CHALMERS
UNIVERSITY OF TECHNOLOGY

Global Manufacturing Networks

– A Case Study of Global Part Management at Volvo Cars

Master's thesis in Quality and Operations Management

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Gothenburg, Sweden 2018. Report No. E2017:130

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Master's Thesis E2017:130
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Cover: Volvo Cars Corporation, XC60
(https://www.media.volvocars.com/se/sv-se/media/photos/list)

Typeset in LaTeX
Printed by Reproservice, Chalmers
Gothenburg, Sweden 2018

Abstract

Actors in the automotive industry use global manufacturing networks to produce and supply customers around the world. The capital-intensive industry is sensitive to long lead times and requires a rapid supply chain in order to provide customers with high quality cars in fierce competition. In order to succeed in this environment, automotive manufacturers have production sites globally. Volvo Cars Corporation has established plants in China and are producing the same car model simultaneously in two different continents. This setup brings a complexity in how parts are managed and sourced since it is hard to produce exactly the same output in two different production processes. Consequently, the purpose of this thesis is to investigate how a car manufacturer handles their global part management and what challenges they are facing today within their global manufacturing network. The study aims to provide recommendations for future steps in order to improve global part management.

The study evaluates Volvo Cars Corporation's manufacturing network and their global part management by using an abductive approach and a single case study. Semi-structured interviews were conducted with employees in Torslanda, Olofström, Shanghai and Chengdu in multiple departments in order to get a holistic view of the investigated area. The multifaceted topic concerns numerous functions, departments, employees and processes, which were studied to capture the situation at Volvo Cars Corporation.

The study identified discrepancies between Volvo Cars Corporation's strategy and how they have configured and coordinated their manufacturing network. By assessing Volvo Cars Corporation's situation through a theoretical framework, areas that need to be improved in order to comply with their current expansion in China are suggested. Traceability, communication and stakeholder responsibility were the identified areas that need to be further assessed in order to improve the manufacturing network. By developing these areas, which affects how car manufacturers is carrying out their global part management, companies can be better prepared in their global setting.

Keywords: manufacturing, production, operations, strategy, configuration, coordination, manufacturing networks, automotive industry.

Acknowledgements

We would like to extend our gratitude towards Chalmers University of Technology for the opportunities provided to us during our studies. The previous years have prepared us and enlighten a curiosity for future adventures.

Thanks to Volvo Cars Corporation for enabling this master's thesis. Special thanks to our supervisor at Volvo Cars, Håkan Carlsson, who continuously guided and helped us in every way needed. We would also like to direct a thanks to Magnus Lindh and Anna Bergelin who have given us feedback and helped us find suitable interviewees within the organization. This thesis would not have been possible without the help and collaboration from all the participants, and we are really thankful for your time and input. We are also thankful for the susceptible reception in China, both in Shanghai and Chengdu, as well as all the assistance provided in order to coordinate our travels.

Thank you to Gouthanan Pushpanathan, our supervisor at Chalmers, who provided direction and feedback. Lastly, we would like to convey our appreciation to the organizations "Göran Wallbergs minnesfond" and "Stiftelsen AAA" that provided funding, which enabled the international aspect to the study.

Gothenburg, January 2018

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1
Introduction

There is an increase in globalization and international competition, which has been described by Sirkin, Hemerling and Bhattacharya (2008) as "competing with everyone from everywhere for everything". The globalization has many reasons but what shape the market dynamics and the landscape, which companies operate in, can be explained by Porter's (1979) five forces; threat of new entrants and substitutes, bargaining power of customers and suppliers together with the internal rivalry among competitors. In order to become global and adapt to the internationalized market, companies have to be aware of the forces that affect the market in order to stay competitive. There have been changes from a regional focus where the production supplied local demands and it have shifted towards an international market. Levitt (1983) wrote in the 1980s that companies started to open local production sites in order to access local markets and avoid trade barriers. Nowadays companies have created a global supply network in order to utilize lower costs of labour and transportation to expand and access a broader market (Friedli, Mundt, and Thomas, 2014). When becoming a global corporation, four dimensions needs to be considered; "a company's market presence, supply base, capital base, and corporate mind-set" (Govindarajan, Wang and Gupta, 2008). The implications of these dimensions increase the complexity in a manufacturing network. Therefore, a strong connection to the business strategy is needed together with more advanced coordination in order to manage the global manufacturing network successfully (Shimokawa, 1998).

The fierce competition in the automotive industry requires companies to have a competitive business strategy that identifies a company's core strengths. According to Skinner (1969), it needs to be a strong link between the business and manufacturing strategy in order to be successful and reach the full potential of the operations. As a pioneer in defining manufacturing strategy, Skinner (1969) identified manufacturing strategy as a potential competitive weapon if managed correctly. When manufacturing is global there is a need for a holistic view (Davies and Kochhar, 2002). Friedli, Mundt, and Thomas (2014) define the combination of network strategy and manufacturing strategy as a strategy layer. This layer is combined with a coordination and a configuration layer, which are used to manage a global manufacturing network.

Volvo Cars Corporation, henceforth referred to as Volvo Cars, utilize a global manufacturing network and have expanded its production from Europe to China (Volvo Cars, 2011) and currently also to the US (Volvo Cars, 2017a). Volvo Cars' decision have led to coordination and strategic alignment issues with their global part

management, that previously did not exist when production was solely regional in Europe. Global part management is an ambiguous term that describes how companies manage parts in a global setting. How to make sure that the right part is at the right place at the right time with the right quality. The part may be supplied to one or multiple factories and supplied by one or multiple suppliers. This master thesis will investigate global manufacturing networks and global part management further by performing a single case study at Volvo Cars.

1.1 Background

Volvo Cars is originally a Swedish car manufacturer that was founded in Gothenburg in 1927 (Volvo Cars, 2017b). Volvo Cars has over the last decade opened multiple production plants and R&D facilities in China and is supported by their Chinese owner Geely, who acquired Volvo Cars in 2010 (Volvo Cars, 2010). This enables Volvo Cars to get access to the local Chinese market. Today, the expansion is ongoing in North America, where a new plant is being built in South Carolina and production is planned to start late 2018 (Volvo Cars, 2017a). Multiple plants will produce the same car models but with local suppliers to utilize shorter lead times. Variation then occur between the locally sourced parts for each region. Because of the variation between the produced parts in different continents, Volvo Cars sometimes uses separate part numbers in order to track the regional differences. Even if the part produced locally, is intended to be identical globally, the additional part number increases the amount of part numbers. The increased amount of part numbers is a large driver of cost. This issue quickly becomes more complex when Volvo Cars is increasing their manufacturing network and soon is supplying the same car, produced in three different continents. In order to manage this issue, a strategic decision has been made that Volvo Cars is aiming for global cars. Global cars are definition of having car models that are being produced in different factories and are intended to be the same regarding quality and performance. With a global car strategy, a car produced in China can for example utilize spare parts and supplier networks from the US and Europe. Volvo Cars' customers are mainly located in Europe, Asia and North America and in order to satisfy them, Volvo Cars needs to coordinate their manufacturing network to produce premium quality cars, with high safety and environmental standards. What does the decision of expanding the global manufacturing network imply for Volvo Cars and how can they act in order to move towards a more coordinated part management?

1.2 Purpose

Car manufacturers that have both global and regional suppliers in their manufacturing network are facing a complex situation regarding their part management. This requires a holistic investigation and therefore, the purpose of the master's thesis is formulated as follows:

The master's thesis' purpose is to investigate how a car manufacturer handle their

global part management and what challenges they are facing today within their global manufacturing network. The study aims to provide recommendations for future steps in order to improve global part management.

