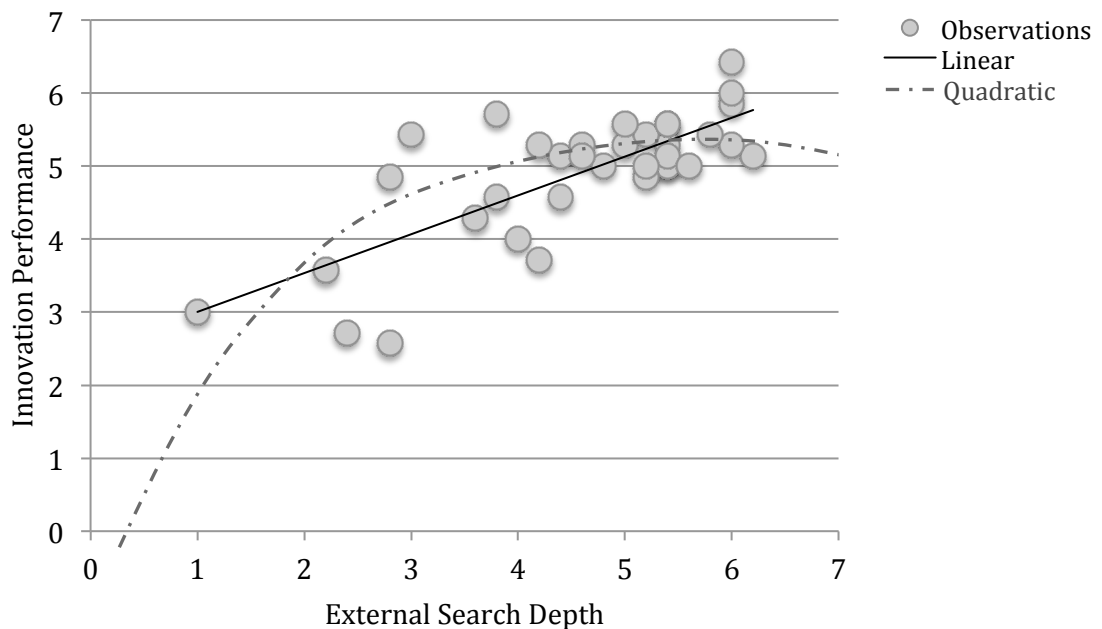
Model 1 shows a positive and significant coefficient of breadth. This means that breadth has a positive impact on innovation performance of German automotive firms. The findings show that greater variety of interaction with external innovation partners during the innovation activity tends to result in better innovation performance, corroborating hypothesis 1. R² is 0,398 or 39,8%, which is decent. This variable shows the proportion of reliability in y (innovation performance) explained by x (external search breadth). Model 2 tested the curvilinear effect (taking an inverted U-curve)

of breadth on innovation performance. This analysis shows whether or not a point of “over-search” exists, whereby greater variety of external innovation partners causes a negative impact on innovation performance. The squared coefficient of breadth has a negative sign but it is not significant even though the R^2 is higher than in model 1. However, the negative sign indicates a tendency that there might be a fall after the optimum point is reached. In this sense, the importance of the diversity of external actors for explaining innovation performance in German automotive companies is observed. Nevertheless, a point of inflection was not found that would cause a negative impact on innovation performance through greater interaction with additional external partners. At this point I would like to present some previous studies that have substantial similarity to this one. Chen *et al.* (2011) identify that for Chinese companies a decrease of innovation performance occurs after interacting beyond 9 external partners. On the other hand, Laursen and Salter (2006) indicate decreasing return of UK companies after a point of interaction with more than 11 external partners was reached. With respect to this analysis it was assumed that a point of “over-search” in relation to the diversity of external innovation partners could not be found since only 5 external actors were analyzed which are not enough to put strain on the results.

Model 3 and 4 indicate the impact of depth on innovation performance. Model 3 demonstrates a positive and significant impact of the depth coefficient on innovation performance with a R^2 of 0,569. The result indicates that in terms of an external search strategy an intense relationship with external innovation partners tends to have a positive effect on innovation performance of German automotive firms. Model 4 tests hypothesis 2 stating that there must be a point whereby deeper and more intense relations with external partners are disadvantageous for the company. The squared coefficient of depth has a negative sign but, in contrast to breadth, it is significant. Consequently, in the analysis of the depth variable it seems that a curvilinear approach might fit better to the German automotive industry considering a R^2 of 0,601 that indicates a

good fit. The result proves moreover that “over-search” in the German automotive context exists. Figure 2 presents the optimum level of interaction, which lies between 5 and 6. In this sense, in terms of deeper interaction with external innovation partners related to firms’ external search strategy a saturation point could be identified.

