EXPLORING THE COLLABORATIVE INTEGRATION OF SERVICE PROVIDERS IN THE NEW PRODUCT DEVELOPMENT PROCESS OF AUTOMOBILE MANUFACTURERS

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Abstract

This Doctorate of Business Administration thesis examines the collaborative integration of engineering service providers (ESPs) in the new product development (NPD) process of automobile manufacturers. Through 11 qualitative key informant interviews with leading suppliers and buyers and the analysis of two case studies with a total of 22 interviewees, the explorative study analyses collaboration models, risks, motives, barriers and best practice guidelines for the identified two most important cooperation models in the field. The thesis draws on the literature of NPD processes, collaborative NPD, early supplier involvement, knowledge management, and relationship management in the automotive sector. The theory provides an introduction and serves as a basis for the developed guideline model. The provided best practice guidelines, sorted into the categories of 'people', 'process', 'collaboration technology', and 'product technology', are expected to improve collaboration in the joint NPD of complex products or technologies if these are applied by the management. Thus, the guideline model serves as a managerial tool to set priorities in the different phases of joint development, facilitate joint activities, and optimize NPD efficiency. Insights from this research are broadly applicable in the context of outsourced development of highly complex products or technologies to service providers. The thesis concludes with the discussion of its contribution to practice and theory and with an outlook on future developments in the ESP market.

Declaration of Original Content

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

Signed: Peter Tobias Mehrle

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‘Those who do not learn from history are condemned to repeat it.’

George Santayana

Contents

Abbreviations

ADAS *Advanced Driver Assistance Systems*

AUTOSIG ***Auto**motive **S**pecial **I**nterest **G**roup*

BoM *Bill of Material*

CAN *Controller Area Network*

CE *Concurrent Engineering*

CEO *Chief Executive Officer*

CM *Configuration Management*

ColE *Collaborative Engineering*

CTO *Chief Technology Officer*

ECM *Engineering Change Management*

ECU *Electronic Control Unit*

EMC *Electro-Magnetic Compatibility*

EoD *Expert on Demand*

ESI *Early Supplier Involvement*

ESP *Engineering Service Provider*

FFE *Fuzzy Front End*

IMVP *International Motor Vehicle Program*

IP *Intellectual Property*

IT *Information Technology*

KIBS *Knowledge Intensive Business Services*

KPI Key Performance Indicator

LIN *Local Interconnect Network*

MIT *Massachusetts Institute of Technology*

MLoC *Million-Lines-of-Code*

MOST *Media Oriented Systems Transport*

NPD *New Product Development*

OBD *On Board Diagnosis*

OEM *Original Equipment Manufacturer*

PCM *Problem and Change Management*

PEID *Product Embedded Information Device*

PLM *Product Lifecycle Management*

PM *Project Management*

PMO *Project Management Office*

PPM *Product Portfolio Management*

PSM *Product Service Management*

QA *Quality Assurance*

RM *Requirements Management*

SE *System Engineering*

SLA *Service Level Agreement*

SoP *Start of Production*

SPICE ***S**oftware **P**rocess **I**mprovement and **C**apability D**E**termination*

SPOC *Single Point of Contact*

SuV *Sports utility Vehicle*

USP Unique Selling Point

VDA *Verband der Automobilindustrie (Association of the Automotive Industry)*

VDI *Verband Deutscher Ingenieure (Association of German Engineers)*

VPN *Virtual Private Network*

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1 Context, Motivation, and Topic Relevance

In the following section, I contextualize the thesis subject and discuss the relevance of the research topic.

1.1 Towards a Third Revolution in the Automotive Industry

The automotive industry has gone through tremendous changes in the last 100 years and has always played a pioneering role for other industries as far as the revolution in systems and processes is concerned. Three major changes can be identified, which have had and will have significant consequences for the automotive business sector and the world economy.

As explained in a later section, the automobile new product development (NPD) process is evolving and engineering service providers (ESPs) are expected by researchers and practitioners to play an important role in this system change, especially in the German market (Bromberg, 2011; Katzenbach, 2015; Kurek, 2004; Lüerßen, 2016; Schäuffele & Zurawka, 2006). In this study, I try to identify best practice guidelines for ESPs and their customers, original equipment manufacturers (OEMs), to handle important joint and collaborative NPD projects. Furthermore, I find evidence allowing the conclusion that such joint development activities are becoming increasingly popular and are of high strategic importance to the key players in the industry.

The automotive industry is currently undergoing a change that many researchers and practitioners are terming the ‘third revolution’. In this revolution, collaborative NPD projects with a major responsibility shift to ESPs seem to have become more relevant. In this study, I explore this special field of collaborative NPD.

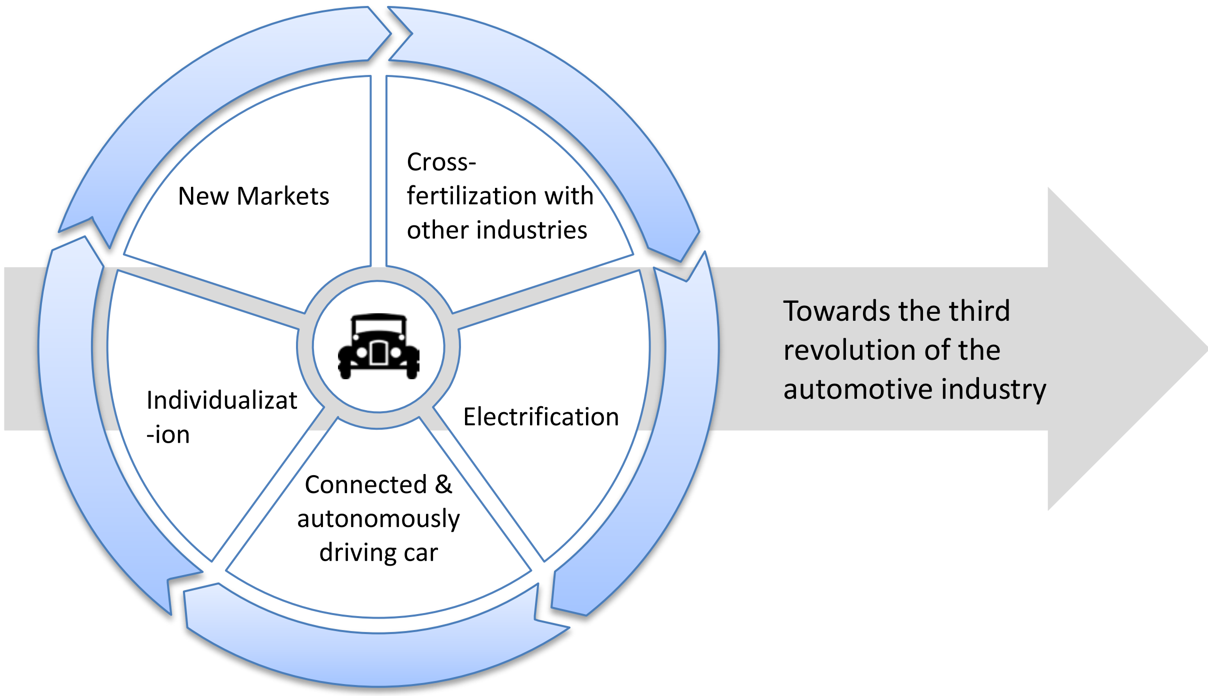

Figure 1: Towards the third revolution of the automotive industry

The above figure contextualizes the ongoing change in the automotive industry and shows which drivers are leading the industry to a third revolution. Adapted from Bernhart et al. (2018), Bernhart and Riederle (2018), and Berret et al. (2017).

1.1.1 The first revolution of the automotive industry: Mass production.

In the early 20th century, Henry Ford introduced the assembly line for the production of motorcars in the United States of America (USA). This change in the production process is named by many researchers and practitioners as the first revolution of the automotive industry. The mass production of motorcars, enabled by the assembly line, allowed the Ford Motor Company to increase productivity greatly. As a result, the company was able to compensate its workers fairly. Since other companies followed Ford's example, this revolution had a massive social impact. As prices fell, the automobile became accessible to all households in industrial countries. The subsequent growth of the automotive industry had an immense impact on the US and global economies. Spin-offs like road construction, tourism, and gas station infrastructure created a significant number of jobs and contributed significantly to the world's wealth increase (Hüttenrauch & Baum, 2007; Weber, 2011).

1.1.2 The second revolution of the automotive industry: Lean production.

In the late 1940s, Taiichi Ohno of the Japanese Toyota Motor Corporation developed the Kanban system (Kanban means signboard or billboard in Japanese) and thereby the first pull-oriented production system. Former production systems were based on pushing, which reflects the ability of the demand forecast to create a push. In a pull-oriented system, the pull comes from the demand. The re-supply and production of new assembly parts is determined according to the demands of internal and external customers. This approach led to a significant reduction of intermediate stocks and thereby to a reduction of inventory or fixed capital. Based on the Kanban philosophy, with the help of several iteration steps, the Toyota Production System was developed. This formed the basis for the second revolution in the automotive industry around the world—that of lean production. In 1991, James Womack, Daniel Jones, and Daniel Roos published their bestselling book, *The Machine That Changed the World* (J. P Womack et al., 1991). This book was considered the Bible of the second revolution in the automobile industry. The book was the main outcome of the authors' research on the International Motor Vehicle Program (IMVP) at the

Massachusetts Institute of Technology (MIT). Essentially, they explained the systematic approach of lean manufacturing or lean management (often simply 'lean'). Basically, lean is the method for the elimination of waste (non-added value) in the production process. This systematic approach to improve the production process was then adapted and used to improve every business process in a company. Lean business process reengineering had a big impact on the modes of developing, conceiving, manufacturing, and producing complex products (Hammer & Champy, 1998). The business processes in companies with complex products witnessed improvements in efficiency and effectiveness through an ongoing change process. Many companies were now able to achieve tremendous reductions in the costs of development, production, and waste. Furthermore, the product quality improved significantly. For the second time, the automotive industry played a pioneering role for industries around the world. The Japanese approach of lean production was adapted and improved upon by international car makers. The businesses that adopted these changes quickly are today among the most profitable car manufacturers in the world. A new market for professional service firms or management consultancies emerged, supporting customers to improve their processes in a lean way. The car maker Porsche exemplifies the tremendous improvement that lean management can bring to a company's profitability. When the new Chief Executive Officer (CEO) Wendelin Wiedeking first invited the Japanese management consultant Chihiro Nakao to the Porsche factory in Zuffenhausen, the company had been making losses for two years and was on the brink of bankruptcy. The production involved a high level of non-quality with a lot of fixed assets and high production costs. After a complete reengineering of the production process, Porsche produced its first defect-free car within 44 years in 1994 (James P. Womack & Jones, 1996, p. 201). Having completely adopted the lean management approach, Porsche generated an operating profit per car of 18.4 per cent in 2018, which made it the most profitable car maker in the world (Doll, 2013; Lukas Bay & Tobias Harmeling, 2018).

1.1.3 The third revolution of the automotive industry: Efficient product variety.

Today, the automotive industry faces new challenges and the automotive community is convinced that the current changes will lead to the third revolution of the automotive industry (Katzenbach, 2015; Weber, 2011). Several drivers for the change can be identified (Berret et al., 2017; Ebert & Favaro, 2017; Hüttenrauch & Baum, 2007; Katzenbach, 2015; OICA, 2017).

1. Fossil fuel is finite and its use has a negative impact on the world's climate and ecosystem, which is becoming increasingly relevant for society today.
2. The availability of modern technologies is driving changes in the future use of motorcars as well as in the ways to design and produce them.
3. New markets, internalization, and new actors are driving change in the NPD and production processes.
4. Traditional markets in industrial countries are saturated, and customers are switching to more ecological and individual cars with increased efficiency in terms of consumption and new services integrated within the car.
5. The concept of owning a car is becoming less relevant. New business models like car sharing are being introduced in the market.

These drivers are leading to tremendous changes in the automotive industry. OEMs are now being challenged to conceive cars which are different from the ones they have so far been developing and producing. OEMs are now being driven to design ecological, connected, and autonomously driving cars that are customized for specific markets (Bernhart et al., 2018; Caputo & Zirpoli, 2002; Ebert & Favaro, 2017; Felix Kuhnert & Christoph Stürmer, 2017; *Global Automotive Supplier Study 2018*, 2017; Hüttenrauch & Baum, 2007; Katzenbach, 2015). To cope with this challenge, OEMs need new and additional competencies as new technologies are integrated in the vehicle. Electric engines are partly replacing the combustion engine. Thus, new energy storage and charging solutions need to be found. Furthermore, the use case of a car seems to be changing. A motorcar is no longer merely a vehicle for transporting passengers from A to B. It is also becoming an office, an entertainment room, and a comfort zone for the passenger (Verband der Automobilindustrie e. V. (VDA), 2012). Connectivity has introduced further challenges relating to information security, robustness, and usability. The car is becoming a 'computer on wheels'. The complexity of functions that are integrated in the car demand a focus on usability. Today, users are already overwhelmed with the variety of advanced driver assistance systems (ADAS) and they place too much trust in the embedded IT systems. Thus, insufficient usability could be a cause of critical failures caused by the driver (Ebert & Favaro, 2017). Active and passive safety requirements are increasing. Autonomous driving is no longer a vision but could soon be implemented in serial development. In order to differentiate their products from those of the competition and to respond to the changing customer requirements, OEMs have to produce more variants of their products. As a result, the probability of finding exactly the same configuration of a Volkswagen Golf on the streets today is lower than winning the lottery (Hüttenrauch & Baum, 2007). Thus, the production, documentation, information technology systems, and supplier networks are all increasing in complexity. With the rise of car sharing, a new business case for automobile manufacturers is growing increasingly important in urban areas. Consequently, the automotive industry is being forced to open doors for new technology and infrastructure partners and to create new competencies in their NPD systems. Today, 50–70 per cent of the development effort of the automobile NPD process is software development and testing. Ninety per cent of the innovations in the car industry are driven by software or electronics (Bernhart et al., 2018). Figure 3 provides an overview of software innovations in automobiles over time. These innovations are accompanied by an increasing level of complexity. On-board software in a car is today in the 100-million-lines-of-code (MLOC) range. Unlike other fields, in automotive software development, practically all quality requirements such as safety, cybersecurity, usability, performance, and adaptability have to be fulfilled with a high level of security. From embedded real-time firmware to complex cloud solutions, every use case is applied. Missing any of those quality requirements could result in injury to human beings, as well as expensive recalls and lawsuits (Ebert & Favaro, 2017).

For autonomous driving, the research field of artificial intelligence is becoming more and more relevant for the automotive industry. Today, even neural networks are being tested in cars.

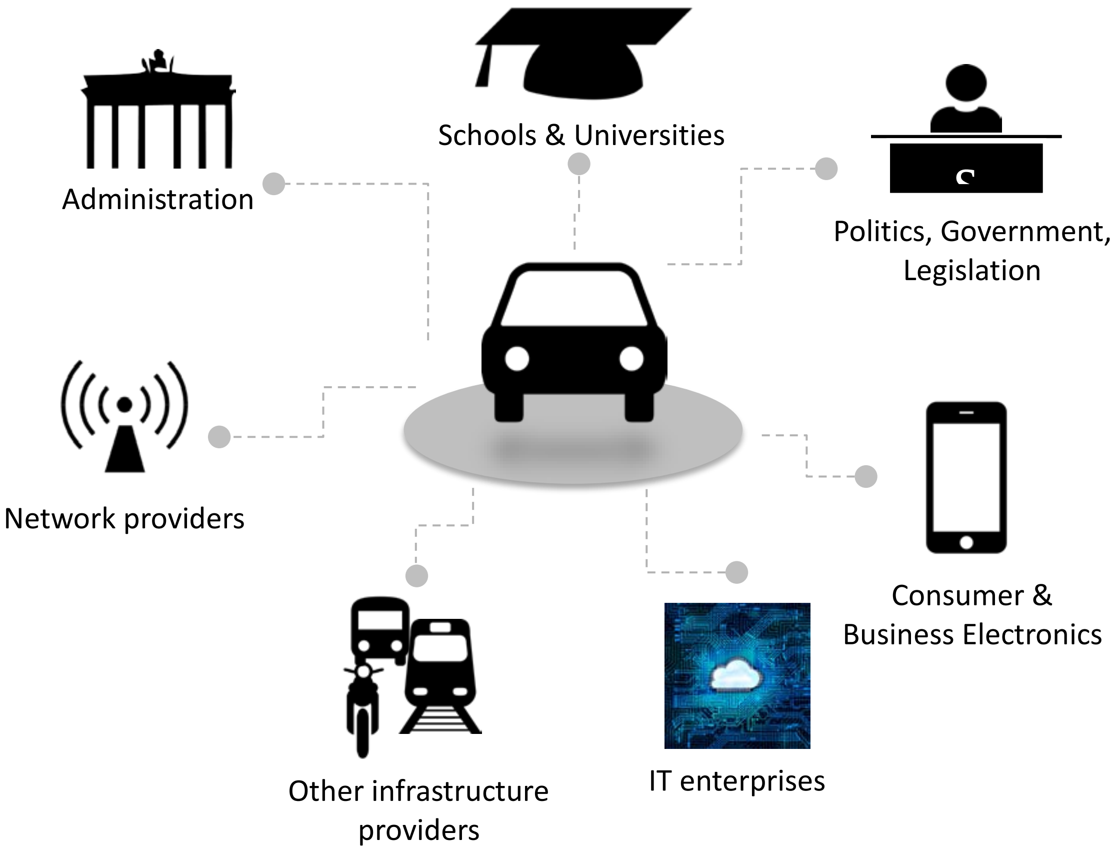

Figure 2: The automotive industry and its new partners

The above figure depicts the challenge faced by the automotive industry to involve new partners. The car and the new services provided by the automotive industry induce new partnerships. Adapted from VDA (2012).

Furthermore, new markets are becoming very important for the automotive industry. The most important market for automobile manufacturers today is China, which leaves the USA far behind in terms of the number of cars sold per annum. In 2017, some 25.8 million cars were sold in China as compared to 17.23 million cars sold in the US. India and Russia have also become critical markets for the automotive industry. According to leading automotive research institutes, these markets are generating the biggest growth expectations for the coming decades (Bernhart & Riederle, 2018; OICA, 2017). This development is giving rise to new challenges for the car industry. First, existing car makers have to get ready to develop and produce specific products locally which fit the requirements of the local customer. Therefore, existing OEMs need to build local competences in these emerging countries. This would enable the OEMs to compete in the market and to build partnerships with local production partners and suppliers. Furthermore, new local OEMs may start to play a key role. These companies are challenged to increase their level of competence rapidly in order to compete with the traditional OEMs.

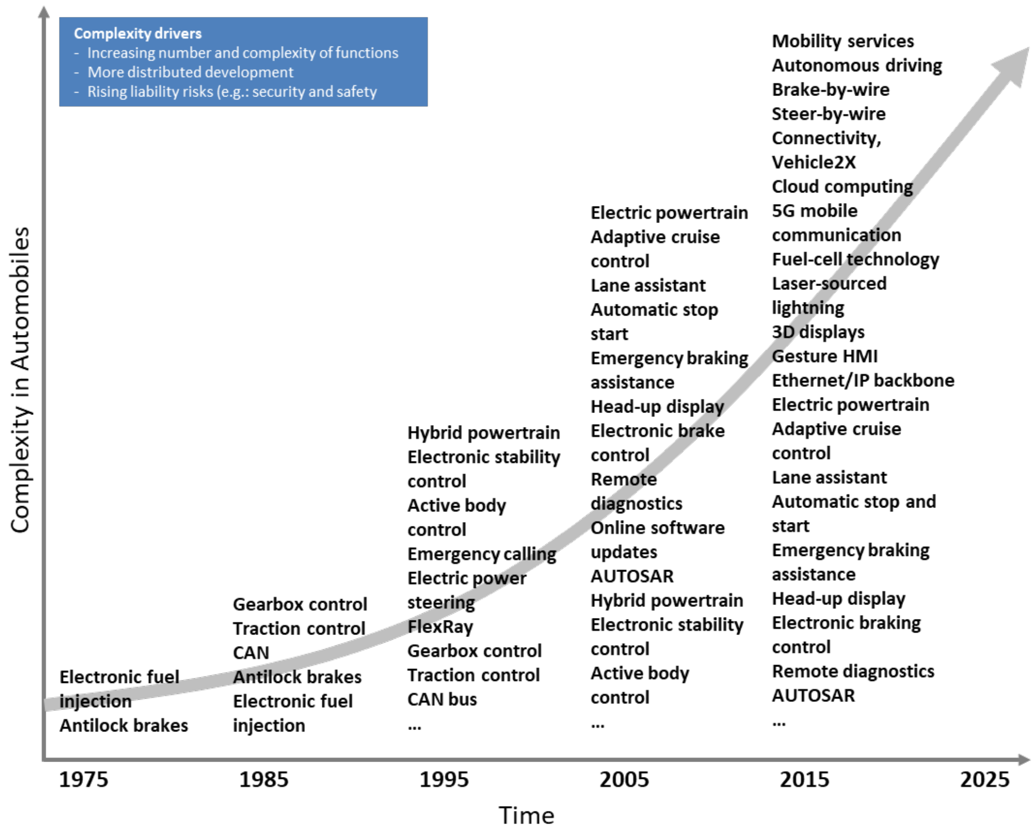

Figure 3: Complexity drivers in the automotive industry

The above figure presents an extract of software innovations that have been built into cars over time. These innovations fuel advances in the automotive sector and in mobility but they exponentially increase complexity as well. Adapted from Ebert and Favaro (2017).

To summarize, the automotive industry is undergoing an all-embracing overhaul of its NPD and production processes. These changes could have a significant impact on the future of the industry and its key players. The final product is going through changes in its use case and core technologies. The main changes are the challenge to serve new markets, cooperation and cross-fertilization with other industries (energy, telecommunication, etc.), electrification of the powertrain, individualization of the final product, and challenges associated with connecting the car to the internet.

Researchers and practitioners generally agree that these changes will lead to a revolution in the existing NPD and production systems in the automotive industry (Ebert & Favaro, 2017; Felix Kuhnert & Christoph Stürmer, 2017; Gassmann, 2006; Verband der Automobilindustrie e. V. (VDA), 2012). The main challenges in this revolution are coping with the requirement of a significant increase in product variety, with an efficient NPD and production process, integration of new technologies and services in the car, and the need for more efficient cars in terms of energy consumption. The goal, therefore, is to achieve efficient product variety.

OEMs are changing their development competencies away from component development to playing the role of a system integrator and are outsourcing the development of vehicle subsystems and modules to Tier 1 suppliers (Caputo & Zirpoli, 2002; Handfield & Lawson, 2007; Ro et al., 2008; Zirpoli & Caputo, 2002). By definition, a Tier 1 supplier is a manufacturer that supplies products directly to a company without dealing with a middleman or with other manufacturers. These outsourced development tasks are outside of the OEMs' core competencies. For projects with involved system supplier development, OEMs start strategic alliances with carefully chosen system or module suppliers (Handfield & Lawson, 2007; Kotabe et al., 2003; Lawson et al., 2009; Nellore & Balachandra, 2001; Rouibah & Caskey, 2005; Takeishi, 2001; Un et al., 2010).

When outsourcing to a Tier 1 supplier, the intellectual property (IP) of the solution is usually generated at the Tier 1 level. In this case, the Tier 1 company sells licenses or parts to the OEM to generate profit. This approach has led to the present situation where automobile manufacturers face a low degree of vertical integration of their product.

The degree of vertical integration is defined as follows:

Degree of vertical integration = value added / sales revenue

Here the value added is the sales revenue of the company minus the purchased goods or services.

Today, the degree of vertical integration in the automotive industry is below 20 per cent on average. At the beginning of the 1980s, this value was still above 50 per cent (Meißner, 2013; von Göpfert et al., 2016, pp. 175–217). The NPD organizations at OEMs are affected by this development. The organizations have transformed partly into project management organizations that handle the management of the suppliers that carry out the development tasks (Meißner, 2013).

Thus, OEMs seem to focus on their core competencies and apply consequent insourcing strategies in the field of those competencies to avoid becoming too dependent on system suppliers (Oh & Rhee, 2010; van Echtelt et al., 2007; Wasti & Liker, 1999).

But the changing business environment in the automotive industry will lead to a strategic change for the OEM. Traditional automobile OEMs are challenged to stay on top of the pyramid when it comes to innovation power in the automotive sector.

New players outside of the business, like Apple, Google, and Amazon, newcomers in the automotive field from emerging markets (e.g. Beijing Automotive Industry Holding Corporation, Dongfeng, BYD, Great Wall Motors, Quoros), and brand new OEMs created by private investors like Tesla, are challenging the positioning of traditional OEMs. Volkswagen announcing that it would open its electric car platform to the competition with the goal to make it an industry standard (Karius, 2019) is a strong sign of the ongoing paradigm change in the industry. In selling its platform to other car makers, Volkswagen's strategic intention is to ensure increased vertical integration of its products. The Volkswagen management seems to have understood that IP is not protectable but the rapid generation of new IP (innovation) is of utmost importance. Hence, VW has secure in-house competencies and is attempting to develop them further.

This development could lead to a return to a higher degree of vertical integration in the automotive industry in the coming years (Robinet, 2018).

OEMs tend to reduce outsourcing to component, system, and module suppliers and seek development or production partners that offer services like a full-service provider. Since such cooperation models between OEMs and development partners is relatively new, there are few reports in the literature and no best practices for successful cooperation in this area (Schneider, 2011). The content of the collaboration is often a result of the substantial increase in the number of functions in the car and the development of functions related to driver assistance, safety, energy consumption reduction, and environmental friendliness.

In this market context, ESPs have to position themselves appropriately. Having emerged as an important innovation force with more than 200,000 employees around the world, ESPs could become the extended NPD force for OEMs, bringing both flexibility in the workforce and the internalization of IP through handover processes.

OEMs need partners that can develop more products that are innovative. The need for innovation capacity has rarely been as high as it is today.

Therefore, I focus this research on the business models of ESPs in the automotive industry.

1.2 The Role of Engineering Service Providers in This Context

In this thesis, I explore the collaborative integration of ESPs in the NPD process of automotive OEMs. ESPs are professional service companies that support their customers to develop their products. The first engineering companies came up in the early 1980s, working mainly as outsourcing offices for design drawings in Germany. With the digitalization of the NPD process, OEMs were able to outsource different tasks to ESPs. Information technology (IT) solutions were introduced into the main business processes of OEMs. Thanks to these developments, professional service firms gained the opportunity to perform more complex services for their customers and a new type of service firm evolved. Engineering and technology consulting firms arose out of small engineering offices. Today, they are able to support their customers over the whole value chain (Kurek, 2004; Lüerßen, 2016; Rentmeister, 2002). The present-day ESPs represent an important innovation force in the automotive industry. According to the German Association of Engineers, over the half of all engineers in Germany work for service companies. The services they render to customers and the products they supply represent a large part of the innovative power of the economy. To support the competitiveness and innovation of engineers in the service sector, the Association of German Engineers—Verband Deutscher Ingenieure (VDI)—has set the VDI standard 4510 'engineering services and requirements for engineering service providers'. Standardization and quality optimization based on this standard should create new work perspectives. The VDI guidelines contain landmark recommendations to assist engineers in providing engineering services and educational institutions with the transfer of required skills through instructional content. It contains job descriptions, a phase diagram, and the requirement profile of an ESP (VDI, 2006). The creation of this standard by an important association underlines the importance of the engineering service market.

For the reasons explained in Chapter 3, the perimeter of this study is limited to the German automotive market. The German automotive industry is, with 20.9 per cent (EUR 370,98 billion), the biggest contributor in terms of revenue shares to the total sales of the manufacturing sector in Germany (Products & AG, 2015b). Therefore, it seems important enough to be considered as a representative for the needs of this study.

According to Lüerßen (2016), Blöcker (2016), Meißner (2013), and Kurek (2004, p. 12), the services provided by German ESPs can be divided into three main types:

1) Expert on Demand (EoD) contracts –: *24.4 per cent of the total sales of ESPs*
    - Consulting and coaching

- Temporary employment

2) Outsourcing contracts*: 2.9 per cent of total sales*

3) Project contracts*: 72.7 per cent of total sales*

For EoD contracts, the employees of the ESP perform their services in a consultancy mode under the direct supervision of the respective department of the customer. In special cases, which will be discussed below, the employees of the ESP may even be temporarily employed by the customer. For this contract form, the responsibility for the completion of the work remains on the customer's side and the ESP invoices its services on a time basis. Practitioners often use the term 'body leasing' to describe such contracts.

Within outsourcing contracts, the ESP takes over the operation of a special service for its customer. In the automotive industry, this type of contract can be found especially in the operation of test facilities, like engine test benches, test benches for electro-magnetic compatibility (EMC), or test driving. In this case, the ESP is responsible for the smooth operation of the outsourced activity. This kind of contract mostly has a long-term character and is based on service-level agreements (SLAs). Within this relationship, the ESP becomes a specialist for a certain service that it provides to the customer.

Work packages or project contracts describe contractual relationships in which the ESP as a contractor assumes additional risks and responsibilities for the completion of the work. The contractor owes the delivery of a result and is responsible for the organization and execution of the project. In this kind of project, the ESP is responsible for developing a complete system or subsystem (e.g. a vehicle, a powertrain, a piece of software, a gearbox, etc.). As discussed below, this type of activity has become increasingly common over the last two decades. Today, there are many projects in which ESPs are responsible for the development of a complete vehicle or an innovative solution (Grüntges et al., 2012). In such projects, the ESP leads the operative development based on the specifications provided by the OEM and acts as a system integrator for the vehicle subsystems, which are partly provided by other suppliers. According to Lüerßen (2016), the revenues from such work package contracts represent 72.7 per cent of the sales volume of the German ESP market. ESPs seem to have become development partners for OEMs and indispensable for the NPD of the increasing number of products and technical solutions on the market. In his study, Lüerßen (2016, p. 7) analysed the development of the 25 most important engineering and consulting companies in Germany. In 2014, these companies employed approximately 55,000 people in Germany. In contrast, in 2014, the German automotive industry employed approximately 775,000 people (Products & AG, 2015a). Bearing in mind that ESPs mainly employ white-collar engineers working in NPD, the workforce of ESPs in Germany represents a significant share of the total workforce in NPD within the automotive industry. Figure 4 shows the services these engineers generally provide to their customers. By reviewing these services, one may conclude that the workforce of ESPs is capable of performing services over the whole value chain of automotive NPD—from design and conception to testing and validation.

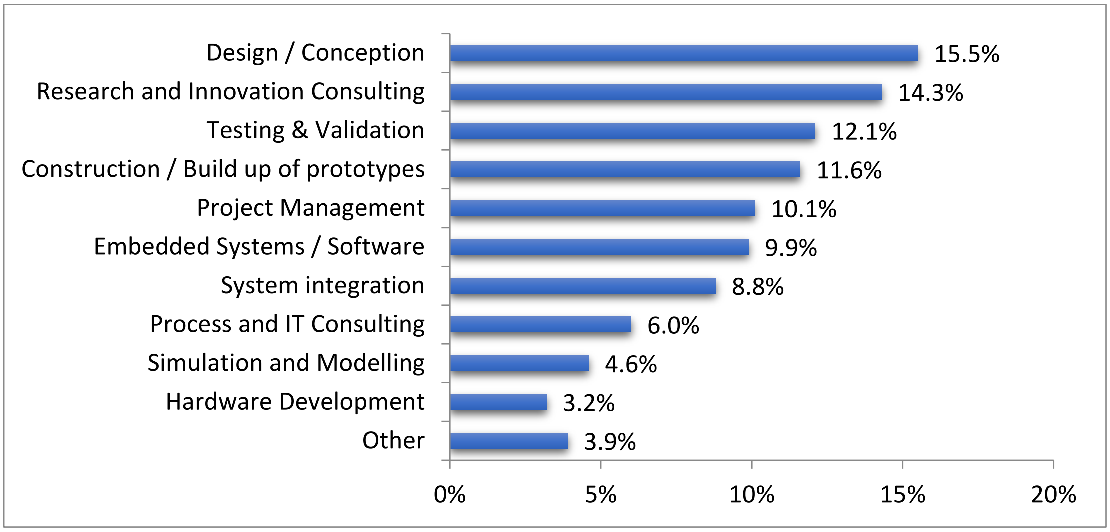

Figure 4: Revenue percentage by business activity of ESPs in Germany

The above figure shows the share of sales revenue generation per activity for ESPs in Germany. Adapted from Lüerßen (2016, p. 33).

For the changing role of ESPs in the automotive development process, several main drivers can be identified. Figure 5 covers the main drivers identified by the literature review in Section 2.

Today, the bigger automobile manufacturers have a significantly higher number of products on the market than they did 20 years ago. This is an outcome of changing customer requirements. Customers today seek more customisability and products which are adapted to their individual needs (Buchner, 2008, p. 30). In the last 30 years, automobile manufacturers have vastly increased their product variety through different levers (Buchner, 2008, p. 19):

1. Extension of the product programme (new products in another class)
2. Product differentiation (e.g. different engine types, different interior design, etc.)
3. Introduction of special models

This increasing product variety has led to the increasing need for NPD resources and efficiency in the NPD process (Hüttenrauch & Baum, 2007). One driver for OEMs to outsource NPD activities to ESPs is the growing need for NPD resources. Furthermore, motivated by the increasing pressure to bring more products to the market in shortened development cycles, OEMs have found solutions to increase the efficiency of their NPD systems. ESPs face a significant cost pressure and are thus often more efficient than the internal R&D departments of OEMs. Accordingly, the outsourcing of NPD projects can increase efficiency and reduce cost (Wolff, 2007). A further main strategy of automobile manufacturers is modularization of the vehicle. The term 'module' describes closed subsystems within the complete vehicle system which can be adapted and integrated in other models. This modularization has enabled ESPs to become system integrators and made it possible for OEMs to outsource the development of complete systems to ESPs (Waltl & Wildemann, 2014).

Furthermore, the longevity of vehicle platforms is decreasing. The platform age in years at the time of substantial revision or retirement has decreased from 8.4 years in the 1980s to 5.9 years in the 2010s for cars (Automotive Product Development Cycles, 2017).

In combination with the increasing demand for product variety, this leads to an exponentially higher number of product launches for a manufacturer. Therefore, the pressure in the development system of an OEM increases with the aim of bringing to the market a higher number of cars that meet the restrictions of time, quality, and cost. More qualified NPD resources are required to cope with this development and development systems must increase in efficiency.

In addition, the product complexity of automobiles has increased significantly in the last three decades. This can easily be shown by the rise in the number of components in the vehicles network architecture and the number of communication systems (CAN, Flexray, LIN, MOST, etc.) built into a car. In 2000, an upper-class car had on average three communications systems and around 30 network components built in. Motor vehicles on the street to today have a much higher number of network components built in and the number of communication systems has increased significantly. The network architecture of a luxury class car on the street today is built of, on average, 100 network components and 34 communications systems (Jaensch et al., 2010). Consequently, the NPD effort is increasing with the rise in complexity (see also Figure 3).

A further important driver of the change in the role of ESPs is the digitalization of the NPD process. Thanks to the possibility to draw technical designs computer aided, automotive manufacturers were able to award technical design tasks to design offices. Thanks to their specialization in technical design work, design offices have increased their efficiency in terms of time and cost. The automotive OEMs therewith had the possibility to increase their development capacity in a flexible way. Today, leading automobile manufacturers have succeeded in digitalizing their complete product lifecycle management (PLM) process (Bozdoc, 2014). This enables the OEM to outsource the development of a complete product.

Furthermore, as stated above, a return to vertical integration in the automobile industry can be discerned. ESPs are partly vertically integrated since they hand over the IP at the end of the project to their customer. ESPs thus provide flexibility in terms of resources, innovation power, cost efficiency, and IP protection to their customers.

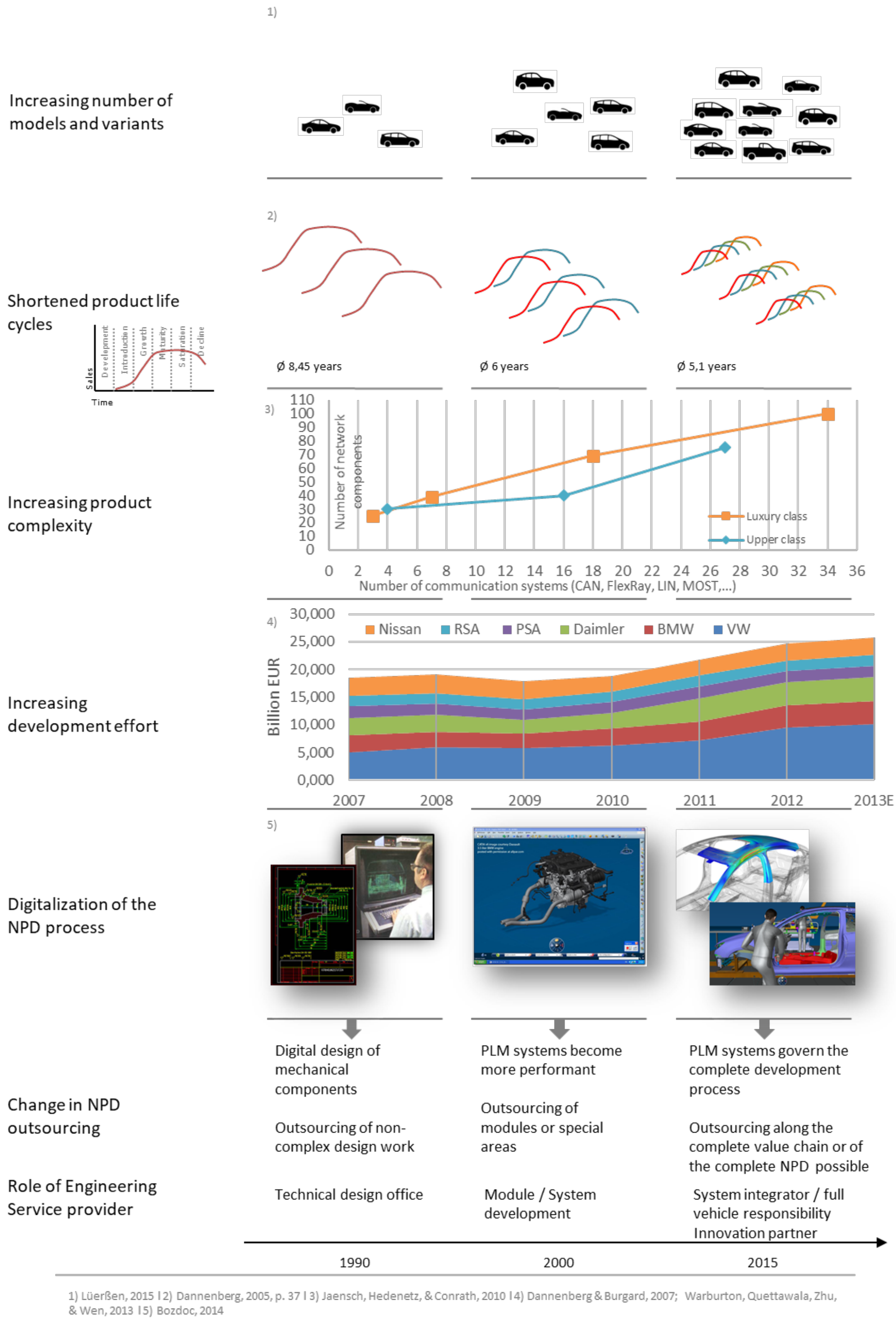

Figure 5: The changing role of ESPs in the automotive NPD process

The above figure shows the role change of the ESP within the automotive NPD process and the boundary conditions which led to this change. Adapted from Blöcker (2016), Bozdoc (2014), Ebert and Favaro (2017), Jaensch et al. (2010), Lüerßen (2016), and Grüntges et al. (2012).

These developments and structural changes in the R&D departments of the automotive OEMs have led to the increased outsourcing of NPD activities in large project volumes to ESPs and system suppliers (Grüntges et al., 2012).

To cope with the growing time pressure, the increasing need for efficiency, and sufficient resource flexibility to develop the increasing number of products and technologies, OEMs consider more often to outsource the complete development process of a product or a technology (Grüntges et al., 2012; Heerwagen, 2019). According to Wolff (2007), OEMs are most likely to outsource the development of a product which is not of strategic importance to ESPs. These may be products which are derived from existing lead products (e.g. variants such as coupé, convertible, sport utility vehicle, etc.). In the first case study, I analyse an NPD project of a car variant under the lead of an ESP.

According to the opinion of the leading ESPs, the growth of the market for technology consulting and engineering services is continuing. Issues such as employee qualification and turnover rate, increasing complexity due to compliance requirements, and the possible reduction of orders by insourcing customers are influencing the future growth of service providers. Lüerßen (2016) interviews industry leaders on their expectations for the future of ESP. The following theses receive the greatest approval:

‘Collaboration with customers is increasingly focused on longer-term, multi-year basis (framework contracts).’

The high level of approval for this thesis is linked to the continuing trend of customers delegating large packages of tasks. The basis for the discharge of great responsibility to ESPs is a multi-year collaboration, as this enables the ESP to gain a high level of know-how regarding the client's internal processes.

‘Traditional ESPs need more and more IT resources and expertise.’

To continue to be a manufacturer’s development partner, ESPs focus on creating innovative solutions to future-oriented topics such as software, electrics/electronics, and embedded systems. IT resources and competencies are increasingly needed for this. According to Blöcker (2016), the range of services offered by ESPs will expand significantly with the integration of new IT-based systems (e.g. connectivity, Industry 4.0).

‘The industry will consolidate strongly over the next years.’

This assumption is considered by ESPs to be relevant to development. The increasing price and competitive pressure could lead to a situation in which small niche players face financial difficulties. Large ESP companies could acquire smaller ones and thus increase efficiency by reducing relative overhead costs and optimizing management processes. Inorganic growth through acquisitions could allow a few large engineering service providers to grow in the marketplace (Lüerßen, 2016).

In Germany, there is an additional driver governing the outsourcing of bigger work packages to ESPs. Current political discussions have led to the situation where OEMs may be reluctant to outsource activities within EoD contracts. Since 2017, the German legislation has changed. The maximum duration of temporary employment is now limited to 18 months with a requirement of equal pay after nine months. Thus, OEMs try to avoid EoD contracts. A trend towards outsourcing within project contracts can be observed. According to Lüerßen (2016), in 2015, around 66 per cent of the commercial contracts between the analysed ESP companies and OEMs were contracts with a project or work package character. In 2016, an increase to 72.7 per cent was noted.

A further indicator for the increasing need of OEMs for ESPs that master the full vehicle NPD process is the consolidation of the ESP market. OEMs seek development partners with enough resources and competencies to support them on significant work packages. On comparing the market shares of the top 10 ESPs in Germany in 2014 with the market shares of these companies in 2009, one observes that the top 10 companies gained significant market shares. According to Lüerßen (2016), the market share of the top 10 was at 34.9 per cent in 2004, compared to 38.7 per cent in 2014. Thus, the top 10 companies gained 10.9 per cent of the market shares in five years. A further consolidation of the market is probable and can also be discerned today (Köth, 2019; Lüerßen, 2016). The following table shows the data for the top 10 European automotive ESPs in terms of employees working in the automotive sector and their competence portfolio. A development towards a complete offer along the whole value chain in the automotive industry can be observed. Three of the 10 ESPs can provide nearly every service to help their customers develop a car.

Company	Sales 2018 (in MEUR)	Share of sales automotive	Number of employees in 2018	Approximate number of employees in automotive	Full vehicle development	Development of components and modules for						Development of production plants	Design & Styling	Construction & Calculation	Modelling and Prototyping				Trial and Testing	Documentation and homologation	Project- and Process management	Consulting
						Exterior	Interior	Chassis	Powertrain	Electric/electronic	Safety				Rapid Prototyping	Rapid Tooling	Modelling	Tooling & Molding				
AKKA	1.502	42%	21.000	8.820	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Alten	2.269	25%	33.700	8.358	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x
Altran	3.000	20%	47.000	9.212	x	x	x	x	x	x			x	x				x	x	x	x	x
AVL	1.750	100%	10.500	10.500					x	x	x			x				x	x	x	x	x
Bertrandt	992	90%	12.970	11.673	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
EDAG	792	100%	8.642	8.642	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
IAV	907	97%	7.500	7.275	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x
Magna Steyr	437	100%	4.215	4.215	x	x	x	x	x	x	x		x	x			x	x	x	x	x	x
Segula technologies	NA	50%	11.000	5.500	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Valmet automotive	662	100%	6.000	6.000	x	x	x	x	x	x	x	x		x			x	x	x	x	x	x

Table 1: The top 10 European automotive ESPs and their competence portfolios

The above table shows a ranking of the top 10 European automotive ESPs in terms of employees working in automotive NPD along with the companies' competence portfolios. Five of the companies are part of the presented thesis through key informant interviews and partly through case studies. Adapted from Köth (2019) and Lüerßen (2016)

All in all, the role and responsibility of ESPs seem to have changed in the last three decades and are continuing to change even today. Specialized automotive ESPs started to play a significant role in the industry early on, but they provided specific services, like component design or the development of smaller subsystems. To unburden their engineering organizations, OEMs are now thinking about outsourcing the more complex elements of car development (Grüntges et al., 2012).

ESPs have become responsible for the development of complete vehicles and have changed their role in the NPD process to turnkey NPD partners integrating systems for their customers. Within such projects, the level of sophistication needed in collaboration can be expected to be higher. The OEM is challenged to integrate the respective ESP into its development system and the ESP has to find solutions to collaborate successfully with the teams of the involved stakeholders. These stakeholders are the teams of the OEM as customer and the system suppliers providing subsystems of the vehicle. Within this study, I try to explore best practice guidelines for such collaborative NPD projects. I aim to cluster these best practice guidelines by the focus areas of 'people' (collaboration between the involved people), 'processes' (collaborative business processes), 'collaboration technology' (information technology to improve collaboration), and 'product technology' (aspects on the technology or design of the product to improve collaboration). Considering the actual market development, it may be considered that such guidelines could be helpful for practitioners to guide such projects to success.

When I started my research, the most complex form of outsourcing to ESPs seemed to be the above-mentioned development of a variant car. During the research phase of this thesis, I observed a new phenomenon: Since the ESPs today are leading technology companies with a high level of competence, OEMs have started to outsource even strategic or innovation projects to ESPs. Such projects would otherwise be outsourced to Tier 1 suppliers and thereby OEMs would dispense with the possibility to generate new IP for the company. Especially the development of software innovations, such as in the field of ADAS, is outsourced to ESPs today. This is because ESPs have significant experience in the field of traditional automotive development and are flexible enough to quickly build up competences in the new fields tackled by the automotive industry today, like electrification of the powertrain, ADAS, and digitalization (Grüntges et al., 2012; Holtrup, 2018). A further motivation for OEMs to outsource such projects to ESPs is the situation where the ESP hands over the IP to the OEM after project completion. If the OEM had outsourced such a development to a system supplier, the IP would stay there. By outsourcing to an ESP, the OEM gains access to knowledge and resources while creating new IP for itself, provided that a good IP handover process is guaranteed. According to my information about the market, the outsourcing of crucial innovation projects is still a rare phenomenon. But researchers in the industry expect the digitalization of products and processes in the automotive industry to become the growth field for ESPs (Blöcker, 2016; Schneider, 2011). To satisfy this need of their customers, ESPs are challenged to change their role in the development project and become innovation partners. In such projects involving very high technical uncertainty, the level of sophistication in collaboration can be expected to be even higher. Therefore, in aiming to cover this case and see if the best practices identified for variant development could also work for significant outsourced software innovation projects, I analyse in the second case study an ADAS system development outsourced to an ESP in a turnkey project contract.

Figure 6 shows the different roles ESPs play today in automotive NPD and the existing cooperation models. Furthermore, I illustrate in which phase of the research I gathered data on the two outlined cooperation models.

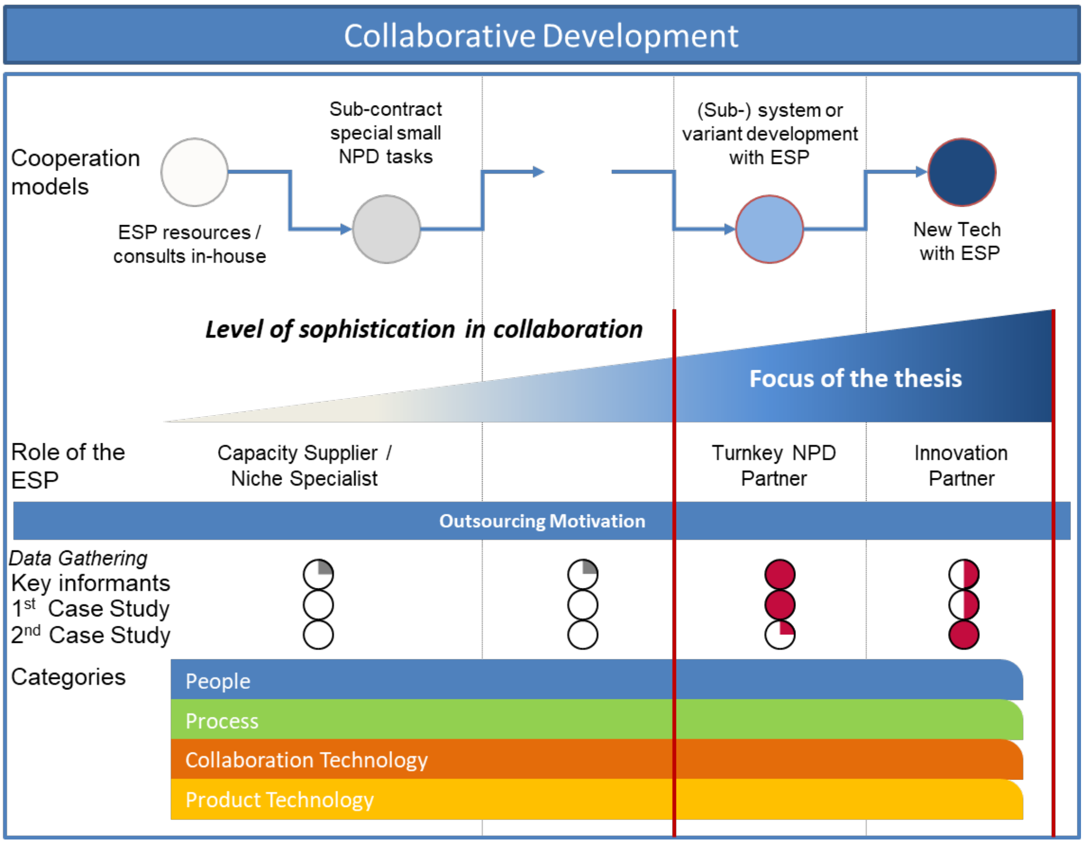

Figure 6: Continuous change of the NPD process in the automotive industry and increase of sophistication in collaboration

The above figure shows the change of cooperation models within the NPD process in the automotive industry and the implications for the ESP. Furthermore, the focus of the study is illustrated and the data gathering is represented. Adapted from Afonso, Nunes, Paisana, and Braga (2008), Binder, Gust, and Clegg (2008), Cooper (1999), Katzenbach (2015), Lüerßen (2016), Rentmeister (2002), Un et al (2010), and Wolff (2007).

1.3 Theoretical Framework and Shortcomings of Existing Research

This research project focuses on knowledge-intensive business services (KIBS). I analyse the process co-development of products and technologies in the business ecosystem of collaborative automotive NPD, wherein several stakeholders work together to create a value proposition. Within this theoretical context, I focus the research project on the special role that ESPs play. Figure 7 shows this focus of the thesis. I analyse the special case of complex NPD projects that are outsourced to ESPs. Efficient and effective collaboration processes can be considered as an important success factor in such projects of joint problem-solving in the field of KIBS (Un et al., 2010). Hence, in this research project, I apply an inductive qualitative research approach based on a constructivist–pragmatic epistemology. I explore collaboration processes in the field of collaborative NPD and value co-creation, with the goal of deriving best practice guidelines through key informant interviews and two qualitative case studies. The mutual processes of collaborative NPD have seldom been empirically studied (Gassmann, 2006). Having analysed the current body of knowledge in the field of collaborative development, I conclude that the developed models are highly abstract and require intensive studies to derive managerial implications. I believe that practitioners in the field of collaborative NPD need concrete best practice guidelines that are easy to understand and applicable to their specific use case. Therefore, I focus this research on the specific business case of collaborative NPD with ESPs. Engineering services in the automotive sector have become an important business field over the last two decades, and researchers expect the field to expand further (Blöcker, 2016; Holtrup, 2018; Köth, 2019; Lüerßen, 2016).

Research in collaborative NPD management is mostly focussed on the perspective of the OEM and/or on the management of the supply chain. Collaborative seller–buyer relationships and especially the perspective of ESPs are mostly neglected in the literature (Athaide & Zhang, 2011; Handfield & Lawson, 2007; Lawson et al., 2009; Meißner, 2013; Rentmeister, 2002; Rouibah & Caskey, 2005; Wolff, 2007). Hence, 'little empirical research on the antecedents or consequences of these relationships' exists (Athaide & Zhang, 2011). Therefore, managers seeking guidance on how to manage their NPD relationships lack appropriate insights. In the systematic literature review in Section 2 of this thesis, I identify this gap in the current body of knowledge on collaborative automotive NPD. The existing literature does not offer in-depth analysis of the presented special case of collaborative NPD. Therefore, a derivation of best practices which could serve as management implications for practitioners is limited. Tranfield et al. (2003) identified evidence-based research as a possible mechanism to create guidelines for the decision process of managers and thus help them to create a competitive advantage. Within this study, I try to apply an evidence-based research approach within the theoretical framework of value co-creation, collaborative NPD, and co-development.

Rosen (2009) defines the term 'collaboration' as 'working together to create value while sharing virtual and physical space'. Dominguez (2011) defines it as 'highly diversified teams working together inside and outside a company with the purpose to create value by improving innovation, customer relationships and efficiency while leveraging technology for effective interactions in the virtual and physical space'. This definition covers all focus areas of my thesis—that is, collaboration of people, on and with technology, within the NPD process. Based on this definition and on my knowledge in management and consulting, I chose the top categories for the categorization of the research findings in the proposed best practice model. In management consulting projects, the categorization framework People – Process – Technology is often used to categorize improvement levers, since it allows to categorize all improvement measures for an organization. People perform a task or work in an organization using processes and technology to streamline and improve these processes. Bruce Schneier helped to make the so called “golden triangle” more popular (Schneier, 2015). From the early 90ies on, this framework was used in a lot of consulting projects, aiming to improve organizations. Since I try to identify best practices to improve the collaboration in NPD project organizations, in which the technology of the conceived product can also be an important factor for the collaboration effectiveness, I decided to enlarge the framework and to distinguish between “collaboration technology” and “product technology” for the top categories.

Consequently, in this study, I categorize my research findings within the four following main categories: “people”, “process”, “collaboration technology”, and “product technology”. The chosen sub-categories are recommendations to improve collaboration, identified in the literature and the expert interviews.

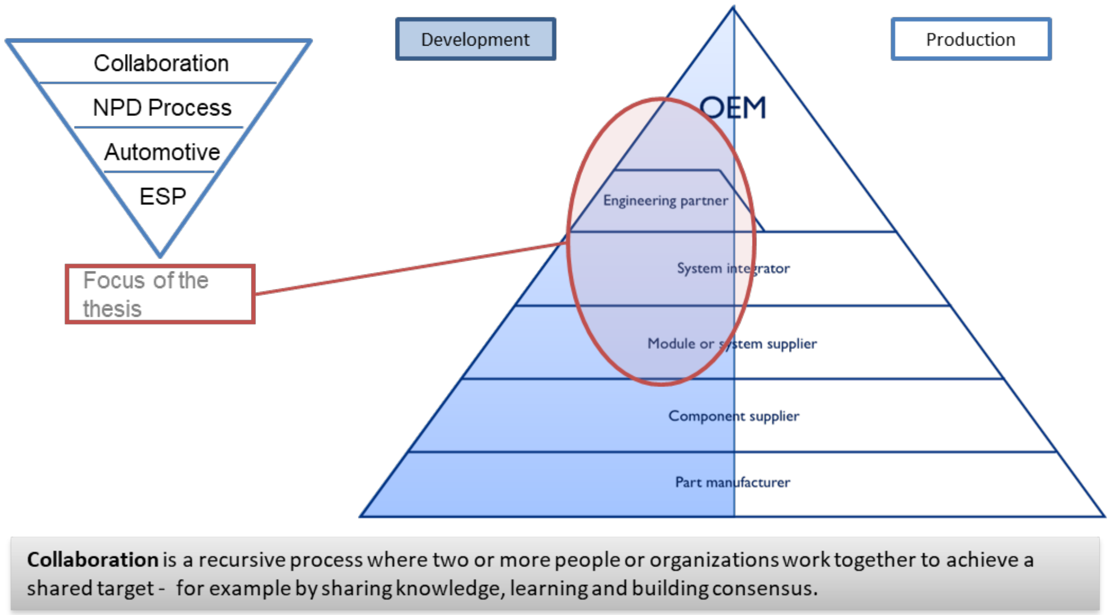

Figure 7: Focus of the thesis

The above figure shows the focus of the present thesis, which is collaboration between the ESP and the other stakeholders within the NPD process of automobile manufacturers for complex NPD projects. Adapted from Kurek (2004).

1.4 Research Objectives and Research Questions

The main objective of this study is to explore best practice guidelines to improve the collaboration between ESPs and OEMs in joint NPD projects based on the theory of collaboration and NPD models. Therefore, I intend to explore NPD processes within the automotive manufacturing sector and, furthermore, examine how service providers collaborate with automotive manufacturers in relation to the NPD process.

Additionally, I wish to gain insight into the strategies applied by practitioners to improve collaboration in this context. Moreover, I will explore if any barriers to successful collaboration in relation to service provider–automotive client NPD processes exist, taking into consideration other stakeholders in the NPD process.

The research objectives can therefore be summarized as follows:

RO 1. Identify the NPD processes within the automotive manufacturing sector.

RO 2. Identify how service providers collaborate with automotive manufacturers in relation to the NPD process.

RO 3. Identify the barriers to successful collaboration in relation to the service provider–automotive client NPD process, taking into consideration other stakeholders in the NPD process.

RO 4. Identify best practice guidelines to enhance the NPD process in the service provider–automobile manufacturer relationship.

Based on these research objectives, the following research questions can be defined.

RQ 1. What development process model(s) exist in the automobile industry?

RQ 2. What role do ESPs perform in the collaborative development process of automotive manufacturers?

RQ 3. What barriers exist (if any) to hinder the role that service providers play in an automotive manufacturer's development process?

RQ 4. Based on the theory of collaboration and technology development models, what best practice guidelines can be established to improve the collaboration between service providers and automotive manufacturers in collaborative development projects?

These research questions imply an explorative research approach, as discussed in Section 3.

1.5 Thesis Structure

The structure of the thesis is depicted in Figure 8 below.

In Chapter 1, I discuss the background of automotive, collaborative NPD with the involvement of ESPs and give a market overview. In this chapter, the research subject is introduced and its relevance is shown. Finally, the thesis structure is presented.

In Chapter 2, I start with a discussion of NPD models in the automotive industry and the evolution of these models. Furthermore, I describe the roles that ESPs play in these NPD models. After this section, through a systematic literature review, I provide an overview of the existing body of knowledge in the field of collaborative NPD, discuss the complexity aspects of NPD, the organizational aspects, the motivation and risks of outsourcing NPD, the barriers to successful collaboration in NPD projects, recommendations for joint NPD, early supplier involvement (ESI), knowledge management, and relationship management. I conclude the chapter with a summary of the literature review and a discussion on knowledge gaps. Moreover, I introduce a preliminary recommendation model for joint NPD projects with the aim of guiding further research and categorizing findings. In this model, I derive recommendations with the target of mitigating the identified risks of outsourced NPD. The chapter ends with a discussion on the resulting preliminary recommendation model.

RO 1 and RO 2 as well as RQ 1 and RQ 2 are mainly addressed in Chapter 2.

In Chapter 3, I present the research design of this thesis. In this chapter, I discuss my ontological and epistemological points of view and justify the applied methods and methodologies. Moreover, I discuss the two main research methods—key informant interviews and case studies—as well as the sampling. I conclude with the ethical considerations.

Chapter 4 mainly addresses RO 3 and RO 4. Based on the outcomes of the key informant interviews and the case studies, I identify the barriers and best practices for successful collaboration in joint NPD projects under the leadership of an ESP. The findings of the key informant interviews are compared to the findings from the two case studies. In this chapter, RO 3 is met and RQ 3 is answered. I conclude on the discussion of the research findings and develop a best practice guideline model for joint NPD projects under the leadership of an ESP and discuss how such a model can be applied in practice. This model presents a holistic view of the management capabilities and business activities which are required to conduct joint NPD projects under the leadership of an ESP. The management implications for the main stakeholders are defined. With the development of this model, I answer RQ 4 and achieve RO 4.

In Chapter 0, I summarize the results of the research thesis and provide conclusions on the research objectives. Furthermore, I outline the contribution of the study to praxis and theory. Finally, I point out implications for further research and offer an outlook on NPD and the ESP market.

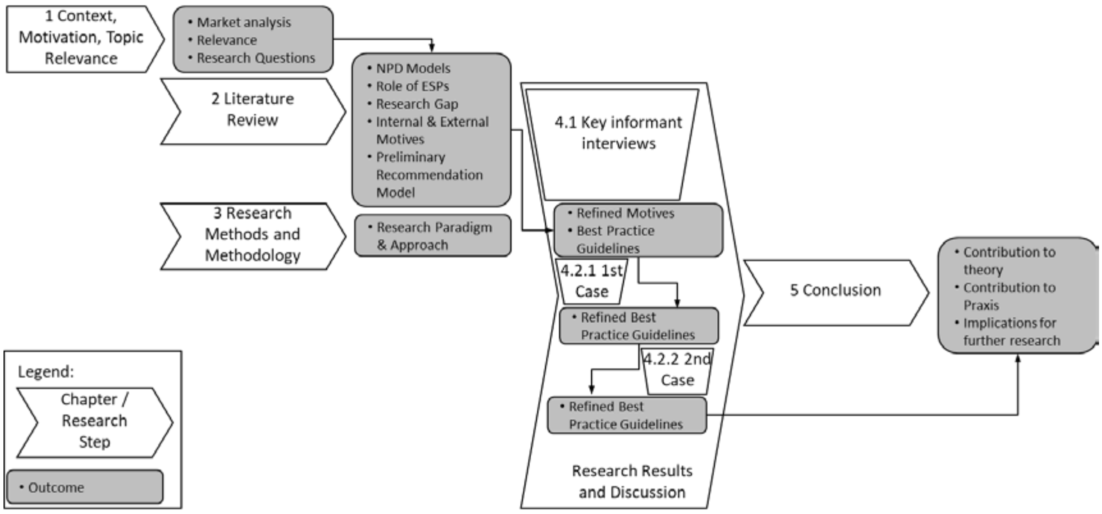

Figure 8: Thesis structure

The above figure outlines the structure of the presented thesis and presents the outcomes of each chapter and research step.

Starting in the literature review, with the identification of the NPD process models, motives, and risks of outsourcing turnkey NPD projects to ESPs, I confirm the relevance of the research topic and identify a research gap. Subsequently, I identify recommendations for NPD projects under the lead of an ESP based on the theoretical body of knowledge, which is mostly focussed on supplier integration and not on the special case of ESPs. These recommendations serve as a categorization of the best practice guidelines that are identified at a later stage and that are confirmed, rejected, or extended by the experts in the key informant interviews. Furthermore, the key informants provide their practitioner’s insight and I derive barriers and best practices out of the analysis of the interviews. With the help of the case studies, I confirm, reject, or extend the barriers and best practices to outsourced automotive NPD under the lead of an ESP.

2 Literature Review

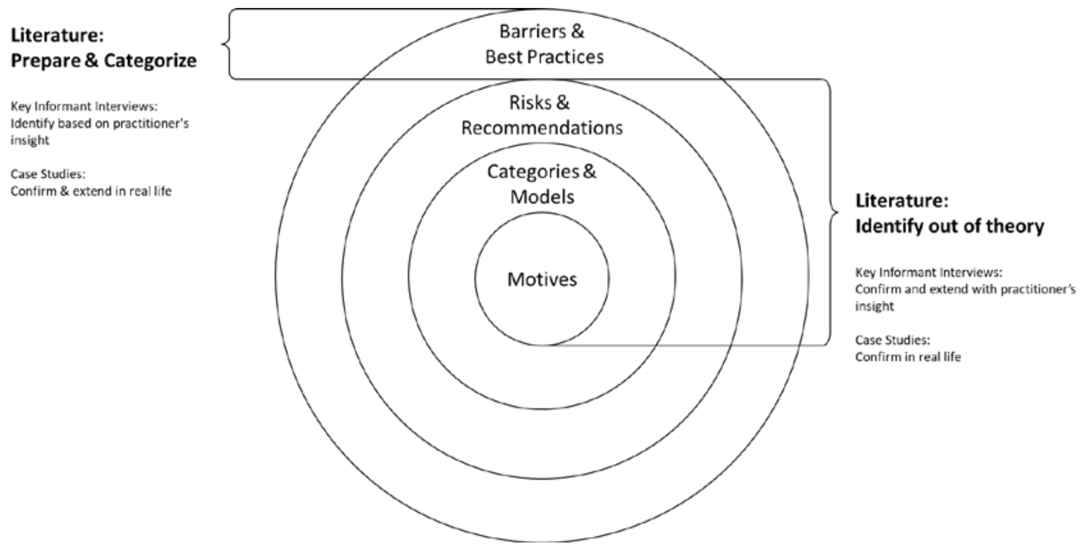

Figure 9: Representation of the research project and research steps with a focus on the literature review

The above figure represents the results of the research projects and links them to the research steps undertaken with primary focus on the first step—the literature review.

In this section, I present two literature reviews. In section 2.1, I discuss NPD process models and their application in the automobile industry for car development and software development based on a narrative literature review. In the second part of chapter 2, in section 2.2, I discuss motives, risks, and recommendations for the effective and efficient execution of collaborative NPD projects under the lead of an ESP, which I gathered through a systematic review of the actual body of knowledge in automotive NPD. I conclude this section with a preliminary model to guide further research.

2.1 NPD, Collaborative NPD, and Software Development in Automobile Industry

As discussed, the business environment for R&D organizations is a driver for increasing collaboration within organizations as well as with external organizations like suppliers and ESPs. This trend is reinforced by continued developments in IT and the evolution of research activities in multi-disciplinary activities requiring resources and expertise that are resident not in one organization but in several (Katzenbach, 2015; Pemartín et al., 2018).

In the following section, by performing a narrative literature review, I discuss the development of NPD models in the automotive industry, the actual challenges, and why collaboration seems to be an important success factor for automotive NPD. I decided to perform a narrative review in this part of the research in order to conceptualize the research project with this review and define the NPD models in which the research project takes place. Such an effective review creates the foundation for advancing knowledge and conceptualizes the research project (Webster & Watson, 2002).

With this review, I try to offer preliminary answers to RQ 1 and RQ 2 and therewith lay the groundwork for the achievement of RO 1 and RO 2. These preliminary answers shall then be confirmed in the research phase, particularly through the key informant interviews.

2.1.1 NPD models in the automobile industry.

The NPD process in the automotive industry starts with a definition of the top-level requirements. These can be defined based on the results of the market research, idea generation, or the so-called fuzzy front-end (FFE). The FFE is the phase during which the R&D organization defines the concept of the product. According to the *PDMA Tool Book 1 for New Product Development* (Belliveau et al., 2004), the FFE generally consists of three tasks: strategic planning, idea generation, and pre-technical evaluation. Often, such activities are chaotic, unpredictable, and unstructured. After the FFE, the formal NPD process starts. The NPD process is typically more structured, formal, and planned.

ESPs usually do not intervene during the FFE phase. They get involved when the top-level requirements are defined. The FFE phase and the definition of the top-level requirements are usually carried out in the R&D departments of the OEM (Le Dain et al., 2011; Wang et al., 2010).

Belliveau et al. (2004) divide the entire innovation process into three parts: the FFE, the serial NPD, and the commercialization. In this thesis, I focus on the serial NPD process for the complete product or subsystems of the product.

2.1.1.1 *The serial NPD process.*

In the early years of the automotive industry, the NPD process was serial. It began with a concept and the product was developed until the creation of prototypes. These prototypes served in the verification of the requirements. Once the development and verification phases were complete, the planning of the production process started. The final validation of the product was only possible once the first produced car was available on the serial production line. If this validation turned out to be satisfactory, the serial production could start.