1.3 Problem analysis and research questions

Car manufacturers that target a global market are facing complexity in multiple areas (Maznevski et al., 2007). Expansion in several regions and highly set ambitions on the manufacturing output to be uniform where ever it is produced, creates challenges that needs to be addressed. Companies in the automotive industry are establishing manufacturing networks in order to supply customers with locally produced cars worldwide (McKinsey Quarterly, 2003). In order for a well-functioning manufacturing network, there needs to be a fit between the strategy, configuration and coordination according to Friedli, Mundt, and Thomas (2014). Rudberg and West (2008) express that the main issues in manufacturing networks are found in the layers of configuration and coordination. Volvo Cars is facing an increased complexity in their manufacturing network and specifically in their part management because of a relatively new ambition to establish new production sites globally. Thus, Volvo Cars' situation will be investigated to identify issues within configuration and coordination that need to be assessed in order to improve car manufacturers' operations.

Volvo Cars' expansion over the last years (Volvo Cars, 2017a) is a strategy that requires a proactive approach in order to succeed. Volvo Cars needs to manage their global manufacturing network, and an increasing part complexity is a challenge. The increased part complexity drives cost since Volvo Cars has to adjust parts' interfaces, which is called fitting process, in order not to compromise the quality of the globally produced cars. Adjusting interfaces locally is today a required measure to take, in order to achieve a final result, which meets Volvo Cars' high demands. The fitting process can be more or less complex depending on the situation and what parts that are interacting. When dealing with sheet metal parts, which are hard to manufacture and have difficult production processes to adjust, the interfacing components are often the ones that are needed to be changed. The interfaces between the headlights and the surrounding sheet metal parts are especially hard to align in order to make the gaps between the parts as small as possible. The headlights are complex components to produce as well, with multiple optics that requires high compliance to specification. Tolerances between parts are affecting each other and situations occur which needs to be closely managed. The local adjustments on parts can however lead to unwanted variation between components in China and Europe. In order to trace and separate the different parts between regions, an additional part number is issued, which is one cause for the increasingly complex global part management. Other causes for having local parts with separate part numbers could be due to different regulations, tolls and manufacturing processes. Another example of a process that is hard to control is the coloring of interior textiles. It is difficult to produce the exact same color tone between batches, and it cannot be guaranteed between different supplier' plants. Therefore, it is important to separate the regional textiles in order not to mix interior from different suppliers'. These,

sometimes unnecessary, separated part numbers will drive cost and will increase complexity when sourcing parts for production and the aftermarket. Suppose that separate part numbers are the common practice for Volvo Cars' strategy regarding their part management. In that case, differentiated components between regions will eventually lead to differentiated cars for each region. This will ultimately separate logistic networks, disable economies of scale, compromise potential savings for the aftermarket by global sourcing and drive overhead cost to manage two different regional cars. Volvo Cars' expanding manufacturing network increase the global part management challenge and the complexity will grow when an additional factory in the US is established. This can lead to that the same car models are produced in three different continents simultaneously. A problem that barely existed only a few years ago is now becoming an issue for Volvo Cars. The problem spans over multiple disciplines, departments, suppliers and includes limitations in the IT-systems.

Based on problem analysis, the investigation starts with how a car manufacturer manage their global manufacturing network and are handling global parts today. Hence the first research question is formulated accordingly.

RQ1: How does a car manufacturer handle their part management in their global manufacturing network?

The report aims to evaluate the investigated area and be able to surface implications and compromises regarding global part management. The project will also provide recommendations for how a car manufacturer can improve their global part management, which results in the second research question.

RQ2: What do car manufacturers need to consider in order to improve their global part management?

1.4 Delimitations

The thesis will look into Volvo Cars' manufacturing network and their management of global parts with input from Manufacturing, Purchasing, Aftermarket, Product compliance department and the R&D divisions; Quality, Product development, Geometry and Product Documentation. The scope of the project is intended to have an overall view of Volvo Cars' global part management and will therefore not cover details such as IT-solutions regarding part numbers. The project will conduct its research on the sites in Gothenburg, Olofström, Chengdu and Shanghai and will not include Volvo Cars' other locations. This is due to the fact that the R&D offices are located in Gothenburg and Shanghai and there are examples of production projects that are being produced in Gothenburg and Chengdu simultaneously. Olofström produces complex sheet metal parts for the car body and supplies both the Chinese and Swedish production. The project will not include suppliers but focus on Volvo Cars' internal processes. The project will result in recommendations on future steps for car manufacturers' global part management but the process of implementation will not be covered.

2
Method

This chapter will present the method of how the research has been conducted, which includes research strategy, research design, data collection and data analysis. In addition, how to create trustworthiness for the study and what ethical considerations that have been taken are presented.

2.1 Research strategy

The research strategy is a general orientation how business research is conducted. There are two ways of conducting research, a quantitative and a qualitative approach (Bryman and Bell, 2011). By using a deductive orientation, the quantitative research is performed by testing existing theory. The qualitative method instead takes an inductive orientation where observations and findings are used in order to generate new theory. An iterative combination of both deductive and inductive research orientation, where research goes back and forth between the two, is described as abductive reasoning (Bryman and Bell, 2011). Theory was continuously evaluated together with input from interviews using systematic combining (Dubois and Gadde, 2002), thus, a qualitative study with an abductive approach was performed, see Figure 2.1.

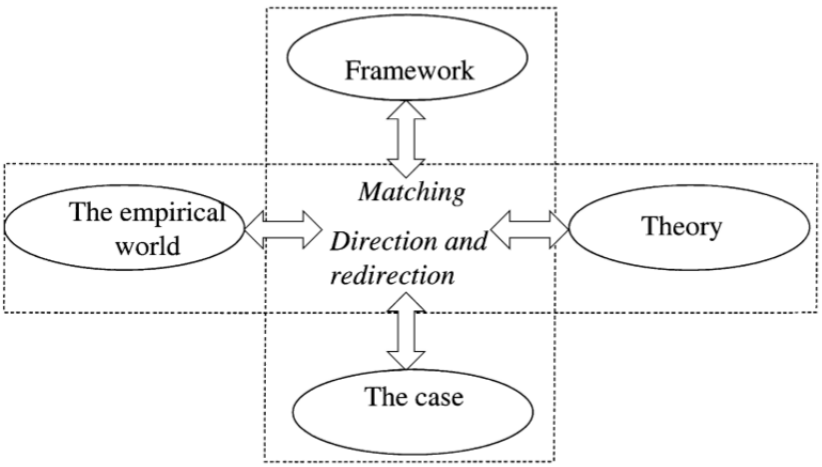

Figure 2.1: Systematic Combining. Source: Dubois and Gadde (2002).

2.2 Research design

The research design was chosen to be a single case study in order to provide depth and the ability to focus on the investigated phenomenon (Yin, 2014). Case studies are widely used to capture real contemporary situations in a detailed way (Patel and Davidsson, 2003). The distinction of using a single case in this study is rationale due to the revelatory aspect mentioned by Yin (2014). The revelatory aspect exists when the researchers have the possibility to analyze an area previously not accessible to social science. Thus, the design for the project was a single case study at Volvo Cars.

The research was structured into three phases, which in combination will answer the research questions. Initially there was an orientational phase where an open mindset was applied in order to gather as much information about the area as possible. The following phase was exploratory where the theoretical framework was formed and the case study conducted. The case study was, together with the theoretical framework, the foundation of the analysis. Lastly there was a recommendation and documentation phase where the results and directions for future research were presented. The framework is illustrated in Figure 2.2.