Figure 2: Predicted Relationship between Innovation Performance and External Search Depth



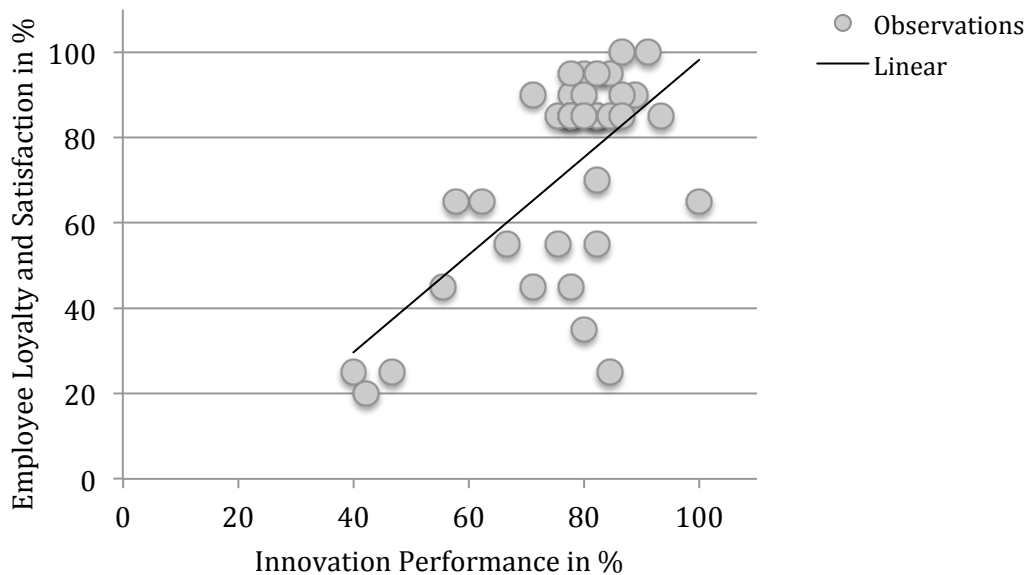
Model 5 demonstrates that interaction with external partners from the firm’s value chain has a positive effect on innovation performance with a R^2 of 0,416. Accordingly, interactions with a) customers, c) other companies in the holding and d) suppliers are important contributors to innovation resulting in higher innovation performance, corroborating hypothesis 3. Although German automotive firms tend to interact with b) competitors and e) universities and research institutes above the average the coefficient is not significant, therefore these variables are not capable of influencing innovation performance and thereby disclaim hypothesis 3.

5.3. Employee Loyalty and Innovation Performance Analysis

The last analysis states the proposed impact of innovation performance on employee loyalty. Innovation performance and employee loyalty have a

strong positive relationship according to their correlation coefficient of 0,639 (Appendix 2). Figure 3 indicates stronger employee-firm relations in firms with higher innovation intensity.

Figure 3: Causality between Innovation Performance and Employee Loyalty



The chart illustrates in the upper quartile a compressed cluster of observations. Although there are statistical variations that can be referred to individual social behavior, the big picture indicates a strong causation that, however, is not proven. The causality figure shows moreover that the connection between employee loyalty and innovation performance is no coincidence and that bidirectional causation might exist.