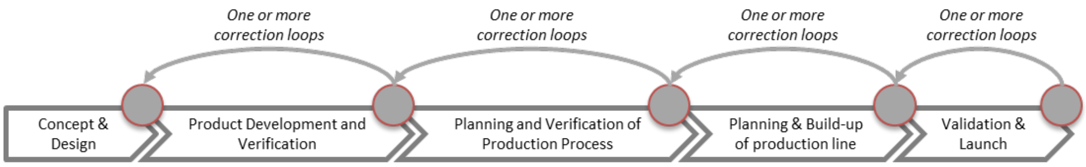

Figure 10: The serial NPD process

The above figure shows the first formalized NPD process in the automotive industry. This process is completely serial with one step being carried out after the other. Adapted from Filipovic and Grossmann (2014), and Le Dain, Calvi, and Cheriti (2011).

Such a serial NPD process is significantly longer than an NPD process today. Furthermore, such a process is very limited in terms of flexibility. A mistake in the concept phase might only be identified during the validation of the final product. A change of concept at a very late stage of the process leads to high costs since the changes have to be applied in all sub-processes, which could lead to a change in the production process. The fact that this process is completely serial and not digitalized makes it difficult to outsource parts of the NPD process (Le Dain et al., 2011; Wognum & Trienekens, 2015).

With the digitalization of the NPD process, a new NPD process model arose: concurrent engineering (CE).

2.1.1.2 *Concurrent engineering and collaborative engineering.*

The concept of CE emerged in the 1980s. CE is a comprehensive and systematic approach to the integrated, concurrent NPD of complex products (Stjepandić et al., 2015, p. 23). The first definition of CE was provided by Winner et al. (1988):

> Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is intended to cause the developers from the outset to consider all elements of the product life from conception to disposal, including quality cost, schedule, and user requirements.

The main change to the serial engineering process is the concurrent execution of product and process design activities. The basic elements of CE are:

- Early involvement of participants,
- The team approach, and
- Simultaneous work on different phases of the NPD (Koufteros et al., 2001).

The focus is on the alignment of design and manufacturing functions as well as the ability to adapt the product according to the customer's demands and the supplier's capabilities.

The team approach of CE also emphasizes personal contact of the team members. Personal contact and face-to-face communication help to limit the conflicts which may arise within cross-functional CE teams (Stjepandić et al., 2015). The early involvement of relevant stakeholders in the NPD process enables the exchange of preliminary information.

Especially in the NPD of complex products, the number of stakeholders taking part in the projects has increased tremendously. The automobile industry is a good example. As the product is highly complex, with low vertical integration at the OEM, it has led to the desire to incorporate multiple lifecycle considerations. This requires an integration of multi-disciplinary knowledge and collaboration between collaborators across various cultural, disciplinary, geographic, and temporal boundaries (Lu et al., 2007).

The digitalization of the NPD process and the appearance of computer-aided design (CAD) and product data management systems as the first PLM systems in the early 1980s (Haydaya & Marchildon, 2012) made it possible for other stakeholders to join the NPD process. Since the product became more complex and the innovation pressure increased, OEMs were forced to involve suppliers with competencies other than those held by the OEM. The rise of the CE concept, the increasing digitalization of PLM and NPD tools, as well as the increasing digitalization completely changed the set-up of such NPD projects. As a result, OEMs today develop only a very small percentage of their product in-house—approximately 40 per cent (Proff & Proff, 2013, p. 272). CE projects thus became highly complex social systems.

This is why most decisions made during the NPD process affect other stakeholders and thereby require input and evaluation across all disciplines. The decision-making process should therefore be collaborative. This emphasis on collaboration led to the introduction of a new term, 'collaborative engineering' (CoIE), which is defined by Willaert, de Graaf, and Mindhoud (1998) as follows:

> Collaborative Engineering is a systematic approach to control life cycle cost, product quality and time to market during Product Development, by concurrently developing products and their related processes with response to customer expectations, where decision making ensures input and

evaluation by all life-cycle disciplines, including suppliers, and information technology is applied to support information exchange where necessary.

ColE as a new business model was introduced to limit waste and increase the success rate of NPD projects. Since the market circumstances led to an opening of the innovation process, collaboration began between the OEM and external sources of knowledge, such as technology providers, ESPs, start-ups, and others. Scholars agree that external knowledge increases the potential number of innovations (Gassmann, 2006; Wang et al., 2010). Therefore, in addition to involving the procurement early in the design process, the supplier itself shall become a team member.

The required logistics and the specification of parts and materials are defined jointly in the beginning of the project. Furthermore, the supplier may take over a part of the responsibility in the NPD process or may be involved in several phases of the NPD project. Such an ESI as part of CE or ColE drew much attention from researchers and practitioners at the end of the 20th century (Wognum & Trienekens, 2015).

According to Zsidisin and Smith (2005), developing and monitoring collaborative relationships is crucial to prevent problems with the performance of the NPD network. Effective and efficient collaboration processes in the innovation or NPD process are important and can improve industrial competitiveness (Lu et al., 2007).

According to Lu et al. (2007), disciplined CoIE is not practised sufficiently. The collaboration of engineers with all stakeholders in complex NPD processes should be analysed in greater depth. Lu et al. (2007) want to establish a scientific foundation of CE to develop this emerging field into a rigorous discipline.

ESPs as system integrators play a key role in the CoIE process. I explore this idea further in later sections.

2.1.2 IT as an enabler for collaborative NPD.

To cope with the current challenge of highly complex NPD networks, improved knowledge, better theories, and more sophisticated tools for CoIE are needed. Increasing globalization will only strengthen the need for collaboration in NPD (Lu et al., 2007). The need for collaborative IT systems is even greater in CoIE.

Today, IT systems are of utmost importance for efficient collaboration in the NPD process. This is especially true for the automotive industry. Since the product involves very high complexity, with a great number of parts and thus an important Bill of Material (BoM), the automotive industry and the defence industry were among the first to implement PLM tools. These tools help to manage the configuration of the product and improve collaboration between stakeholders since they allow communication during the NPD process and the exchange of data on the virtual product. Thanks to PLM, as well as the opening up and digitalization of the NPD process, engineers now have the possibility to work together even if they are situated in different countries. PLM systems have the following purposes and facilitate collaboration through the application of several services (Ferreira et al., 2017; Haydaya & Marchildon, 2012):

- Requirements management (RM)
- Product portfolio management (PPM)
- Configuration management (CM)
- Project management (PM)

- Quality assurance (QA)
- BoM management
- Digital manufacturing
- Supplier relationship management
- Engineering change management (ECM)
- Product service management (PSM)
- Product knowledge reuse/product knowledge management

PLM provides a virtual project space and accompanies the complete NPD process, right from product conception to product launch and beyond.

By adopting a PLM system, an OEM can achieve numerous benefits, such as:

- Delivering more innovative and superior products in less time,
- Improving the success rate of newly introduced products, and
- Establishing more effective collaborative relationships with partners.

Furthermore, a PLM system allows the OEM to monitor the progress of the product at any stage in its lifecycle, analyse errors and issues in any product lifecycle phase, and make and execute suitable decisions. These specific benefits improve the NPD performance of an organization (Haydaya & Marchildon, 2012). PLM systems are mostly used for the first phase of the lifecycle—the beginning-of-life phase—in which the product is conceived and the production is launched.

Haydaya and Marchildon (2012) argue that closed-loop PLM systems have a positive relation with NPD effectiveness. The objective of the closed-loop PLM system is to close the information gap in a product's lifecycle by linking

1) the beginning-of-life phase with
2) the middle-of-life phase (the usage of the product) and
3) the end-of-life phase (market exit, destruction, recycling).

Automotive OEMs today have mostly implemented partially closed-loop systems by combining 1 and 2 with the analysis of aftersales data (big data default analysis and correcting the cause of the error in the product design). The combination with phase 3 is rarely considered in the automotive industry. Such a closed-loop PLM system combines traditional PLM systems with the functionality offered by a product-embedded information device (PEID)—the 'intelligent product'—and by the PLM agent. In the case of automobiles, the PEID are the ECUs of the car and the PLM agent is the analysis tool which gathers the data via the on-board diagnosis (OBD) interface from the ECUs. Such a closed-loop PLM permits the efficient management of product information throughout a product's entire lifecycle.

The introduction of IT systems and especially the internet, allowing digital communication for geographically dispersed teams, have made it possible for OEMs to outsource part of their development work. OEMs today focus more on their core competencies and manage highly complex supplier networks through efficient process organizations supported by complex PLM tools. Nevertheless, the increased number of functionalities of the car and thus the increased number of possible design defaults make it necessary to manage all the data in one PLM. The supplier networks thus need access to the PLM and the legacy systems of the OEM have to be integrated in the closed-loop PLM (Ferreira et al., 2017; Haydaya & Marchildon, 2012; Katzenbach, 2015).

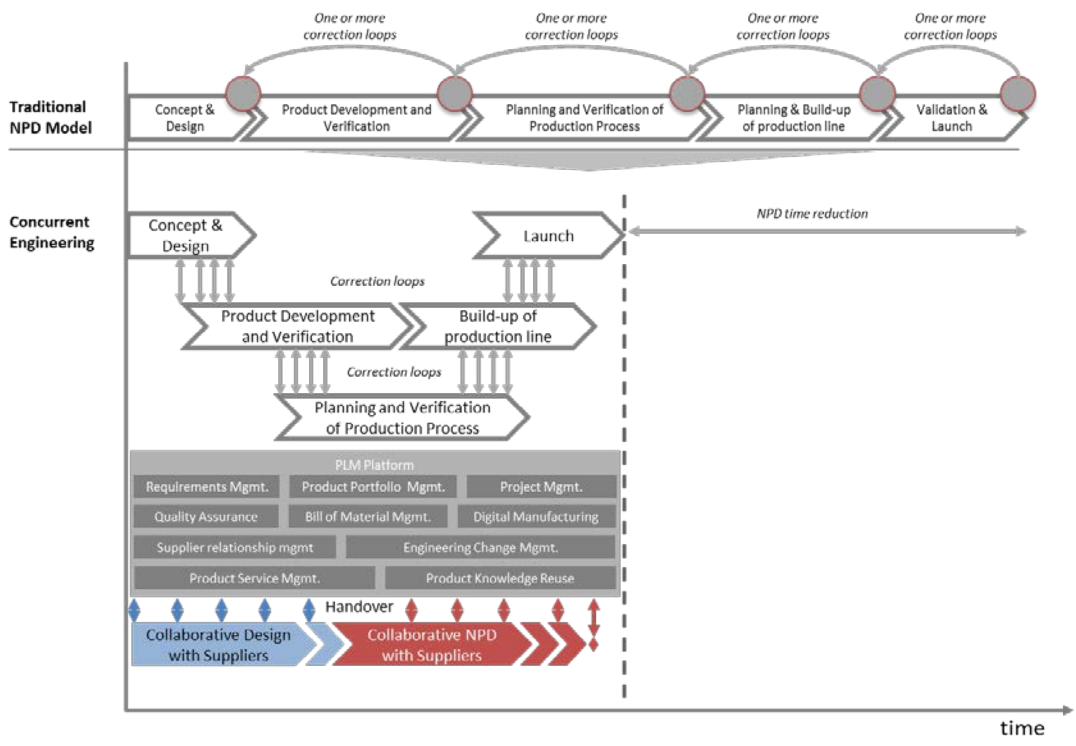

Figure 11: The concurrent and collaborative engineering process

The above figure presents the concurrent and collaborative engineering process. The phases of the NPD process are parallelized, which leads to a significant time reduction and an intensified need for collaboration of the different stakeholders and functions. This collaboration is supported by PLM IT systems. Adapted from Haydaya and Marchildon (2012), Le Dain et al. (2011), and Stjepandić et al. (2015).

In today's business environment, ESPs work on takeover turnkey projects, where they manage the entire NPD process of an automobile for their customers. ESPs are mostly awarded by the OEM with the development of a complete car when the developed product is a variant of a lead car and not of strategic importance for the OEM (Wolff, 2007). In other cases, ESPs develop a technology for the OEM and have an obligation to hand over the created IP to their customer. In such bigger projects, the ESP plays the role of a system integrator and is responsible for the project delivery. Such a project can be characterized as a sociotechnical system. The distributed NPD teams need to manage both the human (organization) and the technical (product and process) elements of their work. In the first case study in

Chapter 4.2.1, I analyse such a product-based NPD project of a car variant under the lead of an ESP. In Chapter 0, I analyse the development of a complex software solution to be integrated into cars under the lead of an ESP. In this case, the OEM did not have enough resources or competencies in-house to develop the solution on its own. Therefore, the OEM chose to award the project to an ESP in order to get the expected outcome within a defined budget and time. Furthermore, the OEM preferred an ESP over a Tier 1 supplier so as to keep the IP in-house after the development. An ESP does not create IP for its own purpose but hands it over when the project ends. In contrast, a Tier 1 supplier may try to keep the IP and sell royalties for usage instead of the IP. In the following chapter, I describe NPD models for software development and the derived implications.

2.1.3 Software development in the automobile industry.

With the rising demand for innovations through new functionalities and the cheaper availability of hardware, the share of software in automobiles is increasing (Ebert & Favaro, 2017). This increased use of software-based functions is leading to challenges in the automotive industry. Car makers are being challenged to review their organizations as well as the definition of their core competencies, processes, methods, tools, product structures, maintenance, and long-term strategies (M. Broy et al., 2007). The far-reaching effects underline the importance of software development projects within the automotive industry. It is important to manage the increasing development complexity with suitable methods and processes.

2.1.3.1 *Software development in projects.*

IT projects, such as the development of a software product, are usually implemented in project form. The project often involves only the operational implementation of an idea in an IT product and thus forms a sub-process to meet customer needs. The satisfaction of one or more customer needs helps the companies involved to achieve economic success and thus represents an important goal.

The following are key features of IT projects that suggest the implementation in project form:

> Complex, evolutionary and visionary tasks [...], a large number of employees involved [...], consideration of interface problems [...], constantly changing conditions [...], difficulties [...] of scheduling and planning as well as risk calculations in the run-up to settlement [...], and regulatory, i.e. legal requirements [...]. (Gruner et al., 2003)

An efficient and effective implementation can be achieved through the execution in the form of a project. The required framework conditions can be created in projects, for example, by introducing a special project-controlling system and change management process. Software developments that meet the above-mentioned criteria are often realized in project form. Often, process models are used for the realization of software projects. In the following section, I discuss the V-model as an example of a software development process model. I limit the discussion to this model alone since it is an advanced software process model and because it is the model used for software development in the second case study.

2.1.3.2 *The V-model and its application in software development.*

In software development, new design approaches emerged in the 1970s. In 1970, Winston W. Royce (1970) presented the first formal description of the waterfall model, although he did not use the term 'waterfall'. In 1979, Barry Boehm proposed the V-model as an adaptation of the waterfall model. Later, the model was developed simultaneously but independently in the US and in Germany. Starting as a software design approach, the V-model quickly became an important standard for system engineering (SE). Such design approaches aim to guide the developer through the process of conception. Since designers cannot be replaced by tools during the NPD process, mistakes cannot be completely avoided. According to Wolf (2018), design approaches help reduce mistakes through predefined, standardized, and documented processes which do not hinder the creative process too much.

In this section, the different design approaches are discussed. Early models such as the waterfall model and the V-model structure the NPD process into successive phases. In addition to phases, modern models also contain roles, activities, documents, and methods. A closer look at the modern models is provided through focus on the German 'V-Modell XT'.

The waterfall model divides the NPD activities into five phases (Sommerville, 2012, p. 57):

1. Requirements analysis
2. System and module design
3. Implementation and module test
4. Integration and system test

5. Installation and maintenance

The frequently chosen cascading representation of the project phases has led to the name ‘waterfall’ (Wolf, 2018). These phases are executed sequentially and with correction loops between two consecutive phases. The activities of each phase are carried out in the defined order and documented, which leads to the phase result. The clearly defined results at the end of a phase are binding requirements for the next lower phase. The advantages of this model include ease of understanding and controllable process flow with little management effort. However, changes in requirements during the project cannot be taken into account or it can be done only with difficulty. Other disadvantages are the late detection of risks during the implementation or the testing since no early feedback possibility is foreseen. The project goal—the actual software system—could move out of focus with this strong document-oriented procedure. Testing can only be started after the completion of the development. Thus, presentation to the management and the users can only be done after the final completion. Nowadays, the use of the waterfall model is generally not recommended. A customized and iterative approach is better suited to today’s fast-changing requirements than completing every development step before starting the next one (Hindel et al., 2006). Because of digitalization, more agile and customer-oriented techniques for complex software or system development are required nowadays. This need for an iterative model led to the creation of the V-model.

The V-model is a representation of a system’s development lifecycle. Within this model, much attention is placed on QA. The V-model describes the activities to be performed in an NPD and the deliverables or results that must be produced. Herein, verification and validation are introduced as planned processes to ensure that the product meets the customer expectations and the defined requirements. The PMBOK Guide (PMI, 2017) defines the two terms as follows in its sixth edition:

> Validation: The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers. Contrast with verification.
>
> Verification: The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition. It is often an internal process. Contrast with validation.

The V-model was first developed as an approach model for software development. A general representation of the software V-model is shown in Figure 12.

In addition to the definition of the development steps (specification steps), the V-model links the test phases to the development phases. In the left branch, the specification process is shown, starting with the functional or technical specification, which is further detailed and is developed as a basis for implantation. Afterwards, on the right branch, the testing against the defined requirements or specifications starts, ranging from a detailed unit test to an integrated system and acceptance test.

The software is created in modules which are than tested on the right side with module functionality tests. In case the tests of the software integrations lead to failures, it is possible to jump back to the left side and perform the different phases again. This prevents faulty results from being integrated into higher-level systems. One level above the review of the technical specifications is validation. The validation describes a systematic process, proving through use cases or user stories that the product provides the required use.

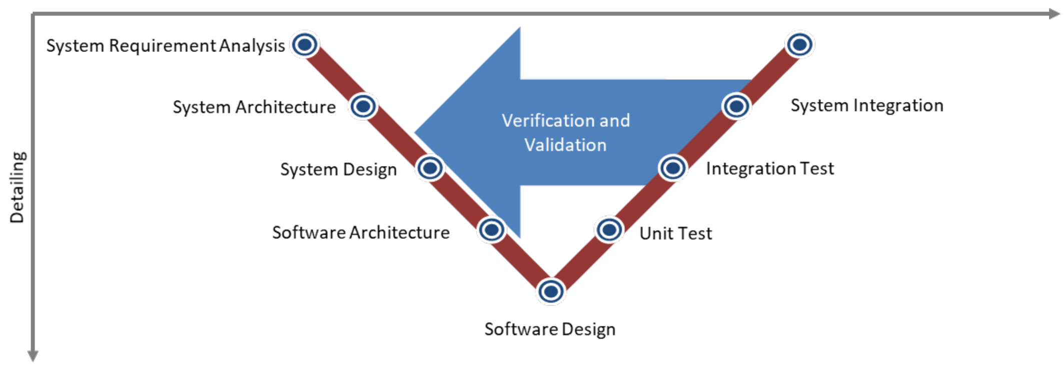

Figure 12: The V-model in software development

The above figure shows a V-model, which is a basic systems development process model, as it is applied often in software development projects. Adapted from Norm VDI 2221, Verband Deutscher Ingenieure (Association of German Engineers, 1993)

Initially developed as a software development approach, the V-model has been further developed as a systems engineering model, which is also applied in the case of mechatronic systems. The idea to split the specification and realization phases and to place them vis-à-vis the integration and testing phases led to the creation of NPD and system engineering standards. Such an SE process provides a path for improving the cost-effectiveness of a system. The early and clear identification of goals, the definition of a concept of operations, user needs, and the operating environment, the redaction of unitary, complete, consistent, traceable, unambiguous, and verifiable system requirements, the detailed design, the implementation, and the rigorous acceptance testing of the complete system ensure that the system meets the top-level requirements (system verification), including its effectiveness in addressing goals (system validation), ongoing operations, and system upgrades over time (Forsberg & Mooz, 1991; Friedrich et al., 2009; Höhn et al., 2015). The V-model allows an early specification of test cases in the left branch in Figure 12. The early definition of test cases after the system requirement definition and the early recognition of failures ensures the quality of the final product from the beginning.

In general, the V-model has served as a general testing model throughout the testing community worldwide. The V-model is seen as a general illustrative description of the software development process.

In what concerns SE adaptation standards, two main types can be identified:

- The United States government standard, and
- the German V-Model.

This study focusses especially on the NPD processes in German automotive companies. Therefore, I focus the review on the German V-model.

The German V-model, or ‘V-Modell’ in German, which was then further developed to the ‘V-Modell XT’, is the official project management methodology of the German government, especially for software development projects. The illustration as a ‘V’ is to ensure that the products on the left side of the V are acceptable by the test and integration organization that implements the right side of the V.

The ‘V-Modell’ takes a more general perspective and defines additional support processes. The left branch of this V-model shows the specification and design process and the right branch shows the verification and validation process. The system design process (left, specification) and the test process (right, verification) are carried out in phases. These phases can be tailored according to the project needs (Manfred Broy & Rausch, 2005; Friedrich et al., 2009).

Today, the ‘V-Modell XT’ and variants of it find application in most software development projects in the automotive industry in Germany (Wolf, 2018). The ‘V-Modell XT’ is a model for planning and realizing projects. It describes roles, work products, activities, metrics, and methods for the NPD project, and is thus a complete NPD process model, particularly for software solutions, as defined by Höhn et al. (2015, p. 22). The development of this process model has been strongly influenced by the idea of a V-formed phase model. The ‘V-Modell’ regulates ‘who’ has to do ‘what’ and ‘when’ during a project. According to the German government, it can be applied to a variety of project constellations. Nevertheless, ‘V-Modell’ projects vary in pattern. The ‘V-Modell XT’ defines three project types, thereby aiming to ensure that the V-model is easily applicable to such project forms. These predefined project types serve to identify the process models that must be used and those which can be chosen additionally for every type. Furthermore, the project types are used for allocating process execution strategies and decision gates. With the definition of the project type, the ‘what’ that must be done is defined.

The model differentiates between three project types:

1. System development project of an acquirer
2. System development project of a supplier
3. Introduction and maintenance of an organization-specific process model

For the purpose of this study, only 1 and 2 are important since I analyse the collaborative integration of ESPs in system development projects.

The ‘V-Modell XT’ defines the following core process modules:

- Project management (PM)
- Quality assurance (QA)
- Problem and change management (PCM)

- Configuration management (CM)

These process modules have also been defined as core processes for PLM systems. Support process modules depending on the project type and the project execution strategy are also defined. For the system development project of an acquirer, the following process modules are defined as mandatory:

- Specification of requirements
- Lifecycle cost management
- Measurement and analysis
- Contract award, project monitoring, and acceptance

For the system development project of a supplier, the 'V-Modell XT' defines the following mandatory process modules:

- Offer preparation and contract fulfilment
- System implementation
- Software development
- Integrated logistic support
- Hardware development
- Evaluation of off-the-shelf products
- System safety and security
- Usability and ergonomics

Furthermore, it defines the following project executions strategies for the project types 1 and 2 and links them to the respective project type:

- Award and conduct of system design development projects

- Incremental system development
- Component-based system development
- Agile system development
- System maintenance
- Enhancement and migration of legacy systems

The choice of the project execution strategy then defines the decision gates given by the model.

I focus this study on joint NPD projects under the lead of an ESP. In the second case study, I analyse a software development project with the ESP as both a supplier and an acquirer since the ESP in this project also has to coordinate and integrate the suppliers of modules. The project analysed in the case study applies a combination of an incremental system development execution strategy and a component-based system development with parts of an agile approach. This problem is further discussed in Chapter 0.

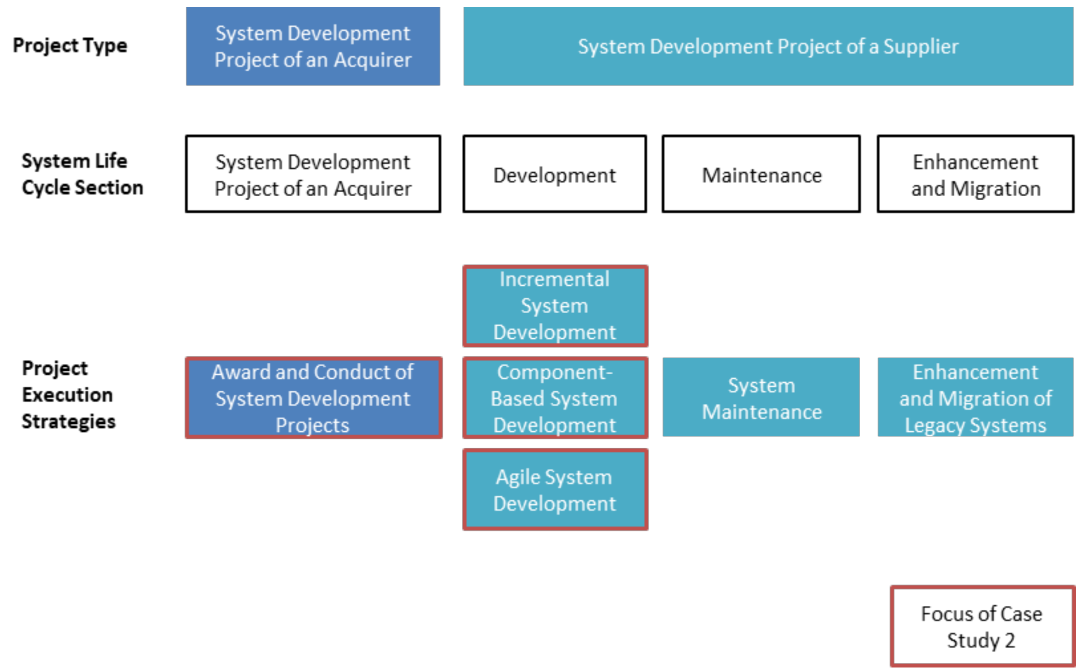

Figure 13: Project types and project execution strategies in software development projects according to the 'V-Modell XT'

The above figure shows the project types relevant to this study as defined in the 'V-Modell XT'. Furthermore, it shows the focus of the second case study presented in Chapter 0. Adapted from Broy and Rausch (2005) and Friedrich et al. (2009).

In the study presented here, I intend to analyse and find best practice approaches that would lead to a more efficient and effective collaboration in NPD projects under the lead of an ESP. Therefore, the focus of the case studies would be on the system development projects of a supplier. Nevertheless, I do not want to limit the review only to the perspective of the supplier, the ESP, and the supplier network. Rather, it should also focus on the perspectives of the acquirer, which is the OEM, because I believe that the project must be managed well on both sides and the acquirer can also contribute to an enhanced NPD performance at the supplier.

Nevertheless, this way of looking at the project allows a better analysis of the process maturity applied in the highly complex software development project that I analyse in the second case study in Chapter 0. In this project, the ESP takes the lead in the development and faces many challenges. These challenges could have been avoided had the right process model been applied.

The V-model is criticized for being overly complex. The high complexity of the process model is accompanied by high costs and bureaucracy resulting from the documentation requirements and the approach. This holds true especially for smaller software development projects. For large and complex projects, it seems to be well-suited (Hindel et al., 2006, p. 22).

The car industry in Germany mostly uses a variant of the ‘V-Modell XT’ for iterative system development.

Moreover, the Verband der Automobilindustrie (VDA), the association of the German automotive industry, started the development of a process maturity model based on the process model. The **Au**tomotive **S**pecial **I**nterest **G**roup (AUTOSIG), consisting of the German automakers Audi, BMW, Daimler, Porsche, and Volkswagen, and of international car makers such as Fiat, Ford, Jaguar, Land Rover and Volvo, started in 2001 the development of the automotive SPICE model—ISO/IEC 15504. The name stands for **S**oftware **P**rocess **I**mprovement and **C**apability D**E**termination (SPICE). The model is an international standard for the execution of maturity assessments of company business processes with the main emphasis being on software development processes. OEMs use this model to assess internal software development departments as well as the software departments of suppliers.

The underlying process model is based on the ‘V-Modell XT’. Please refer to Figure 14 to review all the acquisition, engineering, management, process improvement, and supporting processes defined in the model.

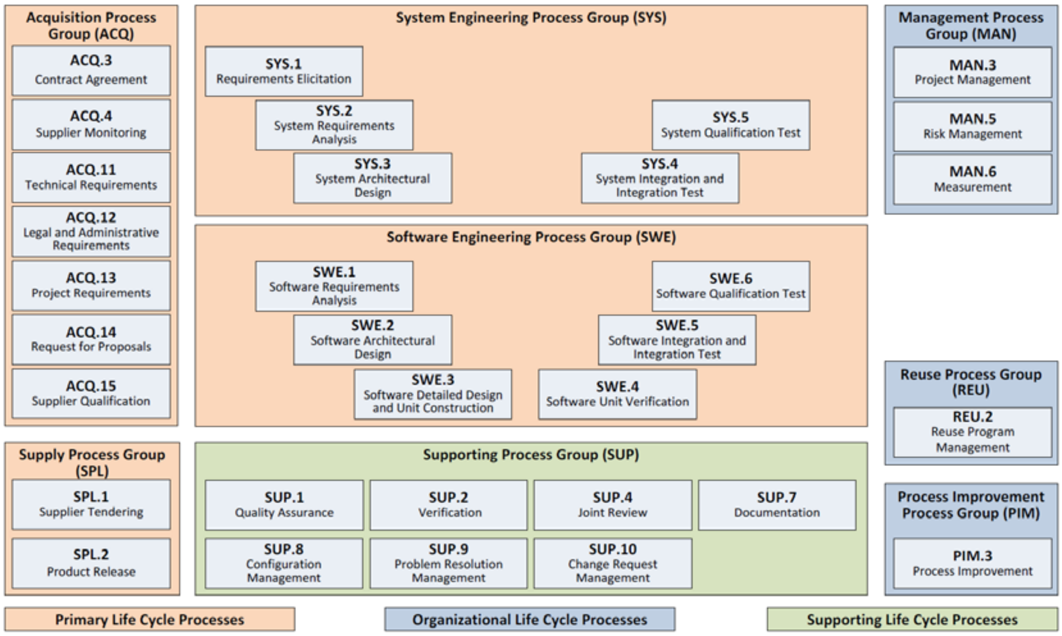

Figure 14: An overview of the automotive SPICE process reference model

The above figure shows the reference model defined in ISO/IEC 15504 (SPICE), which serves as a reference model for the process maturity assessment in automotive systems and software engineering projects. Taken from AUTOSIG (2012).

The focus of this maturity model is the improvement of processes in the own organization (process improvement) and the determination of process maturity or capability (capability determination). Today, the result of a SPICE assessment is a basic selection criterion for qualified ESPs in the fields of electronics and software. At the beginning of nearly every software project in the automotive industry, the applied processes and the desired maturity level of those processes are defined. Following this definition, a SPICE assessment is performed. Based on the assessment results, optimization measures are defined, implemented, and monitored (Höhn et al., 2015; Wolf, 2018).

Automotive SPICE defines five levels of process maturity, which can be found in the table below.

Level 0	**Incomplete process**	The process is not implemented or fails to achieve its process purpose.
Level 1	**Performed process**	The implemented process achieves its process purpose
Level 2	**Managed process**	The previously described performed process is now implemented in a managed fashion (planned, monitored, and adjusted) and its work products are appropriately established, controlled, and maintained.
Level 3	**Established process**	The previously described managed process is now implemented using a defined process that is capable of achieving its process outcomes.
Level 4	**Predictable process**	The previously described established process now operates predictively within defined limits to achieve its process outcomes. Quantitative management needs are identified, and measurement data are collected and analysed to identify assignable causes of variation. Corrective action is taken to address assignable causes of variation.
Level 5	**Innovating process**	The previously described predictable process is now continually improved to respond to organizational change.

Table 2: Automotive SPICE process maturity levels

The above figure shows the possible maturity levels of processes defined in the process reference model as an outcome of assessments according to Automotive SPICE. These levels form the basis for supplier selection and improvement measures. Adapted from Höhn et al. (2015).

Such an Automotive SPICE assessment has also been performed in the project reviewed in the second case study. The model discussed above is therefore of relevance for the study.

2.1.3.3 *Agile development and Scrum.*

In this section, I discuss the principle of agile development, which is often applied in software development projects. The Scrum approach is applied in the analysed project in the second case study.

When it comes to the development of new software products for IT systems or the consumer market, agile working methods represent the state of the art. The traditional development process model in the automotive industry is based on maturity degree consideration and quality gates or milestones. That leads to a situation where software modules in the automotive industry are often released when they are already obsolete in consumer market applications (Wolf, 2018). Thus, competences in the application of agile development methods can be a unique selling point (USP) and of tremendous importance since established automotive OEMs tend to struggle with the application of such methods. Many OEMs look for strategic service partners to which they can relocate software development with the applied agile methods in a bid to speed up the development process. For service providers, this means undergoing an agile and digital transformation as well as investing in their own innovative capability and strength (Zillmann, 2019). In a representative survey of managers working for established OEMs, the respondents ranked competence in the application of agile methods as the third-most-important skill for service companies, after the power of innovation and industry competence (Zillmann, 2019).

In conjunction with agile software development and working methods such as Scrum, the term ‘agility’ is used. In the literature, ‘agile’ is described as the ability of an organization to adapt constantly to its complex, changing, and unsafe environment (Häusling, 2018, p. 28). Agility should not be confused with flexibility. That is because flexibility features such as omitting documentation do not match agile values (Wolf, 2018). Overall, however, the term 'agility' remains fuzzy in professional language, as there are many definitions by different authors and many different approaches to agility theories and concepts. The multiple agile methods use different processes to reach their goals. However, they share common principles and values which are based on the agile manifesto of software development. The agile manifesto describes the philosophy behind agile ways of working and can be read on the website agilemanifesto.org and in the work of Sommerville (2012, pp. 88–89). These principles can be summarized into the following: customer focus, incremental development and regular, continuous delivery, motivated individuals working together closely, business people and developers working together daily throughout the project, openness to change, simplicity, and open face-to-face communication (Sommerville, 2012). Scrum is an agile development approach.

A detailed explanation of the Scrum framework with all events, artefacts, and rules can be found in the *Scrum Guide* by Schwaber and Sutherland (2017). This *Scrum Guide* and the agile manifesto mentioned earlier form the current basis of general agile software development. Scrum is a process framework for managing work on complex adaptive tasks. Various techniques and processes can be used within this framework. The use of certain programming models is not required. The approach focuses less on specific technical approaches to agile software engineering than on managing individual development steps and project management. The Scrum process consists of the planning phase of the overall project goals, a series of sprint cycles, and the project completion phase (Sommerville, 2012). Scrum is not limited to use in software projects though. It can be used in many areas, as described in the *Scrum Guide*. Epics and user stories have proved to be best practices. Especially in projects, comprehensive customer requirements are presented informally in epics, which are subdivided into many user stories. These epics are incrementally filled over sprints (Wolf, 2018). A sprint is set with a beginning and an end. The effectiveness of product management and work techniques are visible in Scrum with regard to improving the product, the team, and the work environment constantly. Part of the Scrum framework are various roles, artefacts, events, and rules (Schwaber & Sutherland, 2017). A sprint is the value-adding project process wherein the development team translates requirements from the product backlog into a product increment within a fixed-duration process. A sprint is a Scrum event. Scrum events are temporary and required to establish regularity. The sprint is a period of one, two, or a maximum of four weeks in which a usable product increment is produced. The duration of a sprint may not be shortened or extended after the start. The sprint lengths in a development project should be equal. The sprint provides a timely framework for sprint planning, daily scrums, development, the sprint review, and the sprint retrospective. These events can be terminated once they have fulfilled their purpose. So, only the time needed is used and waste is avoided. The Scrum events create transparency and grant the opportunity to review and adjust the current status (Schwaber & Sutherland, 2017). Scrum as an agile method allows or even promotes late changes and fuzzy specifications. This leads to challenges in the area of security-relevant product software development in the automotive industry, particularly in turnkey project contract outsourcing and with respect to the Product Liability Act. The strong fuzziness of the service to be provided, the process description, and the documentation of the acceptance criteria do not yet meet the quality standard for the processes of development of safety-relevant systems. In addition, it is difficult to judge clearly the fulfilment of the contract and the conformity of normative requirements in the case of disagreements or product approval. To develop prototypes in the innovation fields of electro mobility and autonomous driving, the application and expansion of agile working methods will be the next milestone for the automotive industry. With a focus on the phases in which agile working methods have a sufficient standard of stringency, the classic automotive industry can assert itself in a competition that is not normatively oriented towards innovative concepts (Wolf, 2018). Currently, agile operations are only used to develop embedded prototype software and supporting IT systems. The experience gained in the prototype development process can subsequently have a benefit in the normative legislative development that is required, for example, in the determination of functional requirements (Wolf, 2018).

In summary, software development in the automotive industry is an increasingly competitive and challenging area. The development of software products takes place in project form. Process models for the development process and normative requirements according to ISO 15504 (Automotive SPICE) provide the framework for work processes but there are no concrete instructions. Rigid process models are no longer considered as state of the art for the development of software. Here, agile working methods are increasingly used in development. For the classic automotive industry, it becomes a challenge to reconcile the normative and legal regulations with the agile values of development. ESP could play the role of change agents for automotive OEMs in this context by applying and implementing agile methods and thus find solutions for the application of agile methods in the automotive industry (Wolf, 2018).

2.2 Discussion of the Systematic Literature Review on Collaboration in Automotive NPD

In the following section, I discuss the findings gained through a systematic literature review on collaboration in automotive NPD. The methodology applied is outlined in Section 3.2.2. Given the context of the study, I limited the systematic review on the field of collaboration in automotive NPD assuming that collaboration in this specific field is intensively researched by academics. Since the automobile is a highly complex product, effective and efficient collaboration and open innovation are important success factors for automotive NPD projects (Gassmann, 2006).

2.2.1 Complexity aspects of NPD.

The complexity of mechatronic products has been increasing rapidly over past years (Hellenbrand, 2013; Katzenbach, 2015). This is especially true for the automobile. Although the automobile industry has become an ‘old industry’, the innovation pressure remains strong and product innovations are essential for the success of the industry (Genta et al., 2014). An increasing complexity of motorcars can be observed. The number lines of software code on the electronic control units (ECUs) in a car has increased exponentially in the last three decades. Today, a modern car has more than 100 integrated ECUs. New functions like automatic parking, autonomous driving, internet connection, and navigation services lead to increasing product complexity (Katzenbach, 2015). Moreover, the number of products developed by automobile manufactures in parallel is also steadily increasing (Kurek, 2004) and the product lifecycle is becoming shorter (Gassmann, 2006). Therefore, the OEM has neither sufficient resources nor the right ones to cope with the increasing innovation pressure. Automobile manufacturers are now faced with the challenge to open up their innovation process, which would enable innovation to move between the external environment and their own internal NPD processes. OEMs need to find ways to integrate external knowledge sources in order to enrich their internal innovation power. This is why the automotive OEM today focusses on its core competencies and products (the so-called lead cars) and outsources the development of product variants (e.g. the coupe). Furthermore, the manufacturer concentrates its innovation power on the core technologies which are brand identifiers. For example, in case of Mercedes, it may be security and comfort, whereas for BMW, it is driver experience (Gassmann, 2006; Gassmann et al., 2004). Thus, OEMs start technology partnerships with innovative companies in order to develop technologies that are not within the core competencies of the OEM itself (Bromberg, 2011).

The resulting need for resources in NPD, because of the increasing complexity in the NPD process and a change in the labour legislation (discussed in a later section of this paper), can be observed in all European countries that have a strong automotive industry as well as in Japan and the USA. This need led to the present-day situation in which ESPs have become powerful innovation partners that play an important role in the NPD and innovation process of automobile manufacturers.

This situation provides the context for the business environment in which the present study is conducted.

2.2.2 NPD organization.

Scholars agree that early supplier involvement in the development process has been increasing in past years (Binder et al., 2008; Gassmann, 2006; Håkansson & Ford, 2002; Handfield & Lawson, 2007; Harmancioglu, 2009; Hoegl & Wagner, 2005; Meißner, 2013; van Echtelt et al., 2007; Wagner & Hoegl, 2006; Wynstra et al., 2001). In NPD, OEMs focus on their core competencies. Subsystems that are outside of this core competence perimeter are subject to outsourcing. Hence, system and module suppliers build up engineering and development competencies for the development of these subsystems. ESPs have to orient themselves to the market because one of their former business cases could be taken over by system or module suppliers. ESPs are being forced to build up more architectural knowledge (Hellenbrand, 2013; Holtrup, 2018; Kurek, 2004; Rentmeister, 2002; Wolff, 2007). In the presented systematic literature review, I discuss the motivation and risks of outsourcing NPD. Furthermore, I identify management implications for ESPs in an open innovation process and deduce a preliminary recommendation model for joint NPD projects.

Gassmann (2006) proposes five approaches to open up the innovation process:

(I) globalization of innovation

(II) outsourcing of R&D

(III) early supplier integration (ESI)

(IV) user innovation

(V) external commercialization and application of technology

ESPs build their business using the second approach in the context of (I), a globalized innovation environment, and (III), early integration of the module or system supplier into the development process. Good knowledge management is crucial in such collaborative NPD projects (Gassmann et al., 2004; Katzenbach, 2015; Wolff, 2007).

Consequently, the content and implications of the identified studies are classified into five categories:

(A) Motivation and risks in outsourcing of NPD (Section 2.2.3)

(B) General recommendations for collaborative NPD projects (Section 2.2.4)

(C) Recommendations in the field of ESI (Section 2.2.5)

(D) Recommendations in the field of knowledge management (Section 2.2.6)

(E) Recommendations in the field of relationship management (Section 2.2.7).

I identified ESI (C) as an important sub-domain of (B). I have explicitly pointed this out since many contributions exist in this field of research. In the following table, this classification of the studies is presented. The following sections meta-synthesize the retrieved evidence using these five categories.

Author, Year	(A)	(B)	(C)	(D)	(E)
Azadegan & Dooley, 2010			X	X	
Bautzer, 2005		X		X	X
Becker & Zirpoli, 2003	X			X	
Binder, Gust, & Clegg, 2008	X	X			
Blöcker, 2016	X	X			
Bromberg, 2011	X				
Caputo & Zirpoli, 2002	X				X
Carson, 2007;		X			
van Echtelt, Wynstra, & van Weele, 2007		X			X
Ferreira, Faria, Azevedo, & Marques, 2017		X		X	
Gassmann, 2006	X	X			
Gerwin, 2004	X				X
Handfield & Lawson, 2007	X	X			X
Harmancioglu, 2009	X	X			
Hirz, 2011		X		X	
Hoegl & Wagner, 2005		X			X
Holtrup, 2018	X				
Hong, Pearson, & Carr, 2009				X	X

Katzenbach, 2015	X	X	X	X	
Kotabe, Martin, & Domoto, 2003	X	X	X		X
Lakemond, Breggren, & van Weele, 2006			X	X	X
Lawson, Petersen, Cousins, & Handfield, 2009				X	X
Lawson, Krause, & Potter, 2015		X	X	X	
Meißner, 2013	X	X			
Mishra, 2009	X	X		X	
Müller & Pöppelbuß, 2015	X			X	X
Nellore & Balachandra, 2001	X	X			X
Oh & Rhee, 2010	X		X		
Pemartín et al., 2018	X	X			
Quesada, Syamil, & Doll, 2006		X		X	X
Ragatz, Handfield, & Petersen, 2002	X	X			X
Rentmeister, 2002	X				
Ro, Liker, & Fixson, 2008	X	X			
Rouibah & Caskey, 2005		X			X
Rundquist & Halila, 2010		X	X	X	
Sanchez & Perez, 2003	X			X	
Siebenhüter, 2014	X				
Schneider, 2011	X	X	X		
Stephan, Pfaffmann, & Sanchez, 2008		X			
Takeishi, 2001	X	X	X		X
Takeishi, 2002	X		X	X	X
Tang & Qian, 2008	X	X			X
Tripathy & Eppinger, 2007		X			
Trott, 2017	X	X		X	
Un, Cuervo-Cazurra, & Asakawa, 2010	X			X	
Wagner & Hoegl, 2006		X			X
Wang, Fu, Ming, Kong, & Li, 2010	X	X			
Wognum, Fisscher, & Weenink, 2002				X	X
Wolff, 2007	X		X	X	X
Wynstra, Arjan van Weele, & Weggemann, 2001			X		X
Zirpoli & Caputo, 2002	X			X	X

Table 3: The contents of the identified studies in five categories

This table categorizes the retrieved evidence. The categories are: (A) motivation and risks in outsourcing of product-level NPD, (B) general recommendations for collaborative NPD projects, (C) recommendations in the field of ESI, (D) recommendations in the field of knowledge management, and (E) recommendations in the field of relationship management.

2.2.3 Motivation and risks of outsourcing NPD (A).

Nowadays, high innovation pressure can be observed in the automotive industry (Gassmann, 2006; Harmancioglu, 2009; Katzenbach, 2015; Schneider, 2011; Trott, 2017; Wang et al., 2010). The product lifecycle is becoming shorter and OEMs are being forced to decrease the time to market of their products and therewith the development time (Bromberg, 2011; Holtrup, 2018; Katzenbach, 2015; Kurek, 2004; Rentmeister, 2002; Sanchez & Perez, 2003). In fact, the time to market is becoming increasingly critical. OEMs have the tendency to reduce the development time from product definition to start of production (SoP). Forty years ago, the development cycle of a car could last up to 10 years, whereas today, OEMs try to reduce the NPD time to 30 months or less (Katzenbach, 2015). In addition, automotive OEMs face the problem of developing more complex products with the same or a smaller amount of resources. The manufacturers do not possess sufficient resources in-house to research and develop the technologies needed for sustainable transportation and to cope with the customer’s demand for variety and product customization (Gassmann, 2006; Holtrup, 2018; Meißner, 2013; Takeishi, 2001; Tang & Qian, 2008; Wolff, 2007; Zirpoli & Caputo, 2002). Furthermore, the integration of new functions into the car is of utmost importance since the consumer expects more services from the vehicle. The automobile is no longer merely a vehicle for transporting passengers; rather, it is a highly integrated product that offers many more digital services than it did earlier. Thus, opening up the NPD becomes relevant.

The outsourcing of NPD activities is a growing trend (Holtrup, 2018; Katzenbach, 2015; Lüerßen, 2016; Pemartín et al., 2018; Schneider, 2011; Un et al., 2010). A steadily increasing demand for NPD services can be observed in recent years, especially in the automotive industry (Bromberg, 2011; Rentmeister, 2002; Schneider, 2011). The outsourcing of NPD activities to service providers or system suppliers allows OEMs to rely on the competences and resources of the suppliers. This increases the OEM's flexibility and can reduce the development time and cost through synergy effects and knowledge sharing. Furthermore, automotive OEMs gain access to new technologies (Holtrup, 2018). The OEMs can rely on the highly skilled personnel of the suppliers and gain access to the knowledge if a supplier management process and a knowledge management process are well established (Binder et al., 2008; Gerwin, 2004; Kotabe et al., 2003; Ragatz et al., 2002). In the studies consulted, internal and external motives for outsourcing have been identified.

The identified internal motives for collaboration in NPD are listed below (M. Becker & Zirpoli, 2003; Bromberg, 2011; Gerwin, 2004; Holtrup, 2018; Kotabe et al., 2003; Meißner, 2013; Müller & Pöppelbuß, 2015; Pemartín et al., 2018; Un et al., 2010; Wolff, 2007):

- IM 1. Minimization of cost (lower labour rates) and cost restructuring (change fixed cost to variable cost)
- IM 2. Access to specific know-how, intellectual property, and wider experience and knowledge
- IM 3. Need for capacity not currently possessed and resource flexibility (resource-dependency perspective)

IM 4. Specifically for outsourcing to ESPs, generate IP for the OEM and thereby increase vertical integration with a flexible workforce

IM 5. Motives concerned with the spreading of the (mostly financial) risks of product development

IM 6. Poor internal performance increases motivation to collaborate

IM 7. Achieve a change in quality by outsourcing a service with a new SLA

IM 8. Use a recruiting channel to build up talent benches with highly competent ESP employees (64.3 per cent of persons leaving ESP companies join customer teams (Bromberg, 2011)]),

IM 9. Concentration on core competencies

The identified external motives for collaboration in NPD are outlined below (Katzenbach, 2015; Wolff, 2007):

EM 1. Globalization or regionalization factors

EM 2. Uncertainty of international markets

EM 3. Change in legislation concerning temporary employment

However, outsourcing has some downside risks. Wolff (2007) finds in his study that the *risk of losing know-how, tacit knowledge, and critical information, and thereby the risk of losing IP* cannot be avoided completely (Nellore & Balachandra, 2001; Rentmeister, 2002; Siebenhüter, 2014; Un et al., 2010; Wolff, 2007). Harmancioglu (2009) discerns that the opportunistic expropriation of tacit knowledge is accompanied by outsourced development. Furthermore, OEMs that outsource NPD experience the *risk of an agency dilemma* and face difficulties in transferring the knowledge generated at the supplier into the internal innovation system

(Harmancioglu, 2009). The principal–agent theory argues that a difference in the goals of the exchange between the principal and the agent exists. To regulate the goals of the joint project, commercial contracts are concluded between the parties (Brennan et al., 2017, p. 64). In NPD, agency problems are mainly based on an asymmetric dispatch of information between the principal (the OEM) and the agent (the supplier or the ESP). Both principal and agent act in self-interest. If the ESP intends to gain knowledge by keeping parts of the developed IP internal, the OEM might not receive the information needed to integrate the developed technology or product. Furthermore, there is the *risk of dependency* on suppliers for the OEM or on an OEM for the ESP (Lüerßen, 2016; Wolff, 2007). A firm that is dependent on an external organization's NPD capabilities may lose some negotiation power and its innovative capability may become vulnerable (Takeishi, 2002; Wolff, 2007). Caputo and Zirpoli as well as Katzenbach discern a *risk of changing the set of core competencies* at the OEM (Caputo & Zirpoli, 2002; Handfield & Lawson, 2007; Katzenbach, 2015). Moreover, *the risk of reduced development project performance through geographically dispersed project teams* is examined by some researchers (Handfield & Lawson, 2007; Mishra, 2009). Harmancioglu defines the *risk of increasing costs* when sourcing partners are geographically and culturally distant. Oh and Rhee (2010) analyse the impact of supplier capabilities on NPD performance. They argue that a product with high technological uncertainty has a negative impact on the supplier's development performance and thereby on the whole NPD project. Thus, *high technical uncertainty risks lead to an increase in the transaction-cost diseconomies of the collaboration* up to a threshold where the risks offset the benefits and impair the OEM's competitive advantage (Oh & Rhee, 2010). Ro et al.

(Ro et al., 2008) define dominant supplier management models which can help to mitigate such risks. Their results and the results of other studies are discussed in the following sections. Blöcker (2016) discusses in his study the ESP market in Germany. Blöcker confirms the motives and risks mentioned above and discusses in detail an additional risk which is specific to ESPs. ESPs have gained more power over the last two decades. With around 93,500 employees in Germany and around 220,000 abroad (Blöcker, 2016), ESPs are important players in the labour market. The price pressure on ESPs and the structure of ESP companies, along with the lack of exhaustive employee codetermination structures, the absence of power of the syndicates, and the lack of exhaustive collective agreements, lead, according to Blöcker, to the discrimination of ESP employees vis-à-vis the employees of OEMs. This could be perceived as an inequity by the employees of the ESP. Such an inequity implies the *risk of a lack of motivation in the project teams* on the ESP side.

Furthermore, Blöcker (2016) describes a second risk in her study. In the German and in other European legislations, a work relationship is created when an employee is completely integrated in the business process of a company and takes orders from an employee of the company, regardless of whether the person has a formal working contract with the company or not. Therefore, ESP employees could try to sue the OEM, for employment, if they are completely integrated in the OEM's business process. In Germany, two possibilities exist to prevent this situation. First, companies should provide complete work packages to the ESP with a clear description of the development result and a physical separation of the teams, or second, they should transfer the resources in a temporary employment relationship. This thesis is focussed on the first scenario: important work packages given to an ESP. Herein, the *risk of legal disputes with the ESP employees* exists. Furthermore, the risk of losing tacit knowledge is confirmed in this scenario (Siebenhüter, 2014).

Siebenhüter (2014) discusses another important risk in bigger joint NPD projects under the lead of an ESP. ESPs traditionally have a higher employee turnover rate than do OEMs. This is because ESP employees often switch to working for the customer when they feel satisfied in the OEM’s organization or want to benefit from a higher level of security. The motivations for engineers to work for an ESP include the following: They might have more interesting projects with different customers, gain faster and more experience in those projects, and thereby have access to greater career opportunities. When engineers have achieved their career goals or get an opportunity to step up in the customer’s organization, possibly even on a higher remuneration level, they often choose to move to a different workplace. More than 70 per cent of the engineers resigning at an ESP join an OEM or a Tier 1 supplier later (Blöcker, 2016; Lüerßen, 2014; Siebenhüter, 2014). The average employee turnover rate at ESPs has increased to 18.5 per cent in 2015, up from 17 per cent in 2014 (Lüerßen, 2014). This implies a *risk of losing project performance due to high employee turnover*.

Below, I list all the mentioned risks once again:

Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP

Ri 2. Risk of agency dilemma

Ri 3. Risk of dependency

Ri 4. Risk of changing the set of core competencies

Ri 5. Risk of reduced supplier performance through cultural distance

Ri 6. Risk of reduced development project performance through geographically dispersed project teams

Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty

Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams

Ri 9. Risk of labour law disputes with ESP employees

Ri 10. Risk of losing project performance due to high employee turnover at the ESP

In the following section, I identify the recommendations identified in the different fields of literature. Starting with the general recommendations, I identify recommendations related to ESI, knowledge management, and relationship management. The recommendations are then used as subcategories and assigned to the main categories of 'people', 'process', 'collaboration technology', and 'product technology'. The identified recommendations are marked in bold.

2.2.4 General recommendations for collaborative NPD projects (B).

Gassmann (2006) advances the view that the outsourcing of NPD offers significant opportunities for global companies to increase their competitiveness and global footprint (Gassmann, 2006; Katzenbach, 2015). Other scholars challenge this view, arguing that the outsourcing of NPD can increase the NPD project performance only under special conditions (Rouibah & Caskey, 2005; Takeishi, 2001; van Echtelt et al., 2007). Much attention is placed on integration of the supplier's development team into the OEM's team. Studies have shown that **joint development teams** have a positive impact on development performance (Binder et al., 2008; Handfield & Lawson, 2007; Hoegl & Wagner, 2005; Mishra, 2009; Wagner & Hoegl, 2006). Such joint development teams can be created either at the OEM's development site (the ESPs have to transfer their teams to the OEM's site) or in a **common project space** which can be at the OEM's location, the service provider's location, or at a neutral place. This recommendation is therefore valid to mitigate the *risk of reduced development project performance* and *the risk of increasing costs through geographically dispersed project teams,* provided that arrangements have been made to avoid the *risk of legal disputes with ESP employees* who may be aiming to sue the OEM for an employment contract. Therefore, a joint project space on neutral ground might be advantageous. But the studies considered in this review have not proposed any solution for this risk. Therefore, I intend to see how practitioners handle this problem in the case studies. Furthermore, scholars argue that it is of utmost importance for all the participating teams to work in the **same IT environment and have modern communication technology at hand**. Therefore, **processes and IT solutions have to be improved continuously and legacy systems have to be integrated with modern solutions** (Katzenbach, 2015; Pemartín et al., 2018; Schneider, 2011). Managers seeking to reduce the time taken from concept to customer development while increasing quality should make suppliers a part of their team through **co-location** or **frequent communication** (Pemartín et al., 2018; Ragatz et al., 2002; Ro et al., 2008). In case of offshore outsourcing, where a client firm contracts NPD work to a vendor firm in a different country, these recommendations become even more important because offshore outsourcing project organizations tend to exhibit significantly lower technical efficiency than project organizations in which the project teams have not been geographically dispersed (Mishra, 2009). Moreover, scholars argue that employee turnover is negatively associated with the technical efficiency of a collaborative NPD project (Bromberg, 2011; Kotabe et al., 2003; Mishra, 2009). Rundquist and Halila (2010) conclude that managers should give time to **the development teams for integration on a personal level**, as this protects knowledge and lowers costs in the long run. Hence, the involved parties are required **to define sustainable project teams at the beginning of the project**. Furthermore, not only the development teams but also the **NPD processes** of the involved parties (OEMs, ESP, system or module supplier) should **be well-aligned** (Lawson et al., 2015; Schneider, 2011; Tang & Qian, 2008; Tripathy & Eppinger, 2007; Wang et al., 2010). Mishra (2009) shows that especially in collaborative NPD projects, misalignment of the development processes are common. Ferreira et al. (2017) argue that semi-structured process management, with flexibility adapted to the level of complexity of the collaborative environment is crucial for the NPD efficiency. Thus, **aligned project management practices** are positively associated with the technical efficiency of projects. The alignment of the PLM system and the CE process seems to be crucial (Ferreira et al., 2017; Hirz, 2011; Katzenbach, 2015; Rouibah & Caskey, 2005; Tang & Qian, 2008; Wognum & Trienekens, 2015). The **interfaces between the modules or subsystems should be clearly defined** in order to permit good integration of the ESPs. This can only be mastered by the OEMs. The central task of the OEM is to manage the participation of the ESP in a way that it is as efficient as possible (Quesada et al., 2006). Therefore, **joint decision-making** between the OEM and the vendor, **two-way flow of information** between the development group at the vendor and the coordination group at the OEM, system-level planning, and a

problem-solving attitude are needed right from the start (Nellore & Balachandra, 2001). Furthermore, a good, **closed-loop PLM system** has a positive impact on the NPD performance (Bautzer, 2005; Ferreira et al., 2017; Hirz, 2011). The recommendations mentioned here help to mitigate the *risk of agency problems* and *the risk of changing the set of core competencies.* By enhancing the ESP's performance and providing well-documented specifications relating to the desired development outcome, the *risk of increased transaction-cost diseconomies of the collaboration through the high level of technical uncertainty* can also be mitigated. Carson (2007) and Harmancioglu (2009) analyse in their studies the impact of control on NPD performance. Harmancioglu argues that the use of behaviour control (formal control during the development activity) should grow weaker with increasing modularity of the developed system. Outcome control (formal control at the end of the development task) should grow stronger with increasing modularity of the developed system. Moreover, he concludes that increasing supplier capabilities decrease the need for behaviour control. Carson (2007) argues that behaviour control has negative impacts on the supplier's development performance. Hence, the following recommendations can be derived: OEMs should choose **highly skilled ESPs** for their outsourced NPD projects and then apply **well-adapted control mechanisms** which do not over-control the vendor (Harmancioglu, 2009). Upon analysing the current market, a consolidation of ESPs can be discerned. The bigger ESPs take over smaller ones and thereby increase their skill level (Blöcker, 2016; Holtrup, 2018; Lüerßen, 2016; Meißner, 2013). This observation of the market may suggest that OEMs seek bigger ESPs with a higher skill level and a skill set along the whole value chain. This is also in line with the development of ESPs towards a system integrator role (Lüerßen, 2016). The right level of outperformed control on the ESP could therefore lead to improved NPD project performance. Furthermore, according to Stephan, Pfaffmann, and Sanchez (2008), it seems advantageous to **outsource the development of modularized systems**. They argue that modularized systems allow better management of the supply chain since the definition of the system interfaces and thereby the responsibility split between the module suppliers are enhanced. This view is supported by the findings of Meißner, (2013) arguing that ESPs take over the development of system modules.

2.2.5 Recommendations in the field of early supplier involvement (C).

Oh and Rhee (2010) define 'collaboration' in the context of supplier management. According to them, collaboration in NPD refers to the active involvement of suppliers from a very early stage as well as an effort to improve quality and reduce development time and expenses. The **early involvement of suppliers in the NPD process** can result in major benefits in terms of money and time (Lakemond et al., 2006; Lawson et al., 2015; Schneider, 2011; Wynstra et al., 2001). This view is confirmed by all researchers that are marked with an X in Column (C) in Table 3. But ESI requires a great deal of thinking and effort. It presupposes active management on behalf of the manufacturer, both in the short term and in the long term, supported by adequate organizational and human management (Katzenbach, 2015; Rundquist & Halila, 2010; Takeishi, 2001, 2002). The ESP, when taking over the role of an innovation partner or system integrator, must do so in line with this management. OEMs and ESPs should define strategies together to involve the system or module suppliers in the development process. To take part in this definition process, the ESPs must be incorporated into the NPD process. This can be achieved only if the **relationship** between an OEM and an ESP is **long-term** (Kotabe et al., 2003; Lawson et al., 2015; Wolff, 2007) and if the OEM devotes enough effort to integrate the service provider. Azadegan and Dooley (2010) discern, in the context of ESI, a positive effect of the supplier's innovative power on manufacturer's cost, quality, product development, delivery, and flexibility performance. One may conclude that OEMs should take into account the innovative power of suppliers when picking a supplier for NPD projects. Thanks to their competencies in one differentiated field, engineering partners often provide support in this decision process. The implication is thus also valid for ESPs. Globally, the research findings suggest that OEMs should involve suppliers early on in the NPD process to ensure improved performance. This can mitigate the risk of increased transaction-cost diseconomies of the collaboration through the high level of technical uncertainty.

2.2.6 Recommendations in the field of knowledge management (D).

To efficiently collaborate on NPD, the learning styles and knowledge management processes of OEMs should fit those of their suppliers (Azadegan & Dooley, 2010; Hirz, 2011; Mishra, 2009; Sanchez & Perez, 2003; Zirpoli & Caputo, 2002). Joint development teams and collaborative working and learning can lead to a beneficial situation for all the involved parties (Lawson et al., 2009, 2015; Takeishi, 2002). But outsourcing NPD also means that the OEMs do not need to build competences in the outsourced development fraction. The manufacturer risks *losing know-how, tacit knowledge, and critical information* (Quesada et al., 2006; Rundquist & Halila, 2010; Takeishi, 2002; Wognum et al., 2002; Wolff, 2007). Thus, the suppliers and especially the ESPs have to put effort into **establishing efficient knowledge handover processes** (e.g. lessons learned process, communication process, etc.) (Azadegan & Dooley, 2010; M. Becker & Zirpoli, 2003; Ferreira et al., 2017; Hong et al., 2009; Müller & Pöppelbuß, 2015; Rundquist & Halila, 2010; Un et al., 2010; Wolff, 2007). This would mitigate the felt *risk of losing know-how, tacit knowledge, critical information, and IP,* as well as the *risk of dependency* at OEMs. An ESP that succeeds in establishing such an efficient knowledge handover process stands to improve its market position. Bautzer (2005) and Katzenbach (2015) conclude that shared product information repositories increase the efficiency of collaborative, product-level NPD projects which can be carried out through alignment of the PLM systems. Thus, all the involved parties should also be interested in aligning the information systems in order to support the daily work of the development teams.

2.2.7 Recommendations in the field of relationship management (E).

The question about which perimeter of the NPD should be subject to outsourcing is widely discussed in the literature. Scholars agree that OEM brand-specific activities should be excluded from collaboration (Müller & Pöppelbuß, 2015; Nellore & Balachandra, 2001; Wolff, 2007). Therefore, OEMs should evaluate which development activities they outsource and the ESPs should not apply for these activities. A prior agreement between the OEM and the ESP could be advantageous. Scholars recommend that OEMs should apply **a strategic supplier involvement process** (Bautzer, 2005; Gerwin, 2004; Hong et al., 2009; Quesada et al., 2006; Rouibah & Caskey, 2005; Takeishi, 2001; Tang & Qian, 2008; van Echtelt et al., 2007; Wynstra et al., 2001; Zirpoli & Caputo, 2002). In this supplier involvement process, OEMs should also involve the ESPs in defining the strategies to integrate suppliers in the development process. Several studies note a positive impact of **long-term relationships** on the NPD performance of the supplier (Caputo & Zirpoli, 2002; Gerwin, 2004; Handfield & Lawson, 2007; Hoegl & Wagner, 2005; Kotabe et al., 2003; Lakemond et al., 2006; Lawson et al., 2009; Müller & Pöppelbuß, 2015; Quesada et al., 2006; Ragatz et al., 2002; van Echtelt et al., 2007; Wagner & Hoegl, 2006; Wognum et al., 2002). OEMs should thus orient their supplier involvement process towards long-term relationships with their partners. This may increase the *risk of dependency* but it might also decrease *the risk of reduced development project performance.* Furthermore, such a long-term relationship and a strategic supplier involvement process would lead to a build-up at the supplier of the OEM's implicit process knowledge. These recommendations could mitigate the *risk of reduced supplier performance through cultural differences* and, where co-location is not possible, a strategic supplier involvement process and therewith a cultural understanding of the NPD organization could mitigate *the risk of reduced project performance through geographically dispersed project teams.*

Fine and Whitney, as cited by Takeishi (2002), identified two categories of dependency: dependency for capacity and dependency for knowledge. While the actual tasks of developing modules or components could be outsourced, the **relevant knowledge should be retained internally** to ensure higher-quality design and to mitigate the *risk of dependency*. This can be achieved by implementing a knowledge management process that works well. Handfield and Lawson (2007) describe in their study that the joint definition of business goals has no positive impact on the NPD project team performance. Hence, the involved parties are not challenged to define common business goals. By applying a supplier involvement process, the OEM systematically chooses the fraction of NPD it wants to outsource to a supplier. This mitigates *the risk of changing the set of core competencies.* **A well-established supplier involvement process** is thus crucial for effective and collaborative product-level NPD (Lakemond et al., 2006).

2.3 Conclusions on Literature Review and Preliminary Recommendation Model for Collaborative NPD Projects

The literature review presented here is split into two sub-reviews, the first of which is a narrative review to discuss NPD process models. This review helps to contextualize the research project and identify the process models in which the projects analysed in the case studies take place and thereby provide orientation for the research and the reader. Furthermore, a framework model developed from the theory of value co-creation is discussed which serves as further research.

In the second review, I chose to do a systematic review that aims to identify risks for collaborative NPD projects under the lead of an ESP. Since this special case of collaborative NPD projects is largely neglected in the literature, I identified internal and external motives for OEMs to outsource development tasks to ESPs and Tier suppliers and also derived the risks of such outsourcing. I focussed the review on the integration of ESPs into the development process of collaborative NPD projects in the automotive industry. It is based on the anticipation of a gap in the literature with regard to the perspective of the ESP in collaborative NPD. Furthermore, I assumed that few empirical studies have analysed the day-to-day management of individual collaborative NPD projects. These expectations were confirmed. I sought to find evidence that, with increased responsibility transferred to it, the ESP must be better involved in the NPD process. This evidence was found as well and it confirmed the relevance of the research questions. The management of ESPs in collaborative NPD projects needs further research attention. However, I was able to conclude the managerial implications in this context. The NPD practices in automotive development have evolved. OEMs focus on their core competencies and outsource subsystem development to suppliers. ESPs play a significant role in this context. Since ESPs hand over the IP at the end of the project, they can be considered as vertically integrated in the IP generation process. In order to improve the efficiency of collaborative NPD projects, OEMs should try to integrate suppliers and development partners in their NPD process. This accompanies the good application of knowledge management practices and an alignment of PLM systems with those of the suppliers. A strategic supplier involvement process should be established and shared with the ESP. Only a processual well-integrated ESP can be become an engineering partner and thus efficiently conduct collaborative NPD projects. Long-term relationships between the involved parties are advantageous for such projects. To create a good market position, the ESP has to be able to address these implications. The ESP needs to prove its ability to integrate well into the development process of the OEM. It must also demonstrate the quality of its development. The challenge is to build up architectural knowledge in order to cope with the new NPD tasks, system integration, and supplier monitoring. The challenge is to integrate system or module suppliers early in the development process of the OEMs.

However, this literature review has the limitation that it is based on only the automotive industry. It may be possible to employ the results of contributions from other industries and use the experiences gained from these. Furthermore, since very few studies dealing with ESPs have been found, I decided to deduce recommendations from studies about 'normal' suppliers and expect them to be applicable to ESPs as well. It remains to be confirmed or denied in the research phase if this derivation was valid.

Based on the identified risks and taking into account the theory of collaboration, ESI, knowledge management, and relationship management, I derived recommendations to improve project performance and mitigate the risks in such collaborative projects.

In summary, the following recommendations for conducting an efficient collaborative NPD project were identified in the literature.