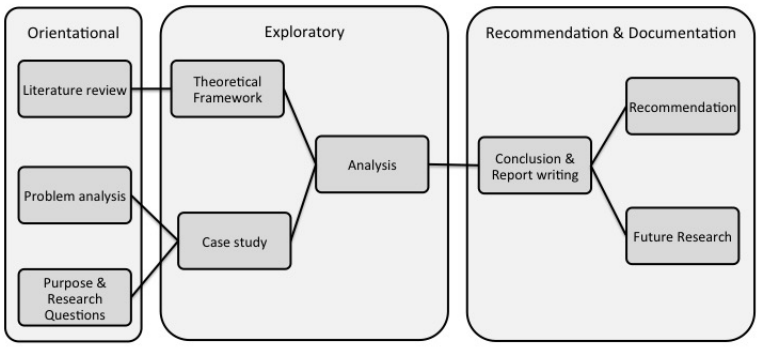

Figure 2.2: Framework of the research's three phases.

2.3 Data collection

Initially the research topic was investigated by using unstructured interviews where the participants freely discussed a few prepared questions. This nature of interviewing technique was adequate for the purpose of orientation (Bryman and Bell, 2011). The literature review consisted of studying scientific articles and books, which together with unstructured interviews provided the orientation for the research. Ensuring that the sources were of high quality and avoided unreliable information, electronic databases such as Chalmers Library, Google Scholar and Emerald Insight were used. Keywords that were important and related to the research area were noted when reading the literature. It provided direction and guidance for further literature review while the research progressed and was an ongoing process during the study.

The data collection was, apart from the review of literature, mainly based on qualitative interviews where the participants in the study elaborated on the research topic. The most suitable interview technique for qualitative research is semi-structured interviews that allow for a high level of flexibility (Bryman and Bell, 2011). Using this technique, enable the interviewees to not only answer specific questions but to speak more freely and cover what they thought was most important within the area as there were variation of knowledge and different perspectives. By using this technique, there were a greater chance to find new relevant areas and aspects, which helped the research, despite the risk of ending up discussing the wrong topic (Bryman and Bell, 2011). Pre-formulated questions were used in order to guide back to the correct topic if the discussion derailed. The order of the questions was of less importance and follow up questions were encouraged if there were certain details that needed clarification. The questions were designed in order to answer the research questions. They were of an open characteristic and aimed to lead to deeper discussions. The questions were based around an interview guide that contained the main points of the investigation. Since the study investigated multiple different functions and departments, the questions in the interview guide needed to be complemented with additional department specific questions. The interview guide was consistent throughout the study and captured the essence of the research questions, see Appendix 1.

The sampling of interviewees took its starting point in a competence group at Volvo Cars and their network of contact. The competence group was a set of senior employees at Volvo Cars with a variety of knowledge, mainly originating from the areas of Manufacturing, Quality and R&D. This competence group was set up based on cross functional knowledge and convenience. In collaboration with this competence group, the respondents were identified and selected in order to answer the research questions. This method of choosing interviewees is called purposive sampling (Saunders, Lewis and Thornhill, 2009). The respondents varied from Senior Managers to employees with specific knowledge that were affected or possessed information about the investigated area. They were spread out among different departments in order to get an holistic view of global part management and global manufacturing networks. From these baseline interviews, additional data gathering was conducted where snowball sampling was used (Bryman and Bell 2011). If respondents had knowledge about possible informants that were relevant to the investigated area, these contacts were evaluated and possibly included in the study as future respondents.

The empirical chapter contains information gained from interviews with personnel from several different departments at Volvo Cars in Torslanda, Olofström, Shanghai and Chengdu, which are presented in Table 2.1. To present the interviewees anonymously, only their title, location and department belongings has been chosen to be included in the table. The departments have been summarized into the following five categories; Manufacturing, R&D, Aftermarket, Purchasing and Product compliance. The interviewees consisted of 7 engineers and 29 managers from various levels in the organization, providing information about the investigated area.

Table 2.1: Interviewees at Volvo Cars.

Title	No.	Department	Location
Senior Managers	2	R&D	Shanghai
Director	1	R&D	Shanghai
Senior Manager	1	R&D	Gothenburg
Managers	5	R&D	Gothenburg & Shanghai
Launch Leader	1	R&D	Chengdu
Engineers	3	R&D	Gothenburg
Plant Manager	1	Manufacturing	Chengdu
Senior Director	1	Manufacturing	Shanghai
Directors	2	Manufacturing	Gothenburg & Chengdu
Senior Managers	2	Manufacturing	Gothenburg & Chengdu
Managers	3	Manufacturing	Gothenburg & Chengdu
Engineers	4	Manufacturing	Gothenburg & Chengdu
Manager	1	Manufacturing	Olofström
Senior Managers	2	Product compliance	Gothenburg
Senior Manager	1	Aftermarket	Gothenburg
Technical Managers	2	Aftermarket	Gothenburg
Directors	2	Purchasing	Gothenburg
Manager	1	Purchasing	Gothenburg
Senior Director	1	Purchasing	Gothenburg

2.4 Data analysis

As described in the data collection, theory was the starting point for the study but as the study progressed, data was continuously matched and cross-referenced with literature. Established theory and sources from Volvo Cars' internal website was used in order to validate the respondents' answers and to question the situation at Volvo Cars. The collection of data in the case study included interviews with 36 participants that contributed with a large amount of data. The information gained through interviews needed to be mapped in order to be decipherable and linked to relevant topics in the theoretical chapter. This was done by color coding the respondents' answers into areas of interest, where a color was assigned to a specific topic. These topics could then be linked to the framework by Friedli, Mundt and Thomas (2014) that helped assess the global manufacturing network of Volvo Cars. The participants' answers were judged and evaluated by relating the collected data to literature in order to draw conclusions and provide recommendations for Volvo Cars.

2.5 Trustworthiness

There are different ways of evaluating quantitative and qualitative research studies in terms of trustworthiness. As the method of choice in this study was of a quali-

tative nature, trustworthiness to the research study can be assessed by the criteria; credibility, transferability, dependability, confirmability (Lincoln and Guba, 1985). These considerations are well aligned with the criteria for judging the quality of research designs mentioned by Yin (2009). There were four tests to bear in mind during the different steps throughout the study; construct validity, internal validity, external validity and reliability.

Credibility is evaluated by how believable the findings are, which from an internal perspective correlate to how well the social reality of the chosen company is captured (Bryman and Bell, 2011). To ensure that the situation at Volvo Cars and that the interviewees were understood correctly, confirmation from the supervisor was a recurring point on the agenda to the fortnightly meetings and to have the key informants reviewing drafts of the case study (Yin, 2009). Transferability refers to how well the findings are applicable to other situations or contexts (Bryman and Bell, 2011). In a qualitative research however, this can be an issue as most of this type of research are unique in many ways. This was dealt with by having an elaborate explanation of the case study and account for the social context. The transparency and level of detail will aid others in their judgment of transferability to other settings. Dependability address if the research is repeatable by having well defined methods and in accordance with proper practices (Bryman and Bell, 2011). This was achieved by having an elaborate methods chapter, which aims to present reasons for every step in the research. Even though there is an uniqueness in qualitative studies, the way of conducting the research should generate similar results if others would conduct the research through the methods presented (Yin, 2009). Confirmability evaluates if the researchers' values have affected the results to some degree (Bryman and Bell, 2011). When carrying out qualitative research, complete objectivity is argued to be unavoidable, but measures to prevent biases as much as possible have been taken. To ensure a correct interpretation of the gathered material and information, both researchers attended all the interviews. The semi-structured interview technique can yield views of subjectivity from each of the interviewees and this was handled by comparing responses from related departments and combining it into the bigger picture, mentioned as pattern matching by Yin (2009). It was also important to distinguish what is speculation and fact, which was done by checking the company's intranet and getting confirmation from the supervisor. The use of multiple interviews, both from the same and related departments, and the company as a whole, helped cross-referencing answers (Yin, 2009). This can be called triangulation and by comparing interpreted data, less biased judgments could be achieved (Bryman and Bell, 2011).

2.6 Ethics

When interviewing and interacting with participants in the study, it was important to consider ethical aspects. According to Bryman and Bell (2011) there are four areas where ethical principles are to be concerned; invasion of privacy, lack of consent, deception and harm to participants. Interviews were a key aspect of the study and for ethical considerations regarding them, all interviewees participated voluntarily.