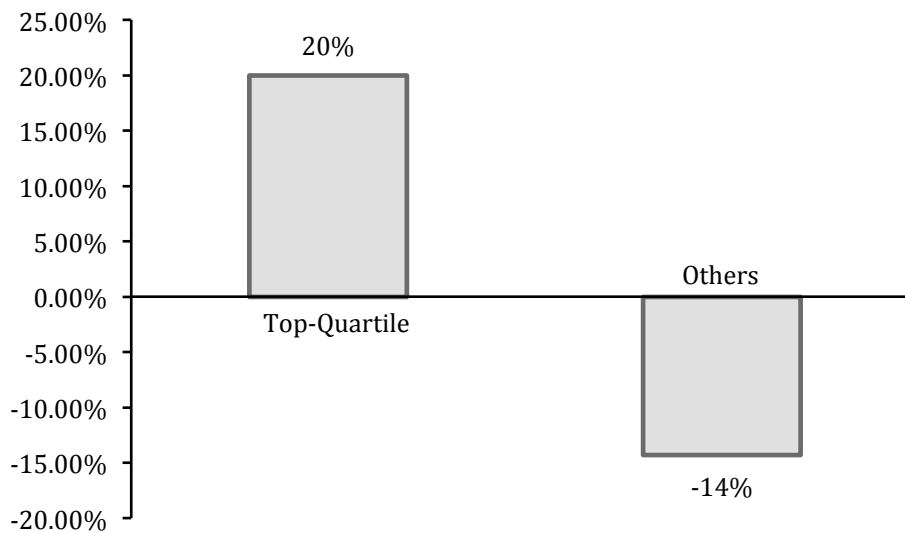
The regression of employee loyalty on innovation performance in table 5 has a positive and significant coefficient of employee loyalty.

Table 5: Regression of Employee Loyalty and Innovation Performance

	Employee Loyalty
Innovation Performance	0,229*** (4,665)
Number of observations	35
R ² (R-squared)	0,475

Further analysis compares companies' innovation rates in the German automotive industry. Figure 4 demonstrates the distribution of employee perceptions among high-performers in the top-quartile and other firms related to their loyalty and job satisfaction. Firms in the top-quartile have an innovation intensity rate of over 75% according to the innovation performance measures. In addition, the employee loyalty score - composed out of the eNPS of Q1 and Q2 - has to be over 75% as well to count as a top-quartile company. Lower scores count to others.

Figure 4: Employee Net Promoter Score: Top-Quartile & Others



Innovation's top performers have an eNPS of +20, compared with a low and negative score of -14 for others. This is a remarkable difference by eNPS standards and it explains how top-quartile companies have more satisfied and at the end loyal employees through better innovation performance. In this sense, it is obtained that R&D employees tend to be more loyal when they are actively integrated within innovation activities in high performing firms, corroborating hypothesis 4.

6. Conclusion

This thesis investigates the impact of external search strategy on innovation performance of German automotive firms. In addition, employee loyalty and satisfaction as a potential side effect of higher firm's innovation performance is also explored.

Firstly, I draw attention to the innovation process to highlight the necessity for firms to involve their environment throughout the search process for new ideas, knowledge and technologies. The results regarding external search breadth and depth show that the diversity and intensity of the interaction with external sources present a positive impact on innovation performance of German automotive firms, which was also obtained by Katila and Ahuja (2002), Laursen and Salter (2006) and Ili *et al.* (2010). However, innovation holds also obstacles. In particular, the existence of "over-search" that hinders innovation performance (Katila and Ahuja, 2002; Laursen and Salter, 2006) was analyzed as well. As regards breadth, a point of "over-search" could not be found which indicates that on average there is still space for more interaction with external actors to extend the diversity of knowledge searching and hence improve firm's innovation performance. Here, I have to say that this result was somehow expected since only five external partners were analyzed which in this case is not enough to prove a curvilinear effect of breadth. Nevertheless, further interaction with external actors will result sooner or later in negative outcomes for the firm because of the complexity of internalizing and integrating all ideas, knowledge and technologies in the innovation process (Arruda *et al.*, 2013).

On the other hand, the depth variable presents a point of "over-search" which corroborates hypothesis 2. This result indicates that German automotive firms when interacting deeply with all five partners within their innovation activity tend to have inferior outcome than the companies intensively interacting with less actors. Therefore, the decision for deep interaction should be made very carefully based on cost and benefit

analysis where the benefits of new discoveries and the costs of divergence should be pondered reasonable (Almirall and Casadesus-Masanell, 2010).

The results also indicate the relative importance of which external actor to interact with. In this sense, interaction with customers, other companies in the holding and suppliers lead to higher innovation outcome than interaction with competitors or universities and research institutes. The results indicate that German automotive companies tend to interact more with actors integrated in their supply chain. This finding could result from knowledge and production routines as well as arise from interacting mainly with actors from the same activity sector. Surprisingly, other companies in the holding play an important role in the innovation activity although German automotive firms tend to not have an intense relationship with them. According to Chesbrough (2003a) innovation can be found in every part of an organization no matter the size. However, mainly large-sized companies are active in the automotive sector and operating globally, so the result could be linked to the increasing and advancing globalization in this sector. Through the global spread of the field of business, new resources and technologies could be acquired worldwide and used for internal purposes. But to finally make this statement further research is necessary. Generally, the results show that the open innovation model is common in the German automotive context (Ili *et al.*, 2010) in forms of interacting with external innovation partners within firm's innovation activity. According to Chesbrough (2003a) this ability enables firm's to explore external sources more effectively and hence achieve greater innovation performance. Furthermore, considering an optimal external search strategy firms should increase their diversity and intensity of interaction but also take the presence of "over-search" into account.