People

Rec 1. Define sustainable project teams

Rec 2. Determine joint development teams with a problem-solving attitude

Rec 3. Provide common project space and promote co-location

Rec 4. Promote frequent communication

Rec 5. Give NPD teams the possibility to integrate on a personal level

Rec 6. Strengthen long-term relationship of OEM and ESP

Process

Rec 7. Ensure two-way flow of information

Rec 8. Apply joint decision-making

Rec 9. Apply right level of control mechanisms

Rec 10. Align PM practices as well as NPD and CE processes

Rec 11. Involve suppliers in the NPD process early on

Rec 12. Establish efficient knowledge handover processes

Rec 13. Apply strategic ESP involvement process

Rec 14. Retain relevant NPD tasks internally

Collaboration technology

Rec 15. Continuously improve IT solutions and integrate legacy systems with modern solutions

Rec 16. Provide common IT environment and align IT systems

Rec 17. Perform NPD work in closed-loop PLM system

Rec 18. Have modern communication technology at hand

Product technology

Rec 19. Outsource the development of modularized systems

Rec 20. Clearly define the borders and interfaces between modules or subsystems

Rec 21. Award projects to ESPs with high technical skills

The following figure summarizes the findings. I chose a form of representation in which I link the different recommendations to the risks they mitigate. This linkage is based on my personal experience and logic. A confirmation of whether this linking is valid shall be given by the research findings. Furthermore, I used a colour code to cluster the recommendations in the main categories. The recommendations will serve as sub-categories for the best practices identified in the research project. In aiming to provide a better overview, I clustered the recommendation sub-categories in the main categories of ‘people’, ‘collaboration technology’, ‘product technology’, and ‘process’. These categories are well-known and often applied in management research. When working as a management consultant, I had the opportunity to learn how to cluster management implications. I often used categorization into ‘people’, ‘process’, and ‘technology’. For this case, I changed the standard categorization and split the technology category into two sub-categories. Figure 15 is the major outcome of the presented literature review. Here, I outline the identified risks and link them to risk-mitigating recommendations found in the literature. The recommendations are furthermore categorized in the main categories. This generic recommendation model serves as framework for the conducted research. The identified recommendations serve as sub-categories for the identification of concrete best practices for collaborative OEM-ESP NPD projects.

Risk	Risk Carrier		Recommendations from literature					
	OEM	ESP						
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 6. Strengthen long-term relationship of OEM and ESP	Rec 7. Ensure two-way flow of information	Rec 12. Establish efficient knowledge handover processes	Rec 15. Continuously improve IT solutions and integrate legacy systems with modern solutions	Rec 16. Provide common IT environment and align IT systems	Rec 17. Perform NPD work in closed-loop PLM system
Ri 2. Risk of agency dilemma	X		Rec 8. Apply joint decision-making	Rec 9. Apply right level of control mechanisms	Rec 21. Award projects to ESPs with high technical skills			
Ri 3. Risk of dependency	X	X	Rec 9. Apply right level of control mechanisms	Rec 12. Establish efficient knowledge handover processes	Rec 14. Retain relevant NPD tasks internally			
Ri 4. Risk of changing the set of core competencies	X		Rec 6. Strengthen long-term relationship of OEM and ESP	Rec 10. Align PM practices as well as NPD and CE processes	Rec 11. Involve suppliers in the NPD process early on	Rec 13. Apply strategic ESP involvement process	Rec 14. Retain relevant NPD tasks internally	
Ri 5. Risk of reduced supplier performance through cultural distance	X	X	Rec 1. Define sustainable project teams	Rec 2. Determine joint development teams with a problem-solving attitude	Rec 5. Give NPD teams the possibility to integrate on a personal level	Rec 9. Apply right level of control mechanisms	Rec 13. Apply strategic ESP involvement process	Rec 21. Award projects to ESPs with high technical skills
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 3. Provide common project space and promote co-location	Rec 4. Promote frequent communication	Rec 10. Align PM practices as well as NPD and CE processes	Rec 16. Provide common IT environment and align IT systems	Rec 18. Have modern communication technology at hand	Rec 21. Award projects to ESPs with high technical skills
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X	Rec 9. Apply right level of control mechanisms	Rec 10. Align PM practices as well as NPD and CE processes	Rec 17. Perform NPD work in closed-loop PLM system	Rec 18. Have modern communication technology at hand	Rec 19. Outsource the development of modularized systems	Rec 20. Clearly define the borders and interfaces between modules or subsystems
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X	Rec 1. Define sustainable project teams	Rec 5. Give NPD teams the possibility to integrate on a personal level				
Ri 9. Risk of labour law disputes with ESP employees	X		No recommendation for mitigation found in the literature					
Ri 10. Risk of losing project performance due to high employee turnover	X	X	Rec 1. Define sustainable project teams	Rec 5. Give NPD teams the possibility to integrate on a personal level				

Figure 15: Risks and recommendations for outsourced NPD projects, derived from the actual body of knowledge

The above figure shows risk mitigation recommendations for collaborative NPD projects under the lead of an ESP. These recommendations were identified through a systematic literature review. Adapted from numerous authors (see Table 3).

The preliminary recommendation model developed here serves as a basis for the further research. I intend to explore the found risks and recommendations for collaborative NPD projects under the lead of an ESP. Based on the literature review, I analyse the practitioner's insight. With this research approach, I hope to adapt the following generalist model for successful collaborative NPD and confirm the risks by identifying concrete barriers within a project lifecycle.

By performing this research, I expect to find evidence that will allow me to confirm, reject, or adapt the recommendations and link best practices to the recommendations based on the practitioner's insights.

This approach is in line with RO 3— identify barriers to successful collaboration in relation to the service provider–automotive client NPD process. With this research project, I hope to find out if the risks identified from the literature are also applicable to NPD projects under the lead of an ESP. This should then allow me to confirm or reject the recommendations and adapt them in order to formulate best practice guidelines for such projects, which is in line with RO 4.

This systematic literature review enabled me to confirm the research objectives and questions and to define a preliminary model that would serve as a basis for the research.

3 Research Methods and Methodology

In the following section, I discuss my ontological and epistemological points of view, the methodical context, and the applied research methods, such as the (systematic) literature review, the key informant interviews, and the case studies.

3.1 Ontological and Epistemological Point of View

A fundamental decision is the research paradigm in which the research is conducted (Maxwell, 2012). This decision can only be based on the ontological position of the researcher based on his general beliefs (Guba & Lincoln, 1994). I believe that conducting research in the field of management is essentially about creating new knowledge or explicitly describing the implicit knowledge of the practitioner. In social and management science, the researcher creates knowledge about human behaviour and interaction in social networks.

When I began my career in 2008, after completing my studies as an engineer and a finance professional, I did not pay much attention to social phenomena and the impact that social science can have on a business. Rather, I believed that everything can be explained with figures and that the solution could be found by adapting some variables. At the time, I had a rather positivist ontological point of view. With the experience that I gained over the years, in project management and as part of the top management of big companies, I understood that research on social phenomena can be of tremendous added value. In the end, it is humans working with each other. Hence, I recognized the following: To improve the effectiveness and efficiency of an organization or a project, I must examine the ongoing social interactions and understand the constructed reality of the different interlocutors in the organization. Thus, my ontological point of view changed over time and I decided to conduct a qualitative study about a use case that I have experienced often in my career and which is neglected in the literature.

Every individual perceives reality differently. The *white* paper on which this essay is written is *white* in colour, but it cannot be assumed that every individual who is reading the essay has the same perception of the colour *white*. Maybe, seeing this paper through the eyes of another person but with my mind, it would appear *red* to me. I 'know' that this paper is *white* out of my experience, but this knowledge is constructed by me through learning. Hence, I believe that it is important to describe reality in a way that enables other individuals to understand how the analysed social phenomena were experienced and why the resulting conclusions were drawn. Every reader knows which colour I mean when I write about the colour *white*, because it has been described and the description is saved in our memory and accepted by others. But I cannot be sure that the construction, the reader's imagination of the colour *white*, corresponds to mine. The researcher is thus challenged to define social phenomena in such a way that every reader can understand what is meant, even if he or she does not construct the same perception of this reality.

Consequently, I am convinced that a reality exists in some form or another but that knowledge about it and the understanding of this reality is human construction. I agree with Remenyi, Williams, Money, and Swarty (1998) who state that it is a necessity to study 'the details of the situation to understand the reality or perhaps a reality working behind them'. However, I also think that the researcher should have the possibility to apply the research strategy that seems to him or her to be the most promising strategy for achieving the wished-for description and analysis of the researched social phenomena. Therefore, I agree that the researcher should study what is of interest and value to him. The result should have positive consequences for the researched context (Tashakkori & Teddlie, 2010). I would thus characterize myself as a constructivist with a pragmatic approach to research methods and methodologies. I agree with the statement that the decision regarding which philosophical paradigm is applicable to the conducted research is of great importance (Guba & Lincoln, 1994). Nevertheless, I am convinced that a philosophical viewpoint may define how the researcher views the analysed social phenomenon, but it should not limit him in the choice of his research methodologies. Thus, I am in agreement with the writers who argue that the researcher should use the research methodology that gives the most reliable result (Johnson & Clark, 2006; Lefley, 2006; Myers, 2013; Saunders et al., 2009). A pragmatic paradigm supports a multiple-method research approach (Howe, 1988; Yin, 2013).

In business and management research, social phenomena are often analysed. The purpose of this genre of research is to give to the practitioner new, comprehensive, and supportive perspectives that help to define problems and deliver approaches that may bring solutions to the identified problems. I believe that the researcher creates the theoretical framework based on the existing body of knowledge and his construction of reality. In my case, I additionally want to confirm this theoretical framework and support it with the opinions of key informants in the field. This investigation leads to the research questions, or the questions towards reality (see

Figure 16). Based on the research questions, the data is collected through the chosen research strategy and the applied research methods over the defined time horizon. In the data, practical problems and the expectations of the business leader are present. Based on the collected data, a critical reflection on the overall picture is conducted. Through the research result, the theoretical framework that is conceived in the beginning is abstracted and differentiated, and a new or adapted framework is created or induced. This can lead to an iterative, exploratory, and inductive research process, like the one represented in Figure 16.

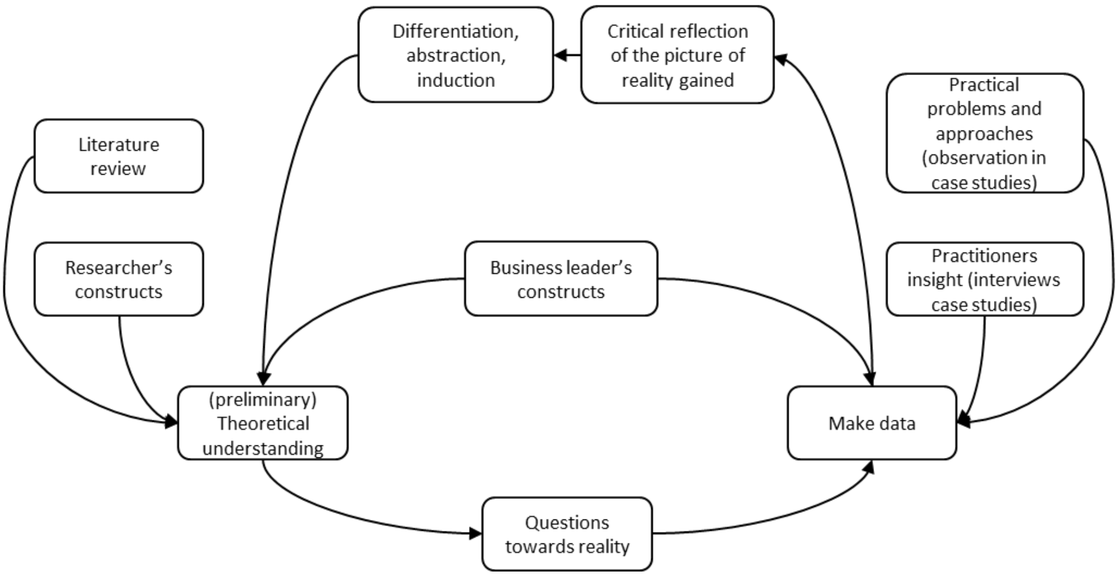

Figure 16: The iterative research process

The above figure shows the applied iterative and inductive research process in this qualitative management research project. Adapted from Gassmann (1999), Kubicek (1977), and Tomczak (1992).

The above figure presents the applied inductive, iterative research process for the case study research. The researcher builds up a theoretical understanding based on his constructs, the literature, and in my case, on the constructs of other senior managers. Out of my constructs and the literature review, I defined the research questions and a provisional model for collaborative NPD projects. Based on the literature review, I was able to define sub-topics which could then be discussed in the key informant interviews. In this way, I was able to confirm and sharpen the research objectives and research questions by means of the key informant interviews. Furthermore, the recommendation model was adjusted. Within the case studies, I focus more on the practical problems. Based on the collected data, new knowledge is created through data analysis, critical reflection, and abstraction, which then leads to a practical model for collaborative NPD models under the lead of an ESP.

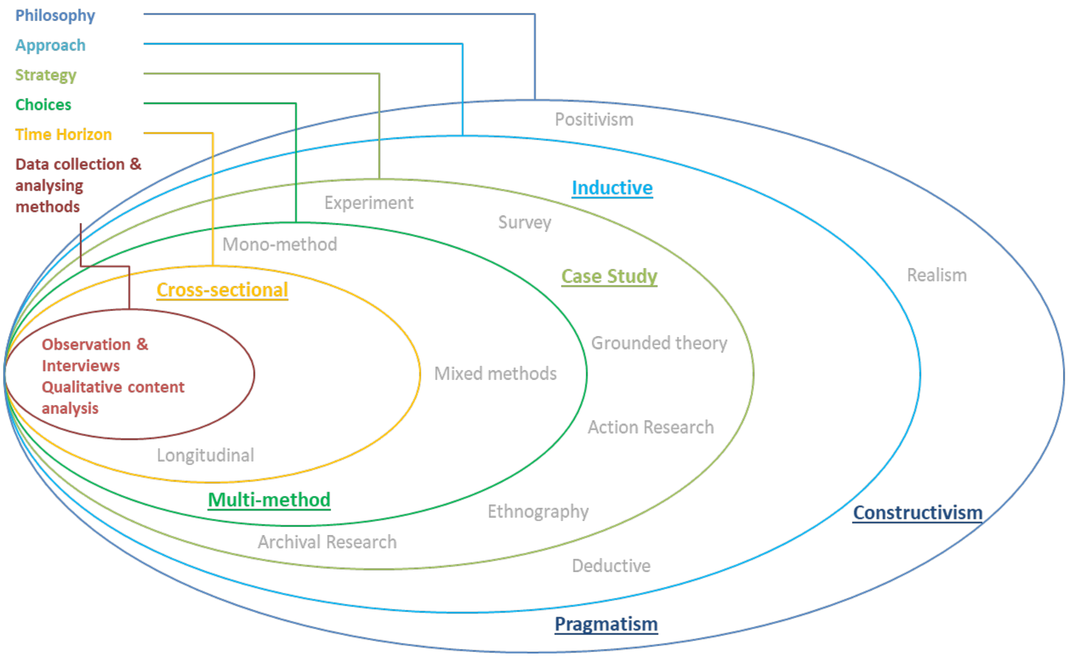

Figure 17: Philosophy, approach, strategy, methodological choice, time horizon, and data collection and analyses of the presented research project

The above figure shows the adopted research philosophy and places the applied methods in their contexts. The highlighted terms are the ones I adopted in this research. Adapted from Saunders, Lewis, and Thornhill (2009).

As stated, I consider myself a constructivist with a pragmatic approach. I believe that reality is socially constructed and subject to change. I am keen to find the most suitable approach to answer my research questions. When it comes to my epistemological point of view, or what I believe constitutes acceptable knowledge, I have come to believe that social phenomena such as collaboration in NPD projects can best be analysed by understanding the subjective meanings and the reality behind them. Therefore, I accept that I am not unbiased and that I am a part of my research in that I influence the outcomes. My values play a significant role in what is being researched. Thus, I chose qualitative data collection methods. I adopted an inductive research approach, aiming to gain the practitioner's insights through interviews and observations and by analysing the qualitatively collected data. With this induction process, I will create a best practice guideline model for NPD projects under the lead of ESPs.

3.2 Applied Methods and Methodologies

In this section, I describe the methods and methodologies applied in this research project. At first, I describe the applied systematic literature review approach that was chosen to analyse the body of knowledge on collaboration in automotive development. In the next subsection, I describe the methodological context of the qualitative research project, outline how the data gathering and the data analysis were performed, and finally discuss bias in the research project.

3.2.1 Narrative literature review on NPD, collaborative NPD, and software development in the automobile industry.

In aiming to provide an overview on applied development models in automotive NPD and to contextualize the research project and especially the two development projects analysed in the two case studies, I decided to perform a narrative literature review on NPD, collaborative NPD, and software development in the automotive industry in order to create a basic understanding of the NPD models and software development models in the field. The purpose of this first narrative review is not to educate myself to understand the literature, as recommended by Arshed and Danson (2015), but to provide the reader with a better understanding of the field of automotive NPD. In this chapter, I want to provide an introduction to automotive NPD. Thanks to my experience in the field of automotive NPD and ESPs, I have a good overview of the applied models in the field and I have reviewed and synthesized the traditional literature in automotive NPD in this chapter. The aim of this review is to support the reader to become familiar with the field. The authors cited in this part are those that I consider to be the leading authors in the field.

3.2.2 Systematic literature review on collaboration in automotive development.

The purpose of conducting a systematic literature review is to enable the researcher to find orientation in his field of research and to identify gaps in the existing work. Through the literature review, the researcher can validate his research questions or even redefine them if necessary (Tranfield et al., 2003). Since the literature plays such a vital role in the research process, it may be concluded that it should provide a complete synthesis of the actual intellectual territory.

With this systematic literature review, I aim to achieve the following outcomes:

1. Confirm the anticipated research gap, which I identified based on my experience as a practitioner in the field of collaborative NPD with ESP

involvement and based on the narrative review I presented in the earlier chapter.

2. Confirm and adapt the theoretical framework, the research objectives, and the research questions.
3. Continuously review the existing body of knowledge in the field of collaborative NPD with ESP involvement.
4. Define a preliminary recommendation model for collaborative NPD projects, which will be the basis for the research project and which should be further sharpened with the results of the research project.

In the beginning of this millennium, research in management was mainly based on narrative reviews (Tranfield et al., 2003). Many researchers postulate that narrative reviews often lack thoroughness, completeness, and only give a descriptive account. Moreover, the choice of the studies is often not free of the researcher’s own biases (Fink, 1998; Hart, 1998). To avoid redundancies, it is essential to take into account all the research work that has already been performed in the field. This permits the researcher to make an original and novel contribution. Therefore, practitioners and academics asked for a re-evaluation of management review processes (Tranfield et al., 2003). Today, also in management science, a systematic literature review is a common research tool and the methodology is used widely (Adams et al., 2017).

The approach of systematically reviewing the existing literature was first applied to medical science with the aim of improving the review process. It had been observed that the applied practice was based on evaluations of insufficient quality and thus the medical recommendations could be unsuitable (McDermott et al., 2004). The systematic review has been identified as a method to improve this process. Systematic reviews enable the researcher to integrate valid information efficiently and to provide a basis for rational decision-making (Mulrow & Cook, 1998). As a result, the reviews in medical science improved significantly in terms of transparency, reproducibility, and synthesis quality. Reviews are retrospective by nature since the studies included are usually identified after they have been completed and reported. It is therefore vital to make the review process as rigorous and well-defined as possible (Light & Pillemer, 1984) while upholding a practical perspective (Higgins & Green, 2008). The limitation of bias is of significance and it can be supported by the use of explicit, systematic methods in the review process. This leads to more reliable results as a base from which to draw conclusions and make decisions (Antman et al., 1992; Oxman & Guyatt, 1993). This is particularly important in the context of agile business environments like automotive NPD. In the context of supplier involvement and collaborative NPD management, the actuality of the referred research studies is crucial. Especially in recent years, development practices are changing so rapidly that it is hard to find up-to-date studies that make a valuable contribution.

In applying a systematic review approach, the researcher is able to develop a set of ‘field tested and grounded technological rules’ (Van Aken, 2001). A strategic recommendation that is based on interpreting such rules would be a satisfying result of this review. Nowadays, managers are challenged to work in a structured and systematic way. It also makes sense to apply a well-organized, systematic approach in management science. Consequently, I decided to adopt the systematic review to analyse the body of knowledge for recommendations to improve the conduct of collaborative NPD projects.

In medical research, complete databases referencing only systematic reviews are available (Cochrane Database). Higgins and Green formulate the following steps for preparing and maintaining a systematic review (2008):

- Formulating the problem
- Locating and selecting studies
- Quality assessment of studies
- Collecting data
- Analysing and presenting results
- Interpreting results
- Improving and updating reviews

Tranfield et al. (2003) adapt this medical research approach to manage research needs and arrive at the following steps:

Stage I - Planning the review
- Phase 0 - Identification for the need for a review
- Phase 1 - Preparation of a proposal for a review
- Phase 2 - Development of a review protocol

Stage II - Conducting a review
- Phase 3 - Identification of research
- Phase 4 - Selection of studies
- Phase 5 - Study quality assessment
- Phase 6 - Data extraction and monitoring progress
- Phase 7 - Data synthesis

Stage III - Reporting and dissemination
- Phase 8 - The report and recommendations
- Phase 9 - Getting evidence into practice

Figure 18: Stages of a systematic literature review

The above figure shows the three stages and nine phases of a systematic literature review. Adapted from Tranfield, Denyer, and Smart (2003).

In his adaptation of the systematic review process, Tranfield et al. focused on Stage II—'Data synthesis' (2003). A report and recommendations are the result of the review, whereas Higgens and Green (2008) propose an interpretation of the results. The approach of Tranfield et al. (2003) is nearer to management practice and wants as its final result to put the evidence into practice. With this review, I aim to offer recommendations for ESPs which can be implemented in practice. Systematic research also has weaknesses. In the medical environment, it has been noticed that systematic reviews are not always equally reliable (Moher et al., 2007). The usage of guidelines and standards, like the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins & Green, 2008), improves the reporting, but such guidelines do not yet exist for systematic reviews in management. Hence, the researcher in management who is conducting a systematic review needs to learn from the guidelines used in medical research in order to perform a systematic review of high quality and reliability. Besides, management science is a rapidly changing field. Shojania et al. (2007) executed a study and found that especially in rapidly changing fields, systematic reviews quickly become obsolete and need updating, sometimes even at the time of their publication. It has thus been suggested to also include grey literature. This suggestion is also valid in management research and has been applied in the presented review (Adams et al., 2017). Furthermore, researchers recommend regularly updating the literature review and repeating the searches continuously.

An important part of the systematic review is the data synthesis. There are several methods for synthesizing data—for example, meta-synthesis, meta-analysis, and thematic analysis.

Management is a relatively new field of science and thus the research questions of the studies are not always comparable. The studies mostly do not measure the same phenomenon in the same way (Tranfield et al., 2003). The management researcher is in most cases not interested in the effectiveness of an intervention. Rather, he or she wants to understand organizational and management processes. It is thus unlikely that a meta-analysis is appropriate for management research. Unlike meta-analysis, meta-synthesis is not limited to synthesizing strictly comparable studies. The researcher is required to construct interpretations and to reveal the analogies among different studies (Noblit & Hare, 1988).

Meta-synthesis allows the researcher to include both quantitative and qualitative studies in the review. In the context of NPD management, qualitative studies can be important and thus it is decided to use meta-synthesis as the chosen synthesis method.

For explorative qualitative studies, scholars recommend a categorization of the research findings (Dixon-Woods et al., 2007; Guba & Lincoln, 1994; Myers, 2013; Noblit & Hare, 1988). The outcome of the meta-synthetizing literature review serves as basis for the qualitative research project. I intend to categorize the research findings by the rather generic recommendations for successful collaborative NPD projects. When working as a management consultant, I often structured transformation projects by the three major categories “people”, “process”, and “technology”. This approach, the categorization, and the identification of transformation measures within these categories are commonly used in transformation projects in the engineering environment (Lee et al., 2008). When starting the research project, I intended to apply this categorization. Progressing in the research project, I noted that the category “technology” summarized two main categories, which could be separated, aiming to provide a better understanding for the reader. Several identified recommendations and best practices referred to “collaboration technology” (collaborative tools like PLM systems, video-conferences, etc.) and others to the “product technology” (modularization of the product, degree of technical uncertainty, etc.). Therefore, in the course of the research, I decided to define these two categories as main categories, regrouping found recommendations as sub-categories, which shall categorise the identified best practices.

3.2.2.1 *Search strategy and identification of research.*

At the beginning of the search process, I established a review protocol and recorded all searches and their results. Since actual research in NPD management is mostly focused on the OEM and their system or module suppliers, I anticipated that very few studies with focus on the ESPs would be found. Thus, I decided to conduct a very wide search and to include all accessible, relevant research databases (c.f. Appendix: List of research databases). The Google Scholar database (http://scholar.google.com/) delivered the most exhaustive results. In order to generate as many results as possible, I ran all the searches in English, German and French. These languages cover the majority of papers published in this field of research. However, to facilitate the reading, the chosen search terms are referred to only in English. The automotive industry is mainly based in Europe (England, France, Germany, and Italy), the USA, South Korea, China, and Japan, and there is growing activity in India. This can be derived from the production statistics of Organisation

Internationale des Constructeurs d'Automobiles (OICA) (OICA, 2017). Asian, Spanish and Italian researchers mainly publish in English. Very little literature has been found in French. Some scholars publish in German. The biggest part of the retrieved literature has been published in English. Therefore, I considered the three search languages as sufficient. Since I speak, write, and read all three languages, I was able to conduct the searches myself.

3.2.2.2 *Search terms, inclusion and exclusion criteria.*

For the definition of the search terms, a panel of experts in automotive development were consulted as recommended by Tranfield (2003). In the course of individual and joint discussions with the expert panel as well as in several brainstorming sessions, we identified the search terms. Four categories were defined:

(I) The business environment or field of research representing the context of the review

(II) The business practice which is being explored

(III) The industrial environment in which the review is being conducted

(IV) The sample that is providing the perspectives

The definition of inclusion and exclusion criteria is crucial to ensure that the retrieved papers are within the scope of the review. Here, five parameters for inclusion and exclusion have been defined (cf. Appendix: Inclusion and exclusion criteria):

(A) The language area in which the study was performed and published

(B) The timeframe in which the study was published

(C) The sample on which the study bases its results

(D) The field of research of the study

(E) The type of the study

The field of research of this literature review is collaborative NPD. Therefore, in (I) the term 'collaborative development' and its synonyms have been defined. All retrieved evidence not dealing directly with collaborative NPD has been excluded (D).

When taking over its new role as a system integrator or an innovation partner, an ESP needs to apply the most recent and efficient practices in collaborative development. The outsourcing of development and the involvement of suppliers in the development process are current business practices (II) which affect the ESP's business environment. Here, only studies which have been published in the year 2004 or later have been considered (B). The data on which the study relies was acquired before the publishing date. In this review, no study was found in which the data was acquired more than four years before the publishing date. Thus, the data acquisition for the included studies was performed at the earliest in 2000. The publishing date was used as a restriction for the searches. If the used database did not permit this restriction, all older studies were excluded manually. The review searches for evidence in outsourced, collaborative NPD that includes the involvement of an ESP. The automotive industry is a special industry. The supply networks are very well-established, the product and development cycle times are short, a high-level modularization of the product is applied, the product is very complex, and it combines software, hardware, and mechanical development (Katzenbach, 2015). In addition, the competition among the OEMs leads to increasing market pressure for innovative products like autonomous driving cars and electric cars. The high innovation pressure creates a clear need to reduce the time to market and the time to customer at OEMs in order to keep pace with ongoing developments. This leads to a unique situation in the automotive industry. Automotive OEMs become system integrators that focus on their core competencies. Important development tasks for subsystem or module development are outsourced to system suppliers. Furthermore, new technologies get integrated into the automobile. The car today is connected to the internet and provides additional IT services. Thus, new partners are emerging in the automobile industry. The ESP has to reorient itself to stay competitive. Since the automotive industry is an example industry for collaborative development, I decided to focus the review only on the automotive industry ([III] and [D]). For the perspective or sample ([IV]) and [C]) of the studies, I initially planned to consider studies that deal with service providers in order to focus on this perspective. Even if in recent years a large body of knowledge analysing the involvement of suppliers in the development of OEMs has been created, the studies mostly focus on the OEM and Tier 1 system or module suppliers. During the search process, it became evident that only a few papers have analysed the perspective of the ESPs (Wolff, 2007). The search thus covers the additional perspective of system or module suppliers. The implications and conclusion found that studies dealing with the involvement of system or module suppliers are considered to be partly also applicable to ESPs. Systematic reviews sit comfortably with studies that use quantitative methods (Tranfield et al., 2003). In management science, qualitative research can make a major contribution to management practices (Dixon-Woods et al., 2007). Hence, the review takes into account both quantitative and qualitative studies.

The resulting search terms are presented in the table below.

(I) Business Environment		(II) Business Practice		(III) Industry	(IV) Sample / Perspective
	AND	AND	AND	AND	AND
Collaborative	Development	Outsourc*	Integration	Automotive	*Service Provider*
OR	OR	OR	OR	OR	OR
Concurrent	NPD	Offshor*	Involvement	Automobile	Supplier (*)
	OR	OR	OR		
	New Product Development	Externalisation	Relationship		
	OR				
	Innovation				
	OR				
	R&D				

(*): This search term has been added after insufficient results of the first searches.

Table 4: The used search terms classified into four categories

This table presents the terms used for search on research databases. The search terms are classified into four categories. Combinations of these search terms have been used for searching.

The combinations of these search terms have been used to search the available literature. An expression placed between two stars has been searched for with exactly this word order. A star at the end of a word means that this term was used leaving the ending of the word open (e.g. for the term 'Outsourc*', the words 'outsourcing', 'outsourced', etc. were found).

3.2.2.3 *Identified studies.*

The search for evidence and the identification of relevant contributions was conducted as presented in the figure below.

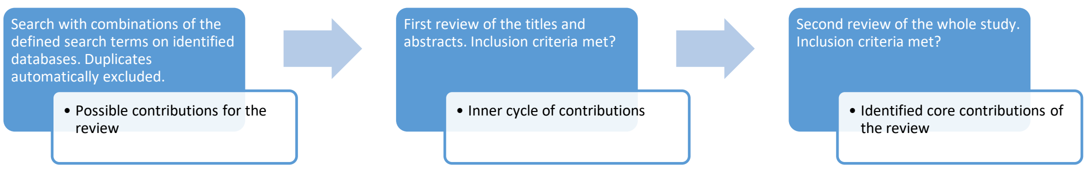

Figure 19: Search process for literature evidence

This figure represents the search process that has been applied to identify relevant contributions within this literature review.

For each search on a database, combinations of the search terms were used. Thanks to the bibliography management tool Zotero (www.zotero.org), which I used for the management of my literature database, duplicates could be excluded immediately. On the search results, I carried out a first review of the titles and abstracts. If the studies met the inclusion criteria on the first view, I considered them for the inner circle. In a second phase, I reviewed all studies in the inner circle. In this second review, I analysed the whole paper, its results, and its conclusion. I then took a decision about the relevance of the study for the literature review. Together with the expert panel, I evaluated the consulted databases on reliability. I started the search process with a first research on the literature database of the publisher Emerald Group Publishing Limited (http://www.emeraldinsight.com/) on 18 July 2010. This search led to a result of six studies, all of which were shortlisted after the first reading of the abstracts. The same day, I performed a second search on Google Scholar and found 492 studies. The first review of these studies led to 45 contributions that met the inclusion criteria. I excluded 447 studies because they contained the exclusion criteria. The next search was executed on 5 September 2010 on the ISI Web of Knowledge. I found 35 studies and included 33 after a first review as these met the inclusion criteria. On 20 September 2010, I carried out a search on the databases of the publisher EBSCO (http://web.ebscohost.com). I considered the following databases as relevant: Business Source Complete, E-Journals, Environment Complete, International Bibliography of the Social Sciences, Library, Information Science & Technology Abstract, PsycARTICLES, Psychology and Behavioral Sciences

Collection, PsycINFO, SocINDEX with Full Text, and the British Library Document Supply Centre Inside Serials & Conference Proceedings. After elimination of the duplicates, 12 studies remained. The first review resulted in eight studies which were taken into the inner cycle. On 21 September 2010, I carried out a search on the database ScienceDirect (http://www.sciencedirect.com/) of the publisher Elsevier B.V. This search resulted in nine studies without duplicates and after the first review, six studies were placed in the inner cycle. This leads to a total of 98 studies in the shortlist of possible contributions. During the detailed review, I scrutinized the reference lists of studies in the shortlist for relevant evidence and found the additional 15 studies to be relevant. With the second, more detailed review, I arrived at the conclusion that 41 studies described core contributions for the literature review.

This in-depth review in 2010 allowed me to gain a deep understanding of the literature in the fields of collaborative NPD, NPD processes, and NPD models.

During the preparation of the doctoral thesis, I regularly repeated the searches in order to stay up to date with the existing body of knowledge. I identified additional interesting studies that were identified later during this phase of research. These have been added to the literature database in Zotero.

Since the preparation of the doctoral thesis took nearly a decade, the research databases changed over the period. Today, the research database Google Scholar is linked to nearly all the databases that were used in the initial research phase. So, it became clear to me that a research on Google Scholar is sufficient. From 2013 onwards, I continuously reviewed the body of knowledge for new studies and added them to the shortlist if they met the inclusion criteria.

At the end of 2018, I was ready to finalize the thesis and write up the research results. I therefore decided to carry out a new in-depth analysis of the literature on 22 September 2018. Since the database Google Scholar is more exhaustive and the reach of the database is very large today, the research in 2018 provided 5,380 results in descending order of relevance. I decided to review the first 300 most relevant studies. Out of these 300 studies, 12 were added to the relevant studies for the literature review. Furthermore, I reviewed the references of the most recent studies and was able to identify further studies that were of relevance for the systematic review. The literature review presented section 2.2 is therefore based on a systematic approach involving a regularly updated database.

3.2.3 Methodological context for qualitative research.

Cross-company collaborative NPD projects are complex, multi-layer value networks that are confronted with an increasing need for efficient collaboration between the various stakeholders taking part in the development process (Bautzer, 2005; Handfield & Lawson, 2007; Hoegl & Wagner, 2005; Wang et al., 2009). These stakeholders are mainly the technical, purchasing, legal, and marketing departments of the OEM, the ESP, and the suppliers.

While collaboration in general is subject to many research contributions, collaborative NPD with the involvement of a ESP is a field which has not received much attention in research so far (Chen, 2005; Handfield & Lawson, 2007; Lawson et al., 2009; Quesada et al., 2006; Rouibah & Caskey, 2005; Wolff, 2007). Therefore, the research is of a rather exploratory and descriptive character. It contributes by extending the existing body of knowledge and unveiling valuable inductive implications for academia. In this respect, the case study approach is a suitable option to study the 'how' and 'why' questions in a complex context (Yin, 2013). The aim is to 'explore' the current practices and theories in collaboration and to 'describe' how the collaboration is performed in reality in the context of automotive NPD. By contrasting theory and practice as well as by identifying discrepancies and patterns, I intend to adapt the theoretical framework and tailor it to the special case of the ESP in highly complex projects.

In order to understand the issues of collaboration in a complex NPD project network, I believe that a qualitative research approach is most suitable. 'Academic' literature on collaborative NPD affirms that the expectations with regard to outsourcing NPD differ and depend on the service in which the expectation is formed (Kurek, 2004). For example, an OEM's purchasing service may expect an easy collaboration with a big shift of responsibility and development volume to the ESP. However, an OEM's technical departments may worry about giving away development responsibility and may have concerns about the ESP's competencies (Wagner & Hoegl, 2006). I want to analyse whether and how the applied collaboration practices can be improved and thus address the defined research questions. Questions 1 and 2 and, in part, 3 and 4 refer to tacit knowledge that is implicitly in the minds of professionals working in automotive development. Consequently, they require a qualitative approach in order to be examined adequately. The research questions 3 and 4 are further addressed by an analysis of two industry projects. Thus, a case study approach is chosen in which qualitative methods are applied.

Research in collaborative NPD management is mostly focussed on the perspective of the OEM. The perspective of the system supplier and particularly the perspective of the ESP is neglected in the literature (Bromberg, 2011; Handfield & Lawson, 2007; Lawson et al., 2009; Rentmeister, 2002; Rouibah & Caskey, 2005; Wolff, 2007). Therefore, for these different perspectives, it is hard to find best practices in the literature which can serve as concrete management implications. Tranfield et al. (2003) identified evidence-based research as a possible mechanism to create guidelines for the decision process of managers and thus help them to create a competitive advantage (Tranfield et al., 2003). In aiming to gain a complete overview of the actual research activities in the domain of collaborative NPD with a focus on service providers, I decided to conduct a narrative literature review to contextualize the research project and a systematic review to define a provisional recommendation model, aiming to guide further research. In the systematic literature review, I intend to identify the theory in the field in order to guide further research and to find a basis for categorization of the research findings.

According to Maxwell (2012), the key strength of qualitative research is the possibility to inductively develop understanding. Edmondson and McManus argue that in a situation in which little or no prior work related to the research objectives exists and where the research questions are relatively new, researchers should apply a qualitative research approach by conducting interviews or through observations

(Edmondson & McManus, 2007). In the research project presented here, I follow their recommendation.

For the time horizon—since I intended to define best practices which, to my knowledge, had not been formulated explicitly before this research project—I chose a cross-sectional study approach, as recommended by Saunders et al. (2009) for such studies. This means that I take several snapshots of the social phenomena within the case studies over a limited period of time.

3.2.4 Data gathering.

In the following sections, I outline the approaches used to gather the data: (1) key informant interviews of business leaders and (2) two case studies along with interviews and observation.

3.2.4.1 *Key informant and case study interviews.*

According to Remnyi and Williams (1998, p. 176), interviews are an essential part of a qualitative research study and an efficient research tool. Interviews as a data collection form is a method of empirical social research. The word 'empiric' describes a methodical and systematic collection of data wherein findings are based on experience. Empirical research thus represents a cycle of theory (assumptions) and findings in which all statements about the subject of research must be verifiable by experience. The research question forms the theory against which hypotheses are set forth. The goal of empirical research is to understand or describe social reality. Through data collection tools such as content analysis, survey, observation, and experiment, empirical research is made more concrete (Stier, 1999). Social research distinguishes between qualitative and quantitative research (Gläser & Laudel, 2010).

In contrast to quantitative research processes in which social reality is expressed in numbers, qualitative social research attempts to describe and explain social actions. The qualitative method considers and analyses different perspectives and reflects on the research process. That my subjective perception as a researcher can influence the research result has to be considered in this method (Kuckartz, 2012). The goal of empirical research is to explain the causes of social facts. Quantitative methods use the explanatory strategy of statistical relationships to derive causal relationships. When using qualitative methods, case studies are used to search for causal relationships and to determine the scope of these relationships in order to explain social facts (Yin, 2013).

For this qualitative research project, I chose interviews as the data collection tool. The conversation plays a special role in qualitative research, as subjective opinions are most clearly expressed through speech (Mayring, 2008).

I decided to start my research projects with interviews of the key informants—that is, leaders in the business of automotive R&D with a focus on ESPs. Based on these interviews, I intend to confirm the research questions and to affirm the contribution of the study to managerial practice. Furthermore, the interview result allowed me to prioritize the research objectives and adjust the research questions as well as integrate additional aspects identified within the depth analysis of the industry expert's opinions. Thereby, I account for the recommendations of research practices in academia, referring to best practice approaches in qualitative research and case study research (Eisenhardt, 1989; *How to... Conduct Interviews Part: 2*, n.d.; Jarratt, 1996; Remenyi et al., 1998, p. 161; Saunders et al., 2009, p. 320). With the key informant interviews, I conducted a broad case study analysing the case of collaborative NPD in the automotive industry with a focus on the integration of ESPs.

The interview results are expected to support the confirmation or modification of the research framework I developed through the literature review and based on my personal experience. The purpose of the interviews is in line with what Patton (2014) described as a way ‘to find out what is on someone's mind […]. We interview people to find out from them those things we cannot directly observe’. According to Saunders et al. (2009, p. 324), it is more probable that a manager will provide information in an interview rather than write it down in a questionnaire. I therefore expect to get more detailed information from the managers by interviewing them.

Finally, based on the systematic literature review and the key informant interviews, I developed a best practice guideline for collaborative NPD projects which is categorized by recommendations that will be used for pattern matching in the following case studies. The case studies will serve to refine the expected pattern.

3.2.4.1.1 *Interview form and applied research practices.*

Saunders et al. (2009, p. 326) recommend the use of semi-structured interviews in explanatory and exploratory studies. This type of interview allows the researcher ‘to “probe” the answers’ (Saunders et al., 2009, p. 326) and to identify where a further understanding of the actual response is required. Since the conducted research aims to make an explorative and descriptive contribution to the existing body of knowledge, I performed the interviews with a basic structure. Thereby, I affirm that all important topics are discussed but the interviews still provide a certain flexibility to account for aspects that the respondent wants to emphasize or considers relevant during the interview. According to Robson (2002), this approach supports one to 'find out what is happening [and] seek new insights'. Easterby-Smith et al. (2008) recommend semi-structured interviews if the questions to be answered are large in number, complex, or open-ended, and it may be necessary to vary the order of the questions. These circumstances can be expected in key informant interviews, wherein it is desirable that the interviewee leads the interview to the topics that are of importance to him or her. Simultaneously, the interviewer needs to ensure that all topics that are of interest to the research are addressed. Jarrat (1996) states that qualitative interviews encourage the respondent to describe the investigated phenomenon and are appropriate if a research is exploratory in nature. Consequently, interviews are a suitable method to apply to my exploratory research project.

According to Saunders et al. (2009, p. 326), it is difficult to design a viable questionnaire schedule for complex issues. I therefore decided to define a list of topics that I want to address and not create a clearly defined time schedule. This list of topics is derived from the preliminary recommendation model I defined in Chapter 2. I chose to follow the recommendation of Patton (2014) and did not address the topics in a predefined sequence. The list of topics that I focussed on is provided below. An example of the interview guide that I provided to the respondents before the interview can be found in Annex III: Example Interview Guide. These topics are based on the findings of the literature review and are linked to the preliminary recommendation model I described in Chapter 2.

- Background of the interviewee and experience with service providers

- Motivation and risks of outsourcing or implementing new models of collaboration within NPD
- Models of collaboration existing in the automotive service provider industry
- Change in the role of service providers; trend in models
- Challenges concerning collaboration for stakeholders in the automotive industry in terms of
    - Process
    - People (relationships)
    - Collaboration technology
    - Product technology
- Aspects of work across different locations and different collaboration models
- Best practices to improve collaboration within automotive industry concerning the involvement of the service provider
    - Steering models and mechanisms
    - Organizational aspects
    - Core processes (sales, recruiting, project management)
    - Competence management
    - Location strategy in relation to collaboration models
    - Future of the service provider market

The method of semi-structured interviewing is particularly time-consuming (Seidman, 2006). Since I conducted this research as a part-time researcher, I had to address this topic by taking enough time to do the interviews as well as by applying project management practices and establishing a project plan to ensure that enough time was allocated for conducting the interviews and the data analysis.

The semi-structured interview approach was well-matched for the research. It enabled me to collect valuable data for the analysis from all the interviews.

3.2.4.1.2 *Interview challenges and applied interview techniques.*

For a researcher who has limited experience in interviewing, interviews can be a challenge (Creswell, 2014). The results or insights gained in an interview strongly depend on the interview skills and the conversational skills of the interviewer (Rubin & Rubin, 2012). Even though I had significant experience in interviewing prior to this research project, thanks to my business and educational practice, I enhanced my interview skills during the research process. I tried to analyse the interviews immediately after conducting them in order to reflect on my questions after each interview right away. In doing so, I applied an approach of self-reflection, as recommended by Rubin and Rubin (2012).

The reliability of the interviews can be challenged. Interviews are not necessarily repeatable since the respondent is in a specific situation when the interview takes place. This personal situation of the interviewee is subject to change. Furthermore, since the topic is complex, I decided to use a non-standardized interview strategy. This has the advantage of greater flexibility during the interview and I can explore more deeply the domains in which the interviewee has more interest. In aiming to analyse the specific situation and to carry out an explorative study, I accepted that the research project is not replicable, neither by me nor by others (Marshall & Rossman, 1999). Nevertheless, I tried to follow the recommendations of other researchers and academics in qualitative research to gain substantial data of high quality, which I describe in the following section.

The interviewee might not be willing to share all the information if he does not feel well or if he feels that the interview was not well prepared. Good preparation of the interview is important and it has a positive impact on the quality of the interview outcomes (Saunders et al., 2009). Hence, I followed the recommendations of Saunders et al. (2009) and prepared the interviews as well as possible. The literature review and my business routine demonstrated to the interviewees that I have extensive knowledge in the field. This encouraged them to speak with me at length. In both types of interviews (key information interviews and interviews with project members in the case studies), I got a good response to my interview requests. Nearly every potential interview partner whom I asked for an interview agreed right away. Only one CEO of an ESP refused because he had apprehensions about sharing confidential data. In general, the confidentiality of the retrieved data was of utmost importance for nearly every respondent. Consequently, as part of the preparation, I provided each interviewee with the following information before the interview:

- Presentation of the research topic, with research objectives and question
- Semi-structured interview guideline
- Information on the university for which the research is being performed
- Information about ethical considerations
- Consent of confidentiality
- Information about the supervisors of the study

Furthermore, if the interview was conducted face to face, I made sure to be in an appropriate location where the interviewee would feel safe and in a pleasant atmosphere. For the senior managers that I interviewed, the interviews were conducted mostly in their offices or over the phone. For the project members, I arranged for small meeting rooms where we could hold the interview without interruption.

Additionally, and in accordance with the recommendations of Saunders et al. (2009), I ensured that my physical appearance was appropriate. As I am relatively young compared to the business leaders that I interviewed, especially for the key informant interviews, it was possible that the interviewees might not consider me to be sufficiently credible. An appropriate clothing style can help to gain the confidence of the interviewees and influence their perceptions (Robson, 2002). Thus, I tried to adopt a formal style of dress, as is standard for the senior management of the R&D department of automotive OEMs.

I began each interview by explaining my research project and why I consider the respondent to be a valuable interview partner. Furthermore, before starting the actual interview, I asked for his or her consent to record the interview on an audio device, while providing an assurance that the transcriptions would be neutralized and the record would be deleted once the research project is finalized. Especially in the interviews with project members of the researched cases in the project case studies, probably because the interviewees were on a lower management level, I felt that the interviewees were uncertain about sharing confidential information. Assuring them that the top management of their respective employers had agreed to the research project and showing the confidentiality agreement which had been signed reassured the interviewees and the interview could then begin. I noted the consent to record of every interviewee on the record itself and provided the same statement on confidentiality and neutralization again on the record, as recommended by Healey and B. Rawlinson, (1993). I believe that this approach created an atmosphere of confidence. The interviewees were open and, to my understanding, as objective as they could be. Following the recommendation of Ghauri and Grønhaug (2005), I started the conversation by focusing on the interviewee's role in the host organization and his or her background. This approach helped to create a relaxed and friendly atmosphere.

As regards the questioning, I placed more attention on asking open questions so as to avoid bias (Easterby-Smith et al., 2008). I also tried to avoid long questions in order to obtain responses to the different aspects that I wanted to explore.

To avoid misunderstandings, I always asked for an explanation when a technical or organization-specific term was used. On my side, I tried to avoid jargon and too many theoretical concepts. If specific terms were needed, I tried to ensure that the interviewee and I had the same understanding of the terms.

Moreover, I asked for concrete examples whenever a participant explained a theoretical concept. To ensure that we understood the same, I tried to summarize complicated explanations of the interviewee directly after each such instance. This approach of attentive listening enabled me to be confident that I had understood the interviewees' explanations and would be able to avoid misstatements (Easterby-Smith et al., 2008).

In addition to recording the data, I took notes during the interview, following the recommendation of Saunders et al. (2009) that this would show the participant that his or her comments are important to me.

3.2.4.1.3 *Sampling of the respondents.*

The choice of the key informants strongly depended on my personal network. Within my professional activity as a project manager, management consultant, senior manager in automotive development, and today Managing Director of one of the world's leading ESPs, I have built up a network of experts and senior managers in the field.

Hence, I had the possibility to interview professionals who had considerable experience in collaborative NPD in the automotive industry. I interviewed senior managers in ESP organizations (I had the opportunity to interview four CEOs and one CTO from the top 10 automotive ESPs in Germany and Austria, which means that all the top 10 companies have been covered) and senior managers in OEM R&D organizations. Based on my professional experience, I expected those two groups of managers to have varying perspectives on the management of collaborative NPD projects involving ESPs. Thus, the expected inherent, different mind-sets support an alignment of the focal points of the research, according to the needs of both groups of interests. Other than my personal network, I tried to get in touch with practitioners in the field who had also contributed to the academic literature. I was able to interview two academics in the field of NPD processes, collaboration, and outsourced NPD whom I have cited often in my literature review.

After starting the interviews, I applied a snowball sampling technique whereby respondents recommend other interviewees, as recommended by Jarrat (1996). The selection criteria for the proposed interviewees are threefold: seniority, position in the organization, and potential knowledge concerning collaborative product development with the involvement of ESPs. My personal background and experience in collaborative automotive development facilitated the choice of the respondents.

In the following table, I depict the respondents for the key informant interviews before the case study. I offered to provide every research participant with a copy of the completed and approved thesis with the aim of ensuring reciprocity (Bryman & Bell, 2018, p. 144). Especially the key informants were easily accessible due to their interest in the topic. All interviews were held in the mother tongue of the respondent. This was German in all the cases except for one respondent who is a native English speaker.

At the time of the interview, KI1-ESP was the CEO of a leading ESP. Before assuming this position, KI1-ESP had served as the head of R&D at a major non-European OEM. KI11-ESP was the head of R&D and Procurement at a major German automotive manufacturer before taking his position as Chief Technology Officer (CTO) at a leading ESP. In general, the managers interviewed often had a background in both worlds—the OEM and the ESP. It can therefore be considered that the interviewees understand both perspectives.

Respondent	Organisation	Professional position	Year of experience in current position	Years of experience in NPD	Interview place	Interview atmosphere	My Impression of the interviewee
KI1-ESP	Leading ESP	CEO	>5 years	>25 years	Phone	Professional, Academic approach, no interruption	Highly interested to share own practitioner knowledge and in the research project, very positive
KI2-ESP	Leading ESP	CEO	>5 years	>25 years	Interviewees office	Professional, no interruption	Highly interested to share own practitioner knowledge, interview timing overdrawn
KI3-OEM	Leading OEM	Strategic Project Manager for product line	>15 years	>35 years	Interviewees office	Professional, no interruption	Highly interested to share own practitioner knowledge, very positive
KI4-OEM	Leading OEM	Lead of R&D IT / PLM & Academic in the field of automotive R&D	>10 years	>35 years	Interviewees office	Professional, Academic approach, no interruption	Highly interested to share own practitioner knowledge and in the research project, very positive
KI5-ESP	Leading ESP	CEO	>1 year	>20 years	Interviewees office	Professional, no interruption	Highly interested to share own practitioner knowledge, very positive
KI6-OEM	Leading OEM	Head of R&D	>5 years	>35 years	Interviewees office	Professional, no interruption	Highly interested to share own practitioner knowledge and interested in the research result, positive
KI7-ESP	Leading ESP	Strategic Project Manager	>5 years	>20 years	At home	Professional, no interruption	Interested to share practitioner knowledge, slight uncertainty because of confidentiality
KI8-ESP	Leading ESP	Head of R&D Electric/Electronics	>10 years	>35 years	Interviewees office	Professional, no interruption	Highly interested to share own practitioner knowledge and interested in the research result, very positive
KI9-ESP	Leading ESP	CEO	>5 years	>25 years	Phone	Professional, one interruption because timing, second meeting had to be planned	Highly interested to share own practitioner knowledge and result of the research, very positive
KI10-OEM	Management Consulting	Principal & Academic	>2 years	>10 years	Interviewees office	Professional, Academic approach, no interruption	Highly interested in the research project, continuation of own research project, very positive
KI11-ESP	Leading ESP / Tier 1	CTO	>2 years	>35 years	Interviewees office	Professional, Academic approach, no interruption	Highly interested to share own practitioner knowledge and in the research project, very positive

Table 5: Key informant interview respondents

The above table depicts the respondents that I interviewed as key informants for the research, with the names neutralized, and showing the type of organization they worked for, their professional position, and their years of experience in the field at the time of the interview.

The interview partners in the case studies are depicted in the respective chapter of the case study since they were chosen during the course of the project and the list of respondents supports the contextualization of the case.

3.2.4.2 *Project case studies.*

According to Remenyi et al. (1998, p. 164), case studies in business and management can contribute to knowledge in different ways. A case study can be regarded in the same way in social science that a laboratory experiment is regarded in natural science (Yin, 2009). Case studies provide rich information and deep insights in the research phenomena. Nevertheless, the case study approach is often criticised for not being generalizable and therefore the research findings might not be applicable in real life. Yin (2009) claims that the problem of “generalization” can be solved by applying multiple case studies. Herein, I chose to conduct two case studies, aiming to strengthen the research results and to make them more robust (Yin, 2009). My aim was to carry out multiple experiments to collect evidence and thus study rich and holistic data. Yin (2009) distinguishes between the logic of literal replication and theoretical replication. For literal replication, very similar cases are chosen and the predicted results are similar as well. The theoretical replication means that contrasting cases are selected, based on the assumption that the created results will be contradictory as well. I investigated two collaborative NPD projects under the lead of an ESP. The project set-up was similar, as explained below, but the expected development result, the level of technical uncertainty in the two projects, and the process maturity of the contributing organizations were very different. Therefore, the expected research findings were contrasting as well. I therefore applied a logic of theoretical replication. I intend to further develop the findings from the literature review and the key informant interviews and see whether the best practice guidelines found so far can be confirmed, rejected, or need refinement according to the findings in the field. Thus, I chose a multiple qualitative approach, as recommended by Yin (2009) and Remenyi et al. (1998). With this approach, I intend to gain a full picture of the interactions in these kinds of projects and, based on this picture, to compare the best practices identified by the key informants with the best practices applied in the field. I anticipated that the case studies may provide evidence that the recommendations, best practices, risks, and barriers might not have been followed. Hence, I would be able to study the consequences that arise if these have been applied or not applied. Such a multiple qualitative data approach is recommended by Yin (2009). Through pattern matching, the expected model gained out of the systematic literature review and the key informant interviews will be refined.

Theory building through case study research is applicable when common theory needs a new perspective (Eisenhardt, 1989). This is true in the context of the present research since the perspective of the ESP in complex collaborative NPD has not drawn much attention among researchers yet, whereas collaboration in general has been discussed extensively. Hence, I aim to contribute a new perspective to the existing body of knowledge: the perspective of the ESP and the special case of NPD projects under the lead of an ESP.

3.2.4.2.1 *Sampling of the studied projects.*

In aiming to explore this special case, I chose projects which fulfil the criteria explained below and to which I could have access.

Figure 20 presents a conventional, macro process model of an automotive development project with four overlapping project phases:

- The phase of project initiation, where the development partners define the characteristics of the collaboration
- The design phase, in which the final product is defined and conceived
- The integration, verification, and validation phase, where the different sub-modules of the final product are integrated, the requirements which have been written in the design phase are verified, and the final product is validated
- The project completion phase, where the partners evaluate the success of the collaboration and perform lessons learned sessions

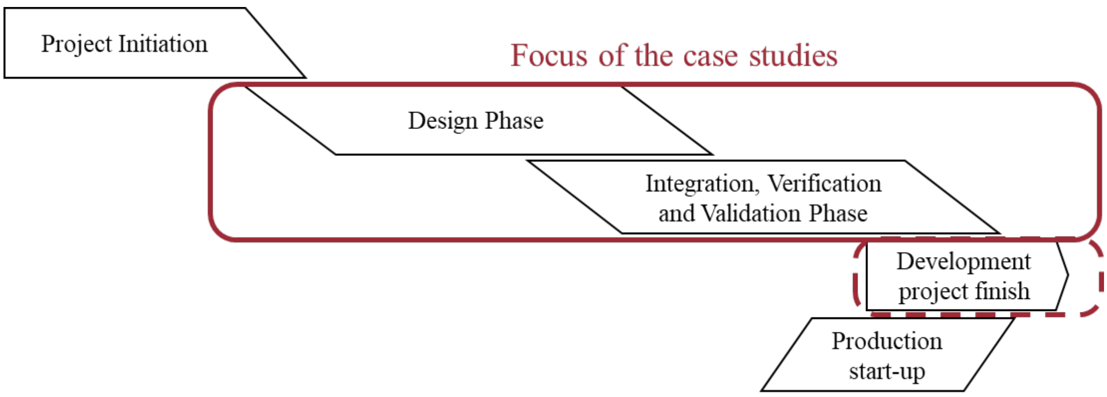

Figure 20: Macro model of the automotive NPD process, pointing out the focus of the case studies

The above figure illustrates a macro development process model of an automotive development. The red frame marks the focus of the case studies. Adapted from Engeln (2011) and the Project Management Institute (2017).

The focus of the case studies is on the two middle phases.

According to Kurek (2004), ESPs can take on three different roles in such projects.

- A turnkey role, in which the ESP takes over major development responsibility and acts independently in the name of the OEM as a system integrator.
- An extended workbench role, in which the ESP takes over parts of the development but under the lead of the OEM's development departments
- A resource providing role, in which the ESP's employees consult, coach, or are temporarily employed by the OEM

As discussed, complex development projects where an additional party—the ESP—takes over major responsibility are highly challenging. Moreover, market analysis shows that these types of projects are becoming more and more common. My experience as well as the information I gained from the literature and the key informant interviews allow me to assume that the collaboration issues between the OEM, the ESP, and the system and component suppliers are very complex. Following the recommendation of Flyvbjerg (2006), I chose these particular cases for my case studies. I expect to gather richer findings in more complex projects since the collaboration takes place between manufacturing and the service industry. Thus, the focus of the study is on the fields 1.2 to 1.3 in the matrix of Table 6.

Role of ESP	Contractual situation	Project Initiation	Design Phase	Integration, Verification, and Validation Phase	Project Finish
Innovation Partner/ System Integrator	Turnkey project contract	1.1	**1.2**	**1.3**	1.4
Extended Workbench	Project contract or outsourcing contract	2.1	2.2	2.3	2.4
Expert on Demand	Coaching/Consulting or temporary employment contract	3.1	3.2	3.3	3.4

Table 6: Classification of automotive NPD projects and representation of the main project phases

The above table presents a matrix of project phases within automotive development projects and options for integrating an ESP in such projects. The fields with bold numbers represent the focus of the multiple case studies.

After the key informant interviews, I conducted a brief research on ongoing collaborative NPD projects under the lead of an ESP as the development partner. Thereby, the two cases have been identified with respect to the project's characteristics and the applicability of the derived research objectives.

I looked for projects fulfilling the following criteria:

- I have access to the project team and the agreement of the companies to conduct the research.

- The project is in the design or the integration, verification, and validation phase.
- The ESP is in the role of an innovation partner or a system integrator.
- The contractual situation is a turnkey project contract.
- The two cases are in two different OEM organizations.

Thanks to my network and the recommendations by the key informants, I was able to identify two projects which fulfil these criteria.

In the first case, I analyse **the serial development of a sports utility vehicle (SUV**) **coupe under the lead of an ESP**. The case study was carried out in 2014 and the project was at the time in the serial design phase. When the project was complete, I had the chance to review the project again with the project leader and participate in a lessons learned workshop in 2018. During the study of this project, I was working in Brussels, Belgium. The core part of the NPD project took place in Stuttgart. Nevertheless, since I was working for the same ESP group and was associated with several company acquisition projects in Germany, I was able to spend between one and four days per week on the project over a period of three months. Since I was working for our Belgian subsidiary, I had no hierarchical power over the project teams. Hence, I think I was considered a neutral observer, as far as it might be possible for colleagues. The analysis of the project was recommended by two key informants in the top management of the OEM. Therefore, the access to the customer and to the ESP was relatively easy since the study was supported by the top management of both companies.

Initially, I intended to focus both case studies on variant development projects under the lead of an ESP. During the period when I performed the key informant interviews and the first case study, I observed a market change. The ESP I work for acquired several other ESPs in Germany with an IT and software development focus. Consequently, we won a significant ADAS development project for a leading OEM in Germany. I had the chance to study this project and decided to do so since I believe the case is rich in data and focuses the research on a potential new model of collaborative NPD. Therefore, **in the second case, I studied the agile software development of a new functionality in the field of autonomous driving for serial application under the lead of an ESP**. The application of a theoretical replication logic allowed it to me to identify best practices which might not be applicable in general for collaborative NPD projects with the involvement of an ESP and such which might be.

The case study was performed at the beginning of 2019. Meanwhile, I was working in Germany for the analysed company as Managing Director. Therefore, I could not expect that the respondents in the case study would consider me as neutral. Furthermore, having moved up in the organization, I had less time to devote to my research project. In addition, the project took place in the northern part of Germany, while I live in the southern part. So, I performed the case study together with a master student who researched the case under my supervision. This allowed me to hold a neutral observer position in the background. The link between the student and me was not published openly to allow her to remain as neutral as possible. Therefore, she too was in the position to take on the role of a neutral observer. The customer welcomed our efforts to improve the collaboration in such projects and was also very open to the study, provided that confidentiality was guaranteed.

In total, we performed 11 interviews in the second case study: five with employees of the OEM (six interviewees, since one interview was conducted with two interviewees due to time limitations) and six interviews with respondents from the ESP (seven interviewees, since one interview was conducted with two interviewees due to time limitations). The interviews with the OEM counterparts were mainly conducted by me with the student present, since at the customer side I could be considered as neutral. The interviews with the ESP counterparts were conducted without me by the second researcher based on the former agreement on the interview guide and the respondents.

Remenyi et al. (1998, p. 177) propose three good practice principles of evidence collection which should be applied to help with the problems of construct validity and reliability:

1. use multiple sources of evidence;
2. create a case study database;
3. maintain a chain of evidence.

I decided to follow this recommendation. The use of multiple sources of evidence is assured by the multi-case study approach and the triangulation approach within the case studies.

In the case studies, I used interviews with key project members and observation (including assessment of project data) as data-gathering tools. The application of these tools is explained in detail in the following sections.

3.2.4.2.2 *Interviews with key project members.*

At the beginning of each case study, I carried-out a 'kick-off' interview with the project leader on the ESP side. The further interview partners were selected based on a stakeholder analysis of the project. Here, I tried to choose people with different perspectives in order to include many interesting points of view, as recommended by Yin (2013). Since the ESP in the chosen case studies plays an integration role, there is a strong need for the project's collaboration process to be investigated. The stakeholder analysis was conducted together with the project leader of the respective project and with the help of the extended project organigram.

The detailed sampling of the interview respondents is explained in Chapter 4 in the respective case study findings section.

For the interviews with the key project members, I applied the same interview approach as for the key informant interviews as explained in Section 3.2.4.1.2.

3.2.4.2.3 *Observation and assessment of project data.*

The observed NPD projects had large project repositories containing a lot of data. As recommended by Eisenhardt (1989), I analysed the data in those repositories during the case study phase. Additionally, I or a researcher under my supervision for the second case study, was part of the project team during the period of the case study as a silent observer. This means that we took part in project meetings, observed the collaborative processes during the daily project work, analysed the created project and process documentation, and regularly had exchanges with the project stakeholders. Such an approach is recommended by researchers in the field of qualitative and case study research (Remenyi et al., 1998; Yin, 2013). Furthermore, one of the projects in which I conducted the case study was finalized before I managed to finalize this thesis. I therefore had the possibility to assist in the lessons learned workshop and analyse the outcomes.

The project members I interviewed and the data which has been gathered are outlined in the respective research finding chapter of each case study.

3.2.5 Data analysis.

Following the recommendation of Maxwell (2012), I tried to analyse the retrieved data immediately after the data gathering.

I applied a qualitative content analysis approach. According to Mayring (2015), the goal of content analysis is to analyse material that comes from some kind of communication. The communication is documented and thus becomes the subject of the content analysis. The qualitative content analysis is a form of text analysis that follows a process model which is adapted to the respective material. A systematic approach according to explicit rules is sought to ensure traceability and controllability by persons outside the analysis. Full traceability and controllability are nearly impossible to achieve. One aspect is that the procedure of content analysis is based on the theory. The category system functions as the analytical instrument of the qualitative content analysis. The texts are structured into categories and analysed by theory. Then, interpretation is used to draw conclusions about certain aspects of the texts (Mayring, 2015). A category system provides for the comparability of results and traceability by third parties. The qualitative content analysis is not a fixed technique. Instead, it is determined by decisions about the procedure and individual analysis steps. Therefore, it needs to be adapted to the material and the question. The decisions and the analysis in qualitatively oriented research must be based on the theory in the field. The theoretical arguments are considered a comparable subject in the procedural decisions. Substantive arguments derived from the state of research should precede procedural arguments. The analysis technique and the general process model are to be adapted to the problem and the material. Mayring (2015) defines three units of analysis to increase the precision of the content analysis. The first analysis unit, which is the coding unit, represents the smallest part of the material that can be assigned to a category and thus evaluated. In contrast, a context unit is the largest part of a text that can be assigned to a category. Another analysis unit is the evaluation unit, which determines the order in which the parts of the text are evaluated. The development of the category system in the relationship between the theoretical question and the material is always in focus. When classifying, it is recommended to review the categories and, where appropriate, to revise them to gain a more detailed explanation of the text. The text will later be re-examined using the new categories.

In the following, I describe the applied process of qualitative content analysis of the gathered data. The basis for my analysis were the interview transcripts, my observation notes, and project documentations retrieved in the case studies.

Thus, the interviews had to be transcribed first. All interview records have been transcribed. Since I had a large number of interview minutes to transcribe in total (11 key informant interviews, nine interviews in the first case study, 11 interviews in the second case study with an average duration of one hour, leading to approximately 31 hours of interview material), I was unable to transcribe all the interviews myself. To reduce time and to focus more on the analysis part, I worked with a transcription service. The first key informant interviews were transcribed by me. This allowed me to see the challenges in the transcription process, set up the transcription rules, and create a transcription glossary for the specific technical terms used in the field of automotive NPD. Seven of the 31 interviews have been transcribed by me. The rest have been transcribed by the touch typist for the key informant interviews and the first case study. For the second case study, the researcher supporting me in the execution of the case study transcribed 10 out of 11 interviews. The transcription rules and the transcription glossary were shared with the transcribers. Furthermore, we discussed the transcript after each transcription to clarify if any terms were not clear, as recommended by Saunders et al. (2009).

Then, I coded the transcripts by segmenting, categorizing data, and assigning names to the segments.

The literature review provided an initial categorization in a preliminary recommendation model (Strauss & Corbin, 2015). Based on this model, I created a classification tree. I started the coding with the following four main categories:

- People
- Process

- Collaboration technology
- Product technology

The recommendations found in the literature were used as sub-categories.

Within these categories, I searched the interviews for concepts relating to collaboration in NPD projects under the lead of an ESP. The concepts I looked for are motives, risks, new recommendations, best practices, and barriers.

Furthermore, within the case study interviews, I examined the interview data in the context of the respective NPD project and tried to analyse if the project phase or the nature of the project affects the opinion of the respondents with regard to the collaboration processes. The result of this analysis was then compared to the result of the project data assessment and to the outcome of the other interview analysis. Thereby, I was able to analyse if the hierarchical level of the respondents affects the view on the collaborative processes. The results of the assessment of the project data by observation either supported or contradicted the findings of the interviews. The views of the key informants and key project members may be supported by the observation results. This enabled me to emphasize the identified practices for collaboration as well as the associated barriers. In case the views of the key informants and project respondents were contradicted by the observation findings, the disagreement may be a barrier to collaboration in NPD projects and therefore need further investigation. My experience in the field of collaborative NPD and ESP business helped me to understand the statements of the respondents and to interpret them. Nevertheless, I constantly had to remind myself not to overinterpret the statements. My involvement in the field may mislead me to judge too quickly or incorporate my view of things in the analysis. This issue of researcher's bias is further discussed in Chapter 3.2.6.

The analysis of the interviews and the documentation of the project data were facilitated by the use of a software tool, as recommended by Yin (2013). For my research, I chose Nvivo 11—a software tool that helps to analyse and organize qualitative research. The key informant interviews and the case studies have been supported by the use of this software tool.

Based on the systematic literature review (theory), my experience in the field of collaborative NPD in the automotive industry and the field of engineering services, as well as the insights I gained from the key informants, I developed a model of best practice guidelines for collaborative NPD projects under the lead of an ESP. This model was then refined using the technique of pattern matching with the results found in the case studies through interviews and observation, as recommended by Yin (2013) and others.

3.2.6 Bias.

My expertise in automotive development helped in conducting the interviews since I understood the problems and issues addressed by the respondents. In this respect, personal experience can also pose a challenge due to possible interviewer bias (Saunders et al., 2009, p. 326). Furthermore, value-free and unbiased qualitative research cannot be achieved (Patton, 2014; Saunders et al., 2009; Strauss & Corbin, 2015). I may impose my own beliefs through my non-verbal behaviour or through my interpretation of the responses. Furthermore, my own experience will influence my perception.