No one was forced to enter the study. The data presented is also anonymous, which prevents data presented in the report to cause any harm, deception, lack of consent or being invasive of privacy. Participants in the study was informed of the aim and how the results may be beneficial for Volvo Cars in order to prevent ethical dilemmas. By communicating and create understanding of the study's possible results, interviewees had a better situation to decide if they wanted to participate in the study or not. The study also needed to consider non-participants and Gorard (2002) highlights potential ethical dilemmas regarding them. In order to not cause harm to this group, non-participants were considered when the researchers presented data.

3
Theoretical framework

The theoretical framework aims to present relevant theory and background information to the area, which the study will investigate. The foundation of the report is within manufacturing and manufacturing strategy, where definitions are stated in order to clarify the meanings for this report. The global aspect is framed in the area of manufacturing networks and a framework is presented, which identify strategy, configuration and coordination as key areas for a manufacturing network. However, manufacturing networks is a broad field that includes multiple different theoretical areas, which are essential to capture the holistic aspects of companies' global operations. For the study, the area of manufacturing networks is presented and the fundamental aspects that it contains are briefly mentioned in this chapter. Lastly, the development of the automotive market will be presented in regard to global trends.

3.1 Manufacturing

Manufacturing can be defined as "the production of machine-made products for sale" (Collins, 2006, p. 246). This involves the processes of converting raw material into goods for a customer. In order to clarify the future meaning of manufacturing in the report, the area needed to be properly defined. Manufacturing is also strongly connected to production which can be defined by "the work of making or manufacturing of goods for sale" (Collins 2006, p. 317). These terms of production and manufacturing are thus closely related in their definitions and can be used interchangeable, which will be done throughout this report. This will also include other terms including production and manufacturing such as, manufacturing- and production strategy and manufacturing- and production networks.

3.2 Manufacturing strategy

Strategy is according to Slack and Lewis (2011) not an obvious term and it is widely used in various settings. There are similar ways of viewing strategy and most include setting broad objectives that are aligned with the overall goal and are more towards long term rather than short term objectives (Slack and Lewis, 2011). This is also emphasized by Anderson, Cleveland, and Schroeder (1989) who states that strategy is long term direction for an organization in order to give a competitive advantage. As previously discussed, manufacturing and production can be used in similarity and thus also manufacturing strategy and production strategy. Another

term within the area which is referred to in literature is operations strategy. However, Gagnon (1999) stated that operations strategy is the new term that is being used when referring to manufacturing strategy. It can be argued that operations is a wider term that incorporates services as well. In this report, operations strategy and manufacturing strategy will be used in similarity with the regards of neglecting services from operations strategy since this is not relevant for the investigated area of global manufacturing networks.

Manufacturing strategy have over the last half century been investigated by multiple different researchers. Skinner (1969) first introduced the "missing link" between corporate strategy and manufacturing and stated that manufacturing strategy is about using the manufacturing functions as a competitive weapon. These findings have been developed and expanded in order for companies to take full advantage of the manufacturing capabilities. Swink and Way (1995) argues that manufacturing strategy will affect decisions and plans that relates to resources and policies concerning sourcing, production and delivery of tangible products. However, manufacturing strategy is not clear nor consistent (Anderson, Cleveland, and Schroeder, 1989). According to Slack and Lewis (2011), there are four perspectives on operations strategy but all should be combined to form a competitive strategy. The four perspectives on operations strategy are; top down, bottom up, market requirements and operations resources, which are visualized in Figure 3.1.

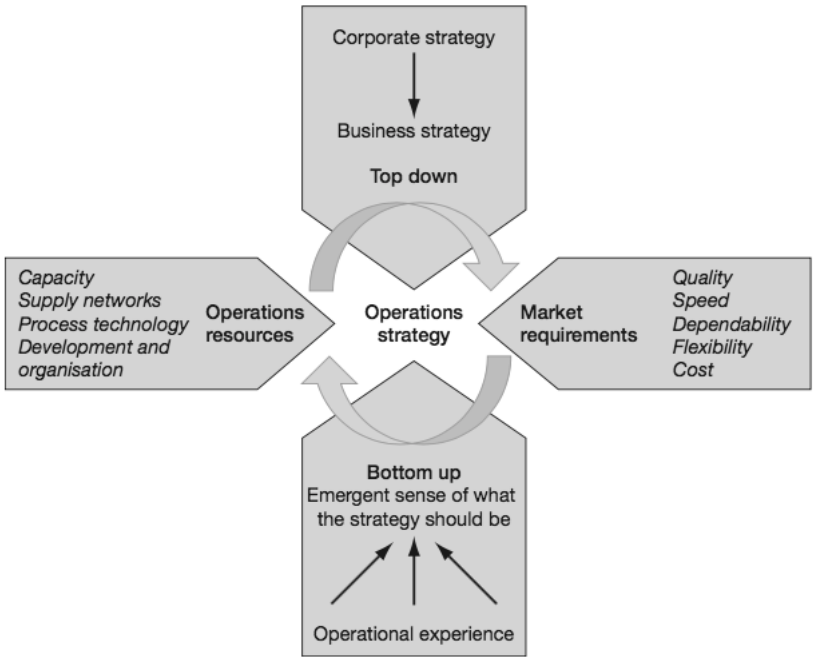

Figure 3.1: Operations Strategy. Source: Slack and Lewis (2011).

The terminology for market requirements and operations resources are more commonly referred to as market-based and resource-based views. These are essential to understand in order to make a strategy fit with the company's resources or to be more aligned with the market environment (Brown and Blackmon, 2005). Most

researchers used to stress the importance of having a market-based view and therefore align a company's resources to market demands and not the other way around (Gagnon, 1999; Dangayach and Deshmukh, 2001). This perspective implicates that the different markets would be the decisive factor whether or not a firm should enter a new market, remain in or exit one (Brown and Blackmon, 2005). Porter (1979) have explained how this would be taken into account in the five forces model where the market perspective plays a big role. However, the resource-based view suggests that the company's resources is the competitive factor, which should be the decisive factor when forming the firm's strategy (Brown and Blackmon, 2005). This perspective ultimately describes the core competences and capabilities of the firm as the competitive edge that needs to be sustained (Hayes, 1985; Slack, Chambers, and Johnston 2010). Dangayach and Deshmukh (2001) as well as Gagnon (1999) have shown that there has been a development from a market-based view to a more resource-based view over time. Since a competitive advantage is not simply provided by a privileged market position, it has become a more important part of the manufacturing strategy to diversify and develop the internal resources for the company (Slack, Chambers, and Johnston 2010; Slack and Lewis, 2011).

3.3 Manufacturing networks

Manufacturing networks originate from operations management theory and focus on the internal networks (Rudberg and Olhager, 2003). A value network is defined as the links between the organization, consisting of both its internal and external contributors to the value chain (Collin, 2006). From an operations management point of view, the manufacturing network focuses on the nodes of the value network (Rudberg and Olhager, 2003). According to Shi and Gregory (1998), the nodes can be seen as representing factories with connections, which is the internal networks of an organization and they cannot be managed in isolation as they both influence and are influenced by each other. In comparison, the external networks focus on the links between the nodes, which is a logistics management perspective, illustrated in Figure 3.2.