As seen above the empirical results demonstrate that firms who use more external search channels are more likely to obtain a higher degree of innovativeness in terms of innovation performance (Laursen and Slater, 2006). The assumption that innovation performance is impacting employee

loyalty was also confirmed. For this rather straightforward hypothesis I found support based on empirical results. I conclude that high innovation performance has a positive impact on employee loyalty and that there might be bidirectional causation between both variables that is however not explicitly tested in this work. It seems that R&D employees that are generally involved in the innovation process enjoy their work more and feel closer to the outcomes of the company, which is reflected at the end in higher innovation performance and firm loyalty.

Limitations and Future Research

Nevertheless, the research analysis holds also limitations. First of all the small sample size has to be mentioned, which reduces statistical analysis possibilities and made it impossible to test further control variables that influence external search strategy and innovation performance. Another critical aspect can be found in the innovation performance approach. When it comes to innovation performance there is no right or wrong. Many measures tend to miss the central point of innovation. This thesis focuses explicitly on the outputs of innovation generating and not on the process itself, therefore, were topics as learning from new techniques, stimulation of new ideas, and adapting the ability to search in new areas only scratched at the surface.

The NPS is often criticized by the scientific world. A reason for the critics is that the proponents of this score criticize other ways of measuring loyalty and promote their own work (Reichheld, 2001; 2003; 2006). It is imputed that the NPS has no sufficient proof of a linkage between the score itself and company growth. Nevertheless, I decided to use this score since it measures best the existing loyalty between two actors. Doubts could arise out of the obviously lower score in *Q1 "recommending the company as a place to work"* compared with the other eNPS out of Table 2, *Q2*. A possible explanation can be found when looking at the gender of the respondents. About 63% male respondents filled in the survey, which is almost two-third. The German federal government has paved the way for more women

in executive boards position of large companies imposing a “female quota” of 30% from 2016. This law affects many large-size German companies, the OEMs included. Therefore growing dissatisfaction occurred among male employees since female employees are rather preferred for promotions in the near future. Nevertheless, this is only one possible explanation out of many and not to be taken for granted.

The last limitation I want to point out is the term “employee loyalty”. I want to highlight that for this research I was only collecting data in the German automotive area where a different understanding of loyalty can be found compared to other cultures and countries. In Northern America, for example, a hire and fire policy might lead from the beginning of the employment relationship to inferior employee-firm relations wherefore further research has to be done to see if findings could also apply.

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Appendix

Appendix 1: Key Measures from the Questionnaire

External Sources of Open Innovation:

A: The breadth of openness

Seven point scale from "Never" to "All the Time"

Please rate how often your company interacts with the following external sources during its innovation activities?

1. Customers
2. Competitors
3. Other Companies in the Holding
4. Suppliers
5. Universities and Research Institutes

With how many different external sources (absolute number), out of the five mentioned in the question above, do you interact with in your typical working day?

1. None
2. One
3. Two
4. Three
5. Four
6. All of them

B: The depth of openness

Seven point scale from "Strongly Disagree" to "Strongly Agree"

How strong are you agreeing regarding the importance of co-operating with the following external sources during your firm's innovation activities?

1. Customers
2. Competitors
3. Other Companies in the Holding
4. Suppliers
5. Universities and Research Institutes

Innovation Performance:

A: Innovation Intensity

Seven point scale from “Strongly Disagree” to “Strongly Agree”

In terms of innovation performance compared to other companies out of the German automotive industry, how would you agree on your company's performance regarding its... ?

1. New product or service innovativeness
2. New product or service success
3. Better customer performance
4. Better financial performance
5. Greater speed of the innovation process
6. Superior quality of the product or service generated
7. Less cost of the innovation process

How would you describe your company in terms of innovativeness?