Since an objective, value-free research seems unlikely, I tried to put myself in the most neutral position possible by making myself aware of the situation. To prepare for the interviews, I read a lot of literature on the conducting of interviews and was therefore aware of the risk of bias. Hence, I tried to be as neutral as possible.

Furthermore, when trying to identify bias, I forced myself to examine the meta-perspective by moving out of the current situation and trying to be a neutral observer. Nevertheless, I have highlighted identified bias in the subsequent paragraphs. Furthermore, I explicitly identified my business background and educational training and reflected on what I brought to the research, as recommended by Creswell (2014).

3.3 Research Ethics

Research ethics are a critical issue in business and management research. In this section, I describe the practices I applied to ensure a consistent research approach. As the confidentiality of each participant had to be guaranteed, I neutralized the names of the participants. The participation was completely voluntary. Moreover, I sent detailed information about the planned research steps before the research intervention. Before starting the research, I asked the participants if the anticipated findings needed to be treated confidentially. If so, I developed a common agreement on the information that defined which details could be published and which would remain confidential. This agreement was signed before publication of the research findings.

Furthermore, I ensured that all research participants would have the possibility to review the research results before publication. For reasons of confidentiality and on request of the participating companies, no brand names or technical details are mentioned. The companies involved were open to participating in the research project but did not want their involvement to be explicitly published to a broad group.

4 Research Findings and Discussion

In this chapter, the research findings are discussed within three main sections: findings based on the key informant interviews, findings from the first case study, and findings from the second case study.

Within the discussions, I match best practices with the recommendations identified in the literature review in Chapter 2 in order to answer the research questions.

To utilize the knowledge gained from the scientific research process, I compare and match the gathered knowledge with the information presented in the theory. Thus, I adopt a utilization perspective and therewith fulfil the duty of knowledge processing after a gain in knowledge (Berger-Grabner, 2016).

For reading convenience, all interview text has been translated to English.

4.1 Key Informant Interviews

In this section, I confirm, reject, and extend the identified motives and risks of outsourcing NPD projects to ESPs as well as the recommendations identified in the literature. Moreover, I identify barriers and best practices based on the practitioner's insight, as gained from the qualitative content analysis of 11 key informant interviews. The backgrounds of the respondents are presented in

Table 5.

This section focuses on the representation of the research project below. In general, the interviewees expressed their assumption that the market would continue to consolidate and larger ESPs would take over project contracts with bigger volumes, higher risk, and more responsibility. The interviews focused mainly on outsourced variant development projects under the lead of an ESP. Only one OEM respondent reflected on joint collaborative software development projects.

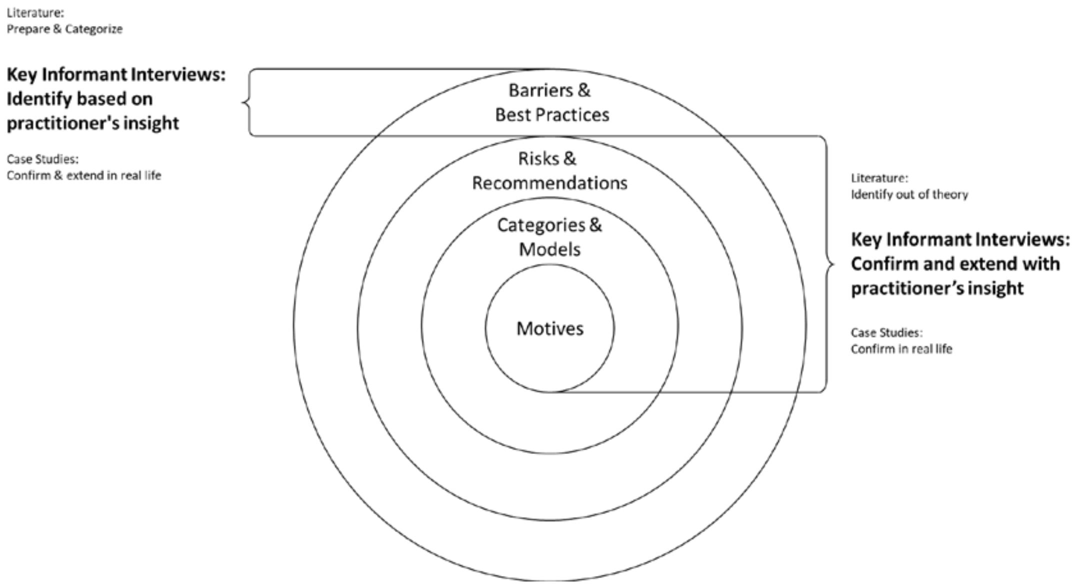

Figure 21: Representation of the research project and research steps with focus on the key informant interviews

The above figure represents the results of the research projects and links them to the research steps undertaken while focussing on the second step—the key informant interviews.

4.1.1 Internal and external motives.

The motives identified in the literature review have mostly been confirmed by the interview respondents. Some of the motives have been adapted and extended. In total, four of the 11 interviewees gave six references on external motives and all 11 interviewees referred 82 times to internal motives.

IM 1. Minimization of cost (lower labour rates) and cost restructuring (change fixed cost to variable cost)

The key informants largely agree that outsourcing to an ESP can lead to an increase in efficiency and therewith to cost reduction. Furthermore, a cost restructuring at the automotive OEMs can be discerned.

> The other, or the main motivation of outsourcing to ESPs, is also to be seen in the fact that the car manufacturers therewith set themselves limitations in their structural cost. (KI1-ESP)

> And the whole thing runs to a well-defined budget. So, for the next two years, the OEM knows pretty much what it has to spend, which is a great thing for the planning within the group. (KI7-ESP)

According to the key informants, OEMs intend to define outsourcing strategies for ESPs in order to gain efficiency in their NPD process, which is in line with the opinion of researchers in the field of automotive NPD (Blöcker, 2016; Carson, 2007; Gerwin, 2004; Harmancioglu, 2009; Rundquist & Halila, 2010; Wagner & Hoegl, 2006). In this strategy, automobile manufacturers want to focus on the development of the lead car and outsource the development of variants. The variant development at ESPs is more cost-efficient according to the majority of key informants since the ESP organization is project-oriented and not commodity-oriented like that of the OEMs. This project orientation leads to a gain in efficiency in the NPD process for variants. In addition, the ESP has a high cost pressure, which is not always the case for the R&D organization at an OEM. Therefore, the ESP will most likely limit the resources working on the project. According to two respondents from an OEM, experience has shown that an outsourced variant development leads to a cost reduction of approximately 30 per cent. Furthermore, two respondents indicated that ESPs are usually more reluctant to introduce engineering changes in the NPD process than the OEM-internal R&D departments and tend to find cheaper solutions to get a reliable product on the market rather than completely change the part.

> On the other hand, that was a very lucrative process. Some of them [ESPs] are even better in engineering change management than the OEM because they are a lot more cost-conscious. They just know that if they change something now, it will be expensive and therefore they do not do it. Whereas the OEM R&D has a different culture. We want to change that now because it's the better solution, no matter what it costs. (KI10-OEM)

> The variety of variants has increased so much that, in my view, the internal capacity of the OEMs is no longer sufficient to do these product developments. The capability is certainly there. But if the car manufacturer now has to adapt its own capacities accordingly to this number of variants, the structural costs would move up enormously. That said, there is a huge motivation to find alternative concepts that come in addition to all the things the OEMs do, like partnerships, joint ventures, and technology alliances. The ESPs are right here to help. (KI1-ESP)

For special development tasks, like software development or engine application, ESPs seem to have more efficient tools and processes which can lead to further cost efficiency. A cost reduction through lower labour rates at ESPs, identified as internal motive by several researchers in the field of outsourcing NPD (Holtrup, 2018; Meißner, 2013; Rundquist & Halila, 2010), has only partly been confirmed by the respondents. Especially the ESP managers emphasized that ESPs have to pay the same salaries as OEMs do to attract highly qualified personnel. Nevertheless, experts from OEM organizations and some of the ESP respondents confirmed that labour costs are lower at ESPs because the average seniority is lower.

> Suppose I go and say, ‘Okay, I will give out my templates, all my process know-how, and so on to such a service provider.’ Then, with low hourly rates, it too can work with high efficiency. So, it's attractive to say, ‘All right, I'll give out my derivatives.’ And that happens a lot. So there is inevitably a high pressure to outsource a variant. (KI6-OEM)

IM 1 has mainly been confirmed by the expert interviews and can be adapted slightly:

IM 1. Minimization of cost (increased efficiency, lower labour rates) and cost restructuring (change fixed cost to variable cost)

IM 2. Access to specific know-how, intellectual property, and wider experience and knowledge

According to the industry experts, in case of established or traditional OEMs, the access to specific know-how is available only in niche areas, such as ADAS, software development, engine application, and EMC testing, which provides a strong motive to outsource to ESPs. In these fields, ESPs can contribute with their own innovations, which can be integrated into a vehicle.

> You need an innovation per vehicle. Otherwise, you will not get the vehicles marketed these days. Everybody can make beautiful cars. That's a matter of

> taste. But how can I still stand out? I can only do that through a clean innovation. And not thousands of innovations. Just one or two right ones per vehicle and you're on the right track. And here, specialized ESPs can help. (KI3-OEM)

Nevertheless, for emerging OEMs, IM 2 can be a strong motive. For example, Chinese companies or completely new players on the market seem highly motivated to gain access to ESP knowledge which they gather while working for traditional OEMs. Therefore, nearly all the experts stated that new OEMs offload the more exhaustive NPD tasks to the ESPs.

> A motivation is certainly what we have addressed. How can I [OEM] make my own development process more efficient? How can I use the methodology of the ESP to get higher speed?
>
> […]
>
> A Chinese manufacturer developing an engine generation for the first or second time gives a great deal of work to the ESP. (KI1-ESP)

Moreover, two key informants indicated that ESPs are often seen as technology transfer agents. While being obliged to keep the IP and innovations of other customers confidential, an ESP transfers implicit knowledge that is gained while working on a project of another customer. This transfer of implicit knowledge seems to be desired by the OEM’s R&D management, since it leads to cross-fertilization and thereby pushes innovation in all organizations.

The following statement exemplifies this:

> ESPs also do an implicit technology transfer. The engineers will not transfer the actual innovation. But, as I learnt in one project, I can apply it to another one as well. (KI11-ESP)

Innovation pressure increases and, therefore, this cross-fertilization effect is also a motive for outsourcing to ESPs. Besides, since ESPs know the NPD process of several OEMs, they can serve as facilitators and mediators in the cooperation projects of major OEMs which are becoming more and more common. One respondent provided a concrete example of a French OEM and a German OEM working together on a common car platform, wherein a French–German ESP supported and facilitated the collaboration.

> If the OEM, as in this example, has no experience with the other group and then the OEM brings in a service provider who has experience with the other cooperation partner, then the ESP certainly also provides support as an integrator and a facilitator. (KI7-ESP)

Another aspect would be the experiences of some ESPs in other industry fields within mobility. Since new technologies are currently being integrated in cars, OEMs turn to these ESPs for help with integrating foreign technology in the automobile. A concrete example could be the integration of an inductive charging platform technology that emerges from a railway technology into an automobile, as stated by one respondent.

Taking into account these aspects, IM 2, identified by researchers in the field of outsourcing automotive NPD (Caputo & Zirpoli, 2002; Grüntges et al., 2012;

Handfield & Lawson, 2007; Katzenbach, 2015; Nellore & Balachandra, 2001; Oh & Rhee, 2010), can be confirmed. Sub-motives for the special case of ESPs have been identified.

IM 2. Access to specific know-how, intellectual property, and wider experience and knowledge

IM 2.1. Access to niche expertise for traditional OEMs

IM 2.2. Access to know-how gained at traditional OEMs for emerging OEMs

IM 2.3. ESP as the transfer agent of implicit knowledge

IM 2.4. ESP as the mediator or facilitator for inter-OEM cooperation

IM 2.5. Access to know-how from other industries and fields

IM 3. Need for capacity not currently possessed and resource flexibility (resource-dependency perspective)

IM 4. Specifically for outsourcing to ESPs, generate IP for the OEM and therewith increase vertical integration with a flexible workforce

IM 3 has been widely confirmed by the interviewees. One principle motive for outsourcing to an ESP is resource flexibility and access to resources (Holtrup, 2018; Meißner, 2013; Rentmeister, 2002). Especially given the circumstances that an OEM has to launch far more products and innovations than before, OEMs need 'more flexibility […] to respond to peaks or dips,' (KI4-OEM) often in the short term. The strategy of gaining resources through outsourcing leads to lower structural costs at the OEM (M. Becker & Zirpoli, 2003; Bromberg, 2011; Holtrup, 2018), but it also bears significant risks, which are explained in a later section. 'The OEM's internal capacity is simply not available. They need innovative support which allows them to cope with the innovation pressure.' (KI11-ESP)

The interviewees argue that OEMs should focus their limited internal capacity on the NPD of lead cars and outsource variants to ESPs.

> If I look at the fact that the variety of platforms, variants, corner types, and so on is still increasing on the market and the diversity of OEMs is also increasing, then I am convinced that it is efficient if I [OEM] do the n-plus first variant not with my own development team. My development team should now be developing the next generation. (KI8-ESP).

When outsourcing NPD tasks to the ESP because of the need for development capacity, OEMs gain the possibility to assign the internal resources to development tasks with a higher innovation degree and technical uncertainty.

> But there is a lot of development work to be done that is not competition-differentiating but basic development work. And I [OEM] can confidently leave that to third parties. Then I can focus on innovations like connected vehicles or lighter vehicles. (KI8-ESP)

According to the key informants, the short-term provision of resources can be reached better through ESPs, because service companies seem to have more efficient human resource management and recruiting processes than OEMs do. Furthermore, ESP employees appear to have a more flexible mindset, since they are often younger and interested to work on different projects for different customers in different locations. This could explain why many engineers choose to join ESPs instead of OEMs. Thus, the need for capacity, as found in the literature review, has been confirmed by the key informants. The interview analysis provided additional insight since the more flexible mindset of ESP employees has not been discussed in the analysed theory.

> Of course, that's where our [ESPs] potential lies. The OEM development departments are relatively spoiled with regard to their location. We're used to being forced to send people to multiple clients and to multiple locations. And when I look at the development teams at [OEM] or at [OEM], they are bound to their location. They do not want to permanently play a role in a project at another location. Thus, we have an interesting opportunity ahead of us because our people are just used to it. And as I said, it's also our daily bread. Our guys are aware of that when they accept the job. There we really have an advantage over the manufacturers—we can simply rely on more flexible teams. (KI9-ESP)

Outsourcing to an ESP brings cost-efficient resource flexibility, while remaining the owner of the created IP, provided that the knowledge handover process works well, which would lead to increased vertical development integration (Kotabe et al., 2003; Müller & Pöppelbuß, 2015). ESPs are service companies. The IP that ESPs generate themselves is process and tool knowledge to improve their service quality. ESPs very rarely create product IP, which they keep in-house to sell the product, licenses, or royalties. Such product or license businesses are mostly focussed on development tools, like testing tools, engine application tools, or software development toolchains, which are sold in very small series. The key informants from the ESP side mainly expressed a reluctance to develop what they call the 'product business' since ESPs mostly seem incapable of managing production processes. Furthermore, a reluctance to enter the area of product liability can be discerned. Therefore, outsourcing to ESPs increases vertical integration at the OEM, as discussed by researchers in the field (Kotabe et al., 2003).

Having analysed the insights of the key informants and bearing in mind the focus of this thesis on outsourcing to ESPs, I decided to combine the two motives—IM 3 and IM 4.

IM 3. Need for capacity not currently possessed and resource flexibility while increasing the vertical integration

Since I combined IM 3 and IM 4, the numbering of the following internal motives changes.

IM 4. Motives concerned with the spread of the (mostly financial) risks of product development

This motive was brought up less frequently by the interviewees. Only the ESP respondents discussed this motivation in the interviews. A reason could be that in the special case of outsourcing to an ESP, the product liability remains at the OEM in most of the cases. There have been attempts to shift the product liability risk to the ESP contractually, but as per the Product Liability Act in Germany and in other industrial countries, the OEM remains liable for the final product that is sold to the consumer (Bauer et al., 2013). OEMs do implement penalties for engineering failures in the project contracts, but they remain responsible for the ultimate damage caused by a development error. Therefore, OEMs and ESPs work jointly on test and validation procedures, aiming to secure the quality and safety of the product. Nevertheless, the ESP respondents discern a shift in entrepreneurial risk since the ESP has to find ways to utilize the resources built up for the projects. 'Of course, you have a very strong shift of entrepreneurial risk from the manufacturer to the ESP.' (KI1-ESP)

Consequently, according to the industry experts, the spread of product liability risk is no motive for outsourcing. However, the spread of entrepreneurial risk can be a motive.

> OEMs have fewer bound resources and hence less risk. Furthermore, they can charge you with penalties—even if, to my knowledge, no ESP would be able to cover the cost of a shift of SoP or something similar. This simply challenges the financial ability of an ESP and would destroy the company. (KI7-ESP)

IM 4 is therefore slightly adapted for the case of outsourcing to ESPs.

IM 4. Motives concerned with the spread of entrepreneurial risks

IM 5. Poor internal performance increases motivation to collaborate

Poor internal performance at the OEMs as an internal motive for outsourcing NPD tasks, as discerned by several researchers in the field (Wolff, 2007), is rarely stated by the interview respondents in the context of outsourcing to ESPs. Instead, the experts discern the pride of the OEM R&D departments. Citing poor internal performance in the OEM teams as a basis for an outsourcing decision could have adverse effects. The internal teams in this case might not be interested to support the ESP in its development project and may block the collaboration. This barrier is discussed later in the paper.

> The R&D teams should not have the impression that they are being repressed by the ESP teams. They have to work together as a team and show respect to each other for their competencies. (KI6-OEM)

The top management of R&D departments often outsources to ESPs to gain cost efficiency during the NPD process. This argument has been discussed under IM 1. Usually, the OEM R&D departments consider themselves as highly innovative and high-performing. ESP teams can contribute cost-efficiency (IM 1), innovation power (IM 2), a change in quality (IM 5—after numbering change), and the takeover of NPD activities which are not among the core competencies of the OEM (IM 7). IM 5 can therefore be considered to have been covered by other motives in the special case of ESPs.

> I think that still plays a big role today—a little benchmark study can be made by giving out a niche version. This way can challenge your [OEMs] developers. This is what I did with [ESP] as strategic project leader of the [car model]. (KI3-OEM)

With the deletion of IM 5, the numbering changes again.

IM 5. Achieve a change in quality by outsourcing a service with a new SLA

Only one respondent relied on this motive in the interview. The interviewee emphasized several times that SLAs are very important and that the quality of the ESP delivery can be tremendously improved by setting a clear delivery process.

> This is only possible with, on the one hand, tough competition and, on the other hand, a clean KPI -based and service-level-controlled provider management. I believe that is precisely the balance between competition, governance, trust, and fair cooperation. (KI4-OEM)

This will also be discussed in the best practices part of this chapter. Furthermore, the motive can also be valid when it comes to outsourcing contracts, which form, as discussed, only a small share of the sales revenue generated by ESPs and are not the focus of the thesis. Nevertheless, this internal motive seems to exist even if it is considered less important for the case of outsourcing NPD tasks to ESPs.

IM 6. Recruiting channel to build up talent benches with highly competent ESP employees

IM 6 seems to be a motive of vital importance since nearly every key informant commented on it and there is general agreement regarding it. The motive is linked to IM 3—resource flexibility. OEMs seem to apply strategies to outsource in times of market instability, when the funds of the company are restricted, and actively recruit teams from ESPs in times of market stability. 'When the market is good, our [ESP] managers need to see more candidates than customers. When the market is less good, we have to push our sales activities and lessen the recruitment.' (KI2-ESP)

This view is supported by the observation that OEMs today invest in shareholdings at ESPs. For example, up to 50 per cent of IAV GmbH (Ingenieursgesellschaft für Automobil und Verkehr) is held by the Volkswagen Group, Porsche holds 28.97 per cent of Betrandt AG, and the Audi Group holds 49 per cent of Elektronische Fahrwerksysteme GmbH. All three are important international players in the ESP business. Therewith, OEMs secure resources while maintaining the flexibility of an ESP in terms of degrees of freedom concerning employee codetermination and improved cost efficiency. According to the key informants, ESPs stand to benefit when their employees leave the organizations and start working with the ESPs' main customers. When ESP alumni become OEM engineers or managers, in most cases, they still have a connection with their former employer and therefore seem to have a preference to award new projects to the former employer. ESPs allow faster career development for their employees since the organizations are smaller and more flexible and career paths are often not regulated by collective agreements (Bromberg, 2011). Furthermore, ESP engineers can work for different customers during their career and even in different industries. This leads to rapid knowledge gain among ESP employees, as stated by the business experts.

> ESPs have to fight to keep the very top people in the company—personnel from project management or even project engineers. Because we are at the point where, whether it is through employee leasing or service contracts, the OEM is always looking out for the good and very good people at ESPs, aiming

> to hire them later. This is a great challenge for us to keep or replace the talent. But one thing is also true: It cannot completely be avoided. And if a good person changes jobs and you treated him will, he will always think of you... (KI9-ESP)

When an engineer is in a later stage of his or her career and wants to settle down and work less in project mode, he or she often chooses to move to the OEM's R&D departments for the continuation of their career. ESPs are thus also talent development providers for their customers.

IM 6 (recruiting channel to build up talent benches with highly competent ESP employees) was therefore confirmed by the key informant interviews.

IM 7. Concentration on core competencies

The interviewed business leaders mainly agree on this motive, as identified by scholars in the field of outsourcing automotive NPD (Gerwin, 2004; Katzenbach, 2015; Ragatz et al., 2002; Ro et al., 2008; Schneider, 2011; Un et al., 2010; Wolff, 2007), but they adapt it for the case of ESPs. By outsourcing to ESPs, OEMs can focus on the lead cars and lead innovations, and outsource the less innovative development tasks and variants to the ESPs. OEM managers discern an excessively strong dependency on Tier 1 suppliers and their innovations. Hence, OEMs want to integrate innovations vertically and lead product development once again. OEMs want to become the global integrators of technology solutions. To remain capable of integrating highly innovative solutions in new products, OEM R&D departments want to regain the lead over the complete NPD process of a lead car and move away from 'mobile phone engineering', a term that is defined by KI6-OEM.

> And with that I get to what I said in the beginning: I suddenly do 80 per cent the base vehicle myself, which I never had before. But in the coupe, I make only the top-level requirements and outsource 90 per cent of the development. Of course, we [OEM] have to gear ourselves more towards project organization for that. This also increases the responsibility of our project organizations which outsource these variants. (KI6-OEM)

According to this expert, OEMs are today often only steering the development of suppliers and do not generate adequate IP in-house. Furthermore, due to this circumstance, the OEM teams lack competencies in some domains with respect to specifying or evaluating the development results of the suppliers. Since OEMs need to remain in charge for the definition of the brand differentiators and the innovation roadmap, they intend to change their organization away from a commodity-oriented organization towards an NPD matrix organization, combining commodity innovation with project organization. ESPs, which are by nature project-oriented companies, can support this change of NPD organization by carrying out variant development projects and providing support in commodity innovation projects.

> In the case of the complete vehicle and integration we have just been discussing, how can I make the concept? How do I create the brand appearance? How do I produce the vehicle, depending on the brand and so on? Who does the serial development? Of course, this has to be done at the OEM. If I now look at an automatic transmission, neither [OEM1], [OEM2],

> nor any OEM alone today can develop such a transmission. It is no longer possible. Theoretically they can, but practically not anymore. This is done by [Tier 1] to a certain extent in almost a black box situation. This leads to dependencies. I've heard that at various OEMs and also seen at [OEM1], if you did not have the relationship with [Tier 1] under control, you just got the good gearbox after [OEM3]. And that's a classic symptom of such a dependency, where you obviously have gone a bit far with your outsourcing. This needs to be changed. We have to become the leader of the innovation roadmap again. (KI6-OEM)

> We [ESPs] should support our customers to gain control over their NPD process again. This is a big opportunity for us. (KI5-ESP)

When supporting innovation projects or as an innovation partner, the service provider innovates for its customer.

> And that's also a job for a service provider: to create an innovation so that the other OEM can put that only into the next generation because of adaptations of the complete body. […] If such innovations could also be introduced by service providers, then it would be a very great achievement. (KI3-OEM)

> If I give the innovative projects to the ESP, of course I want to have more control of what it does. Not how they do it, but what. Therefore, the commodity needs to able to specify well the expected outcome. (KI4-OEM)

Figure 22 shows a derived OEM NPD organization and the fields of intervention of an ESP in such an organization.

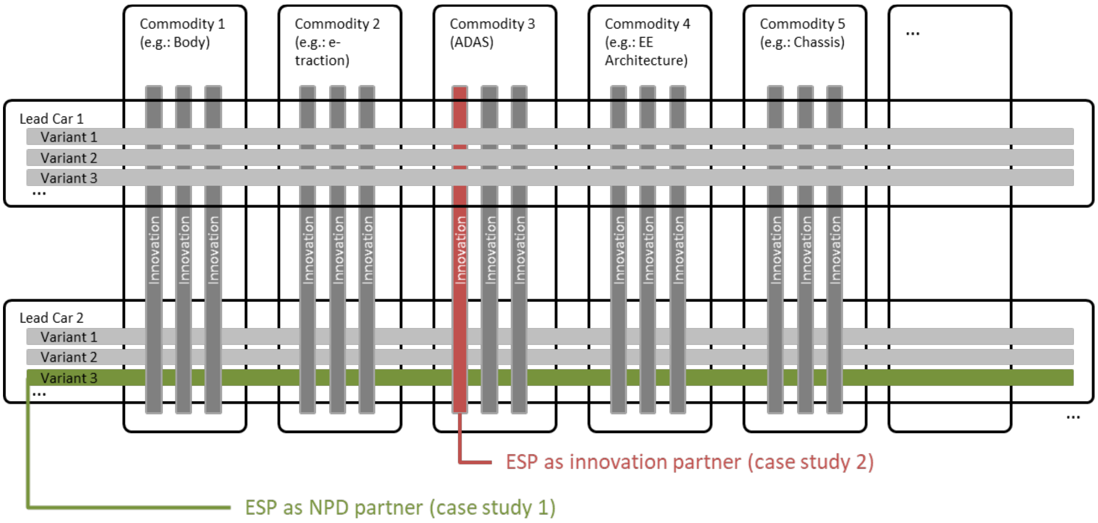

Figure 22: Matrix organization of OEM NPD departments and fields of intervention of ESPs

The above figure shows a possible matrix organization of an NPD department of an automobile manufacturer and the fields of intervention of ESPs in this context.

The vertical integration through outsourcing to ESPs is covered under IM 3. Consequently, IM 7 can be adapted for outsourcing to ESPs as follows:

IM 7. Concentration on core products and key innovations

The internal motives found in the literature have mainly been confirmed by the interview participants and could be slightly adapted to the special case of outsourcing significant development tasks to service providers.

External motives were discussed less often in the interviews. Nevertheless, these motives have been confirmed and extended or changed by the interview respondents.

EM 1. Globalization and regionalization factors

The respondents agree with scholars in the field (Gassmann et al., 2004; Wolff, 2007) that the globalization and localization of production sites have an impact on outsourcing to ESPs. IM 3 (need for capacity not currently possessed and resource flexibility while increasing the vertical integration) is partly grounded in EM 1, as explained by the key informant KI9-ESP in his statement. EM 1 also leads to a change in the strategic set-up of ESP companies. In the last two decades, the consolidation of engineering companies has not only led to the appearance of big players but these players have also developed from local to global players (Lüerßen, 2016; Meißner, 2013), as confirmed by the research participants in the key informant interviews.

EM 2. Uncertainty of international markets

This external motive was not discussed in the key informant interviews. That could be because of two circumstances: (1) The research participants were at the time of the interview employed by a traditional OEM. Such companies already generate most of their sales in international markets and thus the level of uncertainty seems to be on a controlled level, or (2) the key informants were employed by established ESPs, which grew together with the established OEMs to the world-leading position they are in today. Uncertainty of international markets thus seems not to be a motive for the companies that the interviewees had experience with. For emerging OEMs, the uncertainty of international markets could be a motive to outsource to ESPs which are already established in the market they want to develop. This is my interpretation and conclusion based on my experience in the field.

I therefore slightly adapt EM 2 for the specific case of automobile OEMs outsourcing to ESPs:

EM 2. Uncertainty of international markets, where the OEM is not yet established

EM 3. Change in legislation concerning temporary employment

This external motive has been confirmed particularly by the ESP respondents. In Germany, the temporary employment law (Arbeitnehmerüberlassungsgesetz) has changed. Temporary employment is limited to 18 months with an equal pay obligation after nine months (Holtrup, 2018; Lüerßen, 2016). This business case is therefore less interesting for ESPs. Furthermore, the problem of self-employment of freelancers, not paying social security, and the so-called 'fake project contract' business which emerged to help companies avoid minimum wage obligations have led to a change in politics. Politicians are searching for solutions to cope with these problems. Since self-employment and fake project contracts seem common in the blue-collar business, the problem should normally not be a problem for engineering services, where highly skilled personnel are needed. But to avoid potential problems, if a new regulation would, for example, affect all types of outsourcing contracts, OEMs promote real project contracts with clearly defined deliverables and significant volumes. Thus, the uncertainty in legislation and the recent change in temporary employment legislation could motivate OEMs to outsource bigger projects (Holtrup, 2018; Lüerßen, 2016).

Moreover, small project contracts bear a risk. According to the German and European labour legislation, which changes regularly, an employee may be entitled to recourse (sue the client for recruitment) if there is free co-operation (self-employment). This means that the OEM as an instructing company becomes the fictive employer of the external resource because the employee is completely integrated in the work processes at the OEM. European legislation intends to avoid such self-employment because companies often use this strategy to avoid social charges and to circumvent the application of employee protection law. In particular, the external resource could become an employee of the OEM even without a signed working contract if the following circumstances are given:

- the person receives professional instructions
- the person is locally and temporally subordinated
- the person is integrated into the OEM organization
- the work organization of the person is performed by OEM teams
- the person is treated in the same way as other (permanent) employees
- the person has reporting obligations to the OEM
- the person is included in a roster

Not all the points need to be fulfilled. In particular, the integration into the company and the subordination are significant aspects (S. Becker & Tuengerthal, 2016).

Since a major internal motive to outsource to ESPs for OEMs is resource flexibility, OEMs find strategies to overcome this uncertainty. The most common approach is the outsourcing of significant project contracts. Herein, the ESP teams are not integrated in the daily work at the OEM and take instructions only from ESP employees. These circumstances are a barrier to the application of the recommendation of Rec 2 (joint project spaces and co-location), which will be discussed in Section 4.1.2.1.

EM 3 is therefore slightly adapted to:

EM 3. Change in legislation concerning temporary employment and uncertainty over further changes in legislation concerning external resources

Discussions with the industry experts led to a further external motive which I did not find in the literature review. According to the OEM respondents, digitalization of the NPD process leads to the situation where IP can no longer be protected. Apparently, the OEMs tried to establish IP protection tools in their IT landscapes which were not successful. Employee turnover, along with easy access to and the IT-facilitated possibility to copy drawings or documentation, as well as emerging OEMs' increasing capability to reverse engineer innovations or technical solutions have led to a situation where it seems nearly impossible to protect innovations. Therefore, two OEM key informants stated that a technology-leading automobile OEM must be faster than its competitors when it comes to innovation and the integration of new technologies into the automobile.

> I'm trying to protect this through contracts and so on, but de facto it is clear that the only chance is to be better and to be faster than others. IP protection is difficult. (KI4-OEM)

> Right now, we [OEM] try to minimize the risk by getting faster. We say, 'All right, I always run in the front.' Because you cannot actually do it through know-how protection. We tried it in the years from 2007 to 2015 putting a lot of effort in secure data lines, direct data lines, own servers at the [OEM] for development. It was all to prevent data leakage. In the end, we came to the conclusion that it is not possible. And to be faster, we need partners and cross-fertilization. That's clear. (KI6-OEM)

These circumstances lead to increased innovation pressure and, consequently, the motivation to outsource to innovative companies like ESPs.

Based on the outcome of the key informant interviews, I formulated an additional external motive:

EM 4. Difficulty in protect IP due to digitalization of the NPD process leads to increased innovation pressure

After the analysis, I consider two of the IMs as covered by others or not very relevant for ESPs. For IM 2, five sub-motives have been defined. Hence, seven internal motives identified in the theory of general automotive outsourcing and collaboration have been confirmed by the business leaders in the field of automotive NPD for outsourcing to ESPs. The three external motives have been confirmed by the respondents. EM 3 is less applicable to traditional OEMs. The key informants raised a fourth external motive, which I have added. Below I depict the summary of internal and external motives to outsource significant development tasks to ESPs:

IM 1. Minimization of cost (increased efficiency, lower labour rates) and cost restructuring (change fixed cost to variable cost)

IM 2. Access to specific know-how, intellectual property, and wider experience and knowledge

- IM 2.1. Access to niche expertise for traditional OEMs
- IM 2.2. Access to know-how gained at traditional OEMs for emerging OEMs
- IM 2.3. ESP as the transfer agent of implicit knowledge
- IM 2.4. ESP as the mediator or facilitator for inter-OEM cooperation
- IM 2.5. Access to know-how from other industry fields

IM 3. Need for capacity not currently possessed and resource flexibility while increasing the vertical integration

IM 4. Motives concerned with the spreading of entrepreneurial risks

IM 5. Achieve a change in quality by outsourcing a service with a new SLA

IM 6. Recruiting channel to build up talent benches with highly competent ESP employees

IM 7. Concentration on core products and major innovations

EM 1. Globalization and regionalization factors

EM 2. Uncertainty of international markets where the OEM is not yet established

EM 3. Change in legislation concerning temporary employment and uncertainty over further changes in legislation

EM 4. Difficulty in protecting IP due to digitalization of the NPD process leads to increased innovation pressure

These adapted motives bring additional insights to the special case of ESPs, help to classify the risks, recommendations, barriers, and best practices, and allow one to better situate and contextualize the projects analysed in the case studies.

4.1.2 Risks, recommendations, barriers, and best practices by category.

In this section, I identify barriers and best practices by analysing the practitioners' insights as gathered during the key informant interviews. I sort the barriers and best practices according to the categories and recommendations as defined in the literature review. The key informants mainly confirmed the risks and recommendations with different levels of support. In part, the risks and recommendations have been adapted or extended for the special case of ESPs.

The best practices can be seen as ways to put the recommendations into practice. The barriers confirm the risks identified in the literature review with practical problems in collaboration projects under the lead of an ESP. However, best practices could not be identified for all recommendations.

The initial 21 recommendations found in the literature have been consolidated, changed, extended, and reduced to 18 that are applicable to the two cooperation models in focus which are involving ESPs. Furthermore, concrete best practices have been identified and have been assigned to the 18 recommendation sub-categories. I do not consider a recommendation as invalid if it is not supported by best practices, but I expect it to be less applicable to the special case of development projects outsourced to an ESP. This is why I excluded them from the developed best practice guidelines. In the case studies, I analyse the extent to which the recommendations and best practices have been followed or implemented and what barriers appeared in the projects. Recommendations that are not mentioned by the key informants might turn out to be confirmed or supported by best practices in the case studies. The identified best practices are marked in bold.

4.1.2.1 *People.*

In this section, I discuss the insights of the key informants concerning the category of ‘people’. This category drew the most attention from the key informants. Aspects of culture, trust, and implicit knowledge are covered in this category. These seem to be important aspects in collaborative NPD projects under the lead of an ESP. The coding resulted in 140 references given by all 11 interviewees in the ‘people’ category.

The recommendations concerning ‘people’ found in the literature mainly address the risks Ri 1, Ri 4, Ri 5, Ri 6, Ri 8, and Ri 10, as shown in the following matrix.

Risk	Risk Carrier OEM	Risk Carrier ESP	Recommendations from literature		
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 6. Strengthen long-term relationship of OEM and ESP		
Ri 2. Risk of agency dilemma	X				
Ri 3. Risk of dependency	X	X			
Ri 4. Risk of changing the set of core competencies	X		Rec 6. Strengthen long-term relationship of OEM and ESP		
Ri 5. Risk of reduced supplier performance through cultural distance	X	X	Rec 1. Define sustainable project teams	Rec 2. Determine joint development teams with a problem-solving attitude	Rec 5. Give NPD teams the possibility to integrate on a personal level
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 3. Provide common project space and promote co-location	Rec 4. Promote frequent communication	
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X			
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X	Rec 1. Define sustainable project teams	Rec 5. Give NPD teams the possibility to integrate on a personal level	
Ri 9. Risk of labour law disputes with ESP employees	X		No recommendation for mitigation found in the literature		
Ri 10. Risk of losing project performance due to high employee turnover	X	X	Rec 1. Define sustainable project teams	Rec 5. Give NPD teams the possibility to integrate on a personal level	

People

Figure 23: Risks and recommendations identified in the literature review in the 'people' category

The above figure presents a matrix of the risks and recommendations for automobile NPD projects under the lead of an ESP in the category of 'people'. Adapted from numerous authors (see Table 3).

Rec 1. Teams with a problem-solving attitude

All the research participants have confirmed this recommendation. The recommendation is linked with the risk of reduced supplier performance through cultural differences. During the interview analysis, it became clear to me that Rec 5 (define sustainable project teams) is strongly connected to Rec 1. Therefore, I decided to combine these recommendations to create the following:

Rec 1. Define sustainable project teams with a problem-solving attitude

This combined recommendation was established to mitigate Ri 5, Ri 8, and Ri 10, as argued by several scholars (Binder et al., 2008; Mishra, 2009; Wognum et al., 2002). These risks have mainly been confirmed by all participants and barriers in relation with these risks have been defined. The experts confirmed that a major reason for the failure of outsourced NPD projects is the lack of trust between the companies and the cultural differences in terms of orientation.

> The most common reason for project fail is the lack of trust, the lack of trust between the project counterparts. The OEM teams feel challenged by the service provider and the service provider teams feel inadequate. (KI11-ESP)

As described earlier, the barrier of the commodity orientation of OEMs versus the project orientation of ESPs has been defined. Ri 8 (risk of lack of motivation in the project teams on ESP side, due to inequality), as discussed by several academics in the field (Bromberg, 2011; Holtrup, 2018), has not been discussed or identified by the research participants. Either such an inequality does not exist, since ESPs have to pay adequate salaries to their employees, or this risk did not create a problem in the history of the research participants. Ri 10 (risk of losing project performance due to high employee turnover) has been confirmed by the experts—especially the key informants occupying a management position at an ESP—as a challenge. The key informants agree with Holtrup (2018), who argues that ESPs have high employee turnover rates and therefore risk their delivery ability. The concrete barrier of ESP employees being hired by the OEM when they have proven themselves has been identified and discussed widely by the experts. ESPs seem to have developed strategies to mitigate this risk or simply have to accept that this challenge exists. Best practices which could be linked to this risk have been identified and will be discussed.

> You have to avoid the migration of staff. So, an obstacle for an ESP is always the know-how side. (KI9-ESP)

> At a service provider, if such projects get very big and then no follow-up project comes, it will be difficult. I can give an example. We had a lot of problems at the beginning when the [car name] was a complete vehicle project, because somewhere 60, 70 project managers had to be developed. When we finally had them all in-house and the project was finally going well, there was only one more year to go until the end of the project. Then the 60 managers, we have to feed them with interesting projects again. Otherwise, they will be gone relatively quickly. And that is the challenge on the ESP side—to keep the know-how, to keep the employees really constant because these projects are not awarded too often. (KI9-ESP)

To overcome barriers, mitigate risks, and follow the recommendation to define sustainable project teams with a problem-solving attitude, the following best practices could be identified in the key informant interviews.

An automobile NPD project, especially for a variant development, has numerous interfaces to the commodity departments. In variant development, OEMs try to reduce the number of changed parts as far as possible. Up to 90 per cent of the parts are carry-over parts from the lead car. The commodity team needs to be informed if an engineering change is needed. Therefore, in NPD projects, technical subsections of the car are defined which are mirrored to the commodity organization of the OEM. A very efficient best practice defined by the experts is to **nominate a counterpart from both organizations with communication privileges for each technical subsection**. According to the experts, projects risk failure because the ESP project organization does not know whom to speak with in the OEM commodity organization when it comes to engineering changes. So, this best practice has been tested widely.

> Lean is important. You must have a lean line-up. Or say, for example, the project organization is at the ESP. Then I do not need to duplicate this organization again at the OEM. So, here is the best example: We're giving away a variant. Then I do not really need a variant organization in the full image of the line organization from [OEM]. I need a lean monitoring organization that checks up on what the ESP does, not how, and that is available to provide guidance. (KI6-OEM)

The attention of the experts has been drawn to the barrier where OEM teams sometimes seem reluctant to collaborate with the ESP teams once the outsourcing decision is taken. If the OEM teams had the intention to conduct the development in-house or if the OEM teams feel challenged by the ESP, the OEM R&D teams or R&D managers might put themselves in a position in which they are reluctant to support the ESP teams. OEM teams may have the standpoint that the project contract has a turnkey character and thus no support is needed. This is one of the major barriers that result in project failure according to the key informants.

> If you appoint a service provider, of course it looks like you've awarded a complete package outside. And what do the series developers do at the respective OEM? If they have not already worked on a project with a service provider, they lean back right away and say, ‘Do it’. I saw it with the [...] project. Then the discussion at the [project number] goes back in the same direction: ‘Well, we could actually have done that ourselves. Now let the service provider run and let's see what he gets there.’ (KI3-OEM)

The ESP teams are unable to develop the variant of the product without regular synchronization with the OEM’s commodity R&D teams and without any support from the OEM. Of course, this means that the OEM teams need to overcome their reluctance to work with the ESP and go the ‘extra mile’ for a competing development organization. According to senior experts from the industry, the OEM R&D teams should not see the ESP teams as competition but as support, which would allow the OEM organization to focus on other NPD tasks. Therefore, the **OEM top management should explain the outsourcing decision transparently** along with the outsourcing strategy, which will be discussed later. This transparent communication provides a vision to the project stakeholders. Creating a vision has been identified as a success factor by researchers in the field (Nellore & Balachandra, 2001).

> So, we recently outsourced this variant development, for example. My division was responsible for the body that had to work first in the project. I really had to invite all my dear R&D leader colleagues—the centre managers of all commodities—in a room. And I said, 'Guys, we want to outsource this thing and I strongly recommend that you sit with me. We can jointly decide who will be our partner now.' Once we all were convinced, we shared this decision with every engineer in our organization and explained to them why this outsourcing was the right decision. (KI6-OEM)

Furthermore, the OEM's top management **should identify OEM employees who are positive about the collaboration and solution-oriented**.

> That goes down to the employee, who then has to discuss with the OEM development staff. They also need to understand each other. If there is some tension between them, that may not be possible. Then you have to switch people if necessary. (KI3-OEM)

These staff members should be ready **to provide concrete project support** in case the ESP teams face problems during the course of the project.

> It was a joint discussion on how we could get to the market a complex vehicle, for the first time one with a hinged roof. Such a product did not exist all over the world. We had developed this together with [ESP]. And that works only if, when they [ESP teams] have problems during the development, that you

> as an OEM help. Perhaps provide an engineer who helps. But he should not immediately tell the board, 'We have chosen an ESP who is incompetent and does not even get that detail under control.' This togetherness, if it works properly, will help you develop a clean product through collaboration between the OEM and the service provider. (KI3-OEM)

Managers or project members who are negative about working with an ESP should be replaced and put on another project. The interviewed experts agree that the OEM management must implement measures to ensure the success of the project.

> Sometimes, I too have to remove barriers from the way. By barriers, I mean people not willing to corporate, and IT or process issues. This has something to do with management. It's part of the game. (KI6-OEM)

> I need people who can cooperate. They should be collaborative even with their social skills. The ability to cooperate includes recognizing other perspectives, recognizing and respecting others, and learning from others. Here we have to train the employees. (KI4-OEM)

A further best practice, stated mainly by the ESP management, is to **instruct the ESP employees to communicate regularly that they do everything for the best of their customer**.

> And his [ESP project leader] main task must always be to focus on the personal connection. He always conveys to the customer: 'I am only here to make you [OEM] a hero. I'm only here to secure your project. I'm only here for YOUR SoP to be on time. But I do EVERYTHING, and I'm ready to put

> everything out of the way, to address everything that prevents this from happening—even inconvenient decisions that concern you or your organization. (KI8-ESP).

One respondent even recommended the specification of language rules. ESP employees should always emphasize that they are there to support their customer. With the increasing responsibility in projects and the increasing size and competence of ESPs, engineers working for ESPs seem to have a certain arrogance, implying that they are the better engineers. Apparently, these psychological effects exist on both sides: OEM engineers may feel challenged by the competence and efficiency of the ESP engineers, and ESP engineers may feel like 'second-class engineers' who want to overcome their status by emphasizing their competence. Therefore, reassuring the teams on both sides as well as transparent communication and clarification of the customer–supplier relationship should help improve the collaboration. Even if this best practice seems trivial, the experts say that clear communication has been proven to be very effective. Instructing the project engineers to behave accordingly and to communicate in a positive manner is positively correlated with the perceived level of trust. According to the respondents, the social skills of engineers are not always well developed and engineers tend to be arrogant from time to time. To overcome unwillingly created barriers in the personal relationship, reminding the project teams to communicate positively and behave proactively can be helpful. Applying these best practices can help to overcome the barrier of missing trust, which has been stated by most of the respondents. Ri 10 (risk of losing project performance due to high employee turnover) and the barrier of key players switching to the OEM was discussed a lot. The experts have identified the following best practices to overcome this barrier. As discussed, engineers working for ESPs choose to work for an ESP because of the possibility to work on several interesting projects and the career opportunities that an ESP can offer. Thus, the ESP management should **identify the key players and offer them a multi-project expert role** in order to help them to remain in their organization.

> And hence you have to identify the key players and make them stay. Offer them interesting projects and career opportunities. Talents want challenges; money is less important. So, you can offer them multiple projects at the same time—for example, trainings, etc. (KI9-ESP)

Thus, **a well-established talent management process** is crucial for ESPs. When an engineer changes employers, a proper exit meeting should be conducted to ensure that the engineer leaves on good terms. That is because, most often, the engineer who leaves becomes tomorrow's customer for the ESP. Another best practice mentioned by an ESP key informant to overcome Ri 10 (risk of losing project performance due to high employee turnover) is to **have key roles in the project redundantly occupied** by experts from other projects.

> When it comes to the situation that a key persons abandons the project, you should be able to replace the person in the position. This is idealized, but a company with several thousand employees should be able to redundantly occupy project positions. We [ESP] should be able to have a back-up for each position. (KI7-ESP)

Consequently, the ESP should try to create an exchange between the teams of several projects, with the aim that an expert of another project can jump in if a key player is no longer available.

Several best practices to overcome Ri 5 (risk of reduced supplier's performance through cultural differences) and the consequent barriers were identified by the research participants. Multiple best practices were identified concerning the set-up of the ESP teams. According to the industry experts, **ESPs should focus their recruitment on flexible, generalist profiles with interdisciplinary competences**, as emphasized by KI9-ESP:

> The ESP head itself must be very flexible. Say, a flexible engineer. […] This interdisciplinarity is essential when you do a complete vehicle: You have mechanical engineers, you have electricians, you have complete vehicle people, you have people who write software, you have the project management people, you have quality people with you, you have people who calculate costs. The requirement for a person who works for an ESP is above all this interdisciplinarity. He has to integrate himself into these teams. He wants to work with these other groups. He wants to exchange ideas. And he has to rub himself against them. So, a person who only has classical mechanical engineering in mind will never really feel comfortable working with colleagues on larger interdisciplinary teams. (KI9-ESP)

> They need system competence—the most important is exhaustive system competence. (KI3-OEM)

Furthermore, **a mix of personalities in the ESP project team** seems to positively affect the collaboration. 'For me, this idea stands in front: Teams should be composed of different characters. Because you will not have all the qualities that are necessary in one person.' (KI8-ESP) In discussing the project team, several best practices were identified which the experts say have proved effective. The **OEM should define a lean monitoring organization** which reflects the counterpart organization as discussed earlier. This monitoring organization should control what and not how the ESP teams develop. The control mechanisms to be applied will be discussed in the section 'process'.

> This self-responsibility must also show up, for example, in the coordination of the entire vehicle. The ESP must be able to coordinate. In the end, we [OEM commodity] will release it because we say, 'Okay, we only have to release the part in the end.' (KI6-OEM)

Furthermore, according to several respondents, there must be a project leader on the OEM side as well as one on the ESP side. These **two project leaders should be closely involved in their respective organizations and should get along with each other**. The personal connection of the two project leaders seems to be of crucial importance for the success of the collaborative NPD project.

> Both must have a project leader. (KI6-OEM)

> And that has to work between the project leaders. If this level of relationship between the project leaders is wrong, you can forget the whole project. (KI3-OEM)

> The project leader and the most important contact person at the customer—this team must fit. (KI8-ESP)

An additional best practice concerning the team set-up is the **nomination of an experienced chief engineer.** This could be someone who knows the OEM organization and processes well or who is an ex-employee of the OEM. Two respondents referred to a very successful project in which the ESP hired a retired senior engineer of the OEM as the chief engineer. The chief engineer brings implicit process and cultural knowledge as well as technical experience. This approach helps to show the technical competence of the ESP, increasing its credibility and therewith the level of trust that OEM teams have in the ESP teams.

> The project manager is not always the best chief engineer. I have to look at the project. Who is the chief engineer? Who has this role? Who is the one who really knows about the system? […] Who can make the system decisions himself? Should I put a cover on the tank or not? Can I leave the tank there? Can I leave the pipe there or do I have to guide it backwards? There are technical decisions to be made. And that will not always be the project leader. I have to think: Is the role of this chief engineer occupied and does this person realize the responsibility? Has everything been done to find an environment where he can take that responsibility? (KI8-ESP)

Moreover, a best practice noted by the key informants is to **define a sales agent** who negotiates the cost of engineering changes and extra efforts with the procurement departments of the OEM.

> A good sales manager is a role that allows the project manager to also be a good guy. This does not have to be someone from the sales organization. It should be someone who realizes the commercial role. He says, 'Guys, this is a major change. So we need to talk again.' And this commercial guy then has to negotiate this change, for example, in an addendum offer. (KI8-ESP)

The separation of sales, project, and technical management seems to be relevant for the success of the collaboration. With such an organizational structure, the project leader is in control of all aspects in the project and can maintain a positive relationship with his or her counterparts. Negotiating claims with the customer might have a negative impact on the reputation of the project leader. Therefore, the sales agent should be the 'bad guy' who negotiates with the customer's procurement department, since the good relationship of the project leaders seems to be a critical success factor. This does not mean that the ESP project leader should not escalate problems. But the focus should be on the management of the project for the sake of the customer and not on negotiations. A further best practice noted in this context is for the **ESP to choose project leaders who are reliable and authentic** in their commitments and to instruct the project leader to always stick to her or his commitments.

> Reliability is very important. We work with standards in extremely tight schedules. And the topics that are now in the lists of open points are getting longer and more colourful. There is also the issue of binding commitment in dealing with each other. Yes, this is an absolute success factor. (KI5-ESP)

> Open-mindedness, reliability, and binding commitments are key. Your teams have to be trained in this… (KI11-ESP)

A further best practice to overcome Ri 5 (risk of reduced supplier's performance through cultural differences) and the resulting barriers seems to be the regular execution of intercultural trainings within the company especially at the beginning but also during the course of the project. These **trainings should focus on the cultural aspects of the two companies** that are working together. This would help the teams to better understand the reasoning of their counterpart. Even if this best practice does not have an immediate effect, the key informants tend to agree that collaborative projects often fail because of the cultural differences between the organizations. Hence, they are convinced that trainings can be very effective.

> And you can only get better in such a collaboration if A tries at least to understand why a corresponding behaviour of B is acceptable and vice versa. This has to be trained, to be inserted in the heads of our guys. (KI4-OEM)

Moreover, two respondents had good experience with **training their employees to be consensus-oriented and cooperative**. This is true not just for one project but in general. ESP organizations, in particular, should offer such trainings regularly to their employees.

> Cultural things and so on. The future education of engineers will not only be derived from basic technical understanding, mathematics and physics, and technical mechanics and thermodynamics. But especially they should learn

> how to work around the globe, what cultural things are there to pay attention to. (KI2-ESP)

Most of the experts identified a further barrier for collaboration in NPD projects under an ESP's lead. The ESP management might be reluctant to invest in a significant build-up of engineering teams for one significant project, especially if the project is awarded by a new or small customer for the ESP, when no security for a follow-up project is given. This could lead to a significant non-utilization of resources, which would have a negative impact on the financials of the ESP.

> So the few people I need in a concept phase, I have to triple, increase fivefold, and then a hundredfold in a series development phase. And the ESP not only has to have the know-how but above all the capacity. That's why it's a big hurdle to have this capacity freely available. (KI2-ESP)

> Having such a supplier to build huge resources for such a project puts you in a kind of dependency. If you say, for example, that you will not continue now, then the newspaper may say [ESP] has to lay off 500 people because [OEM] does not renew the contract. (KI10-OEM)

In addition to best practices discussed in the category 'process' and in relation with Rec 6 (long-term relationship of OEM and ESP), the key informants state that practice has shown **that ESPs should maintain a mixed-business model**. This means keeping the sales revenue share balanced between project contracts, temporary employment, and outsourcing contracts, as well as industry-wise and customer-wise. This balance of sales revenue share allows the ESP to appoint engineers who are no longer needed on one project on other projects in another contract mode, at another customer, or even in another industry. Hence, the project leader and the project team have more security when building up resources for the project, which is positively correlated with collaboration efficiency.

> I always have certain skills which I can place elsewhere on the market. I can use them everywhere. But I also need skills for a project which I really only need for this task. So first of all, I have to know which ones these are. And secondly I must also have a mixed business model to keep and finance them. (KI8-ESP)

> The project pipeline with interesting projects has to be full. This can also be EoD projects where the experts work in consulting mode for a while. (KI9-ESP)

Rec 2. Provide common project space and promote co-location

The recommendation to have a joint project space to carry out the development in the same location has only been partly confirmed by the respondents. The recommendation was identified in the literature (Ragatz et al., 2002; Ro et al., 2008) and should help mitigate Ri 6 (risk of reduced development project performance through geographically dispersed project teams), as identified by several academics (Handfield & Lawson, 2007; Mishra, 2009). The case of ESPs seems special in this respect. Like most of the other recommendations under ‘people’, this recommendation can be considered a supporting recommendation for the creation of a sustainable, solution-oriented project team. The respondents confirm that too much distance between the development space at the ESP and the OEM hinders efficient collaboration.

> In my projects with French customers, the local distance between customer and service provider was generally relatively large. This made us lose a lot of time. (KI7-ESP)

For collaborative projects involving ESPs, the respondents identified special barriers. Especially in Germany, OEMs face legal uncertainty when it comes to the use of external resources, as explained earlier. Therefore, OEMs seem prudent about creating joint project space with the goal of avoiding the integration of external resources in the regular work process of the OEM organization. Thus, the respondents defined as a barrier the integration of ESP employees in the regular work process due to labour legislation. This barrier correlates with Ri 9 (risk of labour law disputes with ESP employees), which was identified by Blöcker (2016). KI7-ESP mentioned experiencing problems resulting from this barrier when working as a project manager:

> Political stories like discussions with customer’s works councils. If you spend a lot of time working directly with your customer, you may be able to claim a contract of employment after a certain amount of time. Therefore, we could not be integrated in the work processes. This is a real barrier. You always have to be careful to be compliant. (KI7-ESP)

Consequently, OEMs and ESPs have found best practices to overcome these barriers. A best practice identified by the respondents is for the ESP to have **a project front**

office close to the customer's R&D centre. The project front office should accommodate a small project area where project meetings and informal communication can take place.

> A project needs a project space with short ways. This space should be where most of the development tasks are done. There should also be a front office for project management close to the OEM. (KI11-OEM)

> [...] and that is also a success factor for projects. I need short distances and close contacts, which I get by being present. (KI8-ESP)

> You can plan for all the problems and cleanly schedule all development steps. But the uncertainties and the unforeseeable problems that then emerge in between can just be solved faster with the management team close to the customer. (KI7-ESP)

Furthermore, the key informants consider it effective for the **ESP to have only the project management organization close to the customer's R&D centre**. The project leader, the different technical counterparts, and the sales agent should be regularly close to the customer, but the **actual development teams should remain at the main location of the ESP** after a ramp-up phase.

> And that worked very well. You just had to first optimize a lot of small things on the spot until you had the structures clean, where even the [OEM] departments played along and so on. Then it worked well. Because of course it was remote. Because they were not at [OEM] in [city], but they were just then in [city]. And that has increased efficiency. (KI10-OEM)

> If you [ESP] do everything onsite, there is not enough motivation to do it better. When I say, 'Okay, they're all sitting there. I can talk to them anytime.' That's convenient but not efficient. (KI8-ESP)

The respondents claim that a physical presence within the OEM premises is important at the beginning of the first significant joint project to ensure agreement on monitoring and reporting principles. Afterwards, the main work should be conducted at the headquarters of the ESP. According to the respondents, applying these best practices enables the ESP teams to be more efficient and find new ways within the NPD process. If the ESP teams work completely on the customer's premises or nearby, the ESP personnel seem to apply unintentionally the less efficient practices of the OEM and the wished-for efficiency increase through outsourcing to an ESP does not occur. Furthermore, with this best practice, Ri 9 and the related barrier can largely be avoided. Researchers discuss a further risk of outsourcing to an ESP, as identified in the systematic literature review. There is the risk of a lack of motivation in the project teams on the ESP side due to inequality vis-à-vis the OEM teams (inequality in terms of salary, benefits, workplace, etc.). Even if this risk has not been confirmed by concrete barriers in the key informant interviews, the above-identified best practices would also mitigate this risk. The business leaders especially from the ESP side mainly had good experiences with defining a **co-location plan** at the beginning of the collaborative NPD project, outlining in which project phase which resources would be onsite at the project area to synchronize with their customer counterparts. This co-location plan should also be shared with the OEM project leader and the OEM management, so that OEM counterparts are available when needed.

> What is very helpful, in the sense of such a success factor, is structured communication. That always sounds so abstract, but quite concretely that means how I exchange and in what ways do I talk, how do I communicate, and so on. This also means colocation of teams. That means depending on the phase, a phase-appropriate location management. Who is where and when? (KI10-OEM)

When the dedicated project space is too far away from the customer's R&D centre, it quickly becomes a barrier to efficient collaboration. The distance of the office location of the ESP and the OEM has been stated especially by the ESP managers as being a barrier. Several respondents emphasized the importance of the front-facing teams having the possibility to walk over to the customer in order to have a quick meeting or ask a quick question in person if necessary. The proximity of locations also promotes informal communication (Pemartín et al., 2018), which is positively correlated with efficient collaboration, as discussed below. Consequently, a strategic best practice identified by the respondents is for ESPs who aim to take over turnkey project contracts to **have a global footprint with front offices close to the R&D centres** of their main customers. 'The ESPs need a global location set-up with proximity to their customers, from my point of view, in order to be successful in the future.' (KI1-ESP)

Rec 3. Promote frequent communication

Rec 3 is related especially to Ri 6 (risk of reduced development project performance through geographically dispersed project teams), as argued by Quesada et al. (2006). Frequent communication also mitigates other risks and supports other recommendations—such as, for example, Rec 1 (teams with a problem-solving attitude). Frequent communication with modern communication technology (Rec 19) facilitates the off-site work, as discussed in Rec 2 (provide common project space and promote co-location). The barrier of OEM teams being reluctant to collaborate with ESP teams because they feel challenged by the ESP teams has also been discussed in this context, as exemplified by the following statement of KI3-OEM:

> The bad thing is when the OEM project managers stand up and say: 'You're a general contractor and now you're doing it!' That's the worst thing that can happen to a service provider. And that's why I say this is only possible with each other, working from both sides. The service provider has its strengths, the OEM has its strengths, and if you bring them together, you'll get a good result. (KI3-OEM)

The key informants had good experiences **with formally imposed, very regular synchronization meetings between the project counterparts, particularly at the beginning of the project**.

> I believe establishing trust is best done by sitting side by side and working together. Once the trust is there, I need less closeness. (KI10-OEM)

The management of the ESP and the OEM should ensure **that meeting discipline is respected** and that individual project members participate in the meetings even if their daily stress is high and participation seems unnecessary to them as individuals. Apparently, the lack of meeting discipline, especially among the OEM project members, is a concrete barrier in collaborative projects.

> You have to make sure as a service provider that the committees are stable. That they are perceived by the persons and perceived as obligatory dates. This can be a process over the first months of the project, maybe even the first year of the project. You just have to know. It is an important success factor. (KI8-ESP)

A further best practice noted by the experts is to install **frequent joint steering committees, with management attention**, to cut down on decision time. Especially for NPD projects with a short development time and with high technical uncertainty, frequent decision meetings seem critical. The NPD teams need short escalation paths and short decision-processing times for development changes in order to be more efficient. In these steering committees, counterparts from all commodities and CE processes should be present since a change in one subsystem could affect all other subsystems and process steps.

> […] it is absolutely necessary that there are common control circuits. Joint steering committees between the engineering service provider and the management on the OEM side. Meetings where both sides get an overview of the management side, where the sticking points are. (KI1-ESP)

This means that in the case of a variant development, component suppliers also have to be involved. Good preparation for these meetings is crucial in order to keep them short and efficient.

> Supplier is a good keyword. In my experience, the supplier is fully tracked by the OEM and the information is then mirrored to the ESP and vice versa. The smartest thing would be for all stakeholders, all contact persons to sit together at the table and agree on the development of the product. (KI7-ESP)

These best practices emphasize the recommendation of frequent communication and offer practical approaches to implement it in the course of a project.

Rec 4. Give NPD teams time to integrate on a personal level

Nearly every respondent confirmed the importance of this recommendation. Particularly for the management teams of the project, a good personal connection seems extremely important. This recommendation is expected to mitigate Ri 5 (risk of reduced supplier's performance through cultural differences), Ri 10 (risk of losing project performance due to high employee turnover), and Ri 8 (risk of lack of motivation in the project teams on the ESP side due to inequality), as discussed by Rundquist and Halila (2010) in their study on outsourcing NPD tasks. Ri 8 has not been confirmed by the respondents but the best practices identified could anyway contribute to a mitigation of this risk, assuming it exists. Barriers in relation to Ri 5 and Ri 10 have already been discussed. Integration on a personal level also supports Rec 1 (creation of sustainable teams). According to the key informants, the management of all the participating parties (OEM, ESP, component supplier) needs to push team-building measures. The ESP managers stated that **common workshops to create a common understanding** should be organized by the ESP, especially at the beginning of the project. A common understanding of the targets and challenges for the different stakeholders seems to be important.

> You have to understand these peculiarities or these informal processes and wordings well in advance. The project teams have to make sure that they become aware of it in advance and talk about it. These workshops and the communication in these early stages are enormously important. Otherwise, you have one team or a second team that's quite advanced, and the other team is still wondering if it makes sense to go left or right. (KI1-ESP)

Furthermore, teams should be instructed to **show appreciation and respect for the other party**. Especially in critical automotive NPD projects, mutual respect seems to be of utmost importance. 'It is important to treat each other fairly and search for efficiencies together.' (KI4-OEM)

KI7-ESP gave an example from the field of commercial vehicle development, where the customer–supplier relationship and the level of trust between the partners seems more prominent than in the passenger vehicle development departments.

> I now have a new look for the commercial vehicle where I have to say that the partnership is even more pronounced. The work of the service provider is more respected within the commercial vehicle sector. This motivates the teams and ultimately makes us better. (KI7-ESP)

Creating a good ambience and a personal connection has been emphasized as important. This holds especially given that ESP development teams should not be located on the same premises as the OEM teams, as discussed. Therefore, the whole project team should have the chance to **conduct informal meetings** from time to time. Several respondents have indicated **that joint recreational trips are a good investment and positively correlated to NPD efficiency**. According to the respondents, most of the important decisions are taken during informal meetings and the idea generation process is also promoted by informal meetings. Informal time together seems to help in joining the forces of the OEM, the suppliers, and the ESP, and therewith increasing the NPD efficiency significantly.

> It was extreme at [OEM]. They now have a big problem with the fact that they are not all in the canteen at the same time anymore. Because the canteen was too small, they had to introduce shifts. In the past, many things could be clarified informally on the way or while eating. Now they have a problem. Because they have no other mechanisms. They have no review culture, no control culture. They do not have that. And technical decisions, for example, were not documented there. Instead they said, 'Yeah, how do we do it? We thought about it. We do it that way.' Then they discussed it during lunch. That has always been a strength of [OEM]. And it's certainly a strength for a small organization, like a project organization. For [OEM], it now becomes a problem because the canteen is too small. (KI8-ESP)

> That's why it's so important to go skiing together or do something else. I define trust as the capacity to understand the other's behaviour. I do not have

> to be friends with the person I trust. But I have to know how this person will react and act in a given situation. Therefore, we have to push informal communication in the beginning. (KI4-OEM)

Moreover, especially the respondents from the OEM side emphasized that even if the OEM teams feel challenged by the ESP teams, they **should show recognition for the work of the ESP teams**. When they do so, the ESP teams feel appreciated by their customer and gain motivation to go the 'extra mile', which has a positive impact on NPD efficiency.

Rec 5. Strengthen long-term relationship between OEM and ESP

For the outsourcing of significant project contracts to ESPs, the respondents identified this recommendation as one of the most important. According to the literature, this recommendation could, among others, mitigate Ri 1 (risk of losing know-how, tacit knowledge, critical information, and IP) and Ri 4 (risk of changing the set of core competencies) (Binder et al., 2008; Handfield & Lawson, 2007; Kotabe et al., 2003; Lakemond et al., 2006; Quesada et al., 2006; van Echtelt et al., 2007). Ri 1 has been confirmed by the experts along with concrete barriers for collaboration. The risk of losing know-how can transform into a fear of losing know-how at the OEM teams and become an obstacle to collaboration. The ESPs' business model is focused on generating IP and know-how for their customers and handing over the generated know-how (Lüerßen, 2016). A barrier to collaborative NPD projects under the lead of an ESP is an inefficient knowledge handover process or none at all. The resulting best practice is discussed under 'process'. Ri 4 (risk of changing the set of core competencies), as discussed by Takeishi (2002), has also been confirmed by the practitioners. This risk has already become a problem in some OEM organizations, as discussed in the section on internal motives. OEM R&D organizations no longer have adequate competence in some areas. As a result, they are unable to specify properly the technical part they want developed or to assess the development outcome. The respondents identified best practices to mitigate the risks and overcome the barriers. According to most of the key informants, it makes sense to **start the relationship between an OEM and an ESP with small NPD tasks and EoD contracts**. The EoD business model of ESPs allows them to employ staff of the ESP in the OEM's workforce on a temporary basis. The 'leased' employees fulfil tasks under the responsibility of OEM's management and learn a lot about the explicit and implicit processes at the OEM during this time (Holtrup, 2018). These resources can be the key to success for a big collaborative NPD project, since they can work as interfaces between the development teams. Furthermore, they create a personal network and know whom to speak with when problems occur. Additionally, with small NPD projects, the ESP can demonstrate its technical and process competences and therewith increase the level of trust between the companies. The key informants thus expend the recommendation of the academics in the field to strengthen the long-term relationship between the OEM and the ESP with concrete best practices to do so.

> But you learn a lot just by getting the staff involved in a small project in the first place and then reinstalling a few experienced people who have already done something like that. And then it's really passing on from man-to-man. (KI3-OEM)

Trust between the protagonists is considered vital for a successful collaboration. The majority of the interviewees argued that, in the end, it is human beings working with each other and in human relationships, and therefore trust plays an important role. Hence, OEM procurement departments should **award high-volume project contracts to ESPs which already have a long relationship with the OEM.** They should focus less on price considerations. This best practice has proven very effective, say the respondents.

> Of course, the power has shifted into procurement. And they [OEM] go there also with relatively high risks. I have noticed this again and again, even in project-contract awards. On the subject of price, they try out or ultimately select ESPs which, in my view, sometimes do not even get the project done. And then, they have to implement measures to retract again in the end, which eventually costs them more. (KI9-ESP)

> I am convinced. In the projects we talk about, I CANNOT do that, if I do not already have one, let's say a significant team that works for the OEM in a wide variety of areas. So, if I've never done anything for [OEM], then I cannot do such projects with them. (KI8-ESP)

> That means as a best practice, from my point of view, it does not make much sense to start with a partner with the largest possible project scope. But it makes perfect sense to go through one or the other learning phase together, and that can certainly be a smaller project, or even better, several consultants directly working at the customer. (KI1-ESP)

> And that also means that new collaborations are always in trouble and long-term partnerships simply have advantages. (KI4-OEM)

> [OEM] then realized: ‘Ah, we have worked with them now. It works very well with them now. We know exactly how they are ticking, they know how we tick, and that's why it's a strategic partnership. What are the factors that led to this good cooperation? It's just personal integration and process alignment through long-term collaboration.’ (KI10-OEM)

Implicit knowledge of the OEM’s functioning seems to be a critical success factor for collaborative NPD under the lead of an ESP. The key informants support the view of van Echtelt et al. (2007), who argues:

> Long-term collaboration benefits can only be captured if a company can build long-term relationships with key suppliers, where it builds learning routines and ensures that the capability sets of both parties are still aligned and are still useful for new joint projects.