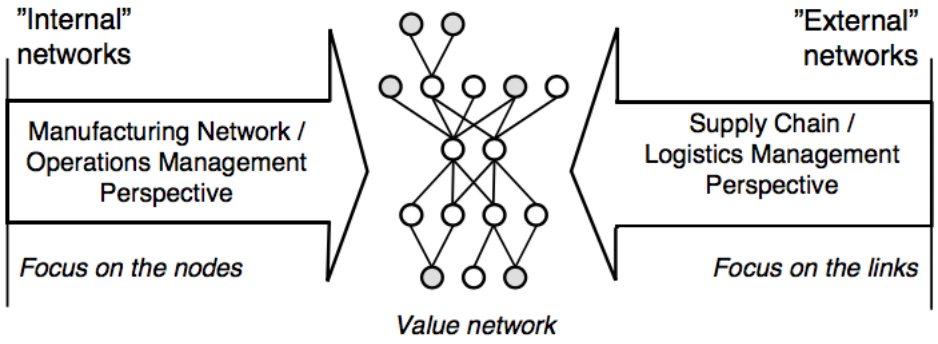

Figure 3.2: Value Network. Source: Rudberg and Olhager (2003).

According to Miltenburg (2009), there are nine manufacturing networks; domestic,

domestic export, international, multidomestic, multinational, global product, global function, global mixed, and transnational. The type of manufacturing network should correlate with the generic strategies for international manufacturing, which are based on the level of pressure for globalization versus local responsiveness (Shi and Gregory, 1998). Rudberg and Olhager (2003) gives another view on different types of networks, which are presented in Figure 3.3, and organizations need to have different approaches depending on their type of network. The classification is useful as it emphasizes on different issues for organizations. The first two types of single organizations, Plant and Intra-firm network, should be more concerned with the issues within the factories. The third multi-organization, Supply chain, should focus on the links, which is the logistic relationships. The fourth type, Inter-firm network, should consider both nodes and links jointly (Rudberg and Olhager, 2003). There are other considerations for the manufacturing network to be made in addition to the generic strategy since organizations have various geographical locations, various activities to serve different markets and the degree of coordination between facilities may vary (Miltenburg, 2009).

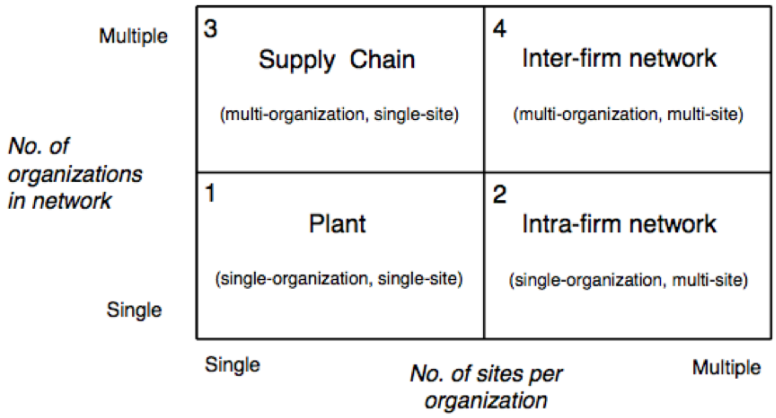

Figure 3.3: Type of networks. Source: Rudberg and Olhager (2003).

When expanding the manufacturing network and shifting from regional, to global manufacturing, coordination complexity will increase while customers' quality requirements will remain. Davies and Kochhar (2002) argue that practices should be evaluated and carried out in a holistic way based on the performance on the complete company group rather than doing sub-optimization on local sites. Shimokawa (1998) identifies that global manufacturing networks have increased and car manufacturers such as GM, Ford, VW, BMW, Mercedes and their Japanese competitors have all expanded their global presence. For these multinational corporations, there is a need for local responsiveness together with the global potential of having international presence. This supports the decision of having manufacturing facilities in different markets around the world (Miltenburg, 2009). Ford approached this pressure of globalization and the need for local responsiveness by stating: "think globally, act locally with agility" (Shimokawa, 1998).

3.4 Framework for assessing manufacturing networks

Friedli, Mundt and Thomas (2014), present a framework for assessing and managing global manufacturing networks. It is a system approach to incorporate three main categories, or layers as they describe them. The layers are Strategy, Configuration and Coordination, which all can be broken down into smaller components that needs to be regarded when managing a global manufacturing network. In order to properly design a manufacturing network there needs to be a "FIT" between the different layers, but also between the sub-components. Thus, network management must be holistically aligned to achieve the "FIT" between the different layers, components and with regards to the context. Friedli, Mundt and Thomas (2014, p.64) synthesized as follow; "an efficiently structured manufacturing network is characterized by a production strategy that takes internal and external context conditions into account, a network configurations that is adjusted on this strategy, and coordination that supports this." The framework is presented in Figure 3.4 and in further detail in the following sections.

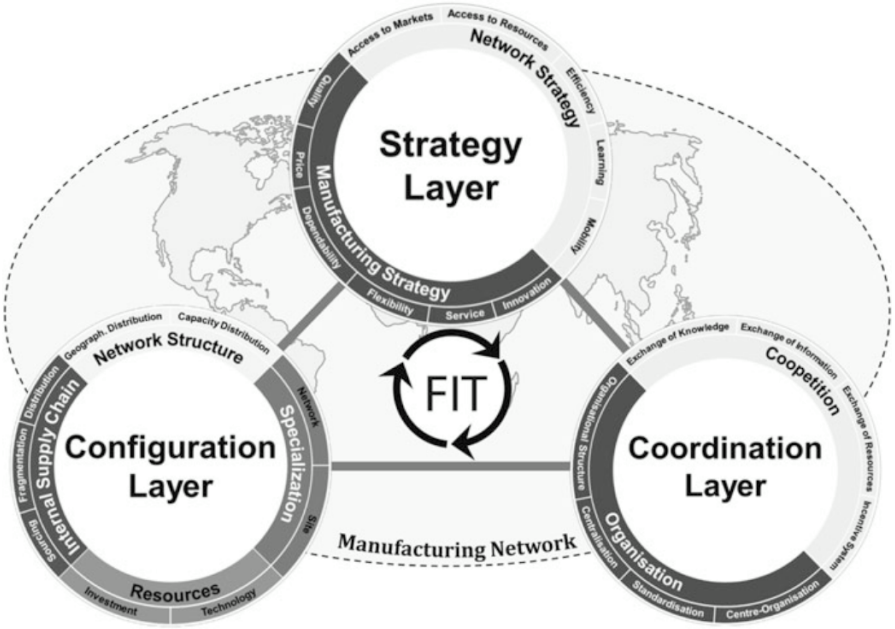

Figure 3.4: Framework for assessing manufacturing network. Source: Friedli, Mundt and Thomas (2014).

3.4.1 Strategy

There are two components in the strategy layer for a global manufacturing network; manufacturing strategy and network strategy. The manufacturing strategy should be derived from the business strategy and will set guidelines for future goals that the company will strive towards (Skinner, 1969). It will regard differentiating factors

concerning fundamental elements such as quality, price, dependability, flexibility, service and innovation for the individual sites (Friedli, Mundt and Thomas, 2014). Network strategy regards how different manufacturing sites are managed together in a network. Friedli, Mundt and Thomas (2014), categorize network strategy into five network specific factors; efficiency, access to markets and resources, as well as learning and mobility, which all need to be viewed holistically. The two components in the strategy layer needs to be addressed properly in order to achieve a well founded strategy for the entire organization. The specific site capabilities should be designed to support the network and both the individual sites and network should serve the manufacturing strategy (Friedli, Mundt and Thomas, 2014).

3.4.2 Configuration

The configuration of the network describes how it is designed. It will regard the physical location of manufacturing sites, the setup of logistics within the network, practices on how to act within the network and the level of specialization (Friedli, Mundt and Thomas, 2014). The configuration of the network is set up in order to achieve the goals of the manufacturing and network strategy. Thus, it is essential to set up the configuration of the network in line with this strategy (Friedli, Mundt and Thomas, 2014).

Network structure
The network structure is mapping the geographical distribution of the network and also the capacity distribution (Friedli, Mundt and Thomas, 2014). It will set an important precondition for the network. Several, smaller sites will create a better flexibility within the network and can answer more quickly to local changes in the market (da Silveira, 2014). This configuration of several smaller sites will however create greater complexity to the network which will need to be managed (Friedli, Mundt and Thomas, 2014).