1. Leader in innovation
2. Always first in the market
3. Innovation high performer
4. First follower in innovation
5. Creative in developing innovation

B: Innovation Capabilities and Efforts

Seven point scale from “Strongly Disagree” to “Strongly Agree”

How strong are you agreeing with the following statements concerning your companies' innovation attitude?

1. We consistently meet or exceed our innovation goals
2. We have a winning, repeatable model for innovation that we apply consistently in different regions and categories.
3. We have currently projects that will meet or exceed our financial targets for innovation.
4. We are prepared for major market disruptions through innovation.

The following statements are indicating innovation capabilities. How much would you agree on them concerning their existence in your company?

1. We have a clear and specific innovation strategy.
2. We have an organizational culture that supports innovation.
3. We have an effective idea generating and development process to create new offerings.
4. We are managing our innovation portfolio well in terms of size, shape and speed.
5. We are effective in scaling new business ideas and supporting them with enough resources.

Employee Loyalty and Satisfaction:

A: Employee Loyalty

Ten point scale from "0" to "10"

1. On a scale from 0-10, how likely would you recommend this company as a place to work to a friend or colleague?
2. On a scale from 0-10, how likely would you recommend your company's products or services to a friend or colleague?

B: Employee Job-Satisfaction

Seven point scale from "Strongly Disagree" to "Strongly Agree"

1. Generally speaking, I am very satisfied with this job.
2. I am generally satisfied with the kind of work I do in this job.
3. I frequently think of quitting this job. (reverse coded)

Appendix 2: Descriptive Statistics

	Observations	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7	8	9
Breadth	35	2,91	1,62	0	5	1								
Depth	35	4,58	1,26	1	6,2	0,846	1							
Innovation Performance	35	4,91	0,89	2,57	6,4	0,631	0,754	1						
Customers	35	5.37	1.52	1	7	0,574	0,727	0,508	1					
Competitors	35	4.63	1.65	1	7	0,675	0,828	0,597	0,622	1				
Other Companies in the Holding	35	4.11	1.81	1	7	0,579	0,709	0,700	0,209	0,537	1			
Suppliers	35	4.43	1.42	1	7	0,655	0,786	0,450	0,525	0,510	0,472	1		
Universities and Research Institutes	35	4.37	1.77	1	7	0,760	0,801	0,616	0,507	0,524	0,446	0,579	1	
Employee Loyalty	35	7.11	2.47	2	10	-	-	0,639	-	-	-	-	-	1

Appendix 3: Overview Innovation Performance

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree	Sample	Mean (weighted)
New product or service innovativeness	0	1	3	4	3	19	5	35	5,46
New product or service success	0	2	2	5	16	8	2	35	4,91
Better customer performance	0	1	1	5	15	10	3	35	5,17
Better financial performance	1	2	3	8	10	9	2	35	4,69
Greater speed of the innovation process	1	2	1	3	12	15	1	35	5,06
Superior quality of the product or service generated	0	3	3	7	10	11	1	35	4,74
Less cost of the innovation process	2	2	7	8	6	8	2	35	4,31
Average:	0,571	1,857	2,857	5,714	11,200	11,429	2,600		

Overall Mean:

4,91

Appendix 4: Importance of Each External Actor

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree	Sample	Mean (weighted)	S.D.
Customers	1	0	1	1	3	12	17	35	6,11	1,30
Competitors	1	1	1	0	10	14	8	35	5,60	1,35
Other Comp. in the Holding	1	3	3	7	13	7	1	35	4,51	1,38
Suppliers	0	1	1	3	11	14	5	35	5,46	1,12
Research Institutes and Universities	1	0	1	2	8	19	4	35	5,54	1,17
Average:	0,8	1	1,4	2,6	9	13,2	7			

Appendix 5: Frequency of co-operation with External Partners

	Never	Almost Never	Rarely	Sometimes	Often	Almost all of the Time	All of the Time	Sample	Mean (weighted)	S.D.
Customers	2	0	1	3	12	8	9	35	5,37	1,52
Competitors	2	1	6	6	9	6	5	35	4,63	1,65
Other Companies in the Holding	5	2	5	5	9	8	1	35	4,11	1,81
Suppliers	2	1	5	8	11	7	1	35	4,43	1,42
Research Institutes and Universities	3	4	2	9	4	11	2	35	4,37	1,77
Average:	2,8	1,6	3,8	6,2	9	8	3,6			