This view is extended by an operational best practice—to start the collaboration with ESPs with EoD contracts or small development tasks. As a further best practice for the case in which no long-term relationship between the OEM and the ESP exists, and a new ESP was chosen by the OEM**, the ESP should try to hire ex-employees of the OEM**—senior engineers who have the needed implicit knowledge. Several respondents recommended hiring retired OEM senior engineers as part-time consultants for the ESP. Such an approach not only increases the level of implicit knowledge of the OEM’s organizational functioning but also builds trust between the two companies, since retired OEM employees are usually recognized engineers with a good reputation. OEM engineers trust their competence and their implicit steering of the ESP. 'For the [project name], [ESP] decided to hire [Name of person] as a freelancer. I think this really helped them to get more insight.' (KI6-OEM)

Furthermore, nearly all the key informants underlined the importance of **lessons learned workshops at the end of each project** to reinforce the relationship, efficiently hand over knowledge, and generate implicit knowledge for both parties.

> Lessons learned workshops with the customer because he also learns from our mistakes or from the development service provider. And the nice thing is that you usually have starting points for new acquisition projects. The participants in these lessons learned sessions are not only developers from the customer but also procurement people, quality people... (KI2-ESP)

> And then we do lessons learned workshops regularly, even in different project sizes. Have we had good experiences so far? We do this completely independent of whether a project has gone well or badly. As a rule, we really try to demand this from the customer on a regular basis and the approach is also well received by the customer's top management. (KI9-ESP)

The above-mentioned best practices have been identified as concrete to-dos for collaborative NPD projects under the lead of an ESP, following the recommendations identified in the literature. The key informants identified a further recommendation. For significant project contracts in which all stakeholders have success-critical assignments of the company, it seems crucial to consider Rec 6.

Rec 6. Align and/or understand each other's company culture

> The processing of a project is enormously different. So, the […] German-speaking cultural area carries out long analysis of tasks and long initial considerations, and then in the last months of project processing, are very purposeful with a lot of analytic data approaches to achieve the target. In comparison, you have in the American culture exactly the opposite, where there is an awful lot of discussion during […] the initial determination of goals. But then […] a very strong commitment and determination of the entire team from the first project meeting till the end. In other words, my experience was that where you needed two or three meetings in Germany, until somebody even moved in the right direction, in America after one intensive discussion, the whole team was committed with a high speed in a certain direction. (KI1-ESP)
>
> In [OEM] achieving the target to only 100 per cent is already half a failure. Thus, in our company [OEM], the average goal attainment level of a manager is 110 per cent. In my collaboration with a culture in another country or with colleagues from another company, I had a completely astonishing discussion: 'Why? You can only have one target and not several! And you cannot overachieve targets!' On the other hand, I have also experienced, here in my own company many years ago, having a boss who said: 'If I achieve my goals to 100 per cent, then I have not set my goals high enough. I can only reach 80 per cent because I always have to strive to optimize myself and get better. And if I can achieve my goals to 100 per cent, then the goals were not

> ambitious enough.' But now you realize, we're talking about values again. And we have to coordinate these things together if we want to do projects together successfully. (KI4-OEM)

For the ESP teams, this is only valid for teams that work with the specific OEM. Ensuring that a project or OEM cultural handbook is available to everyone has been demonstrated to be effective. One interviewee called it a 'collaboration code' which should be defined for each collaborative project. Respondents had good experiences with **establishing a common collaboration code**, pointing out how the two companies want to collaborate, as well as what their common targets and cultural values are. This best practice also promotes mutual respect.

> And if there is such a collaboration code to which you can sometimes refer: 'Here are our two ideas of cooperation—we benefit from it together.' Something like this definitely helps. (KI10-OEM)

> And then we realized, yes, we have talked for years about certain principles of cooperation and principles of technical solutions. But we have never written it down. The two of us sat down spontaneously and had three pages filled with principles of cooperation on different topics and what we want. Curiously enough, we reached a consensus very quickly. We worked that thing out and gave it to all the employees and said, 'Friends, in everything you do, you should reflect those principles.' And those principles are also solution-neutral. This was very helpful. (KI4-OEM)

Furthermore, **ESPs should hire employees with the same regional and cultural backgrounds to handle the front office** duties at the customer.

> At the ESP level, or now specifically speaking for [ESP], it has crystallized out that we install people in each region who have grown up in the region and know the region. In other words, we have this big requirement that a leader in the particular region, or the management structure, are people who come from the region in order to communicate well and provide performance. (KI1-ESP)

> The key to success is, in my understanding, that you need culturally competent people in every project. Above all, the leaders need to understand the culture of the other company or the other country from which the company comes. (KI5-OEM)

> But to have the right people, at the right time, with the right cultural background, in the right place is, from the point of view of the service provider, a very, very important topic. Many projects fail because one does not succeed here. (KI5-ESP)

Common inter-company intercultural trainings at the beginning of the cooperation seem to help in creating a common basis for collaboration. Several respondents emphasized the importance of a common understanding. 'I have to try to understand: What is the culture of the other party? Which behaviour is accepted by the other employees and which is not? Trainings can help.' (KI6-OEM)

One key informant noted the best practice as **giving the same book about cultural values to the managers**, expecting them to read it, and thereby creating a common understanding of social interaction and intercultural phenomena.

> It is an old tradition that my managers and direct reports get a book from me at Christmas. What is the reason? It's a piece of organizational development because I assume that they read it, and that, if we all read that, we also have a common knowledge that brings us together personally in our thinking and acting. Then we [...] work out in the cooperation a common view, a common value world, and so on. When I talk about mental models, and I know that my partner has just read *The Fifth Discipline* by Peter Senge and the section on mental models, then I'm sure how he defines the term 'mental models', or how he defines the term 'shared vision'. When I talk about change processes and I know my partner has read *The Heart of Change* by Kotter, with its eight-step programme, then I know that manager is capable of thinking in this methodology. [...] These gifts are a great investment for me because they will make me and my organization more productive next year and thus contribute to my own personal targets. It is completely selfish. Generating a common value world is very important for successful collaborations. (KI5-OEM)

The OEM respondents confirmed the importance of intercultural understanding and underlined that OEM R&D organizations might culturally not yet be ready to outsource bigger volumes to ESPs. Consequently, the OEM management must choose open-minded managers and instruct them **to apply appreciation mechanisms and to open up their cultural paradigm**. The positive recognition of the development work of the ESP teams by the OEM management seems effective in increasing NPD efficiency at the ESP. 'OEM teams should be open-minded. They should have positive relations and an open culture. ESP teams have to be accountable.' (KI11-ESP)

The above-mentioned recommendation and consequent best practices support the mitigation of Ri 2 (risk of agency dilemma), as identified by Harmancioglu (2009). An agency dilemma in the case of collaborative NPD under the lead of an ESP can exist due to the goal of the ESP management to maximize profit and the aim of the OEM management to minimize costs and get the most added value from the ESP. When the teams have a common cultural basis and work together to achieve the common goal of developing a new product or technology, this dilemma becomes less evident. The two parties understand each other's motivation and help each other to achieve their individual goals while respecting their own goals. Principal–agent theory defines the contract as a basis for the risk in an agency dilemma (Brennan et al., 2017, p. 64). Through the contract, the risk is distributed between the parties. A high level of trust, reciprocal cultural understanding, implicit knowledge, and a long-term relationship may reduce the necessity for a formal contract between the parties and allow more fuzzy requirements and thereby more flexibility, new solutions, and increasing development efficiency. Furthermore, Rec 6 and subsequent best practices can help to mitigate Ri 5 (risk of reduced supplier's performance through cultural differences), Ri 8 (risk of lack of motivation in the project teams on ESP side due to inequality), and Ri 10 (risk of losing project performance due to high employee turnover). By reducing the cultural differences, the supplier performance is expected to increase. Understanding each other's goals and cultural backgrounds appears to generate motivation in the whole project team and reduces employee turnover because the employees feel like they are part of a project team and the mutual respect binds the employees to their employer.

In summary, the analysis of the key informant interviews resulted in 37 best practices which are linked to six recommendations under the category of 'people'.

- Rec 01: Define sustainable project teams with a problem-solving attitude
    - BP: ESP to apply talent management strategies, identify key players in project teams, and offer multiple projects
    - BP: ESP to focus their recruitment on flexible, generalist profiles with interdisciplinary competences
    - BP: Change managers who do not want to collaborate in the project
    - BP: ESP to choose project managers who are reliable and authentic
    - BP: ESP to have a mixed business model to secure resources
    - BP: ESP teams to communicate regularly for the best of the customer
    - BP: ESP to define a strong Chief Engineer
    - BP: ESP to have a sales agent who is distinct from the project lead in the project organization
    - BP: ESP to have key roles redundantly occupied
    - BP: Mix of personalities on the project team
    - BP: Nominate a counterpart from both organizations with a communication privilege for each technical subsection

- BP: OEM teams to provide project support with own positive resources if ESP faces problems in the NPD
- BP: OEM to define a lean monitoring organization for projects under ESP lead
- BP: OEM top management to explain to the project team the outsourcing decision before project start
- BP: Strong project leaders on both sides who get along well
- BP: Train people to be consensus-oriented and cooperative

- Rec 02: Provide common project space and promote co-location
    - BP: ESP project management team onsite at OEM, NPD teams at ESP’s development centre and offsite
    - BP: ESP to establish global footprint with locations close to the main customer’s headquarters
    - BP: ESP to define co-location plan for the project
    - BP: Small ESP project space close to the customer's development centre
- Rec 03: Promote frequent communication
    - BP: ESP to ensure very frequent synchro meetings in the beginning
    - BP: ESP management to request meeting discipline
    - BP: Regular joint steering committees with open communication
- Rec 04: Give NPD teams time to integrate on a personal level
    - BP: Appreciation—parties to respect each other as partners
    - BP: ESP to invest in a common understanding and relationship at project start

  - BP: Go on recreational trips together and give room for informal meetings
  - BP: OEM teams to show recognition to ESP teams for their work
- Rec 05: Strengthen long-term relationship between OEM and ESP
  - BP: ESP employees on EoD missions at the customer, before starting big joint projects
  - BP: ESP to arrange lessons learned workshops at the end of each project with OEM
  - BP: Have ex-OEM key players in the ESP organization
  - BP: OEM to choose ESPs with long-term history of turnkey or innovation projects
  - BP: Start collaboration with small NPD tasks
- Rec 06: Align or understand the culture of the participating companies
  - BP: Give all managers the same book on cultural values
  - BP: Establish a common collaboration code
  - BP: ESP to install employees with the cultural background of the region or even the OEM
  - BP: OEM teams to apply appreciation mechanisms and to share their cultural values
  - BP: Teams to be trained in the culture of the partner (intercultural trainings) to understand the other's reasoning

The recommendations have been partly adjusted and mitigate slightly more of the identified risks, as represented in Figure 24.

Risk	Risk		Recommendations from literature and key informants		
	OEM	ESP			
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 05: Strengthen long-term relationship between OEM and ESP		
Ri 2. Risk of agency dilemma	X		Rec 06: Align or understand the culture of the participating companies		
Ri 3. Risk of dependency	X	X			
Ri 4. Risk of changing the set of core competencies	X		Rec 05: Strengthen long-term relationship between OEM and ESP		
Ri 5. Risk of reduced supplier performance through cultural distance	X	X	Rec 01: Define sustainable project teams with a problem-solving attitude	Rec 04: Give NPD teams time to integrate on a personal level	Rec 06: Align or understand the culture of the participating companies
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 02: Provide common project space and promote co-location	Rec 03: Promote frequent communication	
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X			
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X	Rec 01: Define sustainable project teams with a problem-solving attitude	Rec 04: Give NPD teams time to integrate on a personal level	Rec 06: Align or understand the culture of the participating companies
Ri 9. Risk of labour law disputes with ESP employees	X		Rec 01: Define sustainable project teams with a problem-solving attitude	Rec 06: Align or understand the culture of the participating companies	
Ri 10. Risk of losing project performance due to high employee turnover	X	X	Rec 01: Define sustainable project teams with a problem-solving attitude	Rec 04: Give NPD teams time to integrate on a personal level	Rec 06: Align or understand the culture of the participating companies

People

Figure 24: Identified risks and recommendations, adapted by the key informants in the category of 'people'

The above figure shows the risks and recommendations in the 'people' category for collaborative NPD projects under the lead of an ESP as identified in the literature and extended by the practitioner's insights gained through analysis of the key informant interviews.

4.1.2.2 *Process.*

The category of 'process', like the category of 'people', drew ample attention from the key informants. In total, 136 references related to the 'process' category and the recommendation sub-categories were given by all 11 interviewees. This category covers aspects of the NPD and CE processes, collaboration processes, and management processes, and it mitigates the risks Ri 1–7. In the matrix below, the risks and recommendations identified in the literature in this category are depicted:

Risk	Risk Carrier OEM	Risk Carrier ESP	Recommendations from literature			
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 7. Ensure two-way flow of information	Rec 12. Establish efficient knowledge handover processes		
Ri 2. Risk of agency dilemma	X		Rec 8. Apply joint decision-making	Rec 9. Apply right level of control mechanisms		
Ri 3. Risk of dependency	X	X	Rec 9. Apply right level of control mechanisms	Rec 12. Establish efficient knowledge handover processes	Rec 14. Retain relevant NPD tasks internally	
Ri 4. Risk of changing the set of core competencies	X		Rec 10. Align PM practices as well as NPD and CE processes	Rec 11. Involve suppliers in the NPD process early on	Rec 13. Apply strategic ESP involvement process	Rec 14. Retain relevant NPD tasks internally
Ri 5. Risk of reduced supplier performance through cultural distance	X	X	Rec 9. Apply right level of control mechanisms	Rec 13. Apply strategic ESP involvement process		
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 10. Align PM practices as well as NPD and CE processes			
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X	Rec 9. Apply right level of control mechanisms	Rec 10. Align PM practices as well as NPD and CE processes		
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X				
Ri 9. Risk of labour law disputes with ESP employees	X		No recommendation for mitigation found in the literature			
Ri 10. Risk of losing project performance due to high employee turnover	X	X				

Legend: Process

Figure 25: Risks and recommendations identified in the literature review in the 'process' category

The above figure presents a matrix of the risks and recommendations for automobile NPD projects under the lead of an ESP in the category 'process'. Adapted from numerous authors (see Table 3).

Rec 7. Ensure two-way flow of information

Nellore and Balachandra (2001) recommend a two-way flow of information as a success factor in integrated NPD projects. This recommendation was neither explicitly stated in key informant interviews nor did I find any evidence in the case studies that managers consciously apply it. Therefore, no best practices were identified related to this recommendation. Since several recommendations and best practices relate to communication and the exchange of information, I expect this recommendation to be covered by the other recommendations and best practices. Hence, I decided to delete it from the special model for collaborative NPD process under the lead of an ESP.

Thus, the numbering of the following recommendations changes.

Rec 7. Apply joint decision-making

Numerous key informants confirmed the view of Nellore and Balachandra (2001), arguing that joint-decision making is a critical success factor for an integrated product development project. According to the interviewees, this view is confirmed for collaborative NPD projects under the lead of an ESP. A barrier to efficient collaboration in such NPD projects is the long processing time and unnecessarily formal escalation and decision mechanisms. In development projects, the development outcome is not always clear due to the technical uncertainty of the solution. In the development of a series car (here often variant cars), the uncertainty of the development outcome is less evident than in an innovation project. The higher the technical uncertainty, the quicker decisions should be taken. Therefore, to overcome this barrier, the stakeholder parties of the project should **clarify the technical uncertainty and jointly define the escalation and decision paths to be applied at the beginning of the common project**.

> So, there was a lot of escalation. By the way, an escalation process is also a part of it. An escalation process must work. There must be escalation levels and steps. Every problem may not always be carried straight up to the top boss, but there must be escalation levels that are defined in advance. (KI4-OEM)

> Just what was an issue is engineering change management and then later, when it was really about the details, that there exist predefined clear escalation and communication paths. (KI10-OEM)

The second best practice in relation to the recommendation of joint decision-making is the setting up of regular joint steering committee meetings with open communication, as discussed under Rec 3 (frequent communication). This is applicable here as well. The risk of agency dilemma can also be avoided by implementing these best practices since consensus decisions avoid the overreaching of a party, according to the respondents.

Rec 8. Apply right level of control mechanisms

Scholars and researchers recommend that the right level of control mechanisms in collaborative NPD projects should be applied. Harmancioglu (2009) argues that OEMs should prioritize outcome control over behavioural control. This recommendation is expected to mitigate the risks Ri 3 (risk of dependency) and Ri 5 (risk of reduced supplier's performance through cultural differences). The key informants generally agree on this recommendation. While Stephan et al. (2008) argue that the level of control to be outperformed should be in relation to the level of modularization of the product, the key informants argue that the right level of control mechanisms depends on the level of technical uncertainty and the competences of the ESP. For highly skilled ESP companies, less detailed monitoring mechanisms seem to be needed than for lower-skilled ESPs. Furthermore, the more innovative the project is, the more freedom should be given to the development teams to find their own solutions. Moreover, the level of trust or the relationship between the OEM and the ESP seems to play an important role. For less detailed monitoring mechanisms, the OEM teams need an increased level of trust in the development teams of the ESP, as discussed under Rec 5 (strengthen long-term relationship between OEM and ESP). When scholars discuss the level of modularization, they do this in the context of traditional supplier involvement, where a supplier can take over the development of a complete module (Azadegan & Dooley, 2010; Handfield et al., 2000; Harmancioglu, 2009; Stephan et al., 2008). In my understanding, this scheme does not apply to collaborative (variant) NPD projects that have been outsourced to an ESP. When OEMs outsource a complete product development project over all modules along with the integration of the respective suppliers, the level of modularization of the product is likely to be less relevant for the control mechanisms to be applied by the OEM for the ESP. The ESP is responsible for developing the complete product. Modularization might affect the control mechanisms that the ESP has to apply to the component and subsystem suppliers in the projects. KI4-OEM defined the term 'fuzzy efficiency'. According to this theory, fuzziness in the monitoring processes leads to more flexibility and thereby to development efficiency up to a certain point. The optimum of fuzziness is correlated with the innovative challenge of the project. The more innovative the project is, the more fuzziness should be allowed to give more flexibility to the NPD teams. However, a high level of fuzziness in the requirements requires a highly skilled ESP and a trusting customer–supplier relationship.

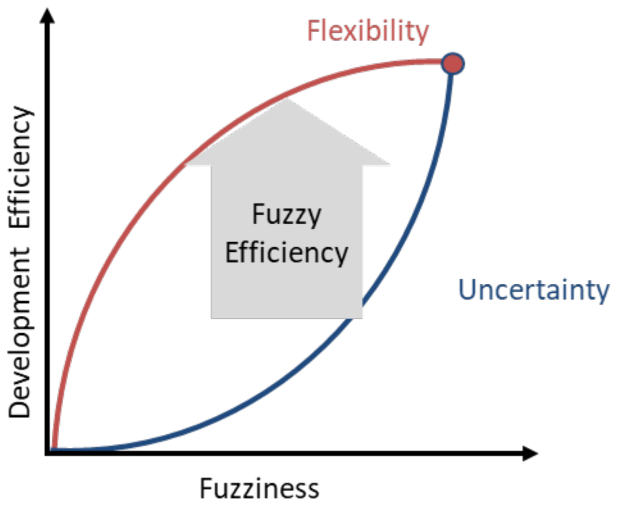

Figure 26: Representation of 'fuzzy efficiency' for projects with different innovation degrees

The above figure presents the concept of 'fuzzy efficiency' as defined by one key informant. Accordingly, increasing fuzziness of specifications leads to higher flexibility of the NPD teams and therewith to increased development efficiency. The optimum of fuzziness depends on the degree of innovation of the respective development project. Adapted from the responses of the key informants.

In general, the respondents agree that OEMs should define in their requirements **what should be developed and not how and that they should adapt the level of preciseness of the requirements to the skill set of the chosen ESP and the technical uncertainty**. Reducing the level of behavioural control mechanisms seems to increase the development performance to a certain extent. The respondents seem to agree with Harmancioglu (2009) and his findings with respect to the case of automotive collaborative NPD with ESPs. 'To specify WHAT I actually want as an OEM is very, very important.' (KI8-ESP)

Consequently, a well-adapted requirement management process shall be applied. The nature of such requirements management has been discussed extensively in various interviews. Not every respondent addressed the topic but the majority at least discussed the barrier of unclear requirements at the beginning of the project. The unclear definition of top-level requirements seems to be a common barrier to efficient collaboration in collaborative development projects under the lead of an ESP.

The interviewees referred in their answers primarily to variant development projects. Software development projects were not addressed explicitly in this context. As discussed earlier, according to the respondents, good requirements management in the context of outsourcing to ESPs means that the **OEM should define high quality top-level specifications before project start**, specifying what should be developed. How it should be developed should be left to the ESP as this may allow the application of new development strategies. The requirements as well as the process models should define what to deliver, when, in which phase, and in what quality, not how the development result should be achieved. Thus, the key informants defined the best practice to perform the steering of the ESP in large project contracts **via clear, predefined KPIs, quality gates, and well-defined SLAs**.

> In the end, if I want to control a supplier at low cost, then I have to give the supplier the greatest possible degree of freedom in the way it performs the

> service. And I can give these degrees of freedom if I describe the performance cleanly with very clear quality and measurement criteria, which have to be provided. Describing this properly and ensuring precision in the description of the expected performance is important. Then I can monitor that via quality gates and KPIs. (KI4-OEM)

> I [OEM] could explain exactly and outline how I would like to have it. Then it will be done according to my request, which is expensive. Or I say, 'You do it the way you think is right, but I want to understand how you do it, and I will look at it to see if it fits the quality.' I would tend to take the second role as an OEM. (KI10-OEM)

According to the respondents, a steering via KPIs in combination with a detailing of the specification in correlation to the level of technical uncertainty and the skill set of the ESP allows the right balance between trust and control. A further best practice supporting the right level of control mechanisms by increasing the level of trust between the companies seems to be for **the ESP to submit a high-quality offer**. In several of the cases reported by the interviewees, the OEM uses the offers of the different ESPs applying for the project and uses these to develop specifications and requirements. This prevents later misunderstandings in the delivery and the quality of the delivery since both parties have an in-depth understanding of what to deliver in what quality before project start.

> The biggest challenge is that everyone involved in the process is well-acquainted with the tasks, their deliverables, the schedule, and the challenges they face. A high-quality offer and a matching workshop to match

> the offered deliveries with the expectations and requirements are a must. (KI5-ESP)

Some of the respondents argue that the ESP needs to be involved in the concept phase to be able to submit a quality offer. This best practice will be discussed in a later section. Two respondents had very good experiences with **a requirements workshop at the beginning of the project**, where the goal was to align the principal's requirements with the agent's offer. These best practices help define a well-adapted development contract between the parties. Synchronized requirements based on a high-quality offer seem to be a good basis for a joint development project. In general, with regard to these best practices, the respondents agree that the parties should invest significant effort in the predefinition of the project. Experience shows that collaborative NPD projects are often lacking in preparation for several reasons, like, for example, a late decision to outsource the development, the reluctance to cooperate with an ESP on the OEM side, lack of involvement in the concept phase, the reluctance of the ESP to invest time, effort, and money in the redaction of a high-quality offer for a project they might not win, and many more. But for success-critical projects, a pre-investment seems to reduce costs in the delivery phase. The ESP management should keep this in mind during their assignment of resources. **An offer winning chance analysis of the current business opportunities and a consequent investment in the offer redaction for the opportunities with the highest award probability** hence might be beneficial for the ESP.

Rec 09. Align PM practices as well as NPD and CE processes

Together with Rec 1, this recommendation gained the most attention from the experts in the key informant interviews and the highest number of best practices were identified in relation with it. The 11 interviewees referred to this recommendation a total of 63 times. Rec 9 is, among others, expected to mitigate Ri 4 (risk of changing the set of core competencies), Ri 6 (risk of reduced development project performance through geographically dispersed project teams), and Ri 7 (risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty). Scholars in the field identify the misalignment of NPD processes as very common, which can lead to significant inefficiency in the NPD (Mishra, 2009; Schneider, 2011; Tang & Qian, 2008; Tripathy & Eppinger, 2007; Wang et al., 2010). The respondents (particularly the OEM respondents) defined the barrier of organizational misalignment, as discussed under 'people'. OEMs being commodity-oriented and ESPs being project-oriented leads to inefficiency if the NPD process and the PM practices are not well aligned and predefined (Mishra, 2009). Together with the identified barrier of incoherent project planning, which appears relatively often, these two barriers often seem to lead to project failure.

> OEMs are typically not—I say it very provocatively—not good project companies. Because they are big, have established processes, outstanding areas where they have gained a lot of experience, where a lot of development can be made through delta-requirements that I can copy and paste. So, the need to really define a project, to define it as such, is not that big. [...] Therefore, the control of an external is rather difficult for OEMs. (KI8-ESP)

> This is more in the direction of process and organization. We always have a challenge. The OEM always organizes itself in very component- or function-oriented way, but then over several series or several vehicles. Take this typical example: The one who does the mirrors makes it over several vehicles at an OEM. When we [ESP] undertake variant development projects, we usually have to put our responsible project supervisors to work differently. Our guy then has to take over the exterior mirrors and other exterior parts, so that this control function is even worth having. This is a mismatch, which has been a huge problem for every project so far. Because we went there and said: 'Yes, this is our head of the exterior, he makes all the exterior parts.' And at the OEM, the counterpart makes only one exterior part on all cars. (KI9-ESP)

The lack of transparency in the OEM's decision-making bodies and escalation paths seems to be a common problem in collaborative NPD projects under the lead of an ESP. The ESP becomes, for a limited period of time, an outsourced R&D department of the OEM. If the project members do not explicitly know what to report to whom in the course of the project, a loss in efficiency seems to be the logical consequence. Therefore, the majority of the respondents stated that **a clear definition of the roles and responsibilities in the project initiation phase** is a success factor. The key informants recommended the creation of an RACI chart as early as during the offering phase of the ESP. This is a methodology to define responsibilities in which, for each task or work product, the **R**esponsible, the **A**ccountable, the **C**onsulted, and the **I**nformed persons are defined. Such an explicit definition of responsibilities and information flows at the beginning of the project seems to have a very positive impact on NPD performance.

> Project planning is coordinated at the beginning and is realistic if all boundary conditions are met. Since the boundary conditions are not met, the planning is actually no longer realistic but must still be implemented. This often makes the project life difficult. (KI8-ESP)

> There are already some topics. And the committees within the OEM landscape have not been making life easier in the last few years either. Sometimes, from my perspective, the guys are more in the way with all their reporting boards and voting rounds than they can do a purposeful job somewhere. (KI5-ESP)

> So that roles are clearly defined, roles and escalation paths. Who escalates with whom to which body and when. Yes, internally, externally, between partners and so on. I have had good experiences with RACIs—whatever you want to call it, responsible, accountable, and so on. […} But there were already clear tasks and role distributions and they were not always consistently defined at every level. Also, it was not always without overlap and not known to all people and not always implemented. The classic syndrome actually. (KI10-OEM)

If this is not covered at the beginning of the project, the ESP teams or the **ESP project management should push strongly to create a common understanding of the roles and responsibilities and especially the project planning**, even if the OEM middle management is reluctant to define it clearly. Because collaborative NPD projects are highly complex social systems, the OEM and ESP respondents agree that an unclear situation on who is responsible for what will lead to a poorer collaboration performance.

> In the beginning, the OEM often lacks the internal communication of this task responsibility. (KI9-ESP)

> And that the ESP creates a clear understanding with the OEM about who does what until when. (KI5-ESP)

> What is extremely important is defining what information is transmitted to which person at what time. That's just a big part of the processes. (KI7-ESP)

This view confirms the view of Nellore and Balachandra (2001). Nellore and Balachandra found in their study on factors influencing success in integrated product development that project management in collaborative NPD projects ‘may have to be on equal footing with line management’ (Nellore & Balachandra, 2001). The key informants noted the best practice of **investing a significant amount of project resources in the creation of a common understanding in the project initiation phase** (two respondents said that both parties should invest 30 per cent of the available project resources on the creation of understanding in the first months of the project). These synchronization meetings should take place in a neutral place, close to the OEM’s premises and ideally in the common project area, as discussed.

> In the initial phase of a partnership, you should at least commit 30 per cent of your resources to gaining a common understanding. (KI4-OEM)

A common ontology seems to be of utmost importance. Hence, a **project dictionary or project wiki should be created and maintained that is accessible to every project member**.

> A very accurate assignment, and above all, questioning and tracing, or cross-checking the definitions is absolutely necessary. (KI1-ESP)

> I need a common ontology. I need a common conceptual world and a common world, along with the connections between the concepts and the relations. And this starts with a common vocabulary. (KI4-OEM)

Discussing the NPD process with a focus on variant development, especially the ESP informants introduced the best practice that an **ESP should maintain its own flexible and generic NPD process model that can be adapted to the requirements of the respective customer**. As per their argumentation, an ESP should have its own NPD process office for explicitly documenting processes and the particularities of the different major customers. This best practice generates an explicit understanding of the customer's processes. The ESP teams can identify particular difficulties in the NPD process of a specific customer, ensure that the interfaces are well-defined, and train the employees on the process.

> So my deep conviction is that the ESP needs its own development process to do that. Then, if I say adapting to the customer process, then it has a whole range of design options. In one embodiment, the complete product development process of the customer is adapted. This is necessary for companies that work very strictly according to these processes. (KI1-ESP)

And the gain in efficiency only comes into play if you have your own PDP [product development process], which nevertheless satisfies the exact requirements but also gives you leeway on the economic side. […]. In other words, there are very extensive and very complex, say, project management tasks. And as [ESP], we have founded a so-called project office. This is an organization where all [ESP] super project leaders are based, the managers who can lead large, double- or triple-digit million-euro projects. They sit in this organizational unit and are also managed in it with a direct link to the CEO. And with them their staff, their colleagues with the whole tooling and process documentation: 'How do I do that? How do I set up a steering committee? How do I do small topics up to the big overall vehicle project? How do I manage it?' The deciding factor is that the employees and small project leaders are also trained in the basic understanding. That is, this must basically be a separate area to train such complex relationships. This can only be done in a separate organization. That's why we have this project office built up as a kind of home for the large project managers and their staff—they are now not talking about what are you doing at [OEM1]? Or what are you doing at [OEM2]? But in particular they take care of process improvements. So, they define the content of this [ESP] product development process and think about the questions of the most complex kind. […] That means I have to look at the [Japanese OEM] development process, compare it with [German OEM] or whoever, and I have to find my best way. In the end, best practice means transferring the best elements of the customer worlds to my [ESP] PDP. (KI2-ESP)

> And now you [OEM] give a complete vehicle outside and now the service provider suddenly stands there. It has a lot of developers who can develop components very well, but only the components. They cannot get a complete vehicle out. That's why an ESP engineer needs a good understanding of the product development process. He only gets that if his company has its own model—well-copied from the OEMs of course—but his own generic model, on which he can train his people. In nuances there are differences between the OEMs. But I keep hearing that when I discuss with the suppliers: Once you get right how one OEM develops, you can transfer it to the other one. That's alright. (KI3-OEM)

> The service provider needs a PDP. And I want to tell you why. He does not need a PDP because he is better or because he is great or because he can help the OEM improve his PDP. He needs a PDP simply because he needs a scaffolding and drawers where he can bring in his experiences. (KI8-ESP)

Interestingly, all the key informants agree that the **macro process model applied in the project** should be from the **OEM.** The ESP resources should keep in mind the particularities of the respective OEM and flexibly adapt to them. The ESP managers can offer proposals to improve the process landscape, but imposing a process model on the OEM seems out of the question, at least for established OEMs.

> In the case of the established ones, you are extremely dependent on their process. Of course, at brand new OEMs, you are completely free. [laughs] They are happy when you bring in your processes. But in the classic and big

> German OEMs, they are very process-sensitive and impose their process, which you have to have internalized. (KI9-ESP)

> In terms of process, the best thing is when the OEM puts his processes on the table and says 'These are my processes'. (KI3-OEM)

Thus, before starting a specific project, the ESP engineers should undergo a crash course in the NPD process of the customer they will be working work for. The **training of ESP engineers in NPD process models** gained much attention. All the key informants agreed that the leading process model, which defines what to deliver in the development of a variant, should be the process model of the OEM.

> It is important in such a training process that you come here and say, 'I now have two quality gates. The two quality gates, I'm thinking, what does the employee need to do at these two quality gates?' (KI3-OEM)

> Not only do I need know-how from the technical side but also the complete process and product lifecycle know-how of the OEM. The ESP needs it. It needs a complete understanding of the development process at the OEM. (KI6-ESP)

> It is definitely an advantage if the ESP knows the processes of the customer. And it also adapts to these processes. (KI7-ESP)

> On the service provider side, the customer knowledge in the sense of customer processes, knowing the customer's IT systems, and the corresponding decision-making networks are of fundamental importance if you want to carry out large projects successfully. (KI9-ESP)

> Process know-how. The process know-how is today the key factor par excellence. (KI2-ESP)

Especially the ESP respondents but also one OEM respondent stated that the OEM should define the interfaces in its process model and let the ESP work out specific sub-processes in its own process and using its own development tools. Here, the feedback of the respondents varied. OEM R&D managers want to stay in control of the development and therefore mostly did not talk about opening up the NPD process. The ESP counterparts and one OEM manager with a process and management perspective said that the ESP should be free to work in its own sub-processes for particular NPD activities, such as, for example, in simulation or engine application. In this sub-process, the ESP should develop with its own tools since the organizations have found this to be a best practice that increases development efficiency. This recommendation will be further discussed under ‘collaboration technology’. Even if the CE process models of the different OEMs appear similar, the particularities of each OEM organization seem to apply. For example, OEMs whose leadership is in technology or quality seem to invest more time and effort in innovation, verification, and validation, and having a more flexible budget, whereas OEMs with a cost leadership appear to place more value on time to market and in the cost delivery of the development. An engineer working for different OEMs must know the particularities of each OEM in order to avoid the delivery of over- or under-quality. This is especially true for established OEMs. For emerging OEMs, an ESP is expected in most cases to provide an NPD process as part of the project contract. Thus, in new markets, an own internal NPD process can be a selling point for an ESP.

Hence, a central NPD process department or project management office was recommended by nearly all informants for leading ESPs. One respondent recommended placing the project managers in such a project management department where the personnel managing the big and critical projects have a direct reporting line to the CEO. A clear differentiator for an ESP seems not only to be the technical qualifications but especially also the project management skills. The ESP management should place significant attention on **developing strong project management skills in the organization**.

> Yes, project management is extremely important. I have to say this as a project manager. BUT it is not paid for by the customer. The customer requires project management but it may not appear in the budget actually. This easily becomes blocking. (KI7-ESP)

> The ability to have good predictability in project management, to create transparency in the project. I think this is also the most important contribution the service provider has to bring—where he can, in my view, be better than the OEM. (KI8-ESP)

> Such a development service provider has a great and powerful coordinating role. That means if I'm a development service provider and also want to look at efficiency, then I have to invest a lot of time, money, and effort in my people and in my processes in the sense of controlling such a project. I believe that real project management is an important key. (KI10-OEM)

Moreover, ESPs have a special role in developing products for their customers. The ESP steers the subsystem suppliers without having a contractual relationship with them. This can lead to a loss in efficiency since the suppliers might not follow the instructions of the ESP without a formal confirmation by the end-customer, which is the OEM. Best practices to overcome this barrier will be discussed under Rec 14 (joint supplier management process). Nevertheless, process alignment best practices have been identified by the respondents to increase NPD performance in this context. **The ESP should strengthen its cost engineering process and align it to that of the OEM.** ESPs that have their own generic database for cost engineering can provide an important added value for an OEM.

> Then I think also of value chain knowledge, despite engineering knowledge and similar things. I think back on my experience from the [OEM] time, working with ESPs. When it came to costing a component 10 or 15 years ago, at the time, you caught them more or less on the left foot if you requested a cost analysis from ESPs. Today, this is one of the basic things an ESP has to bring along. (KI1-ESP)

A further barrier to the collaboration in such outsourced NPD projects, as identified by the industry experts, is the lack of a budget for project management activities at the ESP. When making a request for a proposal, OEMs tend to define a budget for the technical development but do not define a budget for the management activities, which too are outsourced to the ESP. According to the respondents, the OEM management thereby tries to save money on the wrong end. In the absence of a budget for project management activities, the ESP will try to reduce such management activities to a minimum, which could lead to a significant decrease in efficiency and eventually generate more sunk cost for the OEM. Therefore, the majority of the respondents agree that **an aligned budget for project management should be granted to the ESP**. A further best practice to gain NPD efficiency seems to be **jointly defining the documentation and reporting structure at the beginning of the project** and making this structure explicitly accessible to every project member who needs it.

> If I do not understand the documentation structure, that's the biggest challenge of all and the biggest difference in the OEMs. We see that wonderfully in our cooperation projects. You cannot say as a service provider, ‘Ah, wonderful. I have my structure. And I put it all in my structure. And when I'm done, I transfer everything to the structure of the OEM.’ That doesn't work. I have to agree beforehand on the documentation structures. Where and how do I want to document? (KI6-OEM)

The IT reporting platform on which the development results should be documented will be discussed in greater detail under ‘collaboration technology’.

The best practices outlined above mitigate particularly Ri 7 (risk of increased transaction-cost diseconomies of the collaboration through the high level of technical uncertainty) since they allow efficient NPD work by the ESP. Furthermore, Ri 6 (risk of reduced development project performance through geographically dispersed project teams) is reduced. As discussed, ESP teams working off-site may even lead to an increase in NPD efficiency if the best practices noted already are applied. The discussed findings support and extend the views of researchers in the field of automotive NPD in the context of process alignment (Mishra, 2009; Schneider, 2011; Tang & Qian, 2008).

To outsource turnkey projects to ESPs, especially focussing on variant development, the respondents discussed intensively the monitoring processes applied by the OEM. The **implementation of a matrix organization at the OEM with a project-oriented process model** seems to be positively correlated with NPD efficiency in collaborative projects.

> It was a prerequisite that it goes along the [OEM] process. […] The right success factor for me would be to be very good in the processes of the OEM, but also to make it clear where the interfaces in my process are, where I let someone else run, where I do not care about which process he uses to do that, so to speak. So, identify interfaces and let the service provider do the sub-processes in his way to be more efficient. (KI10-OEM)

The commodity orientation should be reduced at OEMs. When taking an outsourcing decision, every commodity should be committed and accept the decision. OEM-internal disagreement between the different commodities seems to be common and it may negatively impact the performance of the ESP. Furthermore, the OEM managers pointed out the best practice to **define and maintain a specific process model or guideline for technical departments to monitor ESPs**, taking into account that this form of outsourcing has significantly gained in importance over the last two decades. Two OEM respondents argue that OEMs should **establish a dedicated staff function for monitoring outsourced NPD projects**. This finding is also supported by Wolff (2007), who researched collaborative NPD strategy in the automotive industry.

By implementing these best practices, OEMs can focus on their core competences while monitoring the outsourced development in a lean way and thereby mitigate Ri 4 (risk of changing the set of core competencies).

> We still have a commodity-oriented release, a component-oriented release. So, there is a fender developer and he releases his fender. It does not matter if it was developed by him or by the service provider. However, you can already see a change coming. That one says: ‘No, we actually make this release as a total release. We're releasing this car as an overall project.’ And that is what makes it just a bit difficult in this phase of change. Of course, you do not want 200 component developers to sign off a service provider project. It is clear. Actually, I would like to have a project organization that can sign off this service provider project, release the complete vehicle, and say, ‘Wonderful, everything is alright’. (KI6-OEM)

According to one respondent who has a software and IT background, especially in case of software development projects, OEMs should **award projects to ESPs with a similar or the same process maturity level**, which should be rather high. This best practice seems applicable particularly to software development projects. Aligning the process maturity seems to decrease transaction-cost diseconomies, since the capability of the service provider is assessed beforehand and allows a judgement of whether the ESP is capable of coping with the technical uncertainty. A mitigation of Ri 7 thus seems to be supported by aligned process maturity.

> For a good collaboration, they must have a common level. Let me give you an example: It does not help at all if the client does a project management with

local heroes in a software development project and the partner has ASPICE Level 5. I can only do something with a high-level partner if I have it myself. And that's why in collaboration, the topic of standards is so important to me. Standards not only in terms of IT but also in process agreements and in the sense of a common understanding of the objects. So scientifically, I need a common ontology. (KI4-OEM)

Rec 10. Early involvement of suppliers in the NPD process

Rec 10 emerges from the theory of ESI and is not necessarily applicable to the outsourcing to ESPs. Nevertheless, especially the key informants working for ESPs suggested that involving the ESP in the concept phase of the product can be positively correlated to later development efficiency. This is especially valid in the case of variant development. When an ESP is awarded a project that involves the development of a new technology in which the innovation degree is high, the ESP is by definition involved in the concept phase. A common barrier discussed by the respondents is the missing availability of the top-level requirements of the product at the beginning of the project. According to the majority of the ESP respondents, the series development of a variant is often supposed to start when some of the concept decisions are still open. The key informants vouch for **selecting ESPs that are most likely to be awarded with variant developments and to involve them in the concept definition of the lead car and of the respective variant** in order to avoid a content break.

The ESP must be in the concept phase of the global platform in order to gain knowledge about the product and to understand the challenges. (KI11-ESP)

> At the first concept decisions. They should include the development service provider, if you then want to transfer the series development to him. In other words, if I want to hand over a variant to an ESP, then I have to take it into the concept phase. Otherwise, there will be a break in content. (KI2-ESP)

Such early involvement allows the ESP teams to assess the feasibility of the endeavours and thus to prepare a more reliable offer for the variant development.

> Usually that is the case. And our experience is quite good if, at this stage, in this conceptual phase, and ultimately in the definition phase, we are already supporting the OEM. Because we then have the advantage that we can estimate much better if what we want to do is realistically feasible and adjust our offer. (KI9-ESP)

This approach is expected to prevent later disputes on the contractual obligations and to increase thereby the development efficiency of the ESP. Also, two OEM respondents had good experiences with the ESP managers being involved in the concept definition of the car to be developed. The ESP managers in this case do not have any decision power but they sit next to the OEM concept designers and learn about the product idea, the challenges, and the desired development outcome. 'The concept development was at [OEM] in-house. And the [ESP] people sat with them. Very effective…' (KI10-OEM)

This best practice consequently generates a certain dependence of the OEM on the chosen ESPs who are involved in the concept phase. According to the respondents, implementing such an approach makes a switch of the supplier after the concept phase more difficult and expensive. Thus, it limits the degrees of freedom of the OEM. But the advantage of increased development efficiency seems to outweigh this potential dependence. In general, a joint concept definition under the lead of the OEM seems advantageous for collaborative NPD projects and can mitigate not only Ri 4 (risk of changing the set of core competencies) but also Ri 10 (risk of agency dilemma) by enabling the ESP to prepare a better offer document and thereby improve the contractual basis. In general, the key informants seem to support the view of Quesada et al. (2006) and van Echtelt (2007), arguing that a strategic supplier involvement process should be applied and suppliers should be involved in the NPD process early on.

The management of component and subsystem suppliers by the ESP is discussed in a later section.

Following the recommendations of the interview partners, I chose to slightly change the wording of Rec 10 to the following:

Rec 10. Early involvement of strategic ESP partners in the concept design

Rec 11: Establish efficient knowledge handover processes

ESPs are challenged to hand over the IP during and after the NPD project to ensure customer satisfaction. The business model of ESPs is to innovate for their customers. Therefore, scholars argue that efficient knowledge handover processes are of utmost importance for collaborative NPD projects (Azadegan & Dooley, 2010; Rundquist & Halila, 2010; Wolff, 2007). This category did not draw much attention in the interviews. Only one interviewee, the CEO of a leading German ESP, focussed partly on this topic. After a thorough analysis of the interviews and the answers, I assume that the interviewees either take efficient knowledge handover processes for granted or implicitly include them in the alignment of PM practices, NPD and CE processes, and IT systems, and this is why they did not elaborate on knowledge handover processes. KI5-ESP argued that the OEM and the ESP should define the control points together. At these control points, the handover of the IP will take place. This best practice is covered by the joint definition of the documentation and reporting structure at the beginning of the project, as discussed under Rec 9. According to KI5-ESP, the **ESP should define the test and verification planning for variant development and the OEM teams should execute or participate in the validation of the final product** by conducting the test drive campaign.

> I do not know of a project where the OEM would not have been interested in what's going on for over 24 months, or maybe even longer. They keep asking questions. They are constantly checking. And some OEMs build very clearly defined control points in a project because they can easily check at the site if the project is going in the right direction with the service provider. A classic

> example of this is the final vehicle testing. I know a lot of projects where the test design and the whole validation planning was done by the ESP, but the actual test was done by the OEM. Because if I take the vehicle and do the tests myself, then I know if the thing holds and it can give me a first-class impression of the development result without being obliged to go through all the calculations and without having to look through the construction. If the car is on the test bench and all test cases have been defined properly, I know where I am. (KI5-ESP)

This enables the OEM to assess right away if the development outcome satisfies the quality specifications or if changes must be made. For variant development, this best practice might be effective and can be considered for further research. With the rise of efficient knowledge handover processes, which seem to be covered in part by the alignment of PM practices and NPD and CE processes, Ri1 (risk of losing know-how, tacit knowledge, critical information, and IP) and Ri 3 (risk of dependency) are expected to be mitigated for OEMs. The alignment of IT systems and PLM systems, as recommended by Katzenbach (2015) and Bautzer (2005), is discussed in the category of ‘collaboration technology’.

Rec 12. Apply strategic ESP involvement process

A strategic supplier involvement process seems to be positively correlated with the NPD performance in collaborative NPD projects in general (Handfield & Lawson, 2007; Lakemond et al., 2006; van Echtelt et al., 2007). The specific case of outsourcing to an ESP has not been discussed in the literature but the majority of the key informants confirmed the necessity of a specific outsourcing strategy to ESPs.

According to the practitioners, OEMs should define a strategic outsourcing roadmap, so that the ESPs have the possibility to prepare for these projects.

> Then I realize that there are always individual actions. Instead of setting up a fundamental make-or-buy strategy where I say, 'These kind of projects, I never do them myself. And to outsource these projects, I have certain requirements.' (KI8-ESP)

Even if ESP companies seem flexible, project-oriented companies, the provision of a 'ready-to-go' development team for a significant project in the short term remains an important challenge, according to the key informants. 'The problem is that service providers are often awarded with unclear ideas on the OEM side.' (KI4-OEM)

Furthermore, two ESP respondents outlined the barrier that a successful project team dissolves if no follow-up project is given to the ESP. A dependency for both parties can thus not be completely avoided, but the application of an ESP involvement process can help reduce the risk.

> The OEM always has incredible problems to ensure subsequent projects. And then, they are surprised, if after a year, when nothing comes, why the team is distributed in all countries of the world. [...] Of course, you always have to face the price competitions. No question. But it makes sense for both to get more continuity in there. To think about a common roadmap. (KI9-ESP)

The key informants identified the barrier of the OEM's procurement team taking too long to award the project. Such delayed contracting may lead to a poorer development performance and a potential delay in the delivery, which can have a significant negative financial impact, according to the respondents. An additional barrier identified by the respondents, especially by the ESP respondents, is the non-fulfilment by the OEM teams of boundary conditions or contractual premises which had been agreed upon in the project contract beforehand. According to the respondents, the ESP teams often lack material, information, and software versions at the beginning of the project which were to be provided by the customer. This is known to hinder the development progress and thereby decrease NPD efficiency.

> The reactivity of the procurement actually delays the project from the beginning. Most of the times, the project deadlines are barely feasible because the awarding is done at a time when the project should have been started long ago. This is not due to the procurement 100 per cent. It is mostly also the technical department, because they do not finalize the specifications in time. […]
>
> What massively blocks the work and what is always a challenge is the following: Assumptions that have been agreed to in the contract are not respected. You make an offer and say you want to do that and you need that and that input condition. It could be information. It could be material. Only in rare cases or never, these input conditions are completely fulfilled by the OEM. (KI7-ESP)

A strategic ESP involvement process can also provide support in overcoming this barrier since an explicit definition of the input deliveries would be provided to the OEM R&D teams in such a process. According to the majority of the respondents, an **aligned commitment of all OEM technical departments for the outsourcing decision** can help to overcome such barriers and mitigate the linked risks. According to the key respondents, **OEMs should start building up strategic partner ESPs in order to have a choice of reliable partners for collaborative NPD projects**.

> That's this [OEM] learning. We took a look at this project one-off and did not think about the time afterwards. And you always have to look at the long-term somehow and create a partnership which is long-term. (KI10-OEM)

This best practice seems to have been introduced by the procurement departments of the OEMs since these functions have experience in the strategic management of suppliers. The strategic identification and assessment of ESP partners also supports the mitigation of the barrier of non-capability of the ESP to deliver the wished-for development outcome. Three OEM respondents referred to variant projects they have experienced in their career in which an ESP was chosen for financial reasons. The chosen ESP was eventually unable to deliver a series mature development outcome. In these projects, the OEM teams had to step in and take over the development since the SoP had to be held. This led to additional effort by the OEM teams and was in the end more expensive for the respective OEM than choosing a capable ESP right away. **A regular capability assessment of the strategic ESPs** seems necessary for the implementation of a strategic ESP involvement process. As discussed, in the special case of ESPs, OEM technical departments seem partly reluctant to outsource significant NPD projects since they would prefer to build up the resources in-house. Therefore, in most of the cases, respondents noted the lack of a strategic outsourcing roadmap. According to the majority of the respondents, OEMs would benefit from the **definition of a long-term technical roadmap about**

which products are going to be outsourced and which products are going to be developed in-house.

> Yes. But in terms of technology, an absolute necessity that I see is making early and open exchanges between the desired roadmap, the manufacturer's technology roadmap, and the options and technology portfolios seen by the ESP. Such an approach is really good from my point of view. At a very early stage, or in a very long-term perspective, there must be regular discussions in this direction. From my time on the OEM side, I've always been pushing hard for [OEM] to release the power-train roadmap confidentially to the strategic ESPs. (KI1-ESP)

> So, the first story is that we have to create the consensus on which variant is mandated where. We need a strategic decision. Because we also have our own capacities. One should not forget that. […]That's why we also need strong lead car organizations that do this relatively early. So, it's best to start in the architectural phase. To say, ‘Okay. So we have this architecture and we want to have these cars on it. This is when we should define, which variants we outsource.’ […] At the time, we had a share in the [major car model] of 30–35 per cent own to 65 per cent externally developed. But this is a vehicle for which the architectural design was launched in 2010, for example. Today, for the new [major car model], we make, say, 80 per cent ourselves, and only 20 per cent we outsource. This is on the base vehicle. But for the variant, where another hat comes on this architecture, we make only 20 per cent

> ourselves—the design, the specifications, and maybe some tests—and 80 per cent, we outsource. (KI6-OEM)

To support the OEM in this activity, several key informants noted the need for **a key account in the ESP sales organization that is dedicated to a specific OEM**. This person or team should provide support in the creation of a joint technology roadmap and work closely with the technical departments of the OEM in order to improve the OEM's trust in the competences of the ESP. Two OEM respondents stated in this context that OEMs should focus on their **lead cars in order to increase the vertical development integration** and outsource a big share of the variant developments. They argued that with increasing digitalization of the NPD process, IP protection would no longer be possible. Therefore, OEMs should define strategic partners in ESPs and **give them full access to the development repository of the specific product, allowing the ESP to work efficiently within the systems of the OEM**.

> Yes, it's really not a joke. It's almost the only way to open all up, to give full access. Because the problem is that these security hurdles at the interfaces will ultimately spoil your efficiency. (KI6-OEM)

> Basically, many systems will eventually be open for the ESP, but they have not been made for it originally. This has to be looked at in a strategic manner. (KI9-ESP)

Keeping the lead cars in-house can also be a motivational factor for the OEM's internal R&D teams because they would remain responsible for the development of the main products. Also, in this context, **the need to start a relationship with an ESP**

with smaller NPD tasks in order to build up implicit knowledge and trust was confirmed. Both the ESP and OEM respondents noted the benefits of a strategic partnership and the consequent increased level of trust. This supports the mitigation of Ri 3 (risk of dependency) and Ri 5 (risk of reduced supplier performance through cultural differences).

Rec 13. Retain relevant NPD tasks of the OEM internally

According to my findings from the literature review, this recommendation is intended to mitigate Ri 3 (risk of dependency) and Ri 4 (risk of changing the set of core competencies), as argued by Takeishi (2002). The topic did not draw much attention from the key informants. To my understanding, the top management respondents consider, to some extent, that outsourcing to ESPs is akin to keeping the NPD task in-house. Only two respondents noted this explicitly. KI7-ESP, a senior project leader at an ESP, stated that he sometimes faces problems in finding a counterpart at the OEM R&D department to assess the development outcome in niche topics like engine application. KI6-OEM mentioned the term ‘mobile phone engineering’, stating that the engineers risk losing the necessary competencies to assess a supplier’s performance since they no longer develop themselves but only coordinate the development of suppliers. He defined the best practice for the OEM as **keeping the lead car development in-house and only outsourcing variant developments,** which has been discussed under Rec 12 (apply strategic ESP involvement process). The risk of thereby changing the set of core competencies does not seem evident to the practitioners or is considered to be mitigated through a strategic ESP involvement process. The retention of the lead car development in-house and the increase in the vertical development integration for this NPD would lead to a competence increase along the whole value chain at the OEM and thereby mitigate the risk of (technical) dependency for the OEM. Hence, I decided to consider this recommendation as covered by Rec 12, particularly the best practice to define a long-term technical insourcing and outsourcing roadmap.

Consequently, the numbering of the recommendations changes and the number 13 is given to the next recommendation.

Rec 13. Apply joint supplier management process

For the special case of collaborative NPD projects under the lead of an ESP, in which the ESP takes over the system integrator role of the OEM, an additional risk and barriers were identified by the respondents. Especially in the case of variant development, the ESP and OEM respondents identified a risk in relation to supplier management. The ESP is fully responsible for the development outcome but the subsystem suppliers have no contractual relationship with the ESP. Therefore, the respondents identified Ri 11 (risk of reduced development efficiency due to unclear supplier steering mechanisms and lacking supplier management competence at the ESP). In my career as a project leader and senior manager of leading ESPs, I too have faced related problems in projects under the lead of an ESP. The suppliers were in many cases reluctant to talk to the project management of the ESP, preferring to negotiate or discuss only with their contracting party—the OEM counterparts.

> The biggest problems we [ESPs] have is usually with suppliers, because they are rarely fully commissioned for the things the ESP expects from them. And

> if one expects any changes from a supplier, he says, 'I have no order for that.' Then you are blocked in the project and it will not continue. You have to go back to the OEM to see how to get this regulated. Then the OEM has to motivate the supplier to do it anyway, with or without money [...]. (KI5-ESP)

Therefore, the respondents recommend setting up a joint supplier management process for outsourced projects in order to overcome the barrier of missing communication between all stakeholder parties, the barrier of reluctant suppliers causing a project delay, the barrier of doubling the management structure at the OEM and the ESP for supplier management leading to increased cost, the barrier of non-involvement of the ESP in the supplier sourcing process, leading to reduced quality, the barrier of missing power of the ESP for negotiating engineering changes with the supplier, leading to decreased NPD efficiency, and the barrier of underqualified subsystem or component suppliers around the world, which can lead to project failure.

> Automotive standards that are considered normal in Europe have not yet been established everywhere. I can remember a project: I was traveling in Brazil quite intensively. [OEM] sourced suppliers who had never delivered a part to them. And quality standards from [OEM] were completely unknown to them. That means we did not just have to develop a product with them, but we also had to do some kind of quality education, which actually cost us more sweat than the actual product it was about. (KI5-ESP)

Hence, a joint NPD supplier management process for the specific NPD project in which the ESP has a system integrator role seems beneficial for NPD efficiency. The majority of the respondents confirmed these problems and noted that good experiences were made through an **official statement of the OEM sent to all suppliers involved in the NPD process, in which the OEM delegates the power of the development officially to the ESP as the prime contractor**.

> The purchasing negotiations are completely done by [OEM]. We have some kind of power of attorney from the purchasing department of [OEM] to the supplier that we have the authority to give instructions and that they have to work together with us. This is not the perfect solution, but it helps. (KI7-ESP)

According to the respondents, implementing this best practice improves collaboration with the suppliers, even if there is room for further improvement. The steering and the management of suppliers is a challenge for ESPs. Especially the ESP respondents emphasized in the interviews that it is of strategic importance for ESPs that want to play a role in this consolidating market **to develop supplier management competences and good knowledge about local component and subsystem suppliers around the world**.

> It's true that suppliers are standardizing their processes globally, but working with suppliers in India is still different from working with the same suppliers in North America or Europe. And here the issue is, in my view, with big project contracts. So, it is necessary for the larger projects that the ESP develops competence here. Whether that competence is just collaboration or even managing sourcing activities and negotiations depends very much on the size of the OEM you work with. But these are the areas of expertise that an ESP absolutely has to expand. (KI1-ESP)

> As an ESP, I have to manage the different relationships with subcontractors. So, I have to have very good people who can do that—both relationship management and supplier management. (KI10-OEM)

The respondents agree mainly that the ESP and the OEM should sit together and find a joint process for how the management of the subsystem suppliers can be handled when the variant development is outsourced. The modularization of the product is an advantage here as it facilitates the definition of the areas of responsibility. As mentioned, OEMs try to use a maximum of identical parts from one car model to another. According to the respondents, the share of carry-over parts in a variant development can be over 90 per cent. Therefore, the number of suppliers that is affected with an engineering change of their part is limited and the management of this limited number of suppliers can also be outsourced to the ESP. If the ESP is involved in the architectural concept design, as discussed, the **ESP should also be involved in the sourcing of the suppliers for the specific variants**. This would allow the ESP teams a better understanding of the decisions and thereby better steering of the suppliers.

> The smartest thing would be that all stakeholders and all contact persons sit together around the table and agree on the development of the product. Unfortunately, in my experience, the OEM massively blocks direct contact with the suppliers for reasons that may be diverse. (KI1-ESP)

The prices paid by the OEM for the different parts are highly confidential since the prices provide a competitive advantage. ESPs can offer support in cost engineering if they have their own reliable database, but price negotiation is normally a core competence of the OEM. Therefore, OEM procurement departments are reluctant to share price information with the ESP. This makes the management of the part suppliers more difficult. A common practice is for the **ESP to perform delta price negotiations with the supplier and get the final confirmation from the OEM**. Only two interviewees explicitly pointed out this best practice. As I am familiar with this approach through my experience as a project leader, I intend to see whether it was applied in the analysed project case studies. According to the interviewed business leaders, the management of the suppliers should be done through regular supplier meetings in which a representative of the OEM participates only if necessary. The delegation of power allows the ESP project management to speak in the name of the OEM. Thus, according to the respondents, **the OEM and the ESP must determine thresholds or limits before the start of the project in which the ESP may move and, if exceeded, obtain the OEM's consent**. These best practices were mainly noticed by ESP respondents. Only one OEM respondent indicated that such an approach leads to an efficiency increase. I believe that respondents on the OEM side do not see such problems since the ESP teams usually find a solution to handle the management of suppliers. Nevertheless, the ESP respondents are convinced that the OEM taking the right precautions for supplier management would improve the efficiency of the ESP and would lead to a better pricing for the OEM.

The above findings are in line with recommendations from the theory of ESI but are adapted to the special case in which an ESP takes over the development of a product or a technology for its customer as a general contractor. The early involvement of all suppliers in the NPD process is positively correlated to NPD efficiency and effectiveness, according to numerous scholars (Lakemond et al., 2006; Oh & Rhee, 2010; Rundquist & Halila, 2010). An ESP as a general contractor increases the complexity in the supplier networks and the management processes should therefore be defined jointly, as outlined above. This special aspect of collaborative NPD projects with an ESP as a general contractor might benefit from further research projects.

In summary, the analysis of the key informant interviews resulted in 33 best practices linked to seven recommendations for the 'process' category.

- Rec 07: Apply joint decision-making
    - BP: Clarify the technical uncertainty and jointly define the escalation and decision paths to be applied at the beginning of the common project
    - BP: Regular joint steering committees with open communication
- Rec 08: Apply right level of control mechanisms
    - BP: ESP writes high-quality offer, which can be transformed in requirements
    - BP: ESP performs an offer winning chance analysis of the current business opportunities and a consequent investment in the offer redaction for the opportunities with the highest award probability
    - BP: OEM steering via clear, predefined KPIs, quality gates, and well-defined SLAs
    - BP: OEM to define quality top-level specifications before project start

    - BP: OEM to define what should be developed and adapt the level of preciseness of the requirements to the skill set of the ESP and the technical uncertainty
    - BP: Offer and requirements workshop at the beginning of the project
    - BP: Establish a dedicated staff function for monitoring outsourced NPD projects
- Rec 09: Align PM practices as well as NPD and CE processes
    - BP: ESP PM to insist on a common understanding of project planning and responsibilities
    - BP: ESP to develop strong project management skills
    - BP: ESP to train its employees in customer NPD process
    - BP: ESP to maintain an internal, flexible NPD process model, adaptable to the requirements of OEM, managed by a central department
    - BP: ESP to strengthen its cost engineering process
    - BP: Implement a project dictionary or wiki that can be accessed by every project member
    - BP: OEM and ESP to jointly define documentation and reporting structure at the beginning of the project
    - BP: OEM and ESP to clearly define the roles and responsibilities in the project initiation phase
    - BP: OEM and ESP to invest a significant amount of the project resources in the creation of a common understanding in the project initiation phase

  - BP: OEM macro process model to be applied in the project
  - BP: OEM to award projects to ESPs with a similar or the same process maturity level
  - BP: OEM to provide an aligned budget for project management to the ESP
  - BP: OEM to implement a matrix organization with a specific project-oriented process model to monitor ESP
- Rec 10: Early involvement of strategic ESP partners in the concept design
  - BP: OEM to involve ESPs considered for serial development in concept phase
- Rec 11: Establish efficient knowledge handover processes
  - BP: ESP to define the test and verification planning and the OEM teams to execute or participate in the validation of the final product
- Rec 12: Apply strategic ESP involvement process
  - BP: All technical departments of the OEM should jointly commit to the outsourcing decision
  - BP: OEM to define a long-term insourcing and outsourcing roadmap and involve strategic ESPs
  - BP: ESP to define a key account organization for each customer
  - BP: OEM to accept that IP protection is no longer possible and give access to ESP
  - BP: OEM to focus on lead car development in order to increase the vertical development integration

  - BP: OEM to perform regular capability and process maturity assessment of the strategic ESP
  - BP: OEM to build up strategic partner ESPs in order to have a choice of reliable partners for collaborative NPD projects
  - BP: Start relationship between OEM and ESP with smaller NPD tasks to gain implicit knowledge
- Rec 13: Apply joint supplier management process
  - BP: ESP to perform delta price negotiations with supplier and confirmation by the OEM
  - BP: ESP should have supplier steering competencies
  - BP: OEM to give an official statement to all suppliers involved in the NPD process, delegating the power of the development officially to the ESP as prime contractor
  - BP: ESP to develop supplier management competences and have good knowledge about the local component and subsystem suppliers around the world
  - BP: OEM to involve ESP in the sourcing of the suppliers for the specific variants
  - BP: OEM and the ESP to determine thresholds or limits before the start of the project in which the ESP may move

The recommendations have been partly adjusted and mitigate slightly more of the identified risks, as represented in Figure 27.

Risk	Risk Carrier		Recommendations from literature		
	OEM	ESP			
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 11: Establish efficient knowledge handover processes		
Ri 2. Risk of agency dilemma	X		Rec 07: Apply joint decision-making	Rec 08: Apply right level of control mechanisms	Rec 10: Early involvement of strategic ESP partners in the concept design
Ri 3. Risk of dependency	X	X	Rec 08: Apply right level of control mechanisms	Rec 11: Establish efficient knowledge handover processes	Rec 12: Apply strategic ESP involvement process
Ri 4. Risk of changing the set of core competencies	X		Rec 09: Align PM practices as well as NPD and CE processes	Rec 10: Early involvement of strategic ESP partners in the concept design	Rec 12: Apply strategic ESP involvement process
Ri 5. Risk of reduced supplier performance through cultural distance	X	X	Rec 08: Apply right level of control mechanisms	Rec 12: Apply strategic ESP involvement process	
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 09: Align PM practices as well as NPD and CE processes		
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X	Rec 08: Apply right level of control mechanisms	Rec 09: Align PM practices as well as NPD and CE processes	
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X			
Ri 9. Risk of labour law disputes with ESP employees	X				
Ri 10. Risk of losing project performance due to high employee turnover	X	X			
Ri 11. Risk of reduced development efficiency due to unclear supplier steering mechanisms and lacking supplier management competence at the ESP	X	X	Rec 13: Apply joint supplier management proc		

Process

Figure 27: Identified risks and recommendations, as adapted from the key informants in the 'process' category

The above figure shows the risks and recommendations in the category 'process' for collaborative NPD projects under the lead of an ESP identified in the literature and extended by the practitioner's insight gained through analysis of the key informant interviews.

4.1.2.3 *Collaboration technology.*

In this section, I discuss the best practices identified in the key informant interviews concerning the category of 'collaboration technology'.

The 'collaboration technology' category garnered less attention from the key informants than the preceding two categories. In total, 28 references were made by nine of the 11 interviewees in relation to the 'collaboration technology' category and the recommendation sub-categories. This category covers IT systems, PLM systems, communication technology, and access rights, among others. Based on my conclusions from the literature review, the related recommendations mainly address the risks Ri 1, Ri 6, and Ri 7.

Figure 28 outlines the recommendations found in the literature and that are linked to the respective risk that the recommendations address.

	Risk Carrier		Recommendations from literature		
Risk	OEM	ESP	Rc1	Rc2	Rc3
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 15. Continuously improve IT solutions and integrate legacy systems with modern solutions	Rec 16. Provide common IT environment and align IT systems	Rec 17. Perform NPD work in closed-loop PLM system
Ri 2. Risk of agency dilemma	X				
Ri 3. Risk of dependency	X	X			
Ri 4. Risk of changing the set of core competencies	X				
Ri 5. Risk of reduced supplier performance through cultural distance	X	X			
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 15. Continuously improve IT solutions and integrate legacy systems with modern solutions	Rec 18. Have modern communication technology at hand	
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X	Rec 17. Perform NPD work in closed-loop PLM system	Rec 18. Have modern communication technology at hand	
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X			
Ri 9. Risk of labour law disputes with ESP employees	X		No recommendation for mitigation found in the literature		
Ri 10. Risk of losing project performance due to high employee turnover	X	X			

Collaboration Technology

Figure 28: Risks and recommendations identified in the literature review in the 'collaboration technology' category

The above figure presents a matrix of the risks and recommendations for automobile NPD projects under the lead of an ESP in the category of 'collaboration technology'. Adapted from numerous authors (see Table 3).

Rec 14. Continuously improve IT solutions and integrate legacy systems with modern solutions

Surprisingly, this recommendation was mentioned by only two OEM respondents and KI5-ESP. Before analysing the interviews, I expected that the ESP respondents would complain about the IT systems they find at OEMs and request improvement, but this was not stated in the interviews. The only barrier that partly related to Rec 14 was the barrier of missing access to the IT systems at project start. Furthermore, one respondent noted that the OEM PLM systems are initially not designed for external access and there could be improvements in this direction.

> If one does not have access, for example, to the [OEM1-PLM], where all the data is stored, or if one cannot connect to [OEM2] at [PLM Tool] where all the data is stored there, or he cannot deliver there, or cannot get the appropriate information out of it. This time is a big problem which we face way too often. (KI5-ESP)

KI4-OEM claimed that OEMs should continuously improve their IT systems. KI4-OEM, in addition to working for an OEM, is a well-recognized academic in the fields of NPD processes, PLM, and IT systems for NPD. KI4-OEM confirmed that the OEM PLM system should cover the documentation of the development outcome and the complete macro NPD process. Therefore, OEMs are challenged to **integrate legacy systems into the closed-loop PLM systems and to define clear interfaces and templates, allowing suppliers to submit their development result efficiently**.