Specialization
Friedli, Mundt and Thomas (2014) categorize specialization into network and site specialization. The network specialization will determine the specialization of each site within the network. The network specialization can be divided into four different strategies (Friedli, Mundt and Thomas, 2014). In a product-oriented strategy, sites will produce specific products at a site without overlap. A market-oriented strategy, where a site will only supply the geographical market were it is located. The process-oriented strategy will specialize at a specific technology which might be suitably for complex products, scale intensive production and process manufacturing that is connected to natural resources. A flexibility-oriented strategy will specialize in both markets, products and processes but for shorter time in order to stay flexible and manage products with short life-cycles. These four different strategies can also be combined resulting in greater complexity and will weaken the idea of a focused factory. The focused factory was highlighted by Skinner (1974) and he concludes that a focused factory will outperform a conventional plant that have a broader mission. This is the same topic that Friedli, Mundt and Thomas (2014) discuss

with their category of site specialization. It is the level of specialization within a technology or a specific product produced that is supporting the overall network.

Resources
Resources will affect the chosen technology and the investment strategy used for production sites (Friedli, Mundt and Thomas, 2014). The technology aspect will, for example, depend on wage levels in the region and will thus affect the rate of return on investments in automation technology. Investments can be made by simply copying the same concept between different sites in order to reach a higher level of standardization within the network. However, taking local circumstances into account, sites will differ between regions, which results in another degree of complexity in the network.

Internal supply chain
The set up of the internal supply chain in a manufacturing network will affect the distribution and purchasing. It will also regard the logistics between different sites, which Friedli, Mundt and Thomas (2014) categorize as the fragmentation of internal supply chain. The supply chain needs to be considered, especially when not only transportation costs but also lead times, tariff barriers and tide up capital will affect the over all performance of the supply network (Abele et al., 2008). The geographical distance and fragmentation of the network will have a big impact on the responsiveness in the supply chain. Regarding procurement and purchasing, decisions have to be made if the sites should go with local or global suppliers. Cost benefits, such as low wages, can be lost if to much material needs to be imported and be affected by tariff and transportation costs. Choosing local suppliers will improve the responsiveness in the supply chain but also add complexity with an increased supplier mix and additional supplier relationships (Friedli, Mundt and Thomas, 2014). Rudberg and West (2008), identifies problems of choosing local suppliers and the need to categorize parts into crucial and non-crucial. The crucial parts are complex and should therefore be given extra attention and probably be managed on a global level since the requirements on these parts are high and needs well developed relationships with the suppliers. Non-crucial parts can be sourced locally and will include simple, standard parts. The choice of procurement should be made with the holistic perspective in order to gain the optimal results (Friedli, Mundt and Thomas, 2014). In a global manufacturing network, the set up of the distribution of the produced products will affect the performance but the distribution is rather a subordinate configuration based on the network structure and layout (Friedli, Mundt and Thomas, 2014).

3.4.3 Coordination

The coordination of the manufacturing network is a combination of organizational and coopetition components (Friedli, Mundt and Thomas, 2014). The organizational component includes management structure and how to distribute responsibility within the network (Friedli, Mundt and Thomas, 2014). The coopetition component regards the relationship perspective for the parties that are of simulta-

neous pursuit of collaboration and competition (Gnyawali and Park, 2011). Parties can be subsidiaries, internal suppliers or departments. Coopetition considers the network as a system of exchange of information, knowledge and resources but also includes the topic of an incentive system.

Organization
In the organizational component the topics included are; organizational structure, centre-organization, centralization and standardization (Friedli, Mundt and Thomas, 2014). The organizational structure will influence the way of working, determine the mandate for decisions and set up areas of responsibility within the network. Centre-organization is closely related to organizational structure and assess how the responsibility will be structured regarding cost and profit. The cost can be dealt with centrally at a head office or decisions for investment can be made locally and likewise how profits can be managed. This decision will influence the level of centralization and standardization but the later topic is broader than cost and profit. It regards the sites autonomy regarding decisive factors. The amount of rules and standards will decide the level of freedom for the sites to choose for example, process technologies and production planning (Hayes et al., 2005). For production that aims for identical products world wide, the same quality standards needs to be global and thus a high level of centralization and standardization is required (Friedli, Mundt and Thomas, 2014).

Coopetition
Having a relationship of both rivalry and cooperation has its origin from game theory, which is a set of concepts regarding decision making during situations of competition, conflict and cooperation (Game theory, 2017). Brandenburger and Nalebuff (1996) defines players within game theory as being either a complementor or a competitor to the business, depending on whether or not they add value to the business when customer view the company's products together with the player's. This approach is highly applicable for network organizations as well. Between geographically spread out sites in a manufacturing network, there can be a high degree of cooperation, such as exchange of best-practices and information sharing. At the same time, sites can also compete for the company's resources or positioning in the network system (Luo, 2005). A well balanced coopetition is according to Gnyawali and Park (2011) challenging to achieve but is very helpful in order to create mutual benefits, address technical challenges and foster innovation. Thus, there is a need to manage the relationship between sites to stimulate the exchange of knowledge and information while distributing the company's resources where it can be put to best use. One of the reasons to build a global manufacturing network is to access technological resources, knowledge and information (Friedli, Mundt and Thomas, 2014). To achieve a good exchange of knowledge and information between sites, an incentive system can be helpful.

The exchange of knowledge is considered to be crucial so that locally gained knowledge can be used in other sites and to distribute global practices in the network (Friedli, Mundt and Thomas, 2014). Discussing transferring knowledge, it is im-

portant to differentiate between sharing content and the method for exchanging knowledge (Friedli, Mundt and Thomas, 2014). Content is used to describe three main areas: technical knowledge about products, process knowledge regarding production and management knowledge about organization, cooperation and culture. Methods refers to the transfer mechanism, where there are multiple frameworks for what action that should be used for different types of knowledge (Ferdows, 2006; Madsen et al. 2008). Ferdows (2006) categorize knowledge into its forms of explicit or tacit, and matches those with the pace for knowledge development, from slow to fast. Depending on what type and pace, Ferdows (2006) suggests an exchanging mechanism for each of these, see Figure 3.5. Transferring practices between sites can be a struggle, but to overcome the barriers it is not enough to simply encourage sharing knowledge. There needs to be a well described goal to be able to apply the proper mechanism to address the situation, for example moving people or having projects that stretch across sites when transferring tacit knowledge.

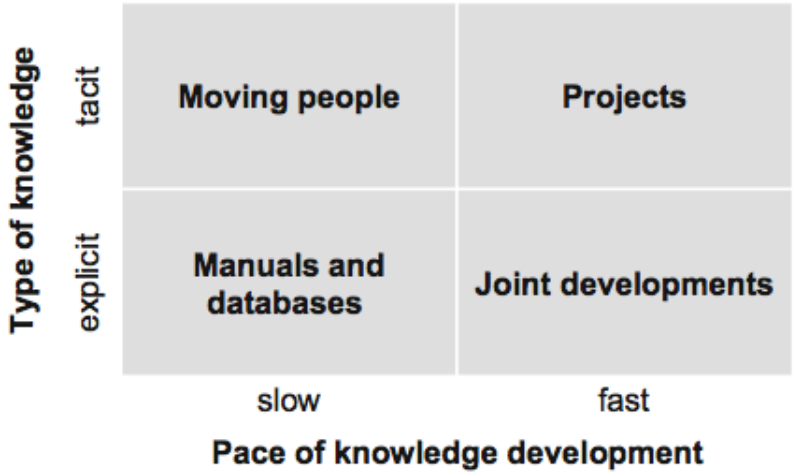

Figure 3.5: Knowledge transfer mechanism. Source: Ferdows (2006).