'We need to integrate the legacy systems and grant access to the suppliers with a suitable access rights management. I think we are well-advanced in this field at [OEM].' (KI4-OEM)

KI-4 OEM also confirmed the barrier of access management for OEM external parties. KI6-OEM noted the barrier of slow data transfer for development models (CAD models or similar) which are large in size. He claims that **OEMs should establish fast secured data exchange models**, allowing all parties to work on a live model from anywhere in the world. Moreover, the participants agree on the barrier of access management.

'We need faster data exchange and that completely. So not only the CAD data, but also the so-called knowledge-based engineering, so our templates, our specifications, everything.' (KI6-OEM)

Therefore, professional, well-managed access management could have a positive impact on NPD efficiency. These best practices follow Rec 14 and can support the mitigation of Ri 1 (risk of losing know-how, tacit knowledge, critical information, and IP).

Even if Rec 14 has not been discussed intensively by the key informants, the findings are in line with the argumentation of Katzenbach (2015), who states that processes and IT solutions have to be improved continuously to allow for efficient NPD.

Rec 15. Provide a common IT environment and align IT systems

Rec 15 gained the most attention in the interviews in the 'collaboration technology' category. Scholars mostly agree that collaborative NPD projects should be carried out in the same IT environment (Katzenbach, 2015; Vasilash, 2009; Wang et al., 2010). The interviewees also mostly agree that a closed-loop PLM system is advantageous for NPD projects in general. Moreover, the business leaders interviewed are generally convinced that only an OEM is able to provide such an integrated PLM system and therefore outlined that the NPD should be documented in the OEM PLM systems. Several respondents disagree that the ESP should have its own internal PLM system. One KI2-ESP explicitly stated that ESPs are challenged to build up their own PLM systems to be able to completely take over the development of a car and to ensure traceability of the development steps that the ESP carries out. According to three OEM respondents, OEMs will never allow development in foreign systems for the main product. Since cars are safety-relevant products, OEMs are subject to strict documentation and development traceability obligations. Furthermore, in the CE process of an OEM, other functions which are not managed by the ESP often need access to the development data even in the development phase. For example, the production process planning requires access to the CAD drawings to prepare the tooling. If the ESP were to develop its own separate PLM system, the development efficiency would most likely decrease. Thus, according to the OEM respondents and several of the ESP respondents, despite the statement of KI2-ESP, OEMs will always have a tendency to retain the development environment in-house and manage the access of the suppliers to it. Developing its own PLM infrastructure might therefore be an unnecessary investment for an ESP. Also, I work as a managing director for a European leader in engineering and consulting, and we decided against investing in our own PLM system. Therefore, in the context of collaborative car variant development projects under the lead of an ESP, I expect it to be a best practice **to document the whole development in the PLM system of the OEM**, even if not all the research participants agree. Nevertheless, the ESP must ensure that it receives regular exhaustive data downloads of the current development state. In case of disputes with the customer, it would be disadvantageous for the ESP to have no documentation of its deliverables.

In case of pure software development, the tool landscape seems less important since the development outcome is purely digital and can be transferred more easily to other tool environments, independently of the toolchain in which it has been developed. A best practice identified here is for the **ESP to maintain a performant toolchain, which would allow it to develop the software efficiently.** Moreover, the majority of the respondents stated that NPD efficiency could improve if the **ESP carried out special development tasks in which the ESP is particularly qualified in its own tool environment**. In practice, ESPs often use their own tools and IT environments for testing, engine application, simulation, and CAD. Such an approach is welcomed by the OEM senior management, provided that the ESP is trusted, reliable, and applies good configuration management.

> Yes, certainly, when we talk about turnkey projects. Once you have agreed with the OEM to use the tools that the service provider usually uses, then it is not contradictory to use them in the OEM development process and in its PLM as well. […] Because, let's say, as far as tools are concerned, service providers are more concerned about using tools than the OEM itself and simply have the more efficient ones. (KI7-ESP)

Following the recommendations of the key informants, ESPs should **invest in their own software tools, focussing on configuration management and special NPD tasks** like simulation or engine application in order to support the OEM in its attempt to digitalize the development process. Having assumed that the NPD should completely take place in the PLM of the OEM, I reached the conclusion that Rec 15 can be combined with Rec 17 (NPD in a closed-loop PLM system with digitalized NPD process). All statements in Rec 14 and Rec 15 implicitly confirm this recommendation. KI6-OEM explicitly stated that the **OEM must provide a closed-loop PLM system with clear documentation rules which are always available**. He referred to an example in the OEM company (among the top five European OEMs in terms of sales revenue) he worked for as the leader of R&D for all car chassis and bodies. This company decided to change its CAD software system and accept all the consequences (training of several thousands of engineers, change of documentation, short-term loss in NPD efficiency, significant change management cost) to make it compatible with the documentation system and the rest of the PLM environment. This is a big investment for the OEM but the company benefits from a streamlined NPD and production tool environment. Hence, Rec 15 and Rec 17 are combined to form the following:

Rec 15. Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side

The best practices identified by the respondents in this sub-category are expected to support the mitigation of Ri 1 (risk of losing know-how, tacit knowledge, critical information, and IP), Ri 6 (risk of reduced development project performance through geographically dispersed project teams), and Ri 7 (risk of increased transaction-cost diseconomies of the collaboration through the high level of technical uncertainty). The importance of a closed-loop PLM system for increased NPD efficiency has also been discussed in the literature (Wang et al., 2010). The case of ESPs has not been looked at in this context in the literature. Hence, the key informants provided clarifications and additional insights to this discussion.

Consequently, the numbering of the recommendations changes.

Rec 16. Have modern communication technology at hand

This recommendation is expected to support the mitigation of Ri 1 (risk of losing know-how, tacit knowledge, critical information, and IP), Ri 6 (risk of reduced development project performance through geographically dispersed project teams), and Ri 7 (risk of increased transaction-cost diseconomies of the collaboration through the high level of technical uncertainty). Only two ESP respondents explicitly addressed the topic, stating that **modern mobile phones and video chat tools support collaboration in such a project**. KI7-ESP mentioned the barrier of loss of efficiency because of bad email behaviour. According to him, too many unnecessary emails are sent. Therefore, he strongly recommends reducing the number of emails by implementing proper documentation and configuration management tools, as stated under Rec 15. Since I spoke only to key informants from big and wealthy companies, I assume that the respondents take the equipment of employees with modern communication technology for granted and therefore did not address the topic explicitly. Nevertheless, I believe that the recommendation is valid and a collaborative NPD project without sophisticated communication technology available would see a significant impact on its NPD efficiency.

Furthermore, I assume that the conclusion based on the literature review can be confirmed: Rec 16 supports the mitigation of Ri 6 and Ri 7.

In summary, the analysis of the key informant interviews resulted in seven best practices that are linked to three recommendations (after the consolidation of two recommendations) for the category of 'collaboration technology'.

- Rec 14: Continuously improve IT solutions and integrate legacy systems with modern solutions
    - BP: OEM to establish fast secured data exchange models
    - BP: OEM to integrate legacy systems into the closed-loop PLM systems as well as define clear interfaces and templates
- Rec 15: Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side
    - BP: ESP to carry out special development tasks in which the ESP is particularly qualified in its own tool environment
    - BP: ESP to invest in own software tools, focussing on configuration management and special NPD tasks
    - BP: ESP to document the whole development in the PLM system of the OEM
    - BP: ESP to maintain a performant software development toolchain
    - BP: OEM to provide a closed-loop PLM system with clear documentation rules which are always available

- Rec 16: Have modern communication technology at hand
    - BP: Provide project team with modern communication technology (video chat, smart phone, exchange servers, etc.)

The recommendations have been partly adjusted and mitigate some more of the identified risks, as represented in Figure 29.

Risk	Risk Carrier		Recommendations from literature	
	OEM	ESP	Rc1	Rc2
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 14: Continuously improve IT solutions and integrate legacy systems with modern solutions	Rec 15: Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side
Ri 2. Risk of agency dilemma	X			
Ri 3. Risk of dependency	X	X		
Ri 4. Risk of changing the set of core competencies	X			
Ri 5. Risk of reduced supplier performance through cultural distance	X	X		
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 14: Continuously improve IT solutions and integrate legacy systems with	Rec 16: Have modern communication technology at hand
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X	Rec 15: Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side	Rec 16: Have modern communication technology at hand
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X		
Ri 9. Risk of labour law disputes with ESP employees	X			
Ri 10. Risk of losing project performance due to high employee turnover	X	X		

Collaboration Technology

Figure 29: Identified risks and recommendations, adapted from the key informants in the 'collaboration technology' category

The above figure presents the risks and recommendations in the 'collaboration technology' category for collaborative NPD projects under the lead of an ESP identified in the literature and extended by the practitioner's insights gained through analysis of the key informant interviews.

4.1.2.4 *Product technology.*

In this section, I discuss the best practices identified in the key informant interviews in the category of 'product technology'. Within this category, I tried to summarize recommendations and best practices that are associated with the technology used in the product and the innovation degree.

The 'product technology' category garnered the least attention from the key informants. In total, 19 references were given by eight of the 11 interviewees in relation to the category and the linked recommendation sub-categories. When analysing the interviews, it became clear to me that the interviewees focussed their answers on the outsourcing of car variants to ESPs. The technology involved and the complexity of the product are well-known to the interview partners. OEMs and ESPs seem to be in control of such outsourcing projects. Hence, I assume that the respondents did not focus their answers on this category. Software development projects have very rarely been addressed. Only KI4-OEM addressed this matter owing to an IT and software development background. Nevertheless, the key informants who commented on topics in this category mainly confirm the recommendations identified in the literature (Stephan et al., 2008).

Figure 30 presents the recommendations found in the literature along with the associated risks.

Risk	Risk Carrier		Recommendations from literature	
	OEM	ESP		
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X			
Ri 2. Risk of agency dilemma	X		Rec 21. Award projects to ESPs with high technical skills	
Ri 3. Risk of dependency	X	X		
Ri 4. Risk of changing the set of core competencies	X			
Ri 5. Risk of reduced supplier performance through cultural distance	X	X	Rec 21. Award projects to ESPs with high technical skills	
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 21. Award projects to ESPs with high technical skills	
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X	Rec 19. Outsource the development of modularized systems	Rec 20. Clearly define the borders and interfaces between modules or subsystems
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X		
Ri 9. Risk of labour law disputes with ESP employees	X		No recommendation for mitigation found in the literature	
Ri 10. Risk of losing project performance due to high employee turnover	X	X		

Product Technology

Figure 30: Risks and recommendations identified in the literature review in the 'product technology' category

The above figure presents a matrix of the risks and recommendations for automobile NPD projects under the lead of an ESP in the 'product technology' category. Adapted from numerous authors (see Table 3).

Rec 17. Outsource the development of modularized systems

Based on my analysis of the current body of knowledge (Stephan et al., 2008; Waltl & Wildemann, 2014), I expect this recommendation to mainly mitigate Ri 7 (risk of increased transaction-cost diseconomies of the collaboration through the high level of technical uncertainty). For variant development, the key informants confirmed that modularization of the product is advantageous for NPD efficiency. In the automotive industry, modularization is a critical success factor because it allows companies to derive variant cars from the lead car with reduced additional development effort. Furthermore, OEMs tend to outsource the development and production of complete subsystems to Tier 1 suppliers. For example, gearboxes are no longer developed by the OEM itself in many cars; instead, they are produced by a Tier 1 supplier. According to KI1-ESP and KI11-ESP, the important challenge for OEMs is to build up centres of competencies for the several subsystems around the world and modularize the engineering packages.

> OEMs have become globalized in the sense that these processes have been unified in terms of equal work packages, equal development steps, and equal maturity levels throughout the development process, across all regions of the world. Aiming at the enormous diversity of products traditionally developed in the automotive industry, an engine used in Europe has no relation whatsoever to what has been used in North America. This has been standardized accordingly. The entire standards, work packages, the quality goals, at the various levels of integration. Everything has been standardized with the aim of being able to modularize, to be able to exchange components, to continue using components of these subsystems. [...] Here, for example, a big requirement is that the OEM also modularizes engineering packages. You will not be able to afford to be located worldwide and have the complete competence in every location. And then they need to be able to put together

> technology packages or development packages. So, combustion development takes place at one site, mechanical development at another site, and integration of the whole into a product at the site where the customer desires. ESPs have to anticipate this and follow their customer. (KI1-ESP)

The modules and their interfaces must be defined in such a way that different modules developed around the world can be integrated into a new product for a specific market in a development centre far away from the commodity development centre or even outside the OEM organization. Therefore, according to KI11-ESP (former member of the board and head of R&D of a major automobile manufacturer), not only does the product have to be modularized but also the NPD and production processes. Hence, the **OEM must remain responsible for the definition of the system structure (modularization) and the interfaces** as well as the **modularization of engineering packages along the NPD process which can be localized in NPD centres** working in a closed-loop PLM system that is accessible around the world.

> The OEM has the control authority. It must determine the modularity of product and process—the system boundaries. (KI11-ESP)

> The OEM is always responsible for the system. It has to hand over the vehicle to the customer at one point in time. And that's why all the interfaces are actually the main task for an OEM. It needs to get the interfaces under control. Because therein lie the most pitfalls. I'll give that to the system supplier. I'll give that to the service provider. That's very easy to do. But to

> have an interface analysis and the know-how, where do I actually want to go with my vehicle? What do I want to block [define as carry-over part]? Why do I want to block it? These things still have to stay with the OEM and they will not be outsourced by the OEM. (KI3-OEM)

For the special case of the automotive industry, where deep experiences in outsourcing and modularization exist, I therefore concluded that Rec 17 can be combined with the recommendation of clear definitions of the borders and interfaces of the subsystem to form:

Rec 17. Outsource NPD of modular engineering packages with clearly defined interfaces and borders

According to the respondents, this recommendation and the identified best practices support the mitigation of Ri 7 (risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty) and Ri 1 (risk of losing know-how, tacit knowledge, and critical information). Since the OEM remains responsible for the system definition, through modularization, OEMs can reduce the Ri 3 (risk of dependency), when outsourcing to a module or component supplier. This does not apply for the outsourced development of a variant, where the supplier is an ESP action as the system integrator.

Rec 17 is focussed on the development of cars. No respondent commented on collaborative NPD of (software) innovations in the context of product technology. This will be discussed in the second case study in Chapter 0.

Rec 18. Award project to technically highly skilled ESP

A high technical and process skill set has been confirmed by nearly all the key informants as a premise to give the lead of a variant development or a technology innovation project to an ESP. This is in line with the opinions of several scholars who argue that OEMs should carefully choose highly skilled suppliers for collaborative NPD projects (Gassmann et al., 2004; Handfield et al., 2000; Lakemond et al., 2006; Wolff, 2007). Thus, the consolidation currently going on in the ESP market, as discussed in Sections 1.2 and 2.2.3, is considered by the respondents as being supportive of the improvement of the NPD efficiency of ESPs. According to the OEM respondents, OEMs are looking for ESPs that can be developed into strategic partners. For a strategic partnership, an ESP must be able to provide the OEM with significant added value and not just flexibility in resources. Thus, according to the respondents, **ESPs are challenged to invest in innovation**.

> So, it is precisely this speed to build up know-how, which is actually an essential requirement for an ESP, because it enables it to differentiate itself from its competitors and the company can make itself interesting for its customers. Therefore, a development service provider should invest at least five per cent of its revenue in innovation projects, which it then uses for sales approaches. (KI2-ESP)

> The ESP has to invest anyway because, at least from my point of view, it is the foundation of a technology-driven or innovation-driven ESP to drive the innovation. Now, I can manage these innovations so that they are customer-relevant, or they are not yet customer-relevant. Not that the topics are now far off, but if I research for something that is 10 years ahead, but my customer

> has a need five years from today to have a product on the market, then you have a mismatch. And if you control the whole thing from the point of view of business, there must, in my view, be a thematic and temporal comparison between self-research and the customer's innovation roadmap. (KI1-ESP)

Several ESP respondents referred to the best practice for the ESP to develop concept study cars as technology carriers with its own innovations built into it. This would demonstrate the innovation power of the ESP. Such investment in innovation should be synchronized with the innovation roadmap of the customers. Therefore, if OEMs want to benefit from the innovation power of their ESP partners, the key informants largely confirm the necessity to share the innovation roadmap. As discussed, OEMs should regularly assess the innovation power of the ESP landscape, which would allow them to choose the most preferred strategic partners. This may also increase the level of trust in the technical capabilities of the ESP. As pointed out under 'process', the maintenance of an ESP-internal generic and flexible NPD process model seems also to be positively correlated with NPD efficiency because the ESP teams have therewith a basic process model for training purposes that they can use to increase their technical capabilities. A topic which was discussed in different contexts is that of IP. The key informants confirmed that ESP companies also transfer implicit knowledge between the OEMs, thereby helping to cross-fertilize innovation, promote network effects, and increase the innovation power of the whole industry. Nevertheless, ESPs have to protect explicit IP that they develop for a customer directly. According to the key informants, successful ESPs demonstrate the highest integrity and confidentiality when it comes to concrete IP. Thus, **ESPs should**

implement formal mechanisms to protect the IP of their customers. Strict separation of project repositories, access to the right management, security barriers between the different project spaces, and non-disclosure agreements with the employees are only some examples of the mechanisms that are applied in the industry. The higher the innovation degree of the projects is, the more an ESP should master such instruments.

> That means I see two opposite things. On the one hand, making know-how available, which is a very special task of the ESPs. Every ESP lives from that very well. The other is the secrecy of the custom solution or the IP. (KI1-ESP)

According to the key informants, a transfer of knowledge which is in the heads of the engineers cannot be avoided. But since it is implicit knowledge, the OEM respondents seem to be more in favour of such a transfer than trying to prevent it. As IP is difficult to protect nowadays, the IP protection mechanisms applied by the ESP are a trust-building measure. OEMs and ESPs are challenged to develop quickly in order to retain the innovation lead.

> I translate again what the consulting company would say: 'Hey, I'm here now because I work with the others too, but I make sure that what they tell me is specific and you will not know that. And they will not know what is specific to you. I am here to guarantee from what I have learned from all that I develop the best solution for you.' (KI10-OEM)

In summary, the respondents agree that because the technical complexity of the product is high, the ESP should be highly skilled in the complete automotive NPD process. Recognition of this technical competence by the OEM can be supported by competence demonstrators, like concept cars and the like, and integration of the strategic ESPs into the R&D roadmap of their customers could be favourable with respect to the innovation power of the OEMs. IP protection plays an important role but the transfer of implicit knowledge is welcomed by all the interviewed OEM and ex-OEM managers. A high skill level of the ESP in technical and process matters, as well as with respect to IP protection mechanisms, is expected to increase the level of trust at the OEM organization in the ESP, thereby improving their relationship and mitigating Ri 2 (risk of agency dilemma), Ri 5 (risk of reduced supplier's performance through cultural differences), and Ri 6 (risk of reduced development project performance through geographically dispersed project teams).

Overall, the analysis of the key informant interviews resulted in four best practices that are linked to two consolidated recommendations for the category of 'product technology'.

- Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders
    - BP: OEM to modularize engineering packages along the NPD process, which can be localized in NPD centres
    - BP: OEM to remain responsible for the definition of the system structure (modularization) and the interfaces
- Rec 18: Award projects to technically highly skilled ESP
    - BP: ESP to implement formal mechanisms to protect the IP of their customers

- o BP: ESP to invest in innovations synchronized with the innovation roadmap of the customers and demonstrate innovation power

The recommendations have been partly adjusted and mitigate some more of the identified risks, as represented in Figure 31.

Risk	Risk Carrier		Recommendations from literature
	OEM	ESP	
Ri 1. Risk of losing know-how, tacit knowledge, critical information, and IP	X		Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders
Ri 2. Risk of agency dilemma	X		Rec 18: Award projects to technically highly skilled ESP
Ri 3. Risk of dependency	X	X	Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders
Ri 4. Risk of changing the set of core competencies	X		Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders
Ri 5. Risk of reduced supplier performance through cultural distance	X	X	Rec 18: Award projects to technically highly skilled ESP
Ri 6. Risk of reduced development project performance through geographically dispersed project teams	X	X	Rec 18: Award projects to technically highly skilled ESP
Ri 7. Risk of increased transaction-cost diseconomies of the collaboration through high level of technical uncertainty	X	X	Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders
Ri 8. Risk of lack of motivation in project teams on the ESP side through remuneration inequality with OEM teams	X	X	
Ri 9. Risk of labour law disputes with ESP employees	X		
Ri 10. Risk of losing project performance due to high employee turnover	X	X	

Product Technology

Figure 31: Identified risks and recommendations, adapted from the key informants in the 'product technology' category

The above figure presents the risks and recommendations in the category of 'collaboration technology' for collaborative NPD projects under the lead of an ESP identified in the literature and extended by the practitioner's insight gained through analysis of the key informant interviews.

4.1.3 Conclusion on key informant interviews.

In summary, the key informants largely confirmed the internal and external motives identified in the literature. The analysis of the interviews allowed adaptation of the internal motives. Analysing the interviews and writing up the findings made it possible to arrive at a conclusion on the different internal motives and a linkage to the identified forms of cooperation between the OEM and the ESP. The external motives are very generalist and, therefore, valid for all types of cooperation models. Following the indications of the key informants and the literature, an OEM manager who wants to outsource to minimize or restructure costs might prefer the cooperation model of variant NPD as this could increase NPD efficiency. If an OEM manager seeks specific knowledge or wider experience and knowledge, the preferred role for the ESP would be as an innovation partner. When looking only for additional capacity and flexible resources, awarding the ESP with EoD contracts might be the best solution. When spreading entrepreneurial risks is the main motive, a project contract for variant development might be the most suitable. In order to achieve a change in quality, outsourcing in the form of an outsourcing contract of a special activity or of an innovation project might be the answer. For the purpose of building up talent benches as recruiting channels for the OEM, EoD contracts are probably a good choice. And an OEM that wants to focus on its core competencies or major projects will most probably outsource the development of product variants or outsource less strategic innovation projects to ESPs, provided that the ESP hands over the IP after the project properly.

In Figure 32, I illustrate these findings. The figure extends Figure 6 with the identified motives and suitability of the ESP's role. Using this figure, an OEM manager who knows the internal motives of the OEM can derive indications about which outsourcing form might be the best choice for the OEM.

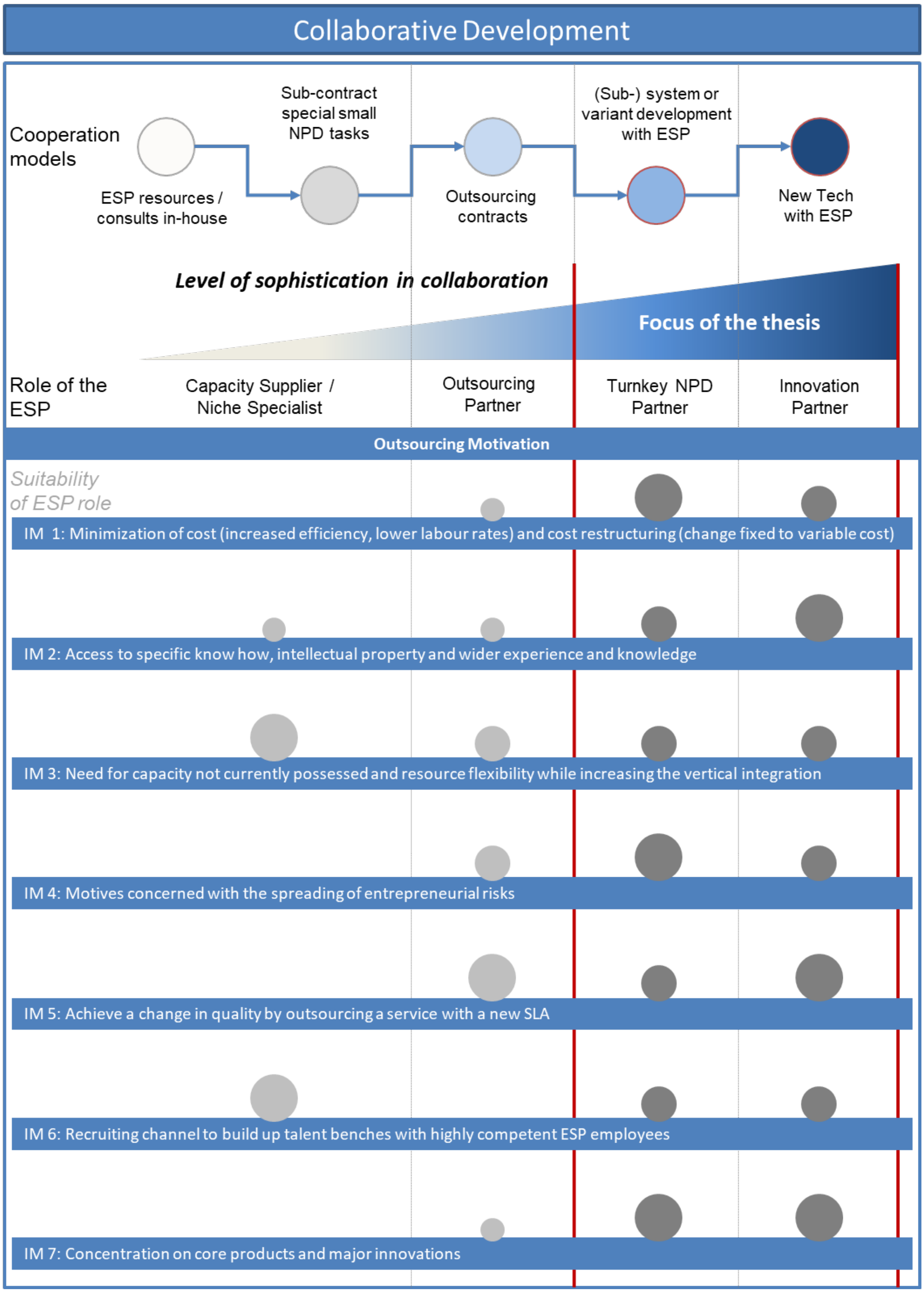

Figure 32: Cooperation models, roles of ESPs in outsourced NPD, and suitability of ESP role to outsourcing motivation

The above figure shows the change in cooperation models between ESP and OEM in automotive NPD. Furthermore, the suitability of the respective cooperation models with respect to internal motives for outsourcing is illustrated. Adapted from numerous authors (see Figure 6) and analysis of the key informant interviews.

The recommendations found in the literature were adapted partly according to the answers of the respondents. Furhtermore, the answers of the respondents were translated into concrete best practices which should be applied in significant collaborative NPD projects under the lead of an ESP. A part of the best practices must be carried out by the OEM in the project, another part is the responsibility of the ESP, and a third part should be executed by both parties. Based on the knowledge I gained in the literature review, in the key informant interviews, and through my project management and ESP expierience, I assigned the identified best practices to the identified cooperation models and checked if they are applicable to this model. The interviewees discussed mainly variant development projects in the interviews. Therefore, most of the identified best practices are applicable to such projects. I believe that most of the best practices are also applicable to significant joint (software) innovation projects. In the second case study, I look for evidence to support this assumption or to change and extend the found best practices for this type of project.

Based on the gathered knowledge, I developed Figure 33, which should provide an overview of the recommendations and the best practices executor in a cooperation project. It can be discerned that the found best practices are most suitable for the two cooperation models in the focus of the thesis. Nevertheless, I expect several best practices also to be applicable to other forms of outsourcing. However, because these cooperation models are not the focus of this study, I expect the best practices not to be exhaustive and assume that other best practices apply in such cooperation models.

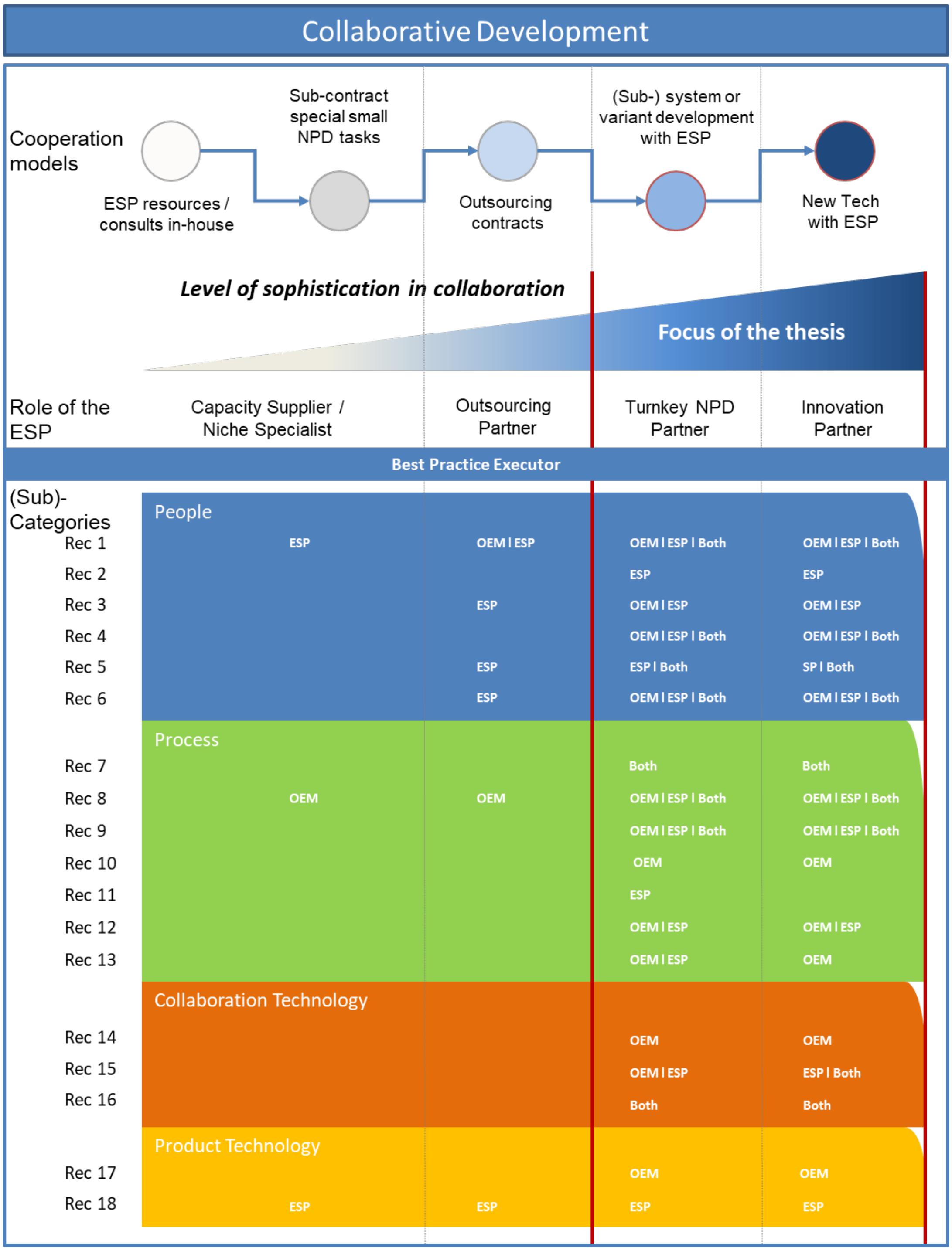

Figure 33: Cooperation models, roles of ESPs in outsourced NPD, and the assigned best practice executor

The above figure depicts cooperation models between OEMs and ESPs, and the role ESPs play in such cooperation models. Moreover, the executor of the found best practices categorized by recommendations is illustrated. Adapted from numerous authors (see Figure 6 and the results of key informant interviews).

The identified barriers to successful collaboration are summarized in the table below.

Category	Identified barrier	Negative Consequences		
People		Cost	Time	Quality
	ESP employees being hired by the OEM when they have proven themselves	X	X	
	Non-integration of ESP employees in the OEM's work process, due to labour legislation	X	X	
	Reluctance of OEM teams to collaborate with the ESP teams	X	X	
	Reluctance of ESP managers to build up resources, if no follow-up project is guaranteed		X	X
	Missing trust	X	X	X
	Key players switching to the OEM	X	X	
	Successful project team disperses, if no follow-up project is given to the ESP	X		X
	Missing communication between all stake holding parties		X	
	Cultural differences	X	X	X
	Local distance between the OEM R&D centre and the ESP front office	X	X	
	Missing meeting discipline	X	X	
Process				
	Commodity-orientation of OEMs versus project-orientation of ESPs	X	X	
	Inefficient or no knowledge-hand over process	X		
	Incoherent project planning	X	X	X
	Unclear definition of top level requirements	X	X	X
	Misalignment of NPD process	X	X	X
	Delayed awarding decision by the procurement of the OEM		X	
	Non-fulfilment of boundary conditions or contractual premises, by OEM	X	X	
	Tier suppliers reluctant to collaborate with ESP	X	X	X
	Doubling management structure at OEM and ESP for supplier management	X		
	Non-involvement of the ESP in the supplier sourcing process			X
	Missing power of the ESP for negotiation of engineering changes with the supplier	X	X	X
	Inefficient or no knowledge hand-over process	X		
	Long processing time and too formal escalation and decision mechanisms		X	
	Missing budget for project management activities at the ESP		X	
	Non-capability of the ESP to deliver the wished development outcome	X		X
	Underqualified subsystem or component suppliers around the world	X		X
Collaboration Tech.				
	Missing access to the IT systems at project start	X	X	
	Slow data transfer	X	X	
	Bad E-Mail behaviour	X	X	

Table 7: Identified barriers to collaboration in NPD projects under the leadership of an ESP

The above table shows the identified barriers to successful collaboration in NPD projects under the lead of an ESP, categorized and with their main negative impact on project performance.

In **Fehler! Verweisquelle konnte nicht gefunden werden.**, I depict the identified best practices, categorize them by the identified recommendations, and assign them to an executing party and a cooperation model in which they are applicable. I focused the analysis on the ESP roles of 'turnkey NPD partner', which handles variant development projects (first case study), and 'innovation partner', which handles the joint development of mainly software innovations (second case study). The key informants provided rich data on 'turnkey NPD partner' and 'innovation partner'. The other identified roles were not discussed extensively in the interviews and the information gained on these roles is very limited. The case studies provided rich data on the respective roles which were studied in the case.

For some best practices, I assume differences between the roles of 'NPD partner' and 'innovation partner'. For variant development projects, the key informants identified as a best practice having the ESP project management teams in a project space close to the customer site but with the development centre at the ESP headquarters. For joint innovation projects, I expect a higher necessity for colocation since the degree of innovation is significantly higher and more coordination between the parties might be necessary. Therefore, I slightly adapted the best practice for this particular case. In the second case study, I will analyse if this assumption is supported by the findings there. Furthermore, I assume that cost engineering skills are less important in innovation projects with a focus on software since no physical parts are engineered on which cost engineering could be applied. An NPD process model for car development is not applicable to the development of a software innovation. Therefore, I adapted the related best practice accordingly. Moreover, I expect supplier management competencies and price negotiations to be less important for the ESP in the innovation phase of a technology. Hence, I expect the related best practices as not applicable to the 'innovation partner'. A development in the PLM system of the OEM is not applicable in case of a software innovation. The PLM system is designed to follow the development of a product. Therefore, in the case of a software innovation project, I expect the OEM and the ESP to be forced to agree on the IT development environment in which the solution will be developed. The documentation of the development outcome nevertheless must be carried out in the OEM PLM. Finally, I assume that modularized engineering packages along the NPD process do not have a positive impact on the NPD efficiency of a technology or software innovation project. Thus, I consider this best practice as not applicable to this case.

Role of ESP		Capacity Supplier / Niche Specialist	Outsourcing Partner	Turnkey NPD Partner (System Integrator)	(Software) Innovation Partner
Cooperation models		ESP resources in consultancy mode / small niche NPD tasks	Outsourcing contracts for special activities	Variant NPD at ESP	New technology / new IP for the OEM
Sophistication of data source		*Very limited information from key informants*	*Limited information from key informants*	*Rich information from key informants Rich information from first Case Study*	*Information from key informants Rich information from second Case Study*
(Sub-)**Category**	**Executor**	**Identified Best Practices**			
People					
Rec 01: Define sustainable project teams with a problem-solving attitude	**OEM**		- Top management explain to the project team the outsourcing decision before project start	- Top management explain to the project team the outsourcing decision before project start - Trust ESP works for the best of the OEM - Provide project support with own positive resources if ESP faces problems in the NPD - Lean monitoring organization	- Top management explain to the project team the outsourcing decision before project start - Trust ESP works for the best of the OEM - Provide project support with own positive resources if ESP faces problems in the NPD - Lean monitoring organization
	ESP	- Talent management in place - Mixed business model (Project, EoD, Outsourcing)	- Talent management in place - Mixed business model (Project, EoD, Outsourcing)	- Talent management in place - Mixed business model (Project, EoD, Outsourcing) - Reliable and authentic project managers - Generalist managers on board - Strong Chief Engineer in place - Communicate regularly for the best of the customer - Sales agent who is distinct from the project lead in the project organization - Key roles redundantly occupied	- Talent management in place - Mixed business model (Project, EoD, Outsourcing) - Reliable and authentic project managers - Generalist managers on board - Strong Chief Engineer in place - Communicate regularly for the best of the customer - Sales agent who is distinct from the project lead in the project organization - Key roles redundantly occupied
	Both			- Pro-active managers in favour of the collaboration - Mix of personalities on the project team - Counterpart from both organizations with a communication privilege for each technical subsection - Strong project leaders on both sides who get along well - Consensus-oriented and cooperative teams, trained to collaborate	- Pro-active managers in favour of the collaboration - Mix of personalities on the project team - Counterpart from both organizations with a communication privilege for each technical subsection - Strong project leaders on both sides who get along well - Consensus-oriented and cooperative teams, trained to collaborate
Rec 02: Provide common project space and promote co-location	**ESP**			- Establish global footprint with locations close to the main customer's headquarters - **Project management team onsite at OEM, NPD teams at ESP's development centre and offsite** - Dedicated mall ESP project space close to the customer's development centre - Define co-location plan	- Establish global footprint with locations close to the main customer's headquarters - **Project management and NPD teams close to the R&D centre of the OEM** - Dedicated mall ESP project space close to the customer's development centre - Define co-location plan
Rec 03: Promote frequent communication	**OEM**			- Meeting discipline (meetings with ESP team as important than internal)	- Meeting discipline (meetings with ESP team as important than internal)
	ESP		- Ensure very frequent synchro meetings in the beginning	- Ensure very frequent synchro meetings in the beginning - Request meeting discipline	- Ensure very frequent synchro meetings in the beginning - Request meeting discipline
	Both			-Regular joint steering committees with open communication	-Regular joint steering committees with open communication
Rec 04: Give NPD teams time to integrate on a personal level	**OEM**			- OEM teams to show recognition to ESP teams for their work	- OEM teams to show recognition to ESP teams for their work
	ESP			- Invest in a common understanding and relationship at project start	- Invest in a common understanding and relationship at project start
	Both			- Appreciation—parties to respect each other as partners - Go on recreational trips together and give room for informal meetings	- Appreciation—parties to respect each other as partners - Go on recreational trips together and give room for informal meetings
Rec 05: Strengthen long-term relationship between OEM and ESP	**OEM**			**- Chose ESP with long-term history in NPD projects**	**- Chose ESP with long-term history in innovation projects**
	ESP		- Start collaboration with small NPD tasks	- Start collaboration with small NPD tasks - EoD experts in place at OEM - Lessons-learned workshop culture in place - Have ex-OEM key players in the ESP organization	- Start collaboration with small NPD tasks - EoD experts in place at OEM - Lessons-learned workshop culture in place - Have ex-OEM key players in the ESP organization
Rec 06: Align or understand the culture of the participating companies	**OEM**			- Apply appreciation mechanisms and have open cultural values	- Apply appreciation mechanisms and have open cultural values
	ESP		- Install employees with the cultural background of the region or even the OEM	- Install employees with the cultural background of the region or even the OEM	- Install employees with the cultural background of the region or even the OEM
	Both			- Create common understanding about cultural values - Establish common collaboration code - Make (company)-intercultural trainings	- Create common understanding about cultural values - Establish common collaboration code - Make (company)-intercultural trainings
Process					
Rec 07: Apply joint decision-making	**Both**			**- Clarify the technical uncertainty and jointly define the escalation and decision paths to be applied at the beginning of the common project** - Regular joint Steering Committees with open communication	**- Jointly define the escalation and decision paths to be applied at the beginning of the common project** - Regular joint Steering Committees with open communication
Rec 08: Apply right level of control mechanisms	**OEM**	- Assess ESP's **recruiting** competence	- Assess ESP's **technical** competence in the domain **- Steering via predefined KPIs and SLA**	- Establish a dedicated staff function for monitoring outsourced NPD projects - Assess ESP's technical competence in the domain - Steering via predefined KPIs and Quality Gates - Define quality top-level specifications before project start - Define what should be developed and adapt the level of preciseness of the requirements to the skill set of the ESP and the technical uncertainty	- Establish a dedicated staff function for monitoring outsourced NPD projects - Assess ESP's technical competence in the domain - Steering via predefined KPIs and Quality Gates - Define quality top-level specifications before project start - Define what should be developed and adapt the level of preciseness of the requirements to the skill set of the ESP and the technical uncertainty
	ESP			- Submit high-quality offer, which can be transformed in requirements - Perform an offer winning chance analysis of the current business opportunities and a consequent investment in the offer redaction for the opportunities with the highest award probability	- Submit high-quality offer, which can be transformed in requirements - Perform an offer winning chance analysis of the current business opportunities and a consequent investment in the offer redaction for the opportunities with the highest award probability
	Both			- Offer and requirement workshop at project start	- Offer and requirement workshop at project start
Rec 09: Align PM practices as well as NPD and CE processes	**OEM**			- Provide an aligned budget for project management to the ESP - Matrix organization with specific project-oriented model to monitor ESP - Implement a matrix organization with a specific project-oriented process model to monitor ESP	- Provide an aligned budget for project management to the ESP - Matrix organization with specific project-oriented model to monitor ESP - Implement a matrix organization with a specific project-oriented process model to monitor ESP **- Award ESPs with a similar or the same process maturity level**
	ESP			- Define RACI chart or similar - ESP PM to insist on a common understanding of project planning and responsibilities **- Establish very strong PM & cost engineering skills** **- Maintain an internal, flexible NPD process model, adaptable to the requirements of OEM, managed by a central department** - Project members trained on customer's NPD process	- Define RACI chart or similar - ESP PM to insist on a common understanding of project planning and responsibilities **- Establish very strong PM skills** **- Own technology development process** - Project members trained on customer's technology development process
	Both			- Implement a project dictionary or wiki that can be accessed by every project member - Define documentation and reporting structure at the beginning of the project - Clearly define roles and responsibilities in project initiation phase - Invest a significant amount of the project resources in the creation of a common understanding in the project initiation phase - Apply OEM macro process model, with defined interfaces	- Implement a project dictionary or wiki that can be accessed by every project member - Define documentation and reporting structure at the beginning of the project - Clearly define roles and responsibilities in project initiation phase - Invest a significant amount of the project resources in the creation of a common understanding in the project initiation phase - Apply OEM macro process model, with defined interfaces
Rec 10: Early involvement of strategic ESP partners in the concept design	**OEM**			- Involve ESP considered for serial development in concept phase	- Involve ESP considered for serial development in concept phase
Rec 11: Establish efficient knowledge handover processes	**ESP**			**- Define the test & verification planning and the OEM teams should execute or participate in the validation of the final product**	

Role of ESP		Capacity Supplier / Niche Specialist	Outsourcing Partner	Turnkey NPD Partner	Innovation Partner
Cooperation models		ESP resources in consultancy mode / small niche NPD tasks	Outsourcing contracts for special activities	ESP as system integrator	New technology / new IP for the OEM
Sophistication of data source		*Very limited information from key informants*	*Limited information from key informants*	*Rich information from key informants* *Rich information from first Case Study*	*Information from key informants* *Rich information from second Case Study*
(Sub-)**Category**	**Executor**	**Identified Best Practices**			
Rec 12: Apply strategic ESP involvement process	**OEM**			- All concerned technical departments jointly commit on the outsourcing decision - Grant full system access to ESP for the specific project - Build up strategical partner ESPs - Start relationship OEM and ESP with smaller NPD tasks, to gain implicit knowledge - Define a long-term insourcing and outsourcing roadmap and involve strategic ESPs **- Focus on lead car development, in order to increase the vertical development integration** **- Perform regular capability assessment of the strategical ESP**	- All concerned technical departments jointly commit on the outsourcing decision - Grant full system access to ESP for the specific project - Build up strategical partner ESPs - Start relationship OEM and ESP with smaller NPD tasks, to gain implicit knowledge - Define a long-term insourcing and outsourcing roadmap and involve strategic ESPs **- Focus on joint innovation projects to increase vertical development integration** **- Perform regular capability and process maturity assessment of the strategic ESP**
	ESP			- Define a key account organization for each customer	- Key account organisation for each customer
Rec 13: Apply joint supplier management process	**OEM**			- Give an official statement to all suppliers involved in the NPD process, delegating the power of the development officially to the ESP as prime contractor **- Involve ESP in the sourcing of the suppliers for the specific product**	- Give an official statement to all suppliers involved in the NPD process, delegating the power of the development officially to the ESP as prime contractor **- Involve ESP in sourcing of the suppliers for the project**
	ESP			**- Develop supplier management competences and have good knowledge about the local component and subsystem suppliers around the world** **- Perform delta price negotiations with supplier and confirmation by the OEM**	
	Both			**- Determine thresholds or limits before the start of the project in which the ESP may move**	
Collaboration Technology					
Rec 14: Continuously improve IT solutions and integrate legacy systems with modern solutions	**OEM**			- Establish fast secured data exchange models - Integrate legacy systems into the closed-loop PLM systems as well as define clear interfaces and templates	- Establish fast secured data exchange models - Integrate legacy systems into the closed-loop PLM systems as well as define clear interfaces and templates
Rec 15: Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side	**OEM**			- Closed-loop PLM system with clear documentation rules	- Closed-loop PLM system with clear documentation rules
	ESP			- Carry out special development tasks in which the ESP is particularly qualified in its own tool environment - Invest in own software tools, focussing on configuration management and special NPD tasks - Document the whole development in the PLM system of the OEM	- Carry out special development tasks in which the ESP is particularly qualified in its own tool environment - Invest in own software tools, focussing on configuration management and special NPD tasks - Document the whole development in the PLM system of the OEM **- Maintain a performant software development toolchain**
Rec 16: Have modern communication technology at hand	**Both**	- Provide project team with modern communication technology (video chat, smart phone, exchange servers ...)		- Provide project team with modern communication technology (video chat, smart phone, exchange servers ...)	- Provide project team with modern communication technology (video chat, smart phone, exchange servers ...)
Product Technology					
Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders	**OEM**			**- Modularize engineering packages along the NPD process, which can be localized in NPD centres** - Properly define system structure (modularization) and the interfaces	- Properly define system structure (modularization) and the interfaces
Rec 18: Award projects to technically highly skilled ESP	**ESP**	- Implement formal mechanisms to protect the IP of their customers	- Implement formal mechanisms to protect the IP of their customers	- Implement formal mechanisms to protect the IP of their customers - Invest in innovations synchronized with the innovation road-map of the customers and demonstrate innovation power	- Implement formal mechanisms to protect the IP of their customers - Invest in innovations synchronized with the innovation road-map of the customers and demonstrate innovation power

Table 8: General best practice guideline model based on key informant interviews

The above table presents the identified best practice guidelines assigned to a recommendation category, the responsible project party, and the respective cooperation model. Assumed refinements between 'turnkey NPD partner' and 'innovation partner' are marked in bold.

In the following chapter, I further analyse if the identified best practices are applied by the practitioners on the field, if the practitioners consider them effective, and if an adaptation of the identified best practice guidelines is considered necessary. The best practice guidelines identified so far are based on the theory and the insights of top management industry experts. I believe that a study of what is happening in the field in actual projects will provide additional helpful insights and rich data which might lead to an adaptation of the above guidelines.

4.2 Case Studies

In this chapter, I analyse two case studies in the field of automotive collaborative NPD. The analysis of the findings is expected to provide additional information on field-applied best practices to improve collaboration in outsourced NPD projects. Furthermore, I expect to confirm or reject the identified preliminary recommendation model.

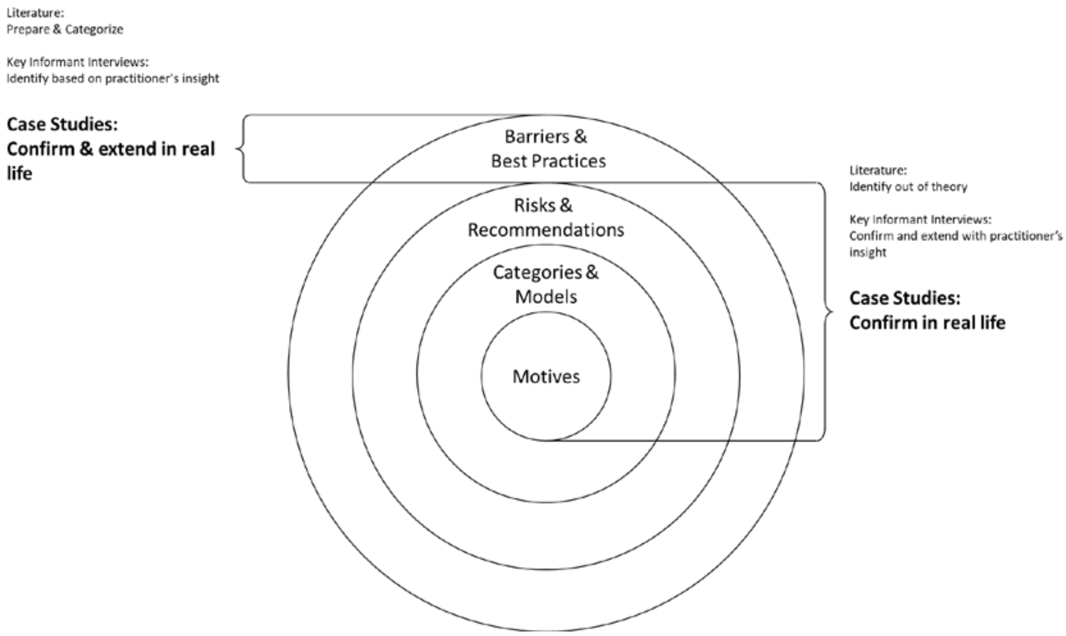

Figure 34: Representation of the research project and research steps for the case studies

The above figure represents the results of the research projects and links them to the research steps undertaken, focussing on the third step—the case studies.

4.2.1 First case study: Serial development project of an SuV coupe under the lead of an ESP.

In this section, I describe the research findings gathered in the first case study—the serial development of an SuV coupe under the lead of an ESP. The case study was carried out in 2014. For the data-gathering process, nine project members were interviewed from both the OEM and the ESP organizations. In addition, I observed the project as a participant–observer and analysed the project documentation (project handbook, project plan, product specifications, presentations, meeting minutes, etc.). Furthermore, at the end of 2016, after the project completion, I had the chance to interview the project leader and participate in a lessons learned workshop. The interview partners for the project case study are depicted in Table 9. I tried to interview project management personnel from both organizations and technical counterparts in order to gain additional insight into the ongoing processes of collaborative variant development projects under the lead of an ESP. I did not interview personnel from the operational level as my observations allowed me to capture and map the tenor of the operative staff.

I interviewed the persons depicted in the table below. To each interviewee I assigned a code according to the order of execution of the interviews. For the respondents from the ESP in the first case study, the code CS1-ESP plus a number was used. For the respondents of the OEM in the first case study, the code CS1-OEM plus a number was used. The interview respondents for the first case study are listed in the table below.

Respondent	Organisation	Professional position	Year of experience in current position	Years of experience in NPD	Interview place	Interview atmosphere	My Impression of the interviewee
CS1-OEM1	OEM	Project leader development variant car	<1 year (for this project) >2 years for other projects	> 15 years	own office	relaxed, very open	interested in the study, very interested to share learnings
CS1-OEM2	OEM	Strategic project leader lead car and variant car	>2 years	> 20 years	own office	relaxed, open	interested in the study and to analyse such phenomena
CS1-OEM3	OEM	Project leader development lead car	>2 years	> 15 years (as of ~5 at ESP)	meeting room	relaxed, open	interested in the study, interested to share learnings
CS1-OEM4	OEM	Product line manager	~5 years	> 15 years (as of 10 at ESP)	own office	relaxed, very open	interested in the study, very interested to share learnings
CS1-ESP1	ESP	Strategic project leader	<1 year for analysed project >2 years for other projects	>10 years	own office	relaxed, very open	interested in the study, very interested to share learnings, partly tried to place messages to the management
CS1-ESP2	ESP	Project management office	<1 year for analysed project >2 years for other projects	>5 years	meeting room	relaxed, very open	interested in the study, very interested to share learnings, used interview to complain about problems
CS1-ESP3	ESP	Full Vehicle Integration / Sub Project Documentation CAx	<1 year for analysed project >5 years for other projects	>10 years	meeting room	relaxed, very open	interested in the study, positive approach, wants to improve things
CS1-ESP4	ESP	Strategic Project Leader phase at the end of the project	>2 years	>15 years	own office	relaxed, very open	interested in the study, very interested to share learnings
CS1-ESP5	ESP	Project Coach	<1 year for analysed project	>35 years (at OEM)	own office	relaxed, very open	interested in the study, very interested to share learnings

Table 9: Respondents in the first case study: Serial development project of an SuV coupe

The above table depicts the respondents of the first case study interviews, with the names neutralized, showing the type of organization they worked for, their professional position, and their years of experience in their field at the time of the interview.

4.2.1.1 *Project context.*

The cooperation project analysed was the second project of this size carried out between the two parties. According to the respondents, the analysed project was the first project in which the ESP had a full general contractor role. Here, a well-established OEM outsourced the serial development of an SuV coupe to a leading ESP. The two companies have a special history and partnership, as explained below. The official decision and start of the early concept phase of the project was December 2012. Design freeze for the concept was in June 2013, which resulted in a top-level specification for the request for a proposal. The ESP was awarded the project in August 2013 and the final top-level specification with a first design study was released in October 2013. The case study was carried out in the second and third quarters of 2014, which corresponds to the early design phase. The SoP was planned for the beginning of June 2016. This milestone was held by the project team.

4.2.1.1.1 *The OEM.*

The customer in the project is an OEM that ranked among the world's top 20 largest manufacturers by production in 2017 (OICA, 2018). Based on my observation and according to Miles, Snow, Meyer, and Collman's organizational strategies (Miles et al., 1978), the OEM can be considered as an analyser organization with a routine and efficient NPD process and well-formalized structures in the serial development department. The R&D expenditure is continuously increasing. It exceeded EUR 9 billion in 2018. At the time of the project case study in 2014, it was above EUR 7 billion, according to the company's financial statements published on its website. These R&D expenditures make the company one of the 10 major R&D spenders in the world, according to the 2018 EU Industrial R&D Investment Scoreboard (European Commission, 2018). As stated by the OEM respondents, from its R&D budget exceeding EUR 7 billion, the company outsources R&D services worth approximately EUR 1 billion. The R&D department employs over 25,000 people and is divided into two main divisions.

- research and predevelopment
- series development

The analysed project is managed by the serial development department. The serial development department applies a 'loose' matrix organization with commodities (functional groups) and vehicle model series (product groups) as shown in Figure 22. 'Analysers' have the entrepreneurial problem of 'how to locate and exploit new market and product opportunities, while simultaneously maintaining a firm base of traditional products and customers' (Miles et al., 1978). For the established automotive industry, this is a well-noted problem. Car manufacturers are challenged to bring new mobility concepts to the market while generating profits with the traditional products. The solution of a hybrid domain that is both stable and changing is applied here. 'But domain must be optimally balanced at all times between stability and flexibility' (Miles et al., 1978). Given this context, the conclusion that one internal motive for the outsourcing decision might be IM 3 (need for capacity not currently possessed and resource flexibility while increasing the vertical integration) is obvious.

According to CS1-OEM2, the OEM R&D department started to outsource its first variant developments around the year 2000. This was mainly for reasons of missing capacity due to an increased number of variants and the related reduction of the NPD time. The lead car development plan of the OEM covers 40 months for the serial development of a car from concept to SoP compared to 72 months in the 1990s. This shortening of the NPD process leads to an additional need for capacity and efficiency increase. The management of the OEM observed an efficiency increase through outsourcing. Therefore, the outsourcing of variant development was promoted since the first collaborative NPD project and the responsibility shift increased over time, according to the respondents. As confirmed by the key informants, the majority of the OEM case study respondents stated that the OEM intends to develop the lead cars in-house and to build up strategic ESP partners for the development of variant cars.

4.2.1.1.2 *The ESP.*

The ESP was founded in the early 1990s by the OEM as an in-house provider of engineering services. In 2011, the OEM sold a large part of its shares to another ESP and became a minority shareholder of the resulting joint venture. According to one of the respondents and also a key informant who worked for the OEM at the time of the interview, the motivation to partly sell the company was to create an independent ESP that would act freely on the open market. The OEM's top management observed a lack in efficiency compared to other ESPs at the subsidiary. By considering the example of other ESPs at which other OEMs hold minority shares, the OEM decided to sell to a successful, international ESP competitor which was trying to gain entry in the German market. In 2018, the OEM also sold the remaining stake to the ESP, because the collaboration was successful and the transformation succeeded. The OEM is the major customer of the ESP.

By the time the project started in 2013, the transaction was already complete and the ESP was considered by the OEM as an external party with the same access restrictions as others. Therefore, I consider this case study as a valid case to analyse the collaboration between an OEM and an ESP in a variant development project. Nevertheless, the implicit knowledge between the two companies can be considered as rich. As regards the matter of location, the two companies have their headquarters close to each other.

Integrated in the structure of the new majority shareholding ESP, the analysed ESP is part of the top 10 European automotive ESPs in terms of sales and employees.

With over 8,000 engineers working for the company, the ESP represents a powerful engineering force.

In 2014, the ESP had realized above 250 million euros in sales with the OEM, which represents nearly 40 per cent of its total sales and approximately 25 per cent of the OEM's expenditure on external R&D services.

4.2.1.1.3 *The outsourcing decision.*

For this project, the ESP was chosen from among several competitors on the recommendation of the R&D department and in accordance with the procurement strategy to build up a strategic partner ESP. A connection to the sale of the shares by the OEM was not stated explicitly by the respondents. Nevertheless, the conclusion that the outsourcing decision was also affected by the strategic approach to convert the ESP into an efficient partner in Germany is obvious.

According to the OEM respondents, the following three criteria were analysed for the outsourcing.

First, there was the technical capability of the ESP to consider. The ESPs that submitted offers were requested to demonstrate their capabilities during the request for proposal phase. A special focus has been placed on experience with former projects and knowledge on the specific modules and processes of the customer. Furthermore, the technical offer, which was based on the award specifications, was analysed in depth by the OEM's technical teams. The quality of the offer allows conclusions on the competence of the ESP according to the OEM respondents.

> Then there is a first offer of applicants. And now comes the special thing which is being discussed, technically, in a big group. The ESP may present one morning how it plans to complete this project. From this we draw conclusions about development competence, total vehicle competence, constructive and experimental competence. And by purposeful inquiries, I think we can already see a lot in this assessment. (CS1-OEM1)

The second criterion was the financial stability of the ESP. The OEM conducted a credit check of the ESP to ensure that the ESP was sufficiently creditworthy. The aim was to guarantee financial stability over the course of the project. Finally, the cost aspect played an important role in the awarding of the project. A trade-off between best price and best technical and process knowledge was made.

The strategic project leader of the OEM (CS1-OEM2) stated a fourth factor: According to him, the OEM intends to build up the ESP as a strategic partner for variant development and thus the supplier qualification also played a role in the awarding process. The OEM intended to build up a capable ESP partner for full vehicle development.

> [ESP] was known as a good extended workbench and as good for component development and partial solutions. But we knew that [ESP] does not have the know-how to take the whole vehicle as general contractor. And that they have their problems there, which they can fix with external support. We all knew that! There was a clear analysis. And it pointed out that here [ESP] was not in the first place, but just in the third place. But nevertheless, we chose [ESP] to build them up as a partner. (CS1-OEM2)

The related best practices under Rec 8 and Rec 12 were applied in the project and judged as effective by the respondents. The top-level specifications were clear at the time of the request for proposal, the process to review the proposal by the ESPs jointly guaranteed a high-quality offer, and the ESP project management made an offer requirement matching workshop with the OEM management in order to create a common understanding and clarify eventual misunderstandings.

4.2.1.1.4 *The product to be developed.*

The developed product is the variant of a variant. At the time of the case study intervention, the OEM was also developing a mid-sized SuV that was based on a sedan. The sedan is one of the core products of the OEM and it is based on a major vehicle platform of the OEM. The analysed project is the development of the derived coupe version of the SuV. For this product, mainly the rear part of the car is changed and a few new functions are implemented. When launched in 2017, the SuV coupe was the first of its class in the automobile market and both cars, the SuV as well as the SuV coupe, were the SuV bestsellers of the OEM, according to information published on the OEM's corporate website.

The main project scope for the ESP comprised the following points (adapted parts, modules, or module groups):

Shell/exterior:

- Adaptation of the windshield, the rear window, the side window, the roof window, the fixed rear window, the radiator cowling, the wiper arm, the wiper blades, the bumper, the crossbeam, the rear door (including hinges and opener), the front spoiler, the rear spoiler, and the body parts

- Component blocking of the side walls, the driver and rear doors, and the auxiliary brake light

Interior:

- Adaptation of the loading floor, the trim of the A, B, C, and D pillars as well as the seat covers and decorative seams of the rear seat
- Component blocking of roof panelling, airbags, blinds, and cameras
- Rear seats

Electrics:

- Adaptation of wiring harness and software functions

Chassis/engine:

- Specific wheel designs
- Adaptation of the tank flap module, the exhaust line, and the cold end
- Engine application and homologation for four engine variants

Furthermore, BOM management, drawing inspection, digital mock-up, calculation, creation of a digital prototype, and weight management needed to be considered.

The ESP budget for the project was between EUR 20 million and EUR 30 million for the execution of the NPD over three years. This represents a significant part of the company's annual sales revenue.

4.2.1.1.5 *The project organization at the time of the case study.*

The project organization is represented in Figure 35. This organizational chart has been taken from the project management handbook whose main author is one of the interviewees. At the beginning of the project, the right organization had to be found. After four months, the project management implemented a so-called 'spokesman model' for reasons that are explored further in the case study findings. The key project leaders are the strategic project lead of the ESP and the strategic project lead of the OEM. The two managers were appointed after two months of project time and form a good team, according to their feedback. The strategic project leader on the ESP side reports to the ESP's director for full vehicle development, who reports to the company's CEO. Thus, the project leader has an indirect link to the highest management of the company and therefore a strong positioning in the organization. The ESP decided to install a project coach and a chief engineer. This project coach, an ex-employee of the OEM, left the OEM just before the project to retire. Now, he consults on the project as a freelancer. The ESP installed several management functions. Furthermore, a module group spokesman for each module group was included in the development process. The module group spokesman comes from the line organization at the ESP. During the project, the employees report to the project leader. For each module group, a sponsor from the line organization is defined who can intervene in the project if deep expert knowledge is needed. Generally, the project has two main technical domains: (1) the module groups in which parts and functions in the module groups are adapted, and (2) the vehicle integration in which the new parts are integrated in the vehicle system and the testing and validation is done. A particular situation applies in this project: The car on which the variant is based was still in development at the time of the case study. The development process of the lead car was approximately 12 months in advance. Therefore, the OEM module group organization for the lead car is still active and a mirror organization is present in the OEM organization.

On the ESP side, the project organization should be defined before the project start. Mirroring the complete commodity organization of the OEM would lead to inefficiencies. But every module that is touched by the ESP needs a spokesman who can speak with the counterpart on the OEM side in order to take decisions and discuss development progress and design or engineering changes. According to the ESP respondents, the consolidation of module groups with fewer changes under one spokesman who was responsible for several module groups is an efficient best practice. This finding is in line with the feedback of the key informants.

On the OEM side, the strategic project leader reports to the product line manager, who reports to the head of product lines, who reports to the head of R&D of the company. The development project leaders in the OEM's organization are responsible for forming the link to the commodities. They report functionally to the strategic project lead of the project they work in and hierarchically to the respective development department. The installation of the strategic project leader was slightly delayed in the analysed case, which led to problems at the beginning of the project, as discussed below.

The core team of the project consists of 71 persons on the ESP side. Several engineers work only part-time on the project and are associated with other projects as well. Therefore, the project staff at the time of the case study consists of approximately

45 full-time equivalents. On the OEM side, two project management resources are assigned to the project and the module group spokesmen on the OEM side work approximately 10–20 per cent on the variant and 80–90 per cent on the lead SuV, according to the respondent CS1-OEM1.

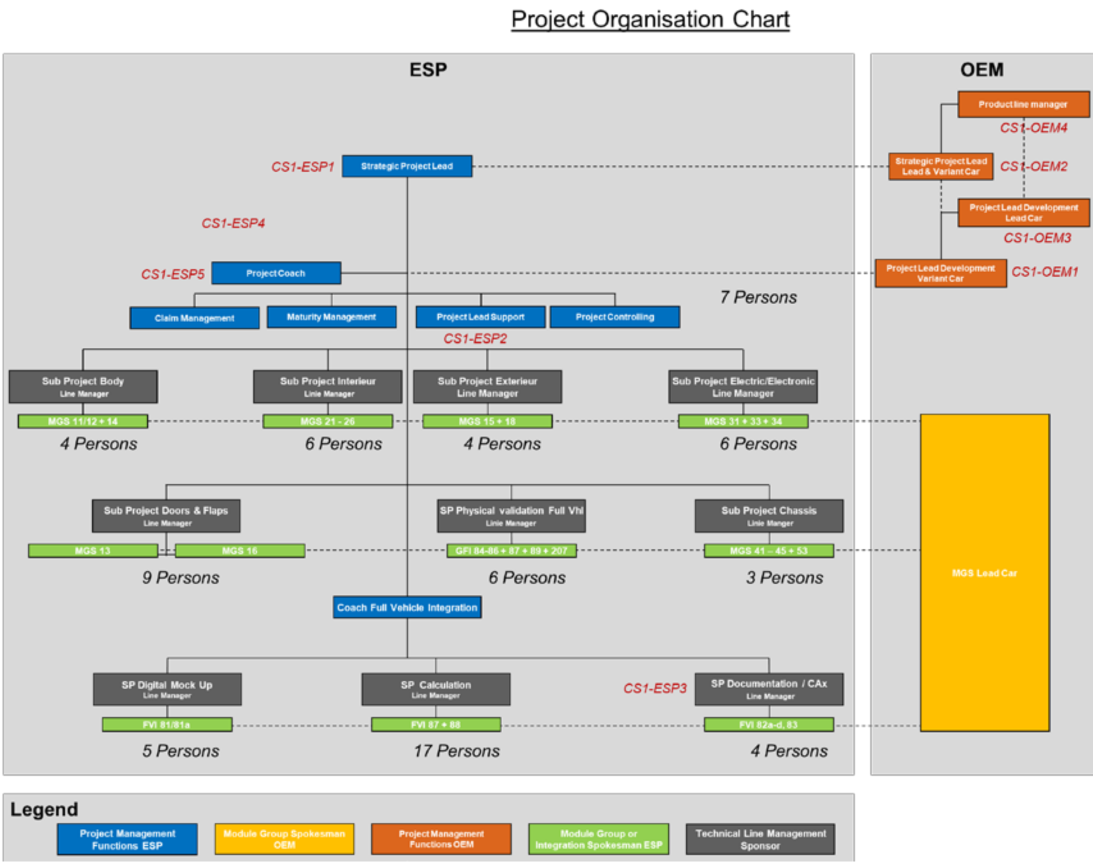

Figure 35: Project organization of SuV coupe NPD project

The above figure shows the project organizational chart at the time of the case study intervention. Names are neutralized. The interview respondents are marked in red on the chart. Taken from the project handbook of the NPD project.

The established project bodies are described below. The ESP conducts two regular meetings for internal steering: (1) the monthly meeting of the project steering committee, in which the project leader reports to the top management of the ESP on the progress of the project, risks, and financials, and (2) the weekly module group meeting in which technical problems and solutions are discussed under the supervision of the project coach and the project leader.

Together with representatives of the OEM, the ESP teams report in the ProTech meeting. In this meeting, the technical progress of the full vehicle is discussed with the development project leader of the OEM every two weeks. Here, mainly the integration team of the ESP reports its progress.

For every module group, monthly module spokesmen meetings are conducted. In those meetings, the module spokesmen of every car development project of the OEM are able to present eventual changes or technical problems and solutions. Designs are released for production in this meeting by the leaders of the different commodity departments. Furthermore, the meeting allows the different module group spokesman to stay up to date on developments in the commodity. Here the respective module group spokesmen of the ESP participate if approved by the ESP project leader and if considered necessary. The participation in these meetings was not clear in the beginning, since the technical departments of the OEM were reluctant to let the ESP teams participate, as is discussed later.

The last regular meeting in the project is that of the Change Control Board (CCB). In this meeting, final engineering changes are discussed, solutions are presented, and the final decision concerning project engineering changes is taken, especially with a focus on product cost. This meeting is conducted by the two strategic project leaders and decisions are taken jointly.

4.2.1.2 *Findings and discussion.*

In general, I observed that the project team's working atmosphere was positive, solution-oriented, ambitious, and proactive. The analysis of the different meeting protocols did not reveal any evidence of significant obstacles in the project. Several technical problems were being discussed at the time of my intervention—for example, the interior design was not at the wished maturity degree when the project was analysed. But, in general, the project management of both sides was optimistic about being able to execute the project in time, with the required quality, and within budget.

According to the respondents, the situation was different at the beginning of the project. The majority of the respondents confirmed a significant reluctance of the commodity departments at the OEM to cooperate with the ESP for several reasons, which I discuss below. The OEM R&D departments were partly against the outsourcing decision and wanted to execute the project in-house. Several module groups of the OEM refused to provide the ESP with the necessary information and to invest time and effort to speak to the ESP teams.

> In the beginning, it did not work because in principle our module groups were blocking. And finally, the module groups of [ESP] were not provided with information. (CS1-OEM2).

With the appointment of CS1-OEM2 as strategic project leader on the OEM side—a manager with a strong positioning and good reputation in the OEM organization—and in parallel the appointment of CS1-ESP1 as a strategic project leader on the ESP side, the two companies succeeded in overcoming this barrier. A central point was a two-day workshop initiated by the two project leaders in a monastery close to the project city. All key players of the project participated in this workshop and, according to the respondents, barriers were cleared and informal relationships between the project stakeholders were created. According to the interviewees, the ESP teams were considered more as partners by the R&D teams of the OEM and less as competitors. Since this meeting and with the implementation of a clearly defined escalation meeting organization, the collaboration has improved significantly. With this action, the management of the two companies acted according to the recommendations of Rundquist and Halila (2010), arguing that an integration on a personal level is of utmost importance for NPD project teams.

> We need the most efficient cooperation model possible between the internal module groups and the module groups at the general contractor. That's the sticking point. And that did not work at the beginning of the project. Only after we conducted a workshop between [ESP] and the [OEM] organization, against the resistance of the [OEM] organization. […] So we just put them together and they met in person. (CS1-OEM2)

Especially in NPD projects where the technical uncertainty is high, these findings support the assumption that a good relationship with an increased level of trust is crucial for an efficient collaboration (Bstieler, 2006; Rundquist & Halila, 2010). The best practices related to Rec 4 (give NPD teams time to integrate on a personal level) are widely supported by these findings.

The outcome of this workshop was also the basis for the redaction of the project management handbook for the respective project. This document is regularly updated by the project management office of the ESP. The handbook has the following contents: the general project rules, the RACI chart, the project target description, the top-level product targets, the project schedule and milestone plan, the budget plan, the capacity plan, the project organization, the description of the project repository, a link to the project dictionary, a description of the project functions, the project bodies, the cost engineering process, role descriptions, and a description of cross-processes, as recommended by the Project Management Institute (2017). This handbook served as a reference document for the whole project and all team members. Such an explicit project management approach has allowed the ESP teams to prove their project management and cost engineering competences. It has also increased the level of trust between the two organizations. Furthermore, the ESP project management applied typical project management practices such as project risk analysis, focussing on the ESP's internal and external risks, risks in terms of cost, as well as social and technical risks. Furthermore, a maturity degree controlling for the parts was applied. The set-up of this controlling was delayed, according to the respondents, which led to a lack of transparency concerning the technical progress at the beginning. With the consequent application of project management practices, the collaboration seems to have gained in efficiency. This approach is in line with the ESP best practices related to Rec 9 (aligned PM practices as well as NPD and CE processes) and thus underlines the opinion of academics in the field (Gassmann, 2006; Lakemond et al., 2006; Tang & Qian, 2008).

According to the respondents, the delayed installation of the strategic project lead on the OEM side and the associated delayed commitment by the OEM's top management to the outsourcing decision were root causes of the collaboration problems at the beginning of the project. According to CS1-ESP2, the ESP teams were partly considered as ‘work thieves’. CS1-OEM2 and CS1-OEM1 also confirmed that the reluctance of the commodity departments to cooperate with the ESP teams was an obstacle at the beginning of the project, which could only be overcome through internal top management escalation and trust-building measures. Implementation of the best practices identified under Rec 12 (strategic ESP involvement process) would likely have prevented these barriers.

A further barrier to good collaboration, as perceived by the respondents at the beginning of the project, relates to Ri 9 (risk of labour law disputes with ESP employees). The analysed OEM organization places much attention on compliance management. Therefore, an efficient collaboration model had to be found to mitigate Ri 9 and avoid an excessively deep integration of the ESP teams into the OEM organization. Especially in the cooperation of those two companies, this point was treated as high priority. Since the ESP teams were partly ex-colleagues of the OEM teams and since the headquarters of the OEM and the ESP were very close to each other, it became necessary to find an explicit collaboration model, separating the project teams. As the variant development that was outsourced was based on a car which was being concurrently developed by the OEM’s internal organization, an inherent monitoring organization for each module was in place. If an engineering change was needed, an OEM module responsible for the basis car was immediately available to discuss this change. This turned out to be very efficient and allowed good collaboration between the two parties, according to the majority of the case study respondents. Since the lead car is still in development, the project management put in place a mirror organization on both sides for each adapted module.

> The colleagues are contact persons for the spokesmen of the general contractor for any questions. And these colleagues ultimately also form the interface to the release of the vehicle, because at the end what we develop here is supposed to become a [car brand]. (CS1-OEM1)

Several key informants stated that for cost-efficiency reasons, the OEM should not install a mirror organization. However, the case study respondents emphasized the necessity of such a mirror organization. ‘A complete mirror organization. This mirror organization is given by the module group spokesmen of the lead vehicle at the OEM.’ (CS1-OEM1)

For the first case study, the special situation of concurrent engineering of the lead car led to the information that a mirror organization was still active in the development of the lead car at the OEM. This has turned out to be very effective for the collaboration, including in terms of cost. Hence, if the ESP plays the role of a turnkey NPD partner, the best practices related to Rec 12 (strategic ESP involvement process) can be adapted or extended to some extent. The OEM should try to **choose variants for outsourcing for which the related lead car development organization is still available during the design phase of the variant**. This should be considered in the **long-term insourcing and outsourcing roadmap for car models and should involve strategic ESPs**.

To avoid excessively deep integration of the ESP project team into the OEM teams and thereby avoid direct instructions or relationships which could be considered as a legal work relationship, the project management team implemented a spokesman model, as illustrated in Figure 36. The communication between the two organizations is directed via a module group spokesman and the project teams are kept separate. Information exchange and assignments are only received by the spokesmen of the ESP, who further dispatch the information in the in the ESP organization.

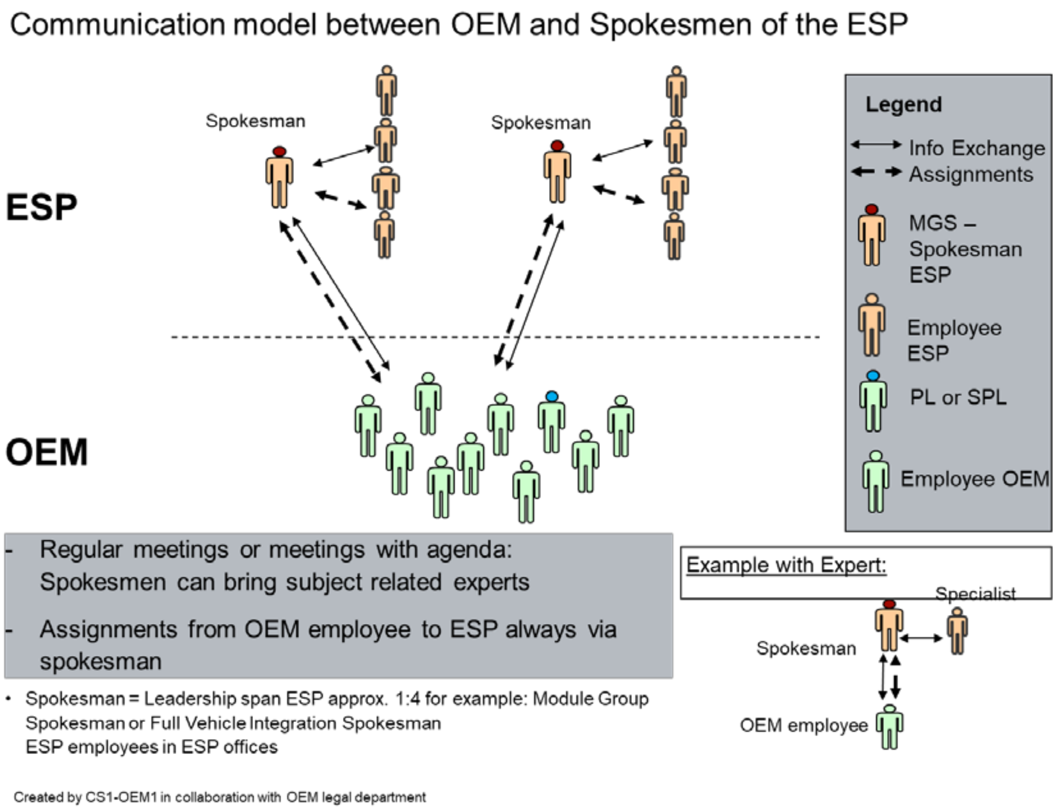

Figure 36: Spokesman model applied in the first case study

The above figure shows the functioning of the spokesman model applied in the analysed project in the first case study. Adapted from the project handbook.

Hence, the best practices for Rec 1 (define sustainable project teams with a problem-solving attitude) referring to the monitoring organization were widely confirmed.

One of them can be slightly refined to **nominate a module spokesman from both organizations with a communication privilege** for the case of variant development projects under the lead of an ESP. According to two OEM respondents, the applied spokesman model has also been approved by the legal department of the respective OEM as effective for the mitigation of Ri 9, which further supports the conclusions based on the findings in the key informant interview analysis. For effective functioning of this model, the ESP management must have module group spokesmen available at the beginning. This availability of the right experts at the project start also seems to have been a problem in the project initiation for the ESP. With the installation of CS1-ESP1, this problem was quickly identified and the right experts were found on the ESP side. This finding emphasizes again the importance of the onsite location or the closeness to the OEM R&D centre of the ESP project management team.

> In principle, they need a clear project structure that can cover our structure. This does not mean that it has to be a copy of our hierarchy or governance but the ESP needs to define counterparts. (CS1-OEM2)

The mirror organization applied within the project also supports a fast decision and release process. In CS1, the project defined in an early stage the release process for engineering changes, which was one of the major challenges, according to the respondents. Considering that the OEM ultimately remains responsible for the product liability, the OEM commodity organization has to release engineering changes together with the project team. In the first case study, the teams of the **ESP prepare a release recommendation and the OEM commodity teams approve the**

ultimate release of the part. For outsourced variant development, this seems to be an efficient best practice for joint decision-making. Therefore, for the application case turnkey NPD partner, best practices under Rec 7 (joint decision making), as recommended by Oh and Rhee (2010) and Quesada et al. (2006) can be extended for the ESP.

> This final delivery responsibility remains with the OEM. To look at it, to confirm it, to approve it, based on a release recommendation of the general contractor. […] And the OEM is held responsible for quality, cost, customer impressions, and things like that. Thus, the [OEM] has to release the vehicle. This is the sales release. (CS1-OEM1)

Through my observations and according to several ESP respondents in the case study, an internal power struggle within the ESP could also be observed. ESPs have today become important companies with several divisions defending their interests. This also holds true for the ESP analysed in this study. Even if ESP organizations might be more project-oriented than OEM organizations in general, all divisions have to 'pull on the same string' (CS1-ESP1) to be able to manage such a critical project.

According to the respondents and the ESP project leader, a major challenge for the project was getting the most qualified resources out of the line organization of the ESP into the project organization. A best practice mentioned here was **carrying out an internal marketing campaign for the project that would explain the challenges and the development done**, in order to rouse the interest of the engineers in the project. Furthermore, an applied best practice that several ESP respondents noted as efficient was implementing **ESP-internal margin sharing accounting to prioritize**

the critical projects over less critical ones for the line managers. The ESP project management experienced the barrier that line managers at the ESP were reluctant to provide their best engineers to the project, since other, less critical projects were more profitable for the profit and loss of the respective line department. The balance of power between the line department that was usually responsible for the recruiting and build-up of the engineering teams—which represent the competences and assets of an ESP—and the project management for crucial projects should be observed carefully by the ESP management. Mechanisms should be established to assign the best engineers to the most success-critical projects for the company. Furthermore, the more critical the project is for the company's success, the more power may need to be granted to the project leader. As explained, in CS1, the ESP management decided to link the project leader to the managing director of the company. Furthermore, the project leader has a regular steering committee involving the top management of the company. This gives the project leader the formal possibility to escalate problems as and when they occur. The best practice under Rec 1 concerning the ESP–OEM project leader twin tip has been applied in the analysed project. The nomination of the two project leaders might have been decided after a delay, which resulted in problems in the project initiation phase. A strong positioning in the respective hierarchy seems important, according to the case study findings. Therefore, the related best practice can be slightly extended to the **ESP-OEM twin tip of project leaders with sympathy for each other and a strong positioning in the respective organization.**

The strong positioning of the ESP project leader in the ESP hierarchy was also important in order to streamline the internal escalation paths within the ESP. According to several ESP respondents, not all ESP team members accepted the leadership of the project leader at the beginning of the project. For example, several engineers from the simulation department discussed problems directly with their customer counterparts before clearing them with the ESP project leader. This often led to the impression at the customer organization that the project leader did not have the teams under his control and the spokesman model was not respected, which could lead to other risks, as discussed. Therefore, escalation paths and hierarchies should also be adapted on the ESP side in order to improve efficiency within the NPD project.

The respondents of the first case study placed emphasis on the words ‘confidence’ and ‘trust’. According to them, the level of trust gained through a long-term relationship between the ESP and the OEM is a critical success factor. The case study respondents confirmed that a long-term relationship between the ESP and the OEM is a precondition for a successful variant NPD project under the lead of an ESP in order to build trust in the competences and the knowledge of the ESP on the OEM side and to generate implicit knowledge on the ESP side. In this case, the personal trust between the employees of the two companies can be described as high, since the companies have a common history and the OEM is still a minority shareholder of the ESP. The trust in the full vehicle development capabilities of the ESP was considered as improvable by the respondents. These findings on trust and relationship are in line with the argumentation of Kurek (2004) and Rundquist and

Halila (2010). As discussed, the supplier qualification for full vehicle development was one of the motives for the outsourcing decision to this ESP. Rec 5 (strengthen long-term relationship between OEM and ESP) and related best practices have been applied and are supported by the findings in the first case study.

Given the special context of the project case study, I observed that a common understanding of the respective company cultures was in place. Both companies have the same roots, which results in similar company cultures. Therefore, the alignment of the company cultures can be considered as implemented in this case. According to the respondents, the ESP staff could be described as somewhat submissive to the OEM staff. At the beginning of the project, the OEM teams lacked discipline in terms of design freezes since other projects were prioritized. This was viewed as a lack of appreciation by the ESP teams. According to the respondents, the ESP teams did not act in a sufficiently self-confident manner in this situation. Both project leaders referred to this in the interviews and stated that the ESP teams could have rejected delayed changes, which led to additional efforts for the ESP, in order avoid additional cost for the project. A further indication that the ESP managers were not sufficiently confident at the beginning of the project is the fact I observed that nearly no additional efforts were claimed by the ESP at the project stage, because the acting persons at the ESP did not dare to. According to the respondents, ESP management teams usually try to claim extra funds for additional efforts in this project phase. When the design freezes are complete, possible incoherencies with the initial specifications which served as a basis for the project contract can be grounds for making such claims. A mutually respectful relationship and an agreed upon collaboration code, as defined in the project management handbook, seem vital for efficient cooperation. A dominant–submissive customer–supplier relationship seems to have the opposite effect. Consequently, best practices under Rec 6 can be considered as partly supported by the findings in the case study.

At the time of the case study, the project space was situated in a part of an office building of the ESP. Here, approximately 50 workplaces were available with several meeting rooms at the disposal of the project. The project space was situated close to the headquarters of the OEM. In the beginning, the project space was not ready and several ESP respondents stated that the project had to move twice before they finally found this reserved office space for the project. This gave rise to additional efforts and a loss in efficiency at project start. According to the majority of the respondents, a project space on the ESP premises, close to the OEM's location, is the right solution for an outsourced car variant development. In the special situation of the analysed project, thanks to the closeness of the ESP headquarters to the OEM R&D centre, the project space was designed so that it could accommodate all active developers of the project and a co-location plan was not necessary. The findings in the case study support the best practices under Rec 2 (provide common project space and promote co-location). An additional remark of the ESP respondents was the importance of ensuring that the project space was close to the offices of the ESP line organization, as this would allow easy personal exchanges. This statement supports the assumption that if the headquarters of the ESP are not close to the R&D centre of the OEM, a project space close to the customer should be created in a front office for the project management staff and the development project space in the headquarters of the ESP. The findings in the case study as well as in the key informant interviews slightly adapt the opinion of academics in the field of collaborative NPD (Binder et al., 2008; Wagner & Hoegl, 2006; Wognum et al., 2002) for the special case of collaborative NPD with an ESPs as turnkey development partner. A common project space seems only to be necessary for the joint management team of the project. The technical development works can be partly done offsite without any negative influence on the development performance.

The OEM is a well-established company with a detailed NPD plan. In the NPD plan, clear quality gates with release criteria for each development step are defined. The ESP teams are familiar with the NPD plan of the OEM. For the tracking of the development progress, the maturity degree is controlled. The maturity degree is defined for each changed part or module and for the integrated vehicle. The development process of a part ends with the so-called blank release. With the blank release, the tool production for the production process is started. The tooling is the most important investment and changes after the blank release should be avoided in automobile development as they induce high additional costs. Several OEM respondents consider it a big challenge to have a proper blank release in the short development time provided by the NPD plan of the OEM. But this is a general problem in the development of new cars and not specific to outsourced NPD. Nevertheless, all the respondents consider the controlling of the maturity degree to be critical. Due to the lack of information about the lead car and a lack of experience with the process, the ESP faced problems with efficiently carrying out the maturity degree reporting at the beginning of the project. With the installation of a project management office and a controller responsible only for this controlling, the ESP project management succeeded in delivering a well-received maturity degree reporting to the OEM. This reporting and regular discussion in the different bodies was considered as an efficient best practice for the monitoring of the development process by nearly all respondents. Therefore, I decided to extend the best practices for the ESP under Rec 8 (right level of control mechanisms) by the best practice to **apply maturity degree controlling and provide consequent reporting to the OEM**. With the award specification, high-level specifications were available for the ESP at project start. The ESP sales teams based their offer on these specifications. According to the OEM respondents, as discussed, the ESP teams lacked in full vehicle competencies when creating the tender documents. The quality of the offer was therefore not the best, compared to the offers of the competitors. Nevertheless, the ESP demonstrated a sufficient level of competence in the tender documents to convince the OEM. According to several ESP respondents, the top-level specification changed after the project start or were not completely clear to all stakeholders at the beginning of the project. Since the specifications left room for interpretation (e.g. CS1-ESP2 stated that the interior noise requirements changed after the awarding), the maturity controlling was even more challenging. With a finalized specification at the beginning of the project, these problems could have been avoided, say the ESP respondents. 'Thus, it is difficult to measure a degree of maturity if it is not clear what is to be done in detail.' (CS1-ESP2)

The noted workshop served as a requirement matching workshop, but was held too late, say the respondents. In general, the best practices identified under Rec 8 (apply right level of control mechanisms) are supported by the findings in the case study and are extended. Not only a good requirements management (Harmancioglu, 2009) seems to be important, but also a process for maturity degree controlling.

The ESP teams were not involved in the concept phase of the car. I could not find evidence supporting or not supporting the application of the related best practice. Nevertheless, information on the concept for the three preferred suppliers might have helped the ESP teams in the offering phase. Furthermore, scholars argue that early involvement of suppliers in the NPD process improves NPD efficiency (Lakemond et al., 2006; Schneider, 2011). Therefore, I decided to leave the best practice under Rec 10 (early involvement of strategical ESP partners in the concept design) unchanged.

Furthermore, especially the ESP respondents identified another barrier to efficient collaboration in the project. ‘Only a small part of the team which prepared the offer is today involved in the project execution.’ (CS1-ESP2)

Some members of the team responsible for the offer preparation either left the company or are currently working on different projects. The interpretation of the requirements and specifications and thereby also the planning of the internal budget was carried out by this sales team. The execution team seems not to fully agree on these budgets. Furthermore, with the change in the shareholding of the ESP company, the profitability targets have increased. Thus, budgets had to be reduced for the different development activities. According to the ESP project management respondents, this leads to additional pressure within the project. From my experience as the project manager and managing director of ESP companies, I know that such a strategy to separate sales from the execution team is commonly applied. The ESP management hopes to increase its sales by adopting such an approach. The project execution teams then usually find a solution to finish the project within the defined budget. In addition, consistent claim management then leads to further sales for the ESP. Consequently, this increased pressure on the development teams might be wanted by the management of the ESP and implicitly also by the OEM, since it leads to increased development efficiency, provided the sales department does not exaggerate. Several ESP respondents stated that the ESP teams were not sufficiently self-confident and did not apply consequent claim management approaches for additional non-specified efforts. According to CS1-ESP4, the technical project leader who completed the project and whom I interviewed after the project, this lack of claim management and an ambitious initial project budget led to the situation where the project did not achieve its profitability targets at the end of the project.

CS1-ESP4 was appointed as the deputy technical project lead after the digital phase under the lead of CS1-ESP1, the strategic project leader. The target was to develop a strong technical project leader to accompany the project coach and chief engineer CS1-ESP5 (ex-OEM senior manager) because it was clear from the beginning that CS1-ESP5 would not stay on for the whole project. When I interviewed him, he was leading the follow-up variant development project for the ESP with this OEM. According to him, the ESP had benefited massively from the development of the predecessor project that I analysed in the first case study. Thanks to this project, process knowledge and overall vehicle competence was built up at the ESP even if it was eventually not possible to achieve all the profitability targets for the project. The follow-up project benefits from this knowledge as it provides confidence that the profitability targets can be exceeded. Thus, a long-term relationship and deep OEM-specific knowledge at the ESP seem to be beneficial for both parties.

> In the project, many new processes have been created. It has to be said that it was a project where everyone had learned a lot, but also really needed to learn. Because these are topics in such a complete vehicle, in a total vehicle responsibility, which is otherwise rarely within the responsibility of an ESP, especially in this process depth—deep into all customer processes. (CS1-ESP4)

In the analysed project, the ESP teams carried out documentation in the PLM system of the OEM and applied a consequent controlling of the maturity degree. Furthermore, the ESP module group spokesmen reported the development progress in the module group meetings at the OEM. These strategies support the knowledge handover. The test and validation were executed by the ESP. Nevertheless, the OEM made the final inspection drives and was involved via the module group spokesmen in the results of the testing phase, ‘to make sure that a [brand-name] is developed.’ (CS1-OEM2)

Thus, Rec 11 (establish efficient knowledge hand over processes) and related best practices are supported by the project findings (Azadegan & Dooley, 2010; Takeishi, 2001).

When the case study was carried out, the development was still in the early stages. This was before the blank release and before the actual supplier negotiations. Only the interview with CS1-ESP4 and my participation in the lessons learned workshop after the project allowed conclusions on the applied supplier management practices. According to CS1-ESP4, the OEM remained fully responsible for the negotiations with the component suppliers. But the engineering changes to the different parts were designed and prepared for decision by the ESP. According to CS1-ESP4, the supplier management is

> […] basically the biggest challenge we have in the project. This is really the topic. We have no contractual relationship with the supplier. The suppliers are themselves partly insecure and ask for the decisions we communicate to them again for confirmation at the OEM. (CS1-ESP4)

In the project, the OEM officially delegated power to the ESP and communicated this to the concerned suppliers, as noted in the key informant interviews. Nevertheless, the challenge seems to persist. According to the lessons learned workshop, during **a kick-off meeting with all concerned suppliers**, the OEM management and the ESP management helped the suppliers to understand the roles and responsibilities in the project and created a trustful relationship, thereby overcoming the identified barrier. This best practice has been applied in the follow-up project and is considered effective. CS1-ESP4 confirmed that the ESP only handles the delta prices of the parts in order to ensure the confidentiality of the supplier prices. The best practices under Rec 13 (joint supplier management process) are supported and partly extended by the case study findings.

In the first case study, the development of the basis car was going on in parallel. Therefore, the documentation had to take place in the PLM system of the OEM to allow real-time traceability of the changes in the lead car development. According to some ESP respondents, an ESP could be more efficient if the teams were working in an internal PLM system and could hand over the data regularly at predefined quality gates. These statements are not in line with my findings from the key informant interviews. Several of the case study ESP respondents argue that the development of a variant or a new car, provided it is based on a completed development, could be achieved in a separate, ESP-internal PLM system which would lead to increased development efficiency. Furthermore, this would allow the ESP to have full traceability of its development process in its own storage. This argumentation contradicts Rec 15 (aligned IT systems with a master closed-loop PLM system on OEM side) and the related best practices (Vasilash, 2009; Wang et al., 2010). For reasons of availability of the monitoring organization at the OEM, an unfinished lead car development has been identified as collaboration-efficiency increasing. The OEM respondents unanimously agreed on the necessity to document the development in the OEM systems, provided that the ESP teams have sufficient accesses. CS1-ESP4 confirms this in the following: ‘So, my clear opinion: Work in the system of the customer, provided you can work efficiently in the customer’s system. Otherwise, you do it twice.’ (CS1-ESP4)

The granting of accesses has been identified as a barrier by all respondents. According to the respondents, the legacy systems of the OEM are highly complex software systems which were initially not designed to give access to organization-external people. Thus, the best practices under Rec 14 (improve OEM's IT systems continuously) are implicitly confirmed by the respondents (Katzenbach, 2015).

> However, this means that a customer must ensure that the ESP, if it carries out such a full vehicle development, has sufficient access to the PLM system and is also trained in it. (CS1-ESP4)

> In terms of rights management in IT systems, [OEM] needs to improve. A general contractor cannot help. Please do not underestimate this. These are grown systems, sometimes even from mainframe times. [IT-system name] is an example. Changing it quickly is not that easy. (CS1-OEM1)

In the analysed project, the project management of the OEM invested a lot of effort in granting access to the ESP teams. According to the OEM respondents, the possibility for the ESP teams to see the development in the lead car and potential changes in modules which might impact the development of the variant car as well is an important advantage and increases the development efficiency significantly.

> My goal is to have, as far as possible, a networking of the general contractor into the work that is done internally. So, the general contractor still notices all changes from the lead vehicle. And everything the general contractor does can directly flow back into the lead vehicle development. Learning from each other is a keyword. Such a strong separation, at least for the projects I've come to know, does not make sense. Both organizations can learn from each other when the changes are known right away. (CS1-OEM1)

Consequently, the OEM respondents confirm the advantages of documentation in the PLM system of the OEM. The main reasons that they mention are traceability of the development data and continued usability after completion of the ESP's project.

Not all ESP respondents seem to agree on this. A possible solution could be to make the ESP PLM system compatible with the OEM PLM system and allow an exhaustive real-time data transfer. But I assume that achieving such compatibility is highly complex. The ESP respondents expressed their concern with not having access to the development progress after the project in case of possible litigation. To avoid this, the OEM and the ESP agreed to **regular data extraction of the development status to ensure traceability for the ESP**. This documentation is carried out through a system deduction for the variant car (BoM, drawing versions, requirement database, etc.). The development was carried out in the PLM system of the OEM, as recommended by the key informants, and the only evidence I found not supporting such an approach were the ESP interviews in the case study. So, I decided to retain Rec 15 and the related best practices as found before the case study, despite the extension concerning the above-mentioned regular documentation. For some of the IT systems in the OEM system landscape, access from outside the OEM's private network was not possible. Therefore, the OEM management provided three level-one laptops to the ESP. These laptops are located in the project space of the ESP and are furnished with a virtual private network (VPN) client which allows direct access to the system landscape of the OEM. A few employees of the ESP who had a concrete necessity to access the OEM network were granted an OEM login user right and they could thereby directly access the OEM's system. For these accesses, an individual non-disclosure agreement between the ESP engineer and the OEM was requested, in addition to the general non-disclosure agreement.

According to the ESP respondents, the obstacles to rights management were reinforced by the following circumstances. During the offer and awarding process, the shareholder situation at the ESP changed. The former 100 per cent daughter of the OEM was no longer a subsidy but a joint venture and the IT systems had been carved out. Therefore, some of the ESP employees who were accustomed to having full access to the OEM systems now had to learn how to work as externals in the OEM's PLM and in the new ESP-internal system environment. These additional efforts and loss in development efficiency through the lack in rights management were not planned in the initial budget, according to CS1-ESP2.

These findings underline the importance of fast data-exchange methods and an integrated PLM system at the OEM that is accessible even to external users with effective rights management.

In CS1, the ESP maintained its own project repository and configuration management tool. Project communication was documented and subversions of the development, presentations, contractual documents, specifications, and the like were stored in this tool. The customer had no access to this data environment. The ESP documents product-relevant data in the PLM system of the customer, whereas intermediate development documentation is versioned and stored in the internal project repository. According to the project team, this is an efficient best practice which is also in line with the best practices related to Rec 15.

Despite the opinion of CS1-ESP1, no other respondent discussed the matter of modern communication technology. Only CS1-ESP1 stated that he had decided to provide modern smartphones to every project team member in order to improve communication since he believes communication is key. When observing the project, I noted that every engineer was equipped with a modern phone, and a laptop, as well as video call, chat, and screen-sharing software, which I often saw in use on the screens of the engineers when they needed to have a quick chat with a project colleague who was currently not present in the project space. Rec 16 (modern communication technology available) and the related best practice therefore finds limited support in the case study.

The modularization of the engineering packages has been confirmed as effective. Thanks to the mirror organization, the management team of CS1 experienced an efficient joint change management process with a CCB. Already, the specifications had defined the cost and other thresholds for engineering changes. Hence, when facing a problem which might lead to increased cost or weight or which could affect the comfort of the car or other criteria, the ESP had to approve the change in the CCB. An application of such a joint change management process supports the mitigation of Ri 2 (agency problems).

> The complete concept finding [for parts] and the complete solution finding are incumbent on the general contractor. Then, in case of doubt, if an impact on specific criteria is expected, on criteria that are important for the series production, this requires approval by the OEM. And what needs to be approved is defined in the specifications. (CS1-OEM1)

The application of the CCB, the module group spokesman concept, the split of the development tasks, and efficient supplier management was only possible thanks to a properly defined modularized system with an NPD plan at the OEM which is oriented to the modules. Rec 17 (outsource NPD of modular engineering packages with clearly defined interfaces and borders) and the related best practices seem to be of utmost importance for the development of a car and therewith also for the collaborative development of a variant car under the lead of an ESP. Thus, I considered no adaptation necessary.

The importance of the skill level of the ESP teams is obvious and all the respondents emphasized it. In the project analysed, an ESP was chosen for strategic reasons. It offered neither the best competence nor the best price compared to its competitors. According to the respondents, the ESP was chosen to qualify it for further projects and to build up a reliable partner with the right skill level. This approach partly supports the best practices under Rec 18 (award projects to ESPs with high technical skills) and I consider no adaptation necessary.

In the case study presented here, I gathered evidence through 9 interviews and participant observations which allowed further elaboration on all findings from the literature review and the key informant interviews. Several best practices could be adapted to the special cooperation model with an ESP as a system integrator for an automobile variant development project. Table 10 depicts the recommendation categories with the related best practices for this cooperation model. Adaptations are outlined in bold and red.

Role of ESP		Turnkey NPD Partner	
Cooperation models		ESP as system integrator	
(Sub-)**Category**	**Executor**	**Case Study Findings**	**Identified Best Practices**
People			
Rec 01: Define sustainable project teams with a problem-solving attitude	**OEM**	Supported by the findings	- Top management explain to the project team the outsourcing decision before project start - Trust ESP works for the best of the OEM - Provide project support with own positive resources if ESP faces problems in the NPD - Lean monitoring organization
	ESP	Extended	- Talent management in place, **internal marketing for important projects** - Mixed business model (Project, EoD, Outsourcing) - Reliable and authentic project managers - Generalist managers on board - Strong Chief Engineer in place - Communicate regularly for the best of the customer - Sales agent who is distinct from the project lead in the project organization - Key roles redundantly occupied **- ESP internal margin sharing accounting, which prioritizes the critical projects over less critical one**
	Both	Adapted & Extended	- Pro-active managers in favour of the collaboration - Mix of personalities on the project team **- Module spokesmen from both organizations with a communication privilege** - Strong project leaders on both sides who get along well **and have a strong positioning in the respective organization** - Consensus-oriented and cooperative teams, trained to collaborate
Rec 02: Provide common project space and promote co-location	**ESP**	Supported by the findings	- Establish global footprint with locations close to the main customer's headquarters - Project management team onsite at OEM, NPD teams at ESP's development centre and offsite - Dedicated mall ESP project space close to the customer's development centre - Define co-location plan
Rec 03: Promote frequent communication	**OEM**	Supported by the findings	- Meeting discipline (meetings with ESP team as important than internal)
	ESP	Supported by the findings	- Ensure very frequent synchro meetings in the beginning - Request meeting discipline
	Both	Supported by the findings	-Regular joint steering committees with open communication
Rec 04: Give NPD teams time to integrate on a personal level	**OEM**	Supported by the findings	- OEM teams to show recognition to ESP teams for their work
	ESP	Supported by the findings	- Invest in a common understanding and relationship at project start
	Both	Supported by the findings	- Appreciation—parties to respect each other as partners - Go on recreational trips together and give room for informal meetings
Rec 05: Strengthen long-term relationship between OEM and ESP	**OEM**	Supported by the findings	- Chose ESP with long-term history in NPD projects
	ESP	Supported by the findings	- Start collaboration with small NPD tasks - EoD experts in place at OEM - Lessons-learned workshop culture in place - Have ex-OEM key players in the ESP organization
Rec 06: Align or understand the culture of the participating companies	**OEM**	Partly supported by the findings	- Apply appreciation mechanisms and have open cultural values
	ESP	Partly supported by the findings	- Install employees with the cultural background of the region or even the OEM
	Both	Partly supported by the findings	- Create common understanding about cultural values - Establish common collaboration code - Make (company)-intercultural trainings
Process			
Rec 07: Apply joint decision-making	**Both**	Extended	- Clarify the technical uncertainty and jointly define the escalation and decision paths to be applied at the beginning of the common project - Regular joint Steering Committees with open communication **- ESP prepare a release recommendation, OEM commodity teams approve the ultimate release of the part**
Rec 08: Apply right level of control mechanisms	**OEM**	Supported by the findings	- Establish a dedicated staff function for monitoring outsourced NPD projects - Assess ESP's technical competence in the domain - Steering via predefined KPIs and Quality Gates - Define quality top-level specifications before project start - Define what should be developed and adapt the level of preciseness of the requirements to the skill set of the ESP and the technical uncertainty
	ESP	Extended	- Submit high-quality offer, which can be transformed in requirements - Perform an offer winning chance analysis of the current business opportunities and a consequent investment in the offer redaction for the opportunities with the highest award probability **- Apply maturity degree controlling and provide consequent reporting to the OEM**
	Both	Supported by the findings	-Offer and requirement workshop at project start
Rec 09: Align PM practices as well as NPD and CE processes	**OEM**	Supported by the findings	- Provide an aligned budget for project management to the ESP - Matrix organization with specific project-oriented model to monitor ESP - Implement a matrix organization with a specific project-oriented process model to monitor ESP
	ESP	Supported by the findings	- Define RACI chart or similar - ESP PM to insist on a common understanding of project planning and responsibilities - Establish very strong PM & cost engineering skills - Maintain an internal, flexible NPD process model, adaptable to the requirements of OEM, managed by a central department - Project members trained on customer's NPD process
	Both	Supported by the findings	- Implement a project dictionary or wiki that can be accessed by every project member - Define documentation and reporting structure at the beginning of the project - Clearly define roles and responsibilities in project initiation phase - Invest a significant amount of the project resources in the creation of a common understanding in the project initiation phase - Apply OEM macro process model, with defined interfaces
Rec 10: Early involvement of strategic ESP partners in the concept design	**OEM**	Supported by the findings	- Involve ESP considered for serial development in concept phase
Rec 11: Establish efficient knowledge handover processes	**ESP**	Supported by the findings	- Define the test & verification planning and the OEM teams should execute or participate in the validation of the final product
Rec 12: Apply strategic ESP involvement process	**OEM**	Adapted & extended	- All concerned technical departments jointly commit on the outsourcing decision - Grant full system access to ESP for the specific project - Build up strategical partner ESPs - Start relationship OEM and ESP with smaller NPD tasks, to gain implicit knowledge **- Define a long-term insourcing and outsourcing roadmap and involve strategic ESPs** - Focus on lead car development, in order to increase the vertical development integration - Perform regular capability assessment of the strategical ESP **- Choose variants for outsourcing for which the related lead car development organization is still available during the design phase of the variant** **- Choose variants for outsourcing with a high level synergies between the lead car and the variant**
	ESP	Supported by the findings	- Define a key account organization for each customer
Rec 13: Apply joint supplier management process	**OEM**	Extended	- Give an official statement to all suppliers involved in the NPD process, delegating the power of the development officially to the ESP as prime contractor - Involve ESP in the sourcing of the suppliers for the specific product
	ESP	Supported by the findings	- Develop supplier management competences and have good knowledge about the local component and subsystem suppliers around the world - Perform delta price negotiations with supplier and confirmation by the OEM
	Both	Supported by the findings	- Determine thresholds or limits before the start of the project in which the ESP may move
Collaboration Technology			
Rec 14: Continuously improve IT solutions and integrate legacy systems with modern solutions	**OEM**	Supported by the findings	- Establish fast secured data exchange models - Integrate legacy systems into the closed-loop PLM systems as well as define clear interfaces and templates
Rec 15: Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side	**OEM**	Supported by the findings	- Closed-loop PLM system with clear documentation rules
	ESP	Slightly adapted and extended	- Carry out special development tasks in which the ESP is particularly qualified in its own tool environment - Invest in own software tools, focussing on configuration management and special NPD tasks - Document the whole development in the PLM system of the OEM
Rec 16: Have modern communication technology at hand	**Both**	Supported by the findings	- Provide project team with modern communication technology (video chat, smart phone, exchange servers ...) **- Regular data extraction of the development status to ensure traceability for the ESP**
Product Technology			
Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders	**OEM**	Supported by the findings	- Modularize engineering packages along the NPD process, which can be localized in NPD centres - Properly define system structure (modularization) and the interfaces
Rec 18: Award projects to technically highly skilled ESP	**ESP**	Supported by the findings	- Implement formal mechanisms to protect the IP of their customers - Invest in innovations synchronized with the innovation road-map of the customers and demonstrate innovation power

Table 10: Adapted best practice guideline model for variant development projects under the lead of an ESP

The above table shows the identified best practice guidelines assigned to a recommendation category—the responsible project party for the ESP role of 'turnkey NPD partner'. Refinements based on the findings in the first case study are marked in red and bold.

4.2.2 Second case study: Agile software development of a new functionality in the field of autonomous driving for serial application.

In this section, I describe and discuss the research findings gained in the second case study: the agile software development of a new functionality in the field of autonomous driving for serial application.

The data gathering was done through participant observation and project participant interviews. As in the first case study, I listed and assigned a code to each interviewee according to the order of execution of the interviews. For the respondents of the ESP in the second case study, the code CS2-ESP plus any number was used. For the respondents of the OEM, the code CS2-OEM plus an index number was used.

Over a period of six weeks, 11 interviews were conducted with a total of 13 persons in the beginning of the year 2019. Two interviews were conducted with two respondents at the same time due to the request of the respondents. For reasons of personal insecurity about what they were allowed to reveal, two respondents wanted to do the interview together with their superior manager. The face-to-face interview mode was chosen in general, with the exception of one telephone interview. All interviews were recorded with the consent of respondents. Depending on the respondent's request, the offices of the respondents or the meeting rooms of the service provider or the car manufacturer served as the premises for the discussions. At the end of the interview, the interviewees were asked to name other potential experts in this area with the aim of preventing the lack of involvement of an important stakeholder.

The interviewee details are depicted in the following table.

Respondent	Organisation	Professional position	Year of experience in current position	Years of experience in NPD	Interview place	Interview atmosphere	Impression of the interviewee(s)
CS2-ESP1	ESP	Regional Division Leader / Project Sponsor	>3 years	>15 years	Own office	Very open, relaxed	Very interested in the study, proactive, direct answers
CS2-ESP2	ESP	Project manager in project management office	>1 year	>5 years	Meeting room	Very open, relaxed	Interested in the study, proactive, Answers sometimes fuzzy
CS2-ESP3	ESP	Department Leader Electric Electronic and ADAS	<1 year	>20 years	Meeting room	Very open, relaxed	Interested in the study, short answers
CS2-ESP4	ESP	Part project leader software development (SPOC)	>1 year	>5 years	Meeting room	Very open, relaxed	Very interested in the study, proactive, open answers
CS2-ESP5	ESP - JV	Site Manager of the site close to the OEM	>3 years	>10 years	Own office	Open, a little hesitant to reveal too much information	Interested in the study, a little defensive, seemed a little far away from the project
CS2-ESP6	ESP - JV	Technical project leader	<1 year	>25 years	Office of Managing Director, joint interview	Thanks to the participation of the MD open meeting. Technical PL insisted on the participation of his MD, to avoid revealing confidential information without consent	Interested in the study, interviewees wanted to make a point and explain their problems, a lot of examples
CS2-ESP7	ESP - JV	Managing Director	>1 year	>15 years			
CS2-OEM1	OEM	System Architect	>1 year	>10 years	Meeting room	Open, too the point	Interested in the study, proactive, open answers
CS2-OEM2	OEM	Part project leader software development	>1 year	>10 years	Meeting room	Very open, relaxed	Interested in the study, proactive, short direct answers
CS2-OEM3	OEM	Part project leader Automated Valed Parking	>1 year	>10 years	Office of Project leader, joint interview	Part project leader insisted on the participaiton of his superior.	The part project leader was a little hesitant to go too much in detail, for confidentiality reasons. Project leader gave explaining answers. Long meeting.
CS2-OEM4	OEM	Project leader	>1 year	>15 years			
CS2-OEM5	OEM	Sub Department leader Praking	>3 years	>10 years	Meeting room	Very open, relaxed	Not very interested in the study, short answers
CS2-OEM6	OEM	Department leader ADAS	>3 years	>30 years	Meeting room	Very open, relaxed	Very interested in the study, proactive, open answers.

Table 11: Respondents in the second case study on the agile software development of a new functionality in the field of autonomous driving for serial application

The above table depicts the respondents of the second case study interviews, with the names neutralized, showing the type of organization they worked for, their professional position, and their years of experience in their field at the time of the interview.

4.2.2.1 *Project context.*

The case study was conducted in a software development project involving a car manufacturer and an ESP. The contract is a project contract and the desired project outcome is an innovative feature designed to allow autonomous parking. The task is the development of a software code according to the specifications of the client and it ends with the transfer of the IP. In this constellation, it is the first time that such a large project scope has been awarded. The project has a planned budget of EUR 30 million to EUR 40 million. It employs about 30 people at the client company and about 250 employees at the ESP. The completed function will be installed at the customer company in a variety of vehicle variants. At the time of the case study, more than a year of the project duration of four years had passed. The project is named Parking 3.0 and it has an innovative project character. I assumed that it would facilitate the gathering of rich findings and that it would be a good subject for my exploratory research. Furthermore, such a project constellation is rare. As far as I know, this project is the first time that an OEM has outsourced such an important innovation development to an ESP. But, according to my market knowledge, the literature review, and the findings from the case study, I assume that such project contracts will appear more often in future for the reasons explained below and in Chapter 2.2.3. I therefore consider the findings of this case study to be valuable and trendsetting. Since the function to be developed is an innovation, it may be concluded that neither the OEM nor the ESP has already implemented a project assignment with this task. The outcome of the project is thus uncertain and it is also associated with a certain degree of risk. In addition, it must be assumed that software development, as a new business area of the OEM and the ESP, will decisively affect the future success of the company. In case of failure, due to the large order volume, there will be an impact on the economic health of the participating ESP. In addition, a failure would damage the good reputation of the ESP in the market. It stands to reason that the complexity of a 'normal' development process is enhanced by the fact that the project task is software development. For the efficient development of software, the special methods of an agile software development process are needed. The project character described and the project framework conditions make the Parking 3.0 project significant for the client company and the service provider as well as for their future collaboration. Therefore, I consider this project to be well suited for analysing the cooperation between car manufacturers and service providers.

In general, I discerned an important uncertainty in the project. A big part of the best practices found earlier were not applied in the project. The project team expressed general dissatisfaction with the development progress and the development efficiency. After the first interview with CS2-ESP1, I realized that I might not be able to identify the best practices applied in this project, or only a few of them. The study of this project would allow an analysis of the consequences that arise if best practices are not applied. This might enable me to derive refinements in the current model or different best practices for such software development projects.

4.2.2.1.1 *The OEM.*

The customer in the project is an OEM that ranks among the world's top 10 largest manufacturers by production in 2017 (OICA, 2018). The group brings together a multitude of brands under one roof. Through modularization, it is possible to use uniform vehicle platforms for a wide variety of brands and vehicle applications. The development departments of the individual brands form excellence centres for different fields of technology. One development department, for example, develops the innovations in the chassis area, another in the propulsion, and the main brand focuses on driving assistance systems. Moreover, the operating business is divided into three industrial segments: passenger cars and light commercial vehicles, trucks and buses, and power engineering (large diesel engines, turbomachinery, special transmissions, components of drive technology, and test systems). The analysed project has been contracted with the main brand in the passenger car division and takes place close to the headquarters and R&D centre in Germany in the department of ADAS development. Like the OEM in the first case study, the company can be categorized as an analyser organization according to Miles, Snow, Meyer, and Collman's organizational strategies (Miles et al., 1978). This OEM, like the OEM in the first case study, is an established manufacturer that is one of the oldest automobile manufacturers in the world. At the time of the project, the company was undergoing a massive restructuring phase. It was investing intensively in the development of new propulsion concepts, energy storage systems, mobility concepts, and ADAS. In the field of ADAS, the OEM can be considered as a prospector. According to the company's financial statement, which is published on the website, the R&D expenditure exceeded EUR 13 billion in 2018 and before. According to the 2018 EU Industrial R&D Investment Scoreboard, this means the OEM ranks among the top 10 R&D investors in the world (European Commission, 2018). The company expects an absolute increase in R&D cost in 2018 and 2019, according to the outlook given in its financial statements. This increase is due to significant investments that are focused, above all, on electrification of the vehicle portfolio, a more efficient range of engines, digitalization, and new technologies.

4.2.2.1.2 *The ESP.*

The ESP is one of the world's leading companies in engineering and consulting. With over 20,000 engineers working in Europe, Asia, North America, the Middle East, and Africa, the company has important development capacities. The ESP's customers come mainly from the mobility sector with a focus on automotive, aerospace, and railways. A big part of the sales revenue is generated in France and Germany. In Germany, the company works mainly in the automotive business. After a series of company acquisitions, the company is today among the leading 10 ESPs in the automotive business, and in the rare position to be able to offer services over the whole value chain of an automotive OEM. The technical integration of the different acquired companies is finalized and all subsidiaries penetrate the market under the same brand. From the point of view of company culture and trust, the integration process still seems to be ongoing, according to the respondents, which leads to problems in the project, as explained below. The ESP holds a 51 per cent interest in a joint venture with one of the brands of the OEM group. Furthermore, the ESP has regional legal entities in Germany. In the Parking 3.0 project, all the software and ADAS competencies of the ESP are needed. Therefore, all legal entities participate in the project. The regional legal entity close to the customer's site is the prime contractor and sub-contracts are issued internally for the different development tasks carried out by the other legal entities. The joint venture company has important competencies in ADAS and vehicle motion management. Therefore, it takes on a lead role in the project.

4.2.2.1.3 *The outsourcing decision.*

The project character is special. According to my knowledge and according to the respondents, this is the first time that an OEM has outsourced the development of such a strategic innovation to an ESP. Therefore, the question arises as to why this project contract has been awarded externally and why it has been awarded to this ESP.

The majority of the respondents (11 out of 13 respondents) named one reason for awarding this project assignment: the resource bottlenecks of the OEM. Four of these respondents, of whom three are from the ESP group, explicitly mentioned capacity issues as the main motivation for awarding this project. For the others, the lack of employee capacity is cited as one reason among others. A main motive for the outsourcing decision thus seems to be IM 3 (need for capacity not currently possessed and resource flexibility while increasing vertical integration).

Moreover, the majority of the respondents agree that the lack of know-how or competence was also a reason for the award.

> Another factor is the know-how. We are looking for partners who already have a few successful projects in the automotive industry behind them. In this case, projects in the automotive industry with software sourcing, electrics, and electronics, so we're able to get the resources or know-how we need. (CS1-OEM6)

Hence, IM 2 (access to specific know-how, intellectual property and wider experience and knowledge) also appears to be a major factor for the outsourcing decision.

Furthermore, some respondents cited cost efficiency as a reason for awarding the project. Two of the ESP respondents and one OEM respondent commented that the ESP is more cost-effective for the project and the budget plan is more reliable. IM 1 (minimization of cost [increased efficiency, lower labour rates] and cost restructuring [change fixed cost to variable cost]) also seems to have been a motive for outsourcing in this case.

In addition, a few OEM respondents address the topic of IP or software development. One interviewee says that it would be advantageous to outsource to an ESP in a project contract form since the IP rights remain with the customer and no further license fees apply. Eventual patent rights for the know-how are on the OEM side, even if the know-how is created by an external company. Respondent CS2-OEM4 describes the development of the software as a new 'core know-how' of an automobile manufacturer, and the functions thus developed as the only distinguishing feature in the future and therefore as decisive for the success of a car manufacturer. Therefore, joint development with an ESP also makes it possible to build new know-how on the OEM side and this is necessary. According to CS2-OEM4, successful development of the software is the way into the future. I assume that the reason why several OEM respondents described the project as 'in-house development' is because the IP rights lie with the customer—a work package service contract exists between the service provider and the OEM in which the ESP develops the IP for the customer. Even if the development is outsourced, the OEM increases its vertical development integration, which is in line with IM3 as the main motive. Nevertheless, initial abnormalities can be discerned here which will be explored in a later section. The OEM respondents refer to this project partly as an in-house development and partly as a joint development, whereas the contractual agreement of the project foresees the ESP as prime contractor and responsible for the software development, which makes joint development possible only to a limited extent.

The statements made by the interviewees suggest that the main reasons for the outsourcing of this project lie in the capacity bottlenecks which are closely related to the missing know-how of the client. Furthermore, cost seems to have played a role. Not only a cost reduction through improved efficiency expected can be expected, but also the budget become more predictable. According to the statements of two

OEM respondents, the internalization of IP generation through IP handover by the ESP can be identified as a reason for outsourcing. The missing competence and the lack of capacity in the field of ADAS development seems to have been a reason to outsource. The OEM wants to keep the IP and the know-how within the enterprise in order to be able to use it in future developments. Furthermore, thanks to the cooperation, the OEM teams seem to expect a build-up of internal know-how for further developments. Thus, IM 1, IM 2, and IM 3 seem to be the main motives for the outsourcing decision in this case. Thus, the internal motives are partially in line with the motives for outsourcing NPD identified in the literature (Binder et al., 2008; Holtrup, 2018; Ragatz et al., 2002).

Initially, the OEM intended to outsource the development and the testing to one ESP. In the final bidding round, two ESPs remained as preferred partners: the ESP which finally won the project and a second ESP which is a 50 per cent joint venture of the OEM. Finally, the OEM decided to split the project and to award the first ESP with the main task: the development of the software, handling the processing of software requirements, the definition of the architecture, the software design of several modules, and the module testing. The software development is focussed on the interpretation of the vehicle situation, which is the most challenging task in this development. The second service provider is in charge of several vehicle motion functions, the final testing, and validation, which includes system architecture validation and system requirements tests. At the time of the case study, the second service provider was not yet active on the project, since the testing starts at a later stage of the project.

4.2.2.1.4 *The project organization at the time of the case study.*

The project is split into several main tasks, as stipulated in the project contract and in the project handbook.

- Project management office (PMO) work package: Handling the overall coordination of all project management processes of the individual work packages, and coordination with the project management team of the customer.
- Error, Requirement, Interface, and Security (ERIS) management work package: Handling the logical requirement definition, the system requirement definition, and the description of the system architecture.
- Software development package: Handling the coding of the software modules.
- Software integration: Implementation of the individual software modules and accompanying tests.

Each work package and sub-work package is managed by a single point of contact (SPOC) on the ESP side.

These SPOCs represent the teams of the service provider. The SPOC acts as an interface between the customer and the distributor of work orders for the team of employees. The SPOCs are part of the different contracted work packages. This organization is similar to the module group spokesman organization in the first case study. According to the respondents, this SPOC organization has been applied for the same reasons as mentioned in the first case study and identified in the key informant interviews. With such an organization, the OEM aims to avoid an excessively deep integration of the ESP project team into the OEM teams and thereby avoid direct instructions or relationships which could be considered as a legal work relationship.

In the project and work package organizational chart, a managing director of the ESP and the department director on the side of the OEM form the top management of the project. This is followed by the regional division director at the ESP with his counterpart, the sub-department director at the OEM. Under the top management are the project leader of the service provider and the project leader on the OEM side. For each work package that is awarded, a sub-project manager is employed on the side of the OEM. These sub-project managers maintain contact with the SPOCs.

4.2.2.1.5 *The product to be developed.*

During the case study intervention, the project was undergoing an important change. The OEM sales department rejected the initially planned function of the software. The initial specification was to develop a functionality that would allow the driver to leave the car in front of a parking garage and the car would search for parking on a specific equipped parking deck and park there automatically. This would lead to increased density on the parking deck, since the car doors could remain closed when parked. Furthermore, the driver would save several minutes of time because the parking manoeuvre would be carried out by the car itself without any support from the driver. But, according to the respondents, the marketing department complained that this functionality would only work in cooperation with car park companies. When the OEM's marketing and sales department reviewed the initial use case, it was concluded that such a functionality had insufficient sales force and the project requirements were therefore changed during the project. From the beginning of

2019, the requirements were updated. The vehicle equipped with this system should now be able to find a parking space in any parking zone and park autonomously.

4.2.2.2 *Findings and discussion.*

The mentioned change in the main requirements led to a significant change in project planning, resource planning, and the feasibility study. The complexity has increased exponentially, say the respondents. Since the environment in which the car parks is no longer controlled but is open to everyone, the safety requirements increase as well. At the time of the case study, the required Automotive Safety Integrity Level (ASIL) was not yet clear to everybody since the use cases were yet to be finalized. A change in the ASIL level can lead to a significant increase in the development efforts. Thus, the technical uncertainty was at a peak when my co-researcher and I analysed the project. After nearly a year of project time, the requirements were not clear to all project members, which led to much confusion. The majority of the respondents agreed that the change in scope significantly increased the complexity of the project. Besides the high technical uncertainty, the project organization was not clear to everyone, the IT development environment was not clearly defined, and the process model to reach ASPICE level 2 was in development. In this section, I further explore these findings and derive barriers and refinements of the found recommendations for highly complex, safety-relevant, automotive software projects under the lead of an ESP.

All respondents from the OEM side and the majority of ESP respondents have identified challenges related to team cohesiveness. According to the respondents, it is challenging not to know the whole team. The OEM management has no direct contact with the development team on the ESP side, which is considered to be a barrier for the collaboration. It is considered difficult to use all resources optimally without knowing the exact level of information of all participants and the available capacity. Based on the observations in the project, it quickly became clear that the outsourcing motivation led to a misunderstanding in the work description of the ESP. In contrast to the first case study which focused on a variant development, the organizations involved in the second case study had no experience in outsourcing or delivering such a project. In a variant development project, the scope of work is clear, interfaces are described in detail, and a project contract with a turnkey character can be defined based on past experience. In the second case study, given the very high level of technical uncertainty, the OEM teams wanted direct control over the development teams. This lack of direct control of the ESP teams and the resulting perception of missing team affiliation can be deduced from the analysed data as being a challenge to collaboration. Without a sense of belonging, the motivation and commitment to drive the project forward was low and thus not very efficient. The SPOC model and the resulting anonymity of those working on the project contribute to a low sense of team affiliation. Due to the recent, yet to be completed integration of several acquired companies into the ESP group, the development service provider does not have a pronounced 'we feeling' among its own employees in the project. In addition, subproject managers on the OEM side only know a small section of the ESP team—the SPOCs. The respondents of the technical department on the OEM side considered it challenging to plan optimally and use all the resources of the large ESP team without a direct line to them and without personal contact with all employees. In addition, it is difficult, says CS2-OEM2,

> if you work in such a work package and somehow behind the SPOCs there are three more levels [...]. I find it very difficult for the project members to identify themselves with the issue somehow. It would be easier if we were somehow in a large group on the road and all working together on the vehicle or somehow closer to it. (CS2-OEM2)

This statement highlights a general problem of the project. The OEM procurement team outsourced a complete project contract with a full responsibility shift to the ESP. But the technical department seems to want to remain responsible for the development of the technical solution and wants to form one team with additional resources from the ESP. A discrepancy in the understanding of the project scope for the ESP can be discerned. Apparently, the major motivation to outsource to the ESP by the OEM's technical department was IM 3 (need for capacity not currently possessed and resource flexibility while increasing the vertical integration). Implicitly and, sometimes also explicitly, the OEM respondents stated that they would have preferred to integrate the ESP teams fully in their development teams, which is not allowed by the compliance regulations of the OEM for the reasons stated earlier. Thus, the applied SPOC system, like the module group speaker system in the first case study, mitigates Ri 9 (risk of labour law disputes with ESP employees), but in the Parking 3.0 project, the system also seems to hinder efficient collaboration. These circumstances made the creation of a sustainable project team with a problem-solving attitude (Rec 1), as recommended by academics (Binder et al., 2008; Handfield & Lawson, 2007; Hoegl & Wagner, 2005; Wagner & Hoegl, 2006; Wognum et al., 2002) and practitioners in the field difficult.

These findings underline the need for **clear communication of the outsourcing decision by the top management of the OEM**. It seems necessary to consider the type of the project before deciding on the form of outsourcing. But if an outsourcing decision in the form of a turnkey project contract is taken, all participants should try to stick to this outsourcing model. The respondents expressed their dissatisfaction with the level of trust in the relationship. They noted that there was little trust between the development partners involved. It seems that the development partners in some areas have little confidence in each other. In project meetings, project managers from both sides often insisted on an arrangement that had allegedly been discussed in the past in order to avoid additional effort by their own team. I regularly observed negotiations and debates over the exact scope of the engagement, which indicates mistrust in the relationship. Based on this observation, I deduce that the involvement of technical and development counterparts in budget negotiations on additional efforts can damage the trustful relationship that is necessary between the counterparts. Having a separate sales agent of the ESP in charge of such negotiations can therefore be advantageous for the collaboration of the individuals who are in charge of the project execution. Particularly important seems to be the relationship between the interface personnel of the OEM and the ESP (SPOCs and part project leader). The two communicating personnel influence the attitude of the entire team through their relationship. So, having a relationship of trust is vital (Bstieler, 2006; Pemartín et al., 2018). The lack of trust leads to time-consuming negotiations and control situations that reduce collaboration efficiency. The OEM teams mentioned in part that they do not trust the competencies of the ESP. Moreover, the ESP teams were considered to lack implicit knowledge of the

OEM's practices and processes. According to the respondents, this can lead to more misunderstandings since the two opponents are not familiar enough to interpret the actions and expressions correctly. Owing to the lack of implicit knowledge, the ESP teams had to invest more time in learning and understanding the project and process landscape of the customer at the beginning of the product, which had a negative impact on development efficiency. Unknown deadlines and unsophisticated project planning by the client company put the project in a position of reactivity and prevented early action. Such relatively late action can lead to additional work and thus to a loss in development efficiency. The following quote emphasizes the importance of implied knowledge.

> If you have this implicit knowledge, [...] you can calculate very precisely, know what you have to deliver when and [...] have an idea of what the expectation is. So not superficially really written down requirements, but the knowledge gained through experience in many years of collaboration. (CS2-ESP7)

These findings underline the importance of a long-term relationship between the OEM and the ESP. One could argue that for such a critical and innovative project, a long-term relationship is even more important than for variant development. In order to gain implicit knowledge and to increase the level of trust, the OEM and the ESP should start their relationship with smaller development tasks. Additionally, **OEMs should award projects to ESPs which have proven their technical competence in the outsourced field** (Azadegan & Dooley, 2010). Implicit knowledge can also be gained through the installation of consultants with an EoD contract in the OEM's organization. Furthermore, having ex-OEM key players join the ESP teams to transmit implicit knowledge is also considered as efficient. Therefore, the identified best practices under Rec 5 (long-term relationship between OEM and ESP) are considered to be supported by the findings from the second case study.

Furthermore, the OEM teams should set up a monitoring organization with the goal of monitoring the development outcome of the ESP and not try to intervene in the daily development of the ESP. In the special case of a software innovation project, the OEM teams also have, in contrast to a variant development project, very little experience in the development process. Therefore, the OEM organization in this project is a learning organization and it is unlikely that the OEM has the capability to provide positive project support if the ESP faces problems. Based on my observation and analysis, I believe that the OEM should find a way to draw the maximum learning from such a project. Therefore, **the OEM counterparts should work directly with the ESP teams in order to follow the progress of the ESP teams and learn from it**. This would show appreciation for the ESP teams and, in my understanding, not cause any compliance problems since the OEM counterparts would not be giving direct instructions to the ESP (Siebenhüter, 2014).

A further barrier stated by the respondents is the absence of a general project leader on the ESP side. In the initial project setup, no general project leader on the ESP side was appointed. The ESP was supposed to provide the technical project lead and a project management office and the OEM was to provide the strategic project leader. Such a project set-up turned out to not be in line with the contract situation and seems to have been overly complex to implement. This is a further indication that the main outsourcing motive for the technical department of the OEM was to have additional resources available and not to outsource a turnkey project contract. During the time of the case study, this problem became clear to the management teams of both companies. After more than a year of the project work, the ESP finally appointed a strategic project leader of its own. Thus, based on the experience gained so far, the majority of the respondents view the internal leadership within the ESP team as inadequate.

> When we talk about an overall project leader, that's missing [...] in the project as well. There should be an overall project leader [...] all seven days and 24 hours. I say just [...] in such a project, where all are distributed [...] and that is missing. We need that. (CS2-ESP2)

Inadequate leadership is a major challenge for efficient collaboration because, without direction, the collaborating parties have no goal to work towards (Rosen, 2009). Furthermore, a certain reluctance to make decisions or take responsibility may be observed on the side of the OEM management. Decisions seem to be made hesitantly or are not officially and transparently communicated to all stakeholders. Indecisiveness makes the leadership seem inadequate because the executing teams of the ESP depend on these decisions for their development progress. The barrier of slow decision-making is discussed further in the following section when the agile development process is discussed. Based on my observations and findings, I assume that a strong project leader twin tip with a good personal basis would have helped overcome the barrier of slow decision-making. Therefore, I believe that the related best practice is also effective in an agile software development project under the lead of an ESP. A further barrier mentioned by the respondents for the collaboration was the localization of the chief engineer and the repeated change of personnel. The chief engineer (or in this case the chief software developer) of the project was provided by the joint venture of the ESP. The joint venture has its headquarters in another part of Germany and the company was unable to provide a technical project manager who could be present at the project location. The person in charge of technical management was changed for the third time at the time of the case study. The new technical project leader, appointed in Q1 2019, was the first person to be located at the project site. For reasons of non-availability of the right profile, the process of finding this person took over a year. The need for implementation of a chief engineer in the beginning of the project is underlined by this finding.

Especially the OEM respondents consider it challenging that the ESP teams work on multiple projects, as they are not always available and need to think and work on different projects with different teams. Others, mainly ESP respondents, however, do not see the work of participants in several projects as challenging, so long as this does not affect the current project work of the customer. Based on my observations, I conclude that the fact that ESP engineers work on multiple projects has, in rare cases, a negative effect on team spirit at the ESP. Some of the key developers on the ESP side gave the impression of being overloaded with too many projects. A synchronized and good resource planning procedure can provide support in avoiding this barrier. The resource planning of the project is managed by the SPOC on the ESP side along with the sub-project managers on the OEM side. Thus, according to the respondents and based on the observations, a narrow interface and a trusting relationship between the SPOCs on the side of the ESP and the sub-project managers on the side of the client company are very important. A mirror organization for the main subprojects with a lean monitoring organization was also implemented in this project and was considered as effective. Nevertheless, the ESP respondents consider the division of technical work packages as improvable, which makes the implementation of a mirror organization with a responsibility split very complex. A clean system structure definition with clear boundaries and interfaces seems to be a prerequisite for the implementation of a functioning mirror project organization (Stephan et al., 2008). The related best practice under Rec 17 (outsource NPD of modular engineering packages with clearly defined interfaces and borders) is thus supported by this finding.

Several respondents on both sides discussed the employee turnover on the ESP side. The OEM respondents stated that they felt powerless since they could not directly intervene or create incentives for the ESP employees. Therefore, on both sides, **clean documentation of the development steps** is considered as important. Efficient knowledge handover processes seem necessary not only to hand over the IP at the end of the project but also to transfer the knowledge gained by one developer to another in case the first developer leaves the project. This allows limited mitigation of the lost know-how if an ESP employee leaves the project. The ongoing integration on the ESP side and the excellent market situation for software developers has led to a relatively high employee turnover in the project. The talent management process of the ESP is in the making and the shortage of skilled labour makes it difficult for the ESP management to redundantly occupy key roles in the project. Nevertheless, these best practices can be considered effective if it is possible to implement them. The documentation structure and the development infrastructure for the project was being developed at the time of the case study and was not clear to everyone, which made it challenging to apply a clean documentation system.

The above-mentioned findings mainly confirm the best practices under Rec 1 (define sustainable project teams with a problem-solving attitude). Refinement is considered necessary for one of the best practices.

As explained, reassembling all project management resources in this one location was challenging for the ESP management. When we studied the project, the management had finally succeeded in placing all project management resources in a dedicated location close to the customer's R&D centre. The project space is a secured partner space of the OEM. In these secured partner spaces, the OEM's network is accessible via computers of the OEM. This common project space was made available approximately six months after project start. Nevertheless, having such a project space available is considered as advantageous by the majority of the respondents. The ESP has locations close to all development centres of its main customers, which the OEM teams view as a good selling point. The findings underline the importance of the best practices identified under Rec 2 (joint project space and co-location).

According to the interviewees, no communication matrix existed and the communication channels and contacts were not well-established. The counterparts on both sides seem to have changed often during the project and a **communication matrix** or an RACI was non-existent. This led to the increased need for unnecessary communication or wasted time explaining things several times, according to the respondents. Regular meetings were scheduled but due to work overload and missing prerequisites like a communication matrix, the meetings were not well-prepared and meeting discipline was considered as improvable. Since no strategic project leader was installed by the ESP at the beginning of the project, the communication was not well-organized and hence not frequent enough at the beginning of the project. These findings support the best practices identified in the literature (Pemartín et al., 2018; Ragatz et al., 2002) and in the key informant interviews in relation to Rec 3 (frequent communication) and allow a slight adaptation compared to the literature recommendations. The high project pressure, unclear organization, and high technical uncertainty require close interaction, increased meeting discipline, and sophisticated meeting preparation by all project members, independently from the organization they work for. I assume that the application of the identified best practices related to Rec 4 (give NPD teams time to integrate on a personal level) would support the collaboration between the project stakeholders. The respondents did not refer to such soft skill measures. The interviewees were generally in fire-fighting mode due to the critical project situation and the recent change in scope. The personnel integration of the NPD teams was not in focus. Nevertheless, I assume that trust-building measures, as defined under Rec 4, would lead to an improvement of the collaboration.

Except for the fact that CS2-ESP1 and some of the project managers and team members were locals with a regional background and possessed good knowledge of the customer, I could not find any evidence for measures applied in relation to Rec 6 (align or understand culture of participating companies). Such measures of cultural alignment seem to fall behind on obvious project management tasks, when projects are in a critical situation. The senior key informants who were interviewed emphasized that a common ontology and understanding of each other's culture is a critical success factor in joint development projects. Thus, I assume that non-application of the identified best practices is one of the reasons for the critical situation of the project at the time of the study.