Exchanging information can in network organizations be viewed in terms of communication ways between subsidiaries, division or sites regarding the intensity level, openness and whether it is formal or informal (Friedli, Mundt and Thomas, 2014). A high degree of sharing information can have a positive effect on the network's level of cooperation but can also cause an increased competition between sites when for example sharing quality or productivity figures (Friedli, Mundt and Thomas, 2014). This must be managed in regards to the coopetition factors within the network since too much competition can reduce the willingness to cooperate and instead optimize the own site's capabilities on a local level instead of having a global perspective. The competition between sites are often for the company's resources, which can be of three types: R&D, production or supporting resources. Some must be shared whereas other resources are strategically distributed in the network to create most value since they are always in a limited supply. To address the situation of coopetition, incentives can be used to either increase cooperation or competition, depending on what level the incentives are set (Friedli, Mundt and Thomas, 2014). If there are incentives for the individual sites, there will be more of a competitive atmosphere

among them whereas incentives on a network level globally, causes a higher degree of cooperation between sites (Luo, 2005). Targets that needs to be covered are financial, market-related, productivity, learning and strategic goals (Friedli, Mundt and Thomas, 2014). Even though financial incentives are easy to connect when reaching targets, there are many other incentives, such as recognition and contribution awards, that can be used to stimulate the achievement of the goals (Luo, 2005).

3.5 Development of the automotive market

As previously discussed, companies have created a global supply and manufacturing network in order to expand and access a broader market (Friedli, Mundt, and Thomas, 2014). Companies become global when the pressure of globalization is high (Miltenburg, 2005). However, Rugman and Collinson (2004) argue that the automotive sector is lagging behind in the globalization. By their definition of a global firm, none of the 29 biggest car manufacturers are reaching their requirements. They are all either too dependent on their home market and have over 50% of their total sales located to it, or they are not established with at least 20% of their sales in all the three big world markets of EU, North America and Asia-Pacific region. This can be explained by different barriers to globalization within the automotive industry (Rugman and Collinson, 2004). The industry operates in clusters and relies heavily on local key suppliers, distributors and other partners for their operations. This leads to 90% of the 55 million vehicles produced 2003 where sold where they were made (McKinsey Quarterly, 2003). Another key issue for a global car is that customers have local preferences (Rugman and Collinson, 2004). American customers like spacious comfortable cars and European customers have a bigger focus on environmentally friendly engines. Finally, local regulations and tariffs, which can vary from 2,5% up to 100% in developing countries, create barriers for global expansion (Rugman and Collinson, 2004). This drives companies to act more locally in order to comply with local demands, which is aligned with Rudberg and West (2008) who say that the global spread forces companies to be more sensitive to local knowledge and demand. To overcome these barriers companies are forced to expand their manufacturing network in order to access new markets, stay competitive and striving towards reaching a global presence.

Industry surveys indicate that there is a current shift in market growth in the industry with a shift from the western world to emerging markets and especially the Asia-Pacific region. 1344 CEOs pointed out China as the national market with the biggest growth potential (PwC, 2014). A forecast have also suggested that China is expected to have 30% of the world market for light vehicles by 2020 (IHS Markit, 2017). In the light of this, there is no surprise that automotive manufacturers want to expand and enter the Chinese market. By investing in production facilities in China, companies creates a local presence and can gain improved flexibility and a more rapid delivery to the local market (da Silveira, 2014). The lower cost of labour in the region also supports the offshoring decision (Ceglowski and Golub, 2007). Offshoring means to relocate manufacturing or other operations to a foreign country and should not be confused with outsourcing, which is when companies are

contracting specific tasks externally (Jabbour, 2010). In the light of the growth potential and the low cost of labor in the Chinese region, there is no question why automotive producers are currently investing in production facilities in China.

4
Empirical findings

The empirical findings chapter will present the retrieved information from the interviews that will be the basis for the study. The data is compiled from interviews performed in Gothenburg, Shanghai and Chengdu. In addition, Skype-interviews have been performed with representatives from Olofström. The result from the interviews will be presented in the following chapter.

4.1 Volvo Cars Corporation

Volvo Cars is a Swedish car manufacturer that, during the last decade, is going through a transition from producing affordable family cars, to premium cars. The transition to a premium brand is currently happening while keeping Volvo Cars' core values of safety and quality in combination with high environmental standards. Volvo Cars is heavily expanding in China and is aiming for 200,000 sold cars in China (Reuters, 2013) and a total of 800,000 cars sold globally by 2020 (Volvo Cars, 2016). In comparison to the 534,000 cars sold in 2016 (Volvo Cars, 2017c), the expansion is rapid and necessary actions needs to be taken to manage the growth. Before the expansion, fewer cars were produced and the production was mainly based in Europe. With this set up, Volvo Cars' strength was their flexibility, close collaboration and geographical location between R&D and Manufacturing. Those have been aspects that have created a competitive edge for Volvo Cars but now needs to be reevaluated to fit with the strategic goals of becoming a global player with the ambition of increasing sales and expanding production to Asia and the US. The CEO has stated that Volvo Cars should have "the same quality and same productivity in all plants" and that the "customer should not need to care if it is a Chinese, American or European car". With this in mind, it is essential to evaluate the diverging outcome from production plants, ensure that the quality is the same globally and that it will not affect the customer.

4.1.1 Product development process

Before introducing a new car, there is an extensive process with different phases, steps, gates and milestones. These are all well specified and defined in internal documents and it is called the Volvo Cars product development system. It specifies when different departments and functions are involved in order to contribute to the new car. In regard to the process of global part management, R&D specify drawings, tolerances and interfaces between the different parts. It is a project organization

that combined with department functions, takes the introduction of the new car into the different phases. For example, supplier selection, prototype verification and tool trial, before the start of production is initiated.

4.2 Part management

During the time between the drawing is made and until the final car is ready for production, various challenges occur regarding the parts used in the car. There will be local variation between parts produced at a Volvo Cars sites or suppliers. Ideally, all parts fulfill specification, characteristics and will vary around the specified nominal metric value. Some parts can however vary around another metric value. The nominal value and how parts are varying around different metrics will be explained further in the report. According to interviewees, the initial outcome from the pre-production phase varies and there might be gaps between the interfacing parts that Volvo Cars does not accept. A department called Perceived quality, analyze customer needs and gives an assessment if the interfaces and outcome from the production meet the customer demands. The highlighted interfaces are lifted on Design Review Meetings (DRM). On these meetings, a department within R&D called Geometry, which specializes in the holistic geometry and the different interfaces between parts, will assess the potential gaps and misalignments between parts. They will review these issues together with other functions such as the Design-, Manufacturing-, and Quality department.

If the outcome from manufacturing does not meet the intended specifications, or that a group of parts does not create a holistically good fit and finish, action needs to be taken. Interviewees from departments related to manufacturing stated that preferably, is a simple adjustment made in order for the outcome to fulfill the requirements. However, this may be a more complex situation that requires an assessment of which part that should be managed or changed in order to create the best outcome. What is easiest to correct, what are the cost involved in the change and what compromises will the change lead to? With the final outcome from the production as the main goal, thorough work is done collaboratively between Manufacturing, Supplier Quality Management (SQM), Geometry and other R&D departments. This process may result in changes on a part within or outside of its initial specifications. The part in focus, or a connecting part that may be easier or cheaper to change, is corrected in order to create a good final outcome for the car. The process of creating a good final result between parts is called fitting process. The fitting process itself is an established process since produced parts will always vary within its specification and processes must be adjusted accordingly. The tolerances are set in order to allow for parts to vary in tolerance chains, in which multiple parts' tolerances are influencing each other. If two different parts are utilizing their allowed tolerances, a third connecting part might not fit in its intended space. Thus, when introducing a new car there will be some fitting process to be made in order to achieve the final best result. In the fitting processes, new target values for Manufacturing to aim for might be set up in order to improve the interfaces between parts. These new target values are updated in a Target Value drawing (TV-drawing).