The project had a regular steering committee as the central decision-making body. The top management of both parties participated in its meeting. According to the respondents, the preparation of this meeting could have been improved. This may be due to the lack of a strong project leader on the ESP side. The respondents expressed their optimism that this situation would improve following the appointment of such a project leader. The best practices under Rec 07 (joint decision-making) are partly supported by the findings (Nellore & Balachandra, 2001). Since the OEM teams seemed to want to stay in direct control of the development process, the decision-making was more on the OEM side. The ESP teams prepared the groundwork for the decisions, and the OEM management decided. The decision-making process at the OEM organization was considered as rather slow by the ESP respondents. Especially in combination with an agile development approach, this is a barrier to efficient collaboration, as outlined below. The applied steering mechanisms were characterized by direct intervention of the OEM management in the project progress. This was considered a limitation of the degree of freedom of the ESP teams. In combination with an assumed insufficient skill level of the ESP team, this is believed to be the main reason for the critical situation of the project. Following the findings gained from the key informant interviews, in cases involving a high level of uncertainty, the OEM management should give more freedom to the development team instead of less. It should focus instead on steering the project via predefined KPIs and quality gates. As discussed in the literature and by several key informants, development efficiency can be improved by increased fuzziness in the specifications and especially in behavioural control to a certain extent (Carson, 2007). Given that the development outcome is still unclear, the OEM was at the time incapable of clearly defining the KPIs that needed to be monitored. Thus, the non-application of the best practices identified under Rec 8 (right level of control mechanisms) contributes to the decreased development efficiency. According to several respondents, the application of such best practices could have avoided the problems which occurred in the project.

The respondents describe as challenging ‘to handle the expectations with very large and even geographically dispersed teams.’ (CS2-OEM6)

It seems important to regularly align expectations with the counterparts, as the lower specification depth in the product description leads to undescribed expectations. Non-expressed expectations cannot be implemented. Therefore, the project team implemented a **regular expectation alignment mechanism** to overcome barriers due to low specification depth.

Moreover, the findings underline the need for a clear and agreed-upon RACI chart or something similar. According to the respondents, the roles and responsibilities of the different stakeholders were not clear to everyone and had not been defined clearly in the project initiation phase. The majority of the OEM respondents identified the lack of project management competence within the ESP team. These interviewees all confirmed that having a complex project task that involves many work packages requires a highly structured and well-trained project management team at the prime contractor. The project management team needs to organize the communication and synchronization between all work packages. Therefore, a dedicated work package with a defined budget has been agreed to in the project contract. Moreover, all respondents agree and the observations have shown that that the process landscape for the development was unclear. Based on the statements heard and the observations made, it can be surmised that only a few communicated specifications were communicated by the client company about the use of certain processes. From the point of view of the ESP respondents, the specification of the requirements and the project plan did not seem to be detailed enough, which made setting up appropriate processes challenging. The agile development of complex functional software for serial application was a very new activity for the OEM, which suggests that there were no implemented and streamlined processes.

‘It's all in the making. That means all the tools we need to do that and all the processes we need to do that in parallel. That is also the [...] big challenge.’ (CS2-OEM4)

The lack of process specifications and communication seem to have led to a significant barrier to efficient collaboration. Since the process model necessary to develop the innovative solution did not exist yet, neither at the OEM nor at the ESP, a best practice could be to jointly define an applicable process model before project start. The different feedbacks allow one to conclude that the project team was missing a common understanding about the roles and responsibility, the process model to be applied, the specifications, and the scope of the project. This finding underlines the need for a common understanding. One could argue that the higher the technical and process uncertainty, the more resources should be invested by both teams in creating a common understanding. Several respondents referred to the importance of the Automotive SPICE process maturity assessment model, which is studied in Chapter 2.1.3, and the possibility to compare the process maturity of the participating organizations by using this model. The OEM requested a minimum automotive SPICE level 2 for all processes applied in the project. The ISO/IEC 33020 describes level 2 as a managed process. To reach this level, the implemented process must achieve its process purpose. It must be 'implemented in a managed fashion (planned, monitored and adjusted) and its work products are appropriately established, controlled and maintained' (VDA QMC Working Group 13 / Automotive SIG, 2015).

When the project began, this process maturity level seemed unachievable. Neither the ESP processes nor the OEM processes met the requirements. The project management office was occupied in developing those processes and preparing a SPICE assessment which would be applied during the project. For future projects, the OEM management teams intend to award projects to partners that have the same or a higher maturity level.

The project contracts foresaw a development oriented on the Scrum approach. The development is incremental and additional functionalities are added after each development sprint. At the time of the case study, the basic situation analysis software was in development. A majority of the respondents stated that the decision paths on the OEM side were too long. With fuzzy initial specifications, 'fast reactions and decisions by the OEM are needed.' (CS2-ESP3)

The rigid OEM organization with many bodies and escalations steps seems not to be well adapted for such an agile development. An example of slow decisions in the OEM organization is the use case change by the sales and marketing department outlined earlier. It took over a year for the OEM teams to decide this change. Several developments were now obsolete, according to the respondents, which led to additional efforts. A rigid OEM organization in combination with an agile development approach seems to lead to a tremendous loss in development efficiency and therewith to increased cost for the OEM. The project character of agile software development, as described in Chapter 2.1.3.3, led to the application of agile working methods in the development process. The product development process of the automobile manufacture is component-oriented and therefore seems difficult to combine with an agile approach.

> That's the prime example of how difficult it is [...], in such a software [...] development project, to control these agile development cycles [...] at the supplier and the OEM so that they really fit together and subsequently, in the result, meet the milestones from the product development process. (CS2-ESP1)

Bringing the classic world of automobile NPD and agile software development together was seen as challenging. The fact that working arrangements between the OEM and the ESP in a software development project first had to be coordinated with or adapted to each other, or that a common working method had to be established, significantly reduced the efficiency of the collaboration. Different working methods appear to inhibit efficient cooperation. Thus, it seems helpful if the OEM and the ESP **jointly agree on the agile working methods to be applied before project start, implement them, and adapt the respective organization accordingly.** Such agreed-upon working methods would make the definition of a documentation and reporting structure redundant. The best practices in Rec 9 (align PM practices as well as NPD and CE processes) are therefore refined for the case of agile software development (Azadegan & Dooley, 2010; Carson, 2007; Wolff, 2007). These findings underline the need for strong and decisive project leaders and well-established escalation mechanisms, which are identified as best practices under Rec 1 (define sustainable project teams with a problem-solving attitude) and Rec 7 (apply joint decision-making).

The best practices to involve the ESP considered for serial development in the concept phase can be adapted. In an agile development approach, the specifications can be adapted during the project and the concept is defined during the development. Therefore, only strategic ESP partners are involved in such innovative projects. In order to involve strategic ESP partners in the concept design early on, the two companies should **award the project to the ESP at a very early stage and jointly implement agile software development methods before starting the development**.

In my opinion, it may be discussed if it is the right decision to outsource via a turnkey project contract, if the technical uncertainty is at the perceived level, and if the OEM teams want to be in charge of the development. A strategic ESP involvement process seems crucial for the OEM to create an environment that enables teams from both parties to carry out such projects efficiently (M. Becker & Zirpoli, 2003; Handfield et al., 2000; Ragatz et al., 2002). I was able to identify evidence supporting only a few best practices related to Rec 12 (strategic ESP involvement process). Nevertheless, I assume that these best practices remain valid also, or even more so, for the outsourcing of innovative software development projects in the automotive industry. Therefore, I decided to keep them unchanged with respect to the findings in the literature and from the key informant interviews.

In software development projects like the one analysed in the second case study, less priority is placed on supplier management since fewer suppliers are involved. The only component supplier with which the ESP teams are in contact from time to time is the provider of the ECU on which the software will be flashed once it is finished. The requirements for the hardware suppliers are defined by the OEM. The sensors, laser cameras, cameras, and hardware infrastructure needed for the functionality have been defined by the OEM before the start of the development of the ‘intelligence’. The feasibility study was performed by the OEM teams earlier and no change in the hardware configuration is expected. Therefore, the respondents consider a joint supplier management process as irrelevant to the analysed software development project.

The majority of respondents and all the ESP respondents addressed the topic of the IT infrastructure. They consider it necessary to have established a common IT infrastructure in the project and to have functioning accesses for the ESP teams. The granting process of these accesses, as well as the provisioning of the required computers and hardware, was described as very time-consuming. In addition, each time a new employee joined the project, time was spent on the grant process and the new employee was unable to work at full capacity for several weeks, according to the ESP respondents. The granting of full system access to the ESP teams is identified as critical. Furthermore, **the access granting process for new project members should be designed in a leaner way**. The OEM respondents confirmed that the IT infrastructure of the OEM was not designed to grant easy access to company-external individuals. Therefore, OEMs are challenged to integrate legacy systems and to provide a closed-loop PLM system (Katzenbach, 2015).

A majority of the respondents believed that there were no uniform guidelines regarding which tools should be used and for what. For every problem, there were several solutions and several tools could be used. Every company and every work package used its own, different tools, which may not have matched those of the customer companies, according to the OEM respondents. An example is that a document management system (DMS) should be selected before project start. Several possibilities existed and were discussed, but the decision was regularly adjourned. The DMS supports configuration management in a complex software project. Particularly with an agile development approach and a lot of developers involved, the consequent application of configuration management mechanisms and versioning of the development stages is very important (Conradi & Westfechtel, 1998; Whyte et al., 2016). Here, the different companies continued to use different DMSs. The current solution was to use Microsoft SharePoint (a web-based collaborative platform that is primarily used as a document management and storage system) as a DMS, but this proposal was not rolled out project-wide.

According to the interviewees, 'everything is actually in the making—meaning all the tools we need.' (CS2-OEM4)

The OEM technical department considered it an important challenge to build up and define the toolchain. The OEM lacked experience in this type of software development project and therefore had no proven tools. Some tools were under construction. According to the interviewees, it was difficult for the project participants to learn and apply new tools. The already deployed IT infrastructure was used in different ways by the project participants. Some participants stated that they used the tool environment on a daily basis, but others did not know 'what are my login data?' (CS2-OEM5)

According to the OEM respondents, the ESP should provide a suitable toolchain for the development of such software. The ESP respondents state that a toolchain was offered to the OEM, but the decision to use it was still pending. Meanwhile, the ESP continued the development on its toolchain, hoping to be able to integrate the development outcome afterwards as needed by the customer.

Some of the interviewees explicitly named the connection to the customer network as a 'big catastrophe.' (CS2-OEM2)

The service provider teams had the possibility to dial into the customer network via a VPN. However, according to the interviewees, technical problems occurred regularly and resolving them took a long time. In addition, when dialled in via VPN, some of the OEM's tools were limited in their performance. This made it a challenge to get the ESP teams working efficiently, say the OEM respondents. The ESP respondents also described the data exchange between the different areas of the ESP organization as time-consuming. Setting up the internal IT infrastructure was only completed after the start of the project. Since the integration of the different acquired companies by the ESP was still ongoing, the IT infrastructure was not yet fully integrated, which led to losses in efficiency.

The OEM respondents mainly stated that the tool environment and the toolchain for the project should be built up jointly by the project team. On the other hand, the ESP respondents expected the OEM teams to provide the tool environment before starting such a development project. According to the ESP respondents, the ESP team is ‘not contracted to build up their tool environment. If they want us to do that, they have to pay for it!’ (CS2-ESP1)

When **starting such a project, a performant toolchain should be available for the whole project, comprising requirement management tools, development tools, document management and configuration management tools, as well as test management tools.**

The best practices related to Rec 14 (improve OEM's IT systems continuously) and Rec 15 (aligned IT systems with a master closed-loop PLM system on the OEM side) are supported by these findings and extended for the case of agile software development projects.

Several respondents argued that for a project like the one studied, with geographically dispersed teams, the use of modern communication technology supports the collaboration. The ESP management decided to provide smartphones to every project team member in order to improve communication. Furthermore, during the observations, as in the first case study, every developer was equipped with a modern phone, and a laptop, and a video call, chat, and screen-sharing software was used often. Rec 16 (modern communication technology available) and the related best practice therefore finds limited support in the case study.

Almost all the respondents have said that with the change in the functional requirements outlined earlier, the complexity of the functions in the technology was increasing and more complex software had to be developed. The integration of the vehicle into the environment created new challenges. The majority of the respondents agreed that developing such an innovation is a big challenge. According to respondents from the ESP and the OEM, the cooperation of several companies is necessary to master such complexity. Project tasks and the problems that arise are too complex for one company alone.

Several respondents suggest that the technological challenge lies in the fact that, first, the technical requirements were vague and, second, the feasibility of the project assignment is questionable as a technical solution is yet to be found. Even if a feasibility study was conducted before starting the project, the change in scope created doubts in the project team about whether this feasibility study was still valid. Especially safety seemed a big challenge. According to respondents from both sides, the specifications of the software feature being developed were not detailed enough. The interviewees from the ESP said they lacked specific information on which technical requirements they should develop and the respondents of the OEM were unable to provide more detailed descriptions in this innovation project. For them, it was a challenge to even set up work packages and delivery items for the entire duration of the project, since the wished-for development outcome was not completely clear to the OEM teams and therefore a detailed work breakdown structure was not feasible. Too many requirements were still unclear. Most of the ESP interviewees addressed the change in scope of the project contract. According to CS2-ESP4, 'the technical scope [had] become much more extensive.'

The change in scope necessitated other functions, scenarios, and test procedures. The effort necessary for this change was difficult to assess in the software project. The change led to challenges and tensions in the collaboration since no corresponding change management had been carried out so far. In addition, the work packages of the software modules were unfavourably divided and distributed from the point of view of the ESP respondents. So, tasks that actually belonged together were processed by different work packages. **A joint commitment on the work breakdown structure and joint definition of the technical modules** in the beginning of the project would have helped to avoid the above-mentioned barriers. At the time of the study, with the installation of the new strategic project leader on the ESP side, efforts were made to refine in detail the work breakdown structure and the interfaces of the modules. Considerations on IP protection were not made in the interviews. I assume that the respondents were occupied with finding solutions to the more operational problems. Also given that the project was in the initiation phase, even if 30 per cent of the project time had already passed, I assume that the project members had not thought about IP protection yet. Thus, the best practices identified in Rec 17 (outsource NPD of modular engineering packages with clearly defined interfaces and border) find support in the case study and are partly extended. The evidence only partly supports best practices referring to Rec 18 (award projects to ESPs with high technical skills).

In general, the project analysed here may be taken as a negative example. The critical situation was accepted by the customer since the expectations on the OEM side for the first phase were relatively low and the customer management seemed aware of the high degree of fuzziness within the specifications. Since the ESP also lacked in performance and skill, the level of trust between the two main actors was not at the desired level. At the time of the intervention, the project management team of the ESP was investing significant efforts to improve the situation, retrieve the barriers that had arisen, and help their customer become aware of what they expected to be the result of the development. Analysing this project clarified to me that most of the recommendations and implementation of most of the best practices presented at the beginning of the project would have significantly improved the collaboration and thereby the development efficiency of this project.

Since I am currently one of the managing directors of the analysed ESP and this project is crucial for the company, I placed the implementation of the identified best practices on my agenda.

Role of ESP		Software Innovation Partner	
Cooperation models		New technology / new IP for the OEM	
(Sub-)**Category**	**Executor**	**Case Study Findings**	**Identified Best Practices**
People			
Rec 01: Define sustainable project teams with a problem-solving attitude	**OEM**	Adapted	- Top management explain to the project team the outsourcing decision before project start - Trust ESP works for the best of the OEM - Lean monitoring organization **- OEM counterparts should work directly with the ESP teams in order to follow the progress of the ESP teams and learn from it**
	ESP	Adapted	- Talent management in place - Mixed business model (Project, EoD, Outsourcing) - Reliable and authentic project managers - Generalist managers on board - Communicate regularly for the best of the customer - Sales agent who is distinct from the project lead in the project organization - Key roles redundantly occupied
	Both	Refine	- Pro-active managers in favour of the collaboration - Mix of personalities on the project team - Counterpart from both organizations with a communication privilege for each technical subsection - Strong project leaders on both sides who get along well - Consensus-oriented and cooperative teams, trained to collaborate
Rec 02: Provide common project space and promote co-location	**ESP**	Supported by the findings	- Establish global footprint with locations close to the main customer's headquarters - Project management and NPD teams close to the R&D centre of the OEM - Dedicated mall ESP project space close to the customer's development centre - Define co-location plan
Rec 03: Promote frequent communication	**OEM**	Supported by the findings	- Meeting discipline (meetings with ESP team as important than internal)
	ESP	Supported by the findings	- Ensure very frequent synchro meetings in the beginning - Request meeting discipline
	Both	Adapted	- Regular joint steering committees with open communication **- Define communication matrix**
Rec 04: Give NPD teams time to integrate on a personal level	**OEM**	No evidence	- OEM teams to show recognition to ESP teams for their work
	ESP	Partly supported by the findings	- Invest in a common understanding and relationship at project start
	Both	No evidence	- Appreciation—parties to respect each other as partners - Go on recreational trips together and give room for informal meetings
Rec 05: Strengthen long-term relationship between OEM and ESP	**OEM**	Supported by the findings	- Chose ESP with long-term history in innovation projects
	ESP	Supported by the findings	- Start collaboration with small NPD tasks - EoD experts in place at OEM - Lessons-learned workshop culture in place - Have ex-OEM key players in the ESP organization
Rec 06: Align or understand the culture of the participating companies	**OEM**	No evidence	- Apply appreciation mechanisms and have open cultural values
	ESP	Supported by the findings	- Install employees with the cultural background of the region or even the OEM
	Both	Partly supported by the findings	- Create common understanding about cultural values - Establish common collaboration code - Make (company)-intercultural trainings
Process			
Rec 07: Apply joint decision-making	**Both**	Partly supported by the findings	- Jointly define the escalation and decision paths to be applied at the beginning of the common project - Regular joint Steering Committees with open communication
Rec 08: Apply right level of control mechanisms	**OEM**	Partly supported by the findings	- Establish a dedicated staff function for monitoring outsourced NPD projects - Assess ESP's technical competence in the domain - Steering via predefined KPIs and Quality Gates - Define quality top-level specifications before project start - Define what should be developed and adapt the level of preciseness of the requirements to the skill set of the ESP and the technical uncertainty
	ESP	Partly supported by the findings	- Submit high-quality offer, which can be transformed in requirements - Perform an offer winning chance analysis of the current business opportunities and a consequent investment in the offer redaction for the opportunities with the highest award probability
	Both	Partly supported by the findings	- Offer and requirement workshop at project start **- Implement regular expectation alignment mechanism, to overcome barriers due to low specification depth**
Rec 09: Align PM practices as well as NPD and CE processes	**OEM**	Supported by the findings	- Provide an aligned budget for project management to the ESP - Matrix organization with specific project-oriented model to monitor ESP - Implement a matrix organization with a specific project-oriented process model to monitor ESP - Award ESPs with a similar or the same process maturity level
	ESP	Supported by the findings	- Define RACI chart or similar - ESP PM to insist on a common understanding of project planning and responsibilities - Establish very strong PM skills - Own technology development process - Project members trained on customer's technology development process
	Both	Adapted & Extended	- Implement a project dictionary or wiki that can be accessed by every project member - Define documentation and reporting structure at the beginning of the project - Clearly define roles and responsibilities in project initiation phase - Invest a significant amount of the project resources in the creation of a common understanding in the project initiation phase **- Jointly define applicable development process model for the project before project start** **- Jointly agree on the agile working methods to be applied before project start, implement them, and adapt the respective organization accordingly** **- Regular expectation alignment mechanism**
Rec 10: Early involvement of strategic ESP partners in the concept design	**OEM**	Adapted	**- Award the project to the ESP at a very early stage and jointly implement agile software development methods before starting the development**
Rec 11: Establish efficient knowledge handover processes	**ESP**	Adapted	**- Clean documentation of the development steps**
Rec 12: Apply strategic ESP involvement process	**OEM**	Partly supported by the findings	- All concerned technical departments jointly commit on the outsourcing decision - Grant full system access to ESP for the specific project - Build up strategical partner ESPs - Start relationship OEM and ESP with smaller NPD tasks, to gain implicit knowledge - Define a long-term insourcing and outsourcing roadmap and involve strategic ESPs - Focus on joint innovation projects to increase vertical development integration - Perform regular capability and process maturity assessment of the strategic ESP
	ESP	Partly supported by the findings	- Key account organisation for each customer
Rec 13: Apply joint supplier management process		Adapted	**Irrelevant in this case**
Collaboration Technology			
Rec 14: Continuously improve IT solutions and integrate legacy systems with modern solutions	**OEM**	Extended	- Establish fast secured data exchange models - Integrate legacy systems into the closed-loop PLM systems as well as define clear interfaces and templates **- Access granting process for new project members should be designed in a lean way**
Rec 15: Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side	**OEM**	Supported by the findings	- Closed-loop PLM system with clear documentation rules
	ESP	Supported by the findings	- Carry out special development tasks in which the ESP is particularly qualified in its own tool environment - Invest in own software tools, focussing on configuration management and special NPD tasks - Document the whole development in the PLM system of the OEM **- Maintain a performant software development toolchain**
	Both	Extended	**- Decide on development IT environment** **- Performant toolchain should be available for the whole project, comprising requirement management tools, development tools, document management and configuration management tools, as well as test management tools**
Rec 16: Have modern communication technology at hand	**Both**	Partly supported by the findings	- Provide project team with modern communication technology (video chat, smart phone, exchange servers ...)
Product Technology			
Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders	**OEM**	Supported by the findings	- Properly define system structure (modularization) and the interfaces
	Both	Extended	**- Joint commitment on the work breakdown structure and joint definition of the technical modules**
Rec 18: Award projects to technically highly skilled ESP	**OEM**	Extended	**- Award ESPs, which have proven their competence in the respective field**
	ESP	Partly supported by the findings	- Implement formal mechanisms to protect the IP of their customers - Invest in innovations synchronized with the innovation road-map of the customers and demonstrate innovation power

Table 12: Adapted best practice guideline model for agile software development projects under the lead of an ESP

The above table presents the identified best practice guidelines assigned to a recommendation category—the responsible project party for the ESP role of 'software innovation partner'. Refinements based on the findings from the first case study are marked in red and bold.

4.2.3 Conclusion on case studies.

The in-depth analysis of two application cases in collaborative development projects under the lead of an ESP allowed a further refinement of the best practices model that was developed based on the literature review and the key informant interviews. The best practices were confirmed as effective in the analysed cases and evidence was found which gave indications to adapt or extend the best practices for the specific use cases. In the first case, the ESP had the role of a turnkey NPD partner for a variant development, collaborating with the OEM as a system integrator. In the second case, the ESP was a software innovation partner, collaborating with the OEM on the development of new technology and generating new IP for the OEM. Even if the collaboration model and the roles of the ESP in the two projects are different, the majority of the best practices identified in the key informant interviews may be considered as effective for both projects. The level of technical uncertainty was identified as a differentiator for the application of best practice guidelines. Here, especially the best practices in the category of 'process' are affected. In cases involving higher technical uncertainty, less strict and more agile process models should be applied. Furthermore, the best practices in the 'collaboration technology' category may need adaptation, depending on the role of the ESP and the cooperation model. In variant development, the focus is on the sophistication of the PLM system, whereas in software development, the focus is on the sophistication of the development toolchain. Furthermore, best practices in the 'product technology' category are partly specific to the cooperation model. In the following table, I summarize the identified best practices and sort them by the main categories and the recommendation subcategories. The first best practice column shows the best practices which I assume, based on the found evidence, to be generally applicable to collaborative development projects under the lead of an ESP. The second column shows specific best practices for collaborative development projects in which the ESP takes on the role of a system integrator and the third column presents best practices for collaborative development projects in which the ESP takes on the role of an innovation partner.

Role of ESP		Lead Developer	Specific for Turnkey NPD Partner	Specific for Software Innovation Partner
Cooperation models		ESP as project lead	ESP as system integrator	New technology / new IP for the OEM
(Sub-)Category	Executor	Common Best Practices	Specific Best Practices	Specific Best Practices
People				
Rec 01: Define sustainable project teams with a problem solving attitude	OEM	- Top management explain to the project team the outsourcing decision before project start - Trust ESP works for the best of the OEM - Lean monitoring organization	- Provide project support with own positive resources if ESP faces problems in the NPD	- OEM counterparts should work directly with the ESP teams in order to follow the progress of the ESP teams and learn from it
	ESP	- Talent management in place, internal marketing for important projects - Mixed business model (Project, EoD, Outsourcing) - Reliable and authentic project managers - Generalist managers on board - Strong Chief Engineer in place - Communicate regularly for the best of the customer - Sales agent who is distinct from the project lead in the project organization - Key roles redundantly occupied - ESP internal margin sharing accounting, which prioritizes the critical projects over less critical one		
	Both	- Pro-active managers in favour of the collaboration - Mix of personalities on the project team - Counterpart from both organizations for each technical subsection - Strong project leaders on both sides who get along well - Consensus-oriented and cooperative teams, trained to collaborate#	- Module spokesmen from both organizations with a communication privilege	
Rec 02: Provide common project space and promote co-location	ESP	- Establish global footprint with locations close to the main customer's headquarters - Project management team onsite at OEM, NPD teams at ESP's development centre and offsite - Dedicated mall ESP project space close to the customer's development centre - Define co-location plan		
Rec 03: Promote frequent communication	OEM	- Meeting discipline (meetings with ESP team as important than internal)		
	ESP	- Ensure very frequent synchro meetings in the beginning - Request meeting discipline		
	Both	- Regular joint steering committees with open communication - Define communication matrix		
Rec 04: Give NPD teams time to integrate on a personal level	OEM	- OEM teams to show recognition to ESP teams for their work		
	ESP	- Invest in a common understanding and relationship at project start		
	Both	- Appreciation—parties to respect each other as partners - Go on recreational trips together and give room for informal meetings		
Rec 05: Strengthen long-term relationship between OEM and ESP	OEM	- Chose ESP with long-term history in innovation projects		
	ESP	- Start collaboration with small NPD tasks - EoD experts in place at OEM - Lessons-learned workshop culture in place - Have ex-OEM key players in the ESP organization		
Rec 06: Align or understand the culture of the participating companies	OEM	- Apply appreciation mechanisms and have open cultural values		
	ESP	- Install employees with the cultural background of the region or even the OEM		
	Both	- Create common understanding about cultural values - Establish common collaboration code - Make (company)-intercultural trainings		
Process				
Rec 07: Apply joint decision-making	Both	- Clarify the technical uncertainty and jointly define the escalation and decision paths to be applied at the beginning of the common project - Regular joint Steering Committees with open communication	- ESP prepare a release recommendation, OEM commodity teams approve the ultimate release of the part	
Rec 08: Apply right level of control mechanisms	OEM	- Establish a dedicated staff function for monitoring outsourced NPD projects - Assess ESP's technical competence in the domain - Steering via predefined KPIs and Quality Gates - Define quality top-level specifications before project start - Define what should be developed and adapt the level of preciseness of the requirements to the skill set of the ESP and the technical uncertainty		
	ESP	- Submit high-quality offer, which can be transformed in requirements - Perform an offer winning chance analysis of the current business opportunities and a consequent investment in the offer redaction for the opportunities with the highest award probability	- Apply maturity degree controlling and provide consequent reporting to the OEM	
	Both	- Offer and requirement workshop at project start		- Implement regular expectation alignment mechanism, to overcome barriers due to low specification depth
Rec 09: Align PM practices as well as NPD and CE processes	OEM	- Provide an aligned budget for project management to the ESP - Matrix organization with specific project-oriented model to monitor ESP - Implement a matrix organization with a specific project-oriented process model to monitor ESP		- Award ESPs with a similar or the same process maturity level
	ESP	- Define RACI chart or similar - ESP PM to insist on a common understanding of project planning and responsibilities - Establish very strong PM skills	- Very strong cost engineering skills - Maintain an internal, flexible NPD process model, adaptable to the requirements of OEM, managed by a central department - Project members trained on customer's variant NPD process	- Own technology development process - Project members trained on customer's technology development process
	Both	- Implement a project dictionary or wiki that can be accessed by every project member - Define documentation and reporting structure at the beginning of the project - Clearly define roles and responsibilities in project initiation phase - Invest a significant amount of the project resources in the creation of a common understanding in the project initiation phase	- Apply OEM macro process model, with defined interfaces	- Jointly define applicable development process model for the project before project start - Jointly agree on the agile working methods to be applied before project start, implement them, and adapt the respective organization accordingly - Regular expectation alignment mechanism
Rec 10: Early involvement of strategic ESP partners in the concept design	OEM		- Involve ESP considered for serial development in concept phase	- Award the project to the ESP at a very early stage and jointly implement agile software development methods before starting the development
Rec 11: Establish efficient knowledge handover processes	ESP		- Define the test & verification planning and the OEM teams should execute or participate in the validation of the final product	- Clean documentation of the development steps
Rec 12: Apply strategic ESP involvement process	OEM	- All concerned technical departments jointly commit on the outsourcing decision - Grant full system access to ESP for the specific project - Build up strategical partner ESPs - Start relationship OEM and ESP with smaller NPD tasks, to gain implicit knowledge - Define a long-term insourcing and outsourcing roadmap and involve strategic ESPs - Perform regular capability assessment of the strategical ESP	- Choose variants for outsourcing for which the related lead car development organization is still available during the design phase of the variant - Choose variants for outsourcing with a high level synergies between the lead car and the variant - Focus on lead car development, in order to increase the vertical development integration	- Focus on joint innovation projects to increase vertical development integration
	ESP	- Define a key account organization for each customer		
Rec 13: Apply joint supplier management process	OEM		- Give an official statement to all suppliers involved in the NPD process, delegating the power of the development officially to the ESP as prime contractor - Involve ESP in the sourcing of the suppliers for the specific product - Explain project roles & responsibilities to the key suppliers in kick-off meeting	
	ESP		- Develop supplier management competences and have good knowledge about the local component and subsystem suppliers around the world - Perform delta price negotiations with supplier and confirmation by the OEM	
	Both		- Determine thresholds or limits before the start of the project in which the ESP may move	
Collaboration Technology				
Rec 14: Continuously improve IT solutions and integrate legacy systems with modern solutions	OEM	- Establish fast secured data exchange models - Integrate legacy systems into the closed-loop PLM systems as well as define clear interfaces and templates - Access granting process for new project members should be designed in a lean way		
Rec 15: Perform NPD work on aligned IT systems with a master closed-loop PLM system on the OEM side	OEM	- Closed-loop PLM system with clear documentation rules		
	ESP	- Carry out special development tasks in which the ESP is particularly qualified in its own tool environment - Invest in own software tools, focussing on configuration management and special NPD tasks - Document the whole development in the PLM system of the OEM	- Development in PLM system of the OEM - Regular documentation of the development status on an ESP system to ensure traceability for the ESP	- Maintain a performant software development toolchain
	Both			- Decide on development IT environment - Performant toolchain should be available for the whole project, comprising requirement management tools, development tools, document management and configuration management tools, as well as test management tools
Rec 16: Have modern communication technology at hand	Both	- Provide project team with modern communication technology (video chat, smart phone, exchange servers ...)		
Product Technology				
Rec 17: Outsource NPD of modular engineering packages with clearly defined interfaces and borders	OEM	- Properly define system structure (modularization) and the interfaces	- Modularize engineering packages along the NPD process, which can be localized in NPD centres	
	Both			- Joint commitment on the work breakdown structure and joint definition of the technical modules
Rec 18: Award projects to technically highly skilled ESP	OEM	- Award ESPs, which have proven their competence in the respective field		
	ESP	- Implement formal mechanisms to protect the IP of their customers - Invest in innovations synchronized with the innovation road-map of the customers and demonstrate innovation power		

Table 13: Best practice guideline model for collaborative development projects under the lead of an ESP

The above table shows the identified best practice guidelines assigned to a recommendation subcategory and the responsible project party for collaborative development projects under the lead of an ESP. The best practices that are generally applicable to such projects are shown in the first best practice column, with specific best practices for specific collaboration models in the second and third columns.

5 Conclusion

In this chapter, I provide conclusions to this research project and offer an outlook on possible developments in the B2B market of ESPs. Furthermore, I summarize the contribution to practice and theory of the presented thesis. Finally, I provide implications for further research. Analysing the literature on collaborative NPD revealed a gap in the theory concerning the collaboration with ESPs in the automotive industry. Scholars agree that the importance of ESPs in the automotive development process will increase in future, that the consolidation of the ESP market will continue, and that ESPs will play an important role in supporting automobile OEMs in the ongoing transition of their products and services (Blöcker, 2016; Lüerßen, 2016). ESPs have evolved from small engineering offices into multinational corporations that support customers around the world (Holtrup, 2018; Kurek, 2004). Several contract forms for outsourcing to ESPs have been discussed and a tendency to outsource large development tasks within turnkey project contracts has been identified. Therefore, I focused the research on best practice guidelines for important development tasks under the lead of an ESP.

Through the literature review, I was able to discuss development models in which collaboration takes place in automotive development. Moreover, I identified the risks of outsourcing development tasks and discussed internal and external motives for the outsourcing. Furthermore, I identified the main categories and assigned recommendations to improve collaboration in development projects that were based on the systematically reviewed literature of collaborative NPD and ESI. These general recommendations served as subcategories for the best practice guidelines that were later identified for the specific case of development projects under the leadership of an ESP.

The first part of the literature review allowed me to fulfil the first research objective: identify the NPD processes within the automotive manufacturing sector.

Tranfield et al. (2003) identified evidence-based research as a possible mechanism to create guidelines for the decision process of managers and thus help them to build a competitive advantage. Consequently, in the next research step, I interviewed 11 key informants, business leaders, and senior industry experts in order to reveal the practitioners' insights on collaboration in the automotive development process with a focus on ESPs. The analysis of the key informant interviews allowed the refining of the risks, motives, and recommendations identified in the systematic literature review. It also led to the identification of barriers. Based on the identified barriers and the practitioners' experience in the field, the key informants revealed best practices for the identified collaboration models of ESPs with automobile manufacturers.

Within two in-depth case studies, I analysed two development projects under the leadership of an ESP. The ESPs played different roles in the two projects. In the first case study, the ESP acted as a system integrator that was leading the development of a variant car. In the second case study, the ESP acted as an innovation partner in a software development project in the field of ADAS. Both roles are expected to be become more important for ESPs in future. Thanks to these case studies, I was able to adapt or extend the identified best practice guideline model to the specific cooperation models.

The main category of 'people' gained the most attention in the key informant interviews. In the first case study, in which the project analysed was running well globally, the respondents emphasized the importance of a trusting relationship and improved people skills to collaborate efficiently in NPD projects. The respondents in the second case study emphasized the recommendations under 'people' as well but put less focus on it than on process issues. I assume that the critical situation in which the project was at the time of the study led to the focus on the 'basic' process and on IT environment issues. The measures under 'people' fell behind. According to my observations and the feedback of the respondents, underestimating the importance of this category is a mistake. It seems much easier to find solutions to the more 'technical' problems in a collaborative project when there is a trusting relationship between the stakeholders. In general, the concepts of trust, confidence, and long-term relationships have been discussed in detail. Collaborative NPD implies a high level of technical uncertainty. The higher the uncertainty and the degree of innovation of the respective project is, the higher the need for a trusting relationship seems to be. Outcome control may be good for the development of standard products, but in highly innovative projects, where the OEM is not yet sure about the development outcome, agile methods may be applied and outcome control may be replaced by fast joint decision-making and change management. Behavioural control may have a negative impact on the performance of the ESP development teams and may be reduced with increasing technical uncertainty.

The main category of 'process' was discussed quite intensively. In this category, best practices have been identified to improve the development process and the collaboration in such processes. The findings imply that OEMs should invest in their process landscape in order to outsource significant NPD tasks. ESPs need implicit knowledge, project management skills, cost engineering skills, and deep process knowledge of their customers. They should be involved early on in the NPD process. The alignment of development practices seems to be of tremendous importance. ESPs can offer support in transforming the development process, helping it become more agile and project-oriented. Furthermore, the challenge of joint supplier management has been identified, especially for car developments under the lead of an ESP.

In the category of 'collaboration technology', the findings imply that the IT systems of the companies are not yet sophisticated enough to allow integrated collaboration on highly complex development projects. A long-term and trusting relationship was considered important here. Granting access to the IT systems means granting access to confidential data and know-how as well as allowing better control of progress in the customer–vendor relationship. OEMs should integrate legacy systems into closed-loop PLM systems and provide an open tool landscape, providing interfaces to which ESPs can connect with their often more efficient development tools for specific tasks.

In the category of 'product technology', I found that ESPs can support their customers with the technical solutions they develop in-house. ESPs have become important competence-driven companies in the field of automotive NPD. By streamlining their innovation roadmap with respect to the innovation roadmap of their customers and by using the competencies they gained in other industries, ESPs can become incubators for new technologies. By aiming to successfully outsource significant development tasks, OEMs invest in clear definitions of the system structure and the interfaces of the system to be developed.

Based on these findings, I was able finalize a best practice guideline model for complex collaborative development projects under the lead of an ESP and hence achieve the research objectives two to four.

I noted how service providers collaborate with automotive manufacturers in relation to the NPD process and was able to identify the barriers to successful collaboration in relation to the service provider–automotive client NPD process, taking into consideration other stakeholders in the NPD process. I also identified best practice guidelines to enhance the NPD process in the service provider–automobile manufacturer relationship.

The research project provided me with tremendous insights into the field of collaborative NPD and ESPs. In a changing and digitalizing world, automotive OEMs and their strategic partners have significant opportunities to develop new business models and provide new services to the consumer. But they can do so only if they succeed in transforming their R&D departments into agile innovation centres and increase the services they provide to the final customer. Automobile OEMs are challenged to look beyond providing just transportation. They should also focus on flexibility, networking, efficiency, and a variety of mobile services. Automobile OEMs might in the future provide complete integrated ecosystems of transportation and ESPs might be their partners in creating them. This intensified collaboration model would require an even higher level of trust between OEMs and ESPs. Implicit knowledge becomes more important here. Reduced control mechanisms can be applied thanks to the increased level of trust. The recommendations that I found under the category of 'people' may support the building of trust between the parties.

In Figure 37 I graphically represent the correlation between the innovation degree of the development task or the technical uncertainty and the sophistication in collaboration and link it to the discussed collaboration models as well as to the level of outcome and behavioural control.

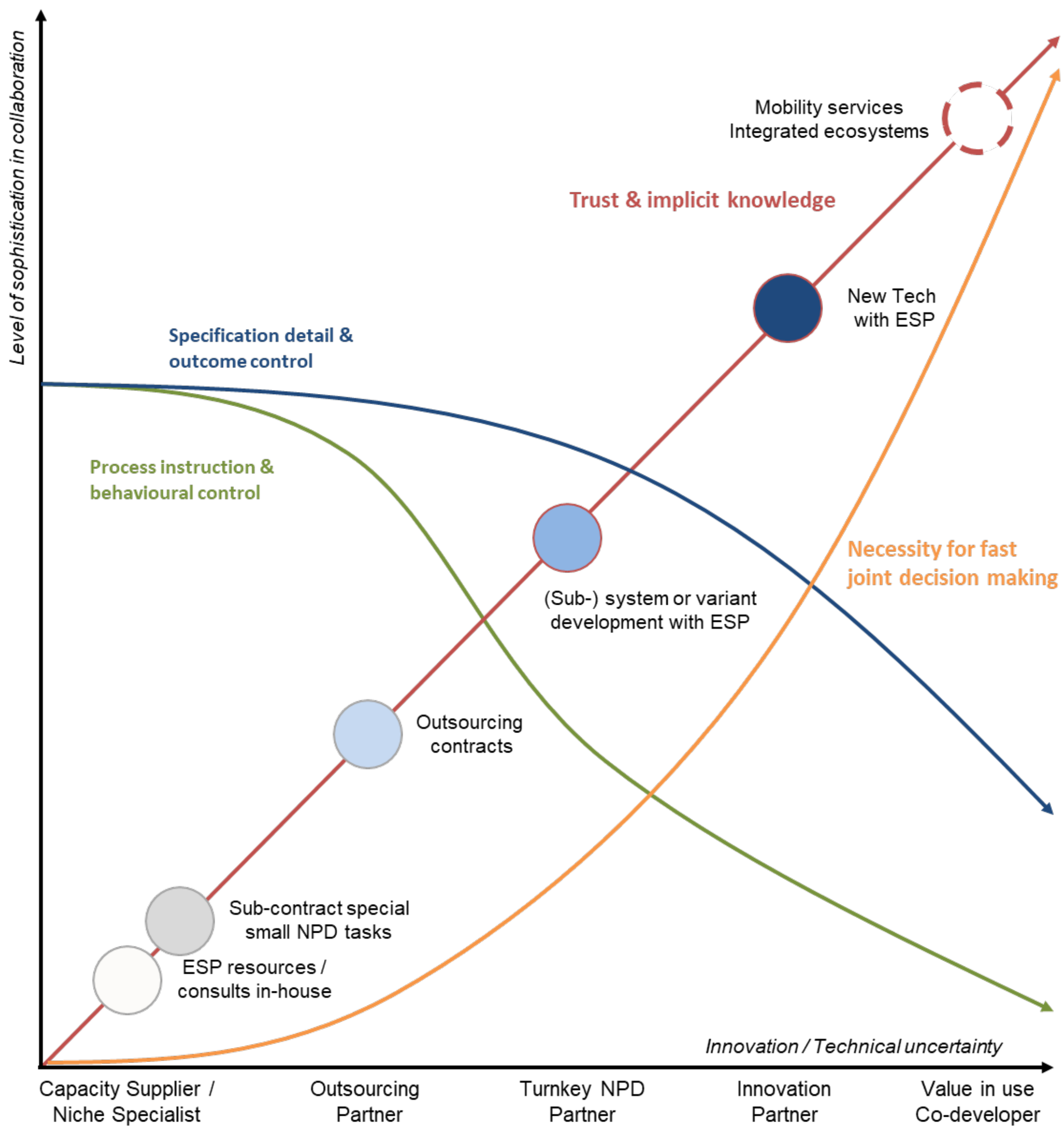

Figure 37: Correlation of innovation degree or technical uncertainty and sophistication in collaboration

The above figure shows a representation of the different cooperation models of automotive OEMs and ESPs and the correlation between trust, joint decision-making, and control.

5.1 Contribution to Practice

The explorative and empirical research in this thesis has shown that NPD projects in collaboration with ESPs can be a highly attractive option for automotive OEMs (Wolff, 2007) provided that the collaborative development project is well-managed. The market analysis shows that the ESP market is currently in a consolidation phase and OEMs have identified the potential of outsourcing significant NPD projects. Thus, the complexity and size of the NPD tasks that ESPs are awarded is increasing. Therefore, the key implication of this thesis is to develop an operational best practice guideline for the successful execution of collaborative development projects under the leadership of an ESP. The model developed in Subchapter 0 can also serve the strategic and tactical considerations of the partners since the prerequisites for successful collaboration are identified. ESP management that intends to follow the market development and enable the company to be ready to succeed in projects where it takes on the role of a system integrator or an innovation partner can use the developed model as a guideline to further improve the services on offer and thereby gain a strategic competitive advantage. OEM procurement departments can use the model to assess potential ESP partners for collaborative NPD projects and thereby gain a further tactical input for the outsourcing decision. The presented research project is mainly based on the practitioners' insights. To my knowledge, the special case of collaborative development projects under the lead of an ESP has never been looked at and analysed to that extent. Thus, even if outsourcing important development tasks to ESPs is a common phenomenon, no best practice guidelines for such collaborative development have existed before this research project. A professional doctorate often contributes knowledge for the practitioner and it is often based on the knowledge of practitioners (Bourner et al., 2001, p. 71). I designed this research project to develop a best practice guideline model, aiming to give guidance to practitioners in the field of automotive development and engineering services. From my point of view as a practitioner in this field, applying the developed best practice guideline model can significantly improve collaboration in such projects and therefore enhance development efficiency, which leads to a competitive advantage for the involved partners.

In his research on collaborative NPD strategy, Wolff (2007) argues that OEMs should create a dedicated staff function for collaborative NPD. The key informants interviewed in this study agree that ESPs should create a dedicated staff function to manage the explicit and implicit knowledge about their customers and to continuously improve the collaboration with automotive OEMs. Both functions can use the developed model as a generic guideline for the improvement of collaborative NPD projects. The best practice guideline model presented in Table 13 shows best practice guidelines categorized under the four main categories of ‘people’, ‘process’, ‘collaboration technology’, and ‘product technology’, and under the recommendation sub-categories. Upon analysing the resulting model, it became clear to me that some of the identified best practices are generic and can apply to all kinds of collaborative projects. Other best practices are specific to the collaboration of ESPs with OEMs in NPD and even more specific to automotive NPD. Several best practices can be categorized as highly operational and should be executed at the project start or during the project. Other best practices are of a strategic nature and should be implemented before awarding a complex outsourcing project to an ESP. In aiming to give a hands-on guideline to managers in ESP or OEM organizations that are intending to start a collaborative NPD project, I developed Figure 38. Here, I distilled the best practices which are specific to this special case of collaboration and indicated the executor of the best practices as well as the nature of the best practice. The grey triangles ( ) indicate the execution of the best practice (OEM execution/joint execution/ESP execution) and the smaller red triangles (▼) indicate the nature and the timing of the best practice. The sign ▼ indicates a more strategic nature of the best practice, which should be executed before the outsourcing decision. The sign ▼ indicates an operational nature of the best practice, which should be implemented at the project start, and the sign ▼ indicates an operational nature of the best practice to be implemented during the project.

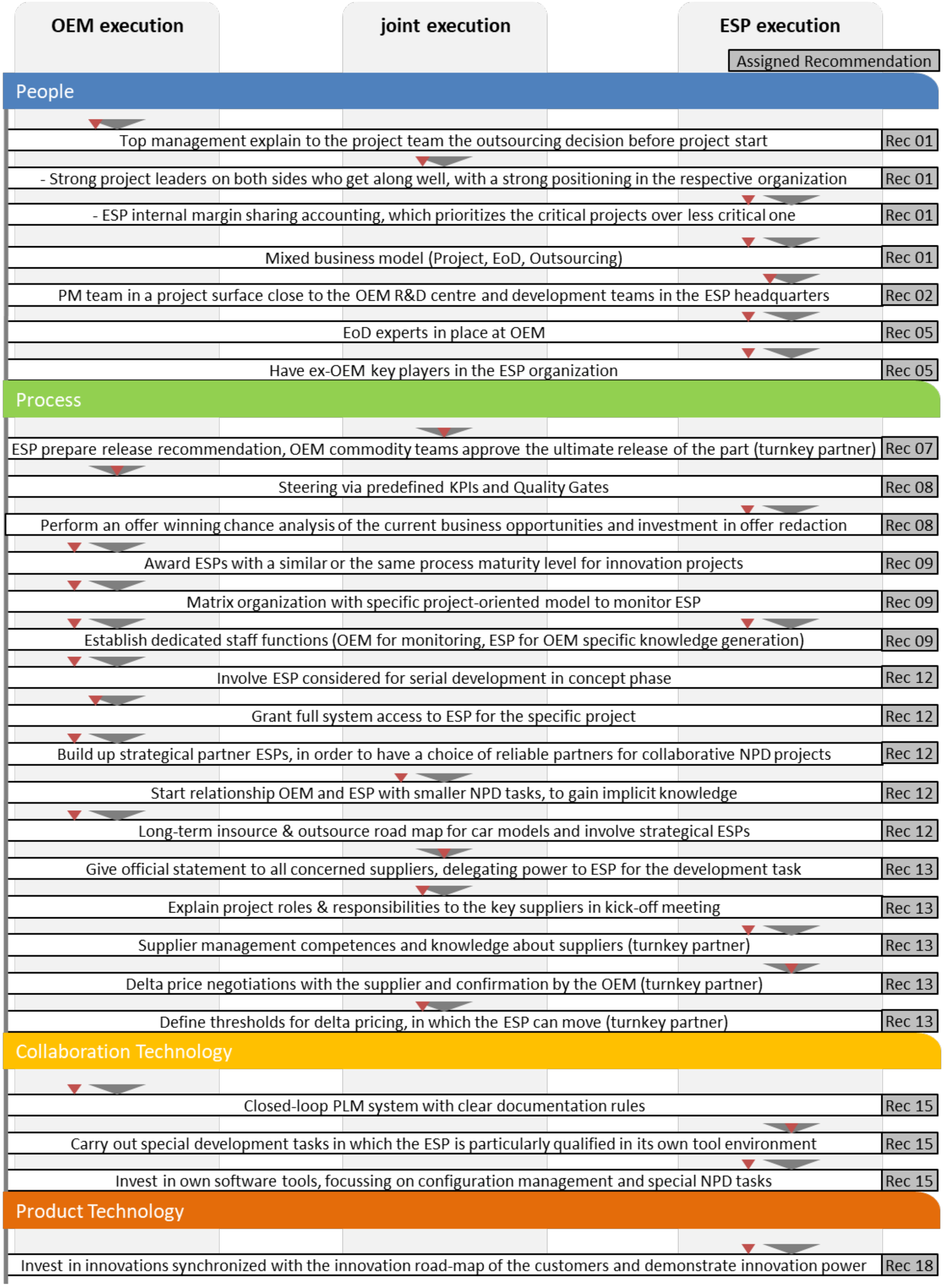

Figure 38: Specific best practices for collaborative NPD projects under the leadership of an ESP

The above figure shows identified and categorized best practices which are specific to the analysed case of collaborative NPD projects under the leadership of an ESP. In the figure, the executing party, the nature of the best practices, and the related recommendation sub-category are represented.

The automotive industry was chosen because of its advanced process maturity and experiences in the development of complex systems. The findings may also be valuable for development projects of other complex systems.

Three weeks before the submission of this thesis, Capgemini, the leading European IT services and IT consulting company announced to purchase Altran, the leading ESP in Europe. Capgemini with over 250.000 employees, as of over 100.000 in India and Altran with over 45.000 employees will build after the take over the largest industry NPD partner, especially in digital technologies. The take-over is considered as a signal how the consulting and engineering market is going to continue to consolidate. Consulting companies become multi services companies. International IT consulting companies transform from pure consulting companies to implementation partners (Agnew, 2019).

In this context, expecting that also other ESPs will be taken over by international IT consulting companies, the here presented study might help managers of acquirers to understand the challenges ESPs face in the collaboration with their customers in the collaborative development of complex products. Furthermore, the resulting guideline can serve as support for R&D department transformation projects.

This further market development shows that ESPs are undergoing transformation and are moving towards innovation service providers. I assume that innovation projects as analysed in the second case study will become more and more important for ESPs. Here the engineering competence of the ESPs is combined with IT services. Large IT consultancies need this engineering expertise and the product and process understanding of ESPs to bring their software development services to market. Thus, the ESP market will continue to evolve. Either existing ESPs evolve into engineering and IT service providers, or IT consultancies become IT and engineering service providers. The combination of IT skills and engineering skills seems to be a critical success factor in B2B marketing for service providers in the automotive industry. The development of the car from a pure transportation mean to a highly complex multiservice product will also fundamentally change the service provider ecosystem.

ESPs are flexible companies that can quickly adapt to new market situations (Kurek, 2004). The results of this work can serve the management of such companies as a decision support and accompany the transformation areas ‘people’, ‘process’, ‘collaboration technology’ and ‘product technology’.

5.2 Contribution to Theory

In this thesis, I contribute to the theory of collaboration and NPD strategy in the context of B2B marketing. New knowledge on the collaborative development projects of complex systems has been generated. I focus on the situation of ESPs in collaborative NPD networks. I started the research with the detection of a significant gap in the theory of collaborative NPD with the involvement of ESPs. This phenomenon had not yet been sufficiently covered in management theory, particularly the collaboration of automotive OEMs, outsourcing turnkey projects to ESPs, and related questions concerning the collaboration with component suppliers in this project form. While many studies discuss the NPD collaboration with component suppliers and gaining advantages through it, the collaboration with ESPs as NPD partners had only been covered indirectly—in supplier integration theory and collaboration theory in NPD in general. However, neither of these theories covers in detail the particularities of significant outsourced collaborative NPD projects under the leadership of an ESP. In such projects, the customer decides to use an ESP to pursue an important part of its origin NPD activities. These relationships are far more complex than OEM-Tier 1 collaboration. The projects are usually critical for the competitive success of both partners and the project situation is considered as challenging for the involved parties. Thus, with this thesis, I contribute to collaboration theory and supplier integration theory.

With the provided research results, I also add to the work of Wolff (2007), who explored in four case studies the collaborative NPD strategy of automotive OEMs and identified different types of NPD outsourcing. Focussing mainly on the OEM perspective, Wolff (2007) discusses in his study strategies of automotive OEMs in the decision process to outsource to different kinds of partners (other OEM, Tier 1, ESP, or capacity provider) for different types of outsourcing (technology, derivate car, or lead car). He focusses on the OEM-perspective and the strategic process. In the limitations and further research section of his study, he points out that the partner perspective has been widely neglected in his study. Furthermore, he notes, that his study did not cover the day-to-day project management of outsourced, collaborative NPD projects. Combined, the study “Collaborative New Product Strategy – the case of the automotive industry” of Wolff (2007) and the here presented study contribute to the theories of alliance management, supplier management, and, my study in particular, collaboration.

The main contributions of this thesis are the identification of risks and motives for outsourcing to ESPs as well as the identification and categorization of barriers and best practices for collaborative automotive development projects under the lead of an ESP, and moreover, the definition of a best practice guideline model for two major and trending cooperation models in the field.

I amend the theory of collaboration with an in-depth analysis of the specific case of collaborative NPD – outsourced NPD to ESPs. Different and distinct recommendations and best practices guidelines for better collaboration of the partners have been identified, categorized, integrated in a hypothesis-driven conceptional best practice model for outsourced NPD projects under the lead of an ESP and initially confirmed by the empirical data gathered. In this way, a foundation is suggested, which facilitates collaboration in highly complex NPD projects.

To my knowledge, before I conducted this research, these contributions did not exist. Collaborative NPD projects under the lead of an ESP are largely neglected in the actual body of knowledge. Thanks to this research project, I was able to extend the knowledge in this field by analysing and explicitly theorizing the practitioner's insight and information.

5.3 Value Co-creation in Knowledge-intensive Business Services

In this section, I briefly discuss the theory of value co-creation. The systematic literature review in Chapter 3.2.1 is limited to literature in the field of automotive NPD. Thus, the theory of value co-creation has not been identified in the systematic search process. My interest in B2B marketing and service marketing helped me discover this field at a later stage of the research process. Since the shortlisted literature is of high interest for the findings, I decided to include this theory in my conclusions. Especially the paper of Aarikka-Stenroos and Jaakkola (2012) was of interest to me. They examine in their study the collaborative process of value co-creation in the context of KIBS. Through an extensive qualitative study, they conclude 'that joint problem solving requires active and reactive participation' (Aarikka-Stenroos & Jaakkola, 2012, p. 24) of the supplier and the customer. Their proposed framework model can be used to check if my research findings cover all aspects of value co-development. Aarikka-Stenroos and Jaakkola (2012) find five key activities constituting the process of value co-creation:

1. Diagnosing needs
2. Designing and producing the solution
3. Organizing the process and resources
4. Managing value conflicts
5. Implementing the solution

Activities 1, 2, and 4 are considered tremendously important 'in the joint problem solving process and can positively or negatively impact the construction of the value-in-use, and therefore merit the special interest of researchers and practitioners' (Aarikka-Stenroos & Jaakkola, 2012, p. 23). These three activities are task-focused and directly related to the technical or other aspects of the supplier, and the customer contributions to problem-solving Activities 3 and 5 are more about managing the interactive process itself (Brennan et al., 2017, p. 275).

According to Aarikka-Stenroos and Jaakkola (2012), suppliers facilitate value creation via the roles of value option advisor, value process organizer, value amplifier, and value experience supporter, while the defined customer roles are co-diagnoser, co-designer, co-producer, co-implementer, co-marketer, and co-developer. The framework model can help managers to understand the activities, resources, and roles that both customers and suppliers can become attuned to. Thus, it can serve practitioners to better control the critical resources they need at any given time and to improve their understanding of the respective roles that need to be played. Hence, managers can gain greater clarity about who can best play the respective roles. Furthermore, the model emphasizes the need to deal with the process aspects effectively and, in particular, accept that value conflicts are nearly inevitable (Brennan et al., 2017, p. 275). Consequently, the key to successful joint problem-solving is to find ways to manage the conflict. Aarikka-Stenroos and Jaakkola (2012) encourage customers and suppliers to positively address such conflicts and find ways to resolve them. Even if the developed framework model is of significant value to the practitioner, it lacks concrete best practice guidelines for special application cases. In this research project, I developed a best practice guideline for joint problem-solving projects—the case of ESPs codeveloping services, products, or technologies with their automotive OEM customers. Comparing my research findings to the framework model allowed a check for exhaustiveness and gives a good overview to the reader of which topics revealed in their model are also analysed in my study.

To make this evident, I placed yellow stars at different points in the model of Aarikka-Stenroos and Jaakkola (2012), indicating whether each point has been discussed in my study and where this study gives additional theoretical or practical insight for the special case of collaborative NPD under the leadership of an ESP.

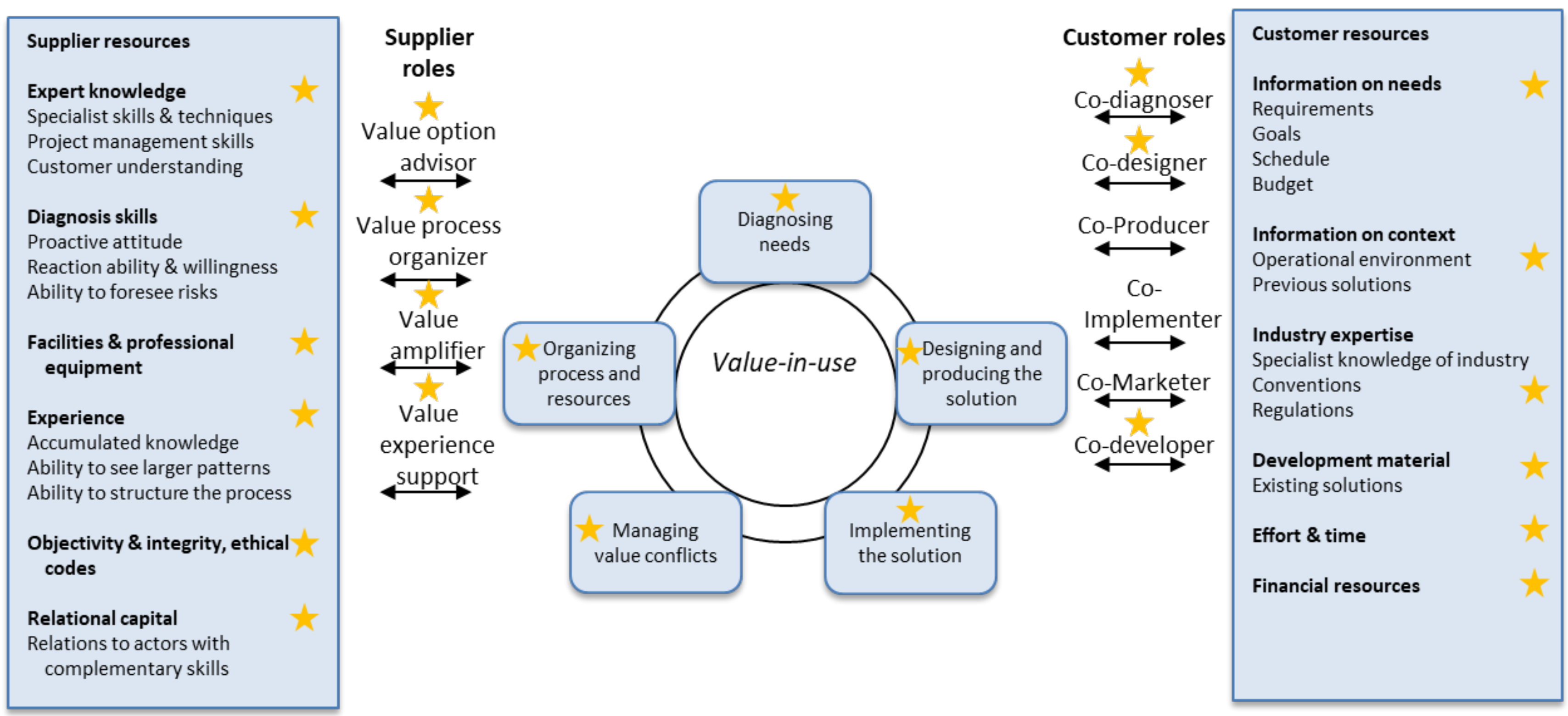

Figure 39: Joint problem-solving as value co-creation in knowledge-intensive services

The above figure shows a framework model on joint problem-solving as value co-creation in knowledge-intensive services, specifying the necessary supplier and customer resources, the roles of suppliers and customers, and key activities. The yellow stars indicate the contribution of the present thesis to the practice and theory of collaborative NPD under the leadership of an ESP. Adapted from Aarikka-Stenroos and Jaakkola (2012, fig. 3, p. 22).

5.4 Limitations and Implications for Further Research

With this study, I was able to answer the research questions. However, several aspects need further and more detailed analysis and research. Besides, this study is characterized by certain limitations, which leave room for further research.

NPD projects and software development projects in the automotive industry are complex project systems that involve a number of important stakeholders. In most cases, the set-up of such projects is difficult to compare since the degree of involvement of the stakeholders and the level of innovation vary (Wolff, 2007). Furthermore, the findings are difficult to generalize since I gained the information from specific case studies.

The study is focussed on the collaboration between established OEMs and ESPs. I did not cover the collaboration of emerging OEMs with ESP companies. Therefore, it would be of great interest to analyse if the identified best practices can also be applied in projects where ESPs support customers that have less experience in the field of automotive NPD or if adaptation is needed. Furthermore, the collaboration processes in the complex OEM supplier network with an ESP as the general contractor in charge of the complete NPD process could benefit from further research. To my knowledge, this special case has never been researched before. The study presented here explores this phenomenon amongst others but focuses on the collaboration processes between the OEM and the ESP. Exploring collaboration processes between the ESP and the component suppliers in such projects could be of great interest.

The second case study analyses a new form of outsourcing development tasks to ESPs. Here, the ESP plays the role of an innovation partner. This form of collaborative NPD projects is relatively new. It could be promising to investigate if the importance of this new form of collaborative development projects can be confirmed.

Furthermore, it would be interesting to analyse if other complex collaboration models of ESPs exist or will exist and if these models imply an adaptation of the best practice guideline model found here.

Moreover, the identified best practice guideline model has been formulated based on a qualitative theory developing research design. The model is open to further development, especially to verification, potentially through quantitative research methods. Furthermore, the complex developments in relation to collaborative NPD activities with the involvement of ESPs also evolve over time. So, it would be interesting to investigate the behaviour and evolution of ESPs in longitudinal studies.

I selected the interviewees and the case studies to ensure a variety of perspectives. However, this has led to limitations in the sample of the interviewees and the case study firms. It would be interesting to expand the OEMs, the ESPs, and the markets analysed to the US, China, and Japan, and especially cover emerging-market OEMs. It would also be interesting to analyse the ways in which these OEMs collaborate with ESPs and if new cooperation models can be identified that have different motivations and risks, which may eventually result in differences in strategy and management. Furthermore, the study is limited to the automotive sector. Other complex product sectors might experience similar challenges with different conditions and determinants. So, further research on collaborative NPD in different sectors could be of relevance as well.

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Annex I: List of Research Databases Used for the Systematic Literature Review

Name	Link to database	Publisher (if applicable)
ISI Web of Knowledge℠	http://apps.isiknowledge.com/	Multiple
Google Scholar©	http://scholar.google.com/	Multiple
Emerald Insight	http://www.emeraldinsight.com/	Emerald Group Publishing Limited
Business Source Complete	http://web.ebscohost.com	EBSCO
E-Journals	http://web.ebscohost.com	EBSCO
Environment Complete	http://web.ebscohost.com	EBSCO
International Bibliography of the Social Sciences	http://web.ebscohost.com	EBSCO
Library, Information Science & Technology Abstract	http://web.ebscohost.com	EBSCO
PsycARTICLES	http://web.ebscohost.com	EBSCO
Psychology and Behavioral Sciences Collection	http://web.ebscohost.com	EBSCO
PsycINFO	http://web.ebscohost.com	EBSCO
SocINDEX with Full Text	http://web.ebscohost.com	EBSCO
British Library Document Supply Centre Inside Serials & Conference Proceedings	http://web.ebscohost.com	EBSCO
Sciencedirect	http://www.sciencedirect.com/	Elsevier B.V.

Annex II: Inclusion and Exclusion Criteria for Systematic Literature Review

Parameters	***Inclusion criteria***	***Exclusion Criteria***	***Argumentation***
(A) Language area	Studies presented in English, German, or French	Studies presented in any other language	Papers in the field are mainly published in one of these three languages
(B) Timeframe	Studies published from 2000 onwards	Studies published before 2000	The context of the study is NPD. In the last decade, the complexity of the automobile increased significantly, particularly due to new technologies
(C) Sample	Studies focusing on the integration of suppliers and/or NPD development providers into the development process at the OEM (collaborative NPD).	Studies focusing on non-collaborative NPD at OEMs.	It has been observed that not much research has been done from the point of view of the supplier. The review discusses the actions to be undertaken by the ESP in order to integrate well into the development process at the OEM and aims to identify best practices.
(D) Field of research	Studies focusing on the collaborative development process in the field of automotive system engineering. Studies dealing with the integration of system suppliers into the development process at the OEM. Major focus: ESPs	Studies focusing on pure software development. Studies not focusing on collaborative NPD process. Studies outside the automotive industry.	The review focuses on the interfaces between the development processes of the involved parties. Therefore, the studies need to focus on the development of complex products with interfaces between mechanics, electro-electronic, and software development. The review only wants to focus on development in the automotive industry.
(E) Type of study	Primary research. Studies analysing quantitative and/or qualitative findings	Book reviews, literature reviews, opinion pieces, reports on applied methods with results which have no scientific proof	The review focuses on the best evidence in management of development processes in the context of modern NPD. It is therefore essential to take into account only primary research. The review focuses only on evidence-based research.

Annex III: Example Interview Guide

Interview guide

Exploring the collaborative integration of service providers in the new product development process of automobile manufactures

Doctorate of Business Administration
Peter T. Mehrle

Interview approach

The interview is intended to be a semi-structured interview - new questions could be brought up during the interview as a result of what the interviewee says.

The framework of topics to be explored is strongly related to the research questions.

The following topics are intended to be explored:

- Background of the interviewee & experience in NPD
- Change of the New Product Development (NPD) process in the last decade for complex products
- Particular changes in the automotive NPD process
- Change of the role of NPD service providers
- Challenges concerning collaboration for stakeholders in the NPD in terms of
  - Process
  - People (relationships)
  - Technology
- Motivation and Risks of outsourcing / implementing new models of collaboration within NPD
- Barriers for collaboration within the NPD process – Involvement of NPD service providers
- Aspects of work across different locations, cultures, and languages
- Best practices to improve collaboration within the NPD process in terms of
  - Processes
  - People
  - Technology
  - Relationship management
  - Steering models and mechanisms
  - Project management, roles responsibilities
  - Transfer of experiences & intellectual property from ESP back to OEM at the end of the contract)
- Future of the NPD-process

Research questions

- What form(s) does the NPD process take in the automobile industry?
- What role do external NPD service providers perform in the NPD process of automotive manufacturers?
- What barriers exist to hinder the role service providers play in the automotive manufacturer NPD process?
- Can best practice guidelines be established for the collaboration of service providers in the automotive manufacturers NPD-process?

Research objectives

- Identify the NPD processes within automotive manufacturing sector
- Identify how service providers collaborate with automotive manufacturers in relation to the NPD process
- Identify the barriers to successful collaboration in relation to the service provider - automotive client NPD process, taking into consideration other stakeholders in the NPD process.
- Identify best practice guidelines to enhance the NPD process in the service provider automobile manufacturer relationship

Ethical considerations

Form of consent used in this investigation

Written consent by the interviewee

Cover letter, interview guideline and thesis presentation has been sent to the interview before the interview meeting.

Benefits of the proposed research to the participants and/or for scientific knowledge in general

The study aims to identify the barriers to successful collaboration in relation to the service provider - automotive client NPD process and best practices for the collaboration of service providers in the automotive manufacturers NPD-process.

The result of the study will be provided to the participants for their professional use.

Adverse effects of the research

No adverse effects are expected.

Risks to the researchers, participants, other persons or the environment

(Environmental, Legal, Physical, Physiological, Psychological, Social, Cultural and Professional)

Not applicable

Confidentiality

Confidentiality will be ensured by storing all data on a secure computer in a locked office.

Anonymity will be ensured by assigning a code to each participant so that no participants can be matched with their data by name.

The only personal identifiers that will be used are age, gender, job title, size of the company the participant is working for and activity of the company.

No participants will be identifiable in any written reports.