When a part is set to go outside of specification, it may still create a good end result. However, when the part goes outside of specification, the part has changed its form, fit or function. "Form-Fit-Function" is often referred to when talking about Volvo Cars' parts. It is the definition when the part goes outside its specification and requires an updated drawing from R&D. Thus, when Form-Fit-Function is changed, R&D is, or should be, contacted in order to update the original drawing. When having global production of the same car models at different sites, parts might vary between different sites and at local suppliers. Parts can differ both in characteristics, color and be within and outside of specification, at different sites and at suppliers. The local variation become even more significant when comparing a varying part from Europe with the same part produced in China. The Chinese part could also vary but possibly around another metric. It is not just the measures that might experience variation but different conditions such as; raw material, processes, local temperature might result in diverging outcome in the surface, color, and other possible characteristics.

4.2.1 Diverging output

During interviews with the Manufacturing department it has been stated that when producing components, everything does not always end up exactly as in the drawings. The drawing will specify a nominal value with outer tolerances where the part is allowed to vary within. The nominal value is where the Manufacturing is supposed to aim towards. However, a manufacturing process will always experience variation of the outcome and no part will be exactly the same, depending on if the difference is measured in centimeters, millimeters or nanometers. To have tight tolerances is a big cost since the manufacturing tools are required to have better precision, or there will be a lot of produced materials that will have to be scrapped in order to reach the quality requirements. In addition, manufacturing has to consider the cost over time. When cutting tools are used, they will be worn down and changed before the processed material goes outside of specification. With tighter tolerances, the tools need to be attended and changed more often. Thus, tight tolerances are not only a big cost initially but also over time in running production. The tolerances in the design process are difficult to set in order for the outcome to always become a perfect fit directly. In addition to the design process, the components will vary in outcome, even within tolerances and the initial outcome in the interfaces between parts might not have a good fit and finish. In order to finally achieve a good fit, the fitting process during the launch of the car into production is essential. The holistic geometry regarding different parts' interfaces is reviewed by the Geometry department.

4.2.2 Categorization of parts

When trying to produce components according to the initial drawing, there are different levels of complexity for the designed parts. Interviewees at the Manufacturing department, describe complex parts such as sheet metal for the car body

and advanced plastic components such as headlights, more difficult than other to keep within specifications. The car body is made in a separate factory and requires heavy investments in machinery and tooling. Thus, it is relatively hard to make changes to the dies that make the sheet metal components for the car body compared to simple plastic components. When there are interfaces between the car body and a plastic part that does not look good or might not fit well, it is often easier and cheaper to change the plastic component. An evaluation is made whenever a component, or a set of components does not fit, match or look good together. If a change has to be made, there is an assessment that will reveal, a not always so clear, hierarchy of what components that should be changed. The assessment is unique and will depend on a lot of different criteria that will have different type of influence on a case by case basis. Criteria that can influence the decision are for example:

- A common part that is used in other product lines or product families are very rarely changed since it will have an impact on other car models than the one that experience the issue right now.

- Investment costs in order to change machinery and tooling for a better outcome in the part produced. Plastic components are generally much easier and cheaper to change than sheet metal for the car body.

- If the part is produced in-house or is sourced from a supplier. If the part is outsourced, Volvo Cars can assess the cost and do not have to consider the alternative cost for time consumed by Volvo Cars employees that might be busy with other projects. However, external partners bring a more extensive processes where the partner needs to assess the problem, provide an offering, source new tools, which in combination entails into long lead times.

4.2.3 Localization of parts

What components that should be localized in a specific region is evaluated case by case for the different alternatives. Some of the criteria that are evaluated are; production volumes, legal requirements, customs, manufacturability and supply chain capabilities. According to a Plant Manager in China, it is beneficial to produce cars where they are sold and also source parts close to where the production is. This will balance currency risks, create a responsive supply chain, decrease tied up capital and reduce trade barriers. Investments in plants and equipment as volumes increase, can decrease tied up capital in parts that would otherwise be shipped. Because the distance between Europe and China, lead times of shipped material between the regions can be up to three months.

When selecting suppliers for the subsequent plant, the development at the first plant have already come far enough to send an already developed and produced component to the second region for them to replicate. This is done in order to have better conditions to achieve the same quality globally, since not everything can be listed in the specifications. Interviewees pointed out that the drawing, complemented by

a physical prototype, gives the supplier good conditions to achieve the same quality for their output.

4.2.4 Different setup between plants

A single process will always experience variation and two similar processes will also experience local variation. Another aspect on the matter is that there are different conditions between sites in Europe and Asia. Cheaper labor cost in Asia will affect the rate of return on investments of automation technology. Thus, the automatization level in European plants will be higher in general due to the wage differences, but is also influenced by other factors. There are other aspects that differ between Volvo Cars' plants in Europe and China. Plants in China are relatively new, only about a decade old, compared to the Swedish plant, which were built in the 1960's. The newer, Chinese plants were not built with the same kind of compromises and pre-existing technology as the Swedish plant, which has a heritage and less possibilities to rebuild. Therefore, the processes differ in both level of automation and plant layout.

The most influencing factors that could potentially create diverging outcome from production have in the interviews, been described as the 4 M:s, which are; Machine, Man, Material and Method. Different processes between the plants, the different types of knowledge of the factory workers, the possible different types of raw material that are used in the process and also different types of methods used, will create variation. In addition, different environment conditions, such as humidity, heat level in the factory etc could affect the outcome from the production.

4.2.5 Interchangeability

It is known that parts can deviate from the nominal specification value and that variation will occur between plants. However, there are major benefits to be gained if parts are similar enough to be used in multiple plants. If parts produced at different locations can be used interchangeable, parts can be sourced from either location if capacity problems occur at one of the sites. This applies to the aftermarket as well. One critical aspect to be able to share material produced at different sites is the aspect of having high level of traceability, which will be discussed further in the report. Running production needs to know where the material is coming from. In addition to that, it has been expressed that there needs to be a manufacturing project when introducing material from another supplier. Time, money and other resources needs to be dedicated in order to make the different parts and connecting interfaces similar enough to be used interchangeable and preparatory work needs to be done in order to not experience complications in quality.

Another question when producing parts in two different locations is, if it is motivated to preventively dedicate resources to compare if outcome of the parts produced between different sites are similar enough to be interchangeable globally. The Geometry department stated that their focus is to get the best fit and finish locally on

the cars produced. It is not reasonable to start comparing parts between China and Europe that are both within specification. If not Form-Fit-Function have changed, the parts should be considered the same, but with the knowledge in mind that parts might vary within specification as well and thus, might not be completely interchangeable. If there is a potential capacity problem or a business case where it might be reasonable to source components from another supplier, preparatory work and good traceability is essential for a quality secured production.

4.3 Traceability

In order to produce a car today with parts produced in-house or outsourced and also replicated in global production in both Europe, China and soon the US, there is a need to have data on the origin of parts and cars produced. The traceability is achieved through various methods and identification systems. The cars have unique Vehicle Identification Number and parts have various levels of tracking systems. Essential parts such as airbags and other security classed components have extremely high traceability and it is possible to track a certain part to a specific car. Other components such as screws and bolts are not tracked by the individual components, but rather in batches from the supplier. As described earlier, certain parts will diverge between plants and have a different outcome from production. When variation occur, there is a need to know the level of variation, how it will affect other areas of the production and how to manage the final outcome on the car.

There are multiple standardized ways of tracking material using various types of IT-systems. However, there are also unconventional ways that are being conducted today. One of them, is separating part numbers of the same part. Separating part numbers of part is a procedure when R&D issues a second part number for a part that is being produced in two locations. One main cause for this is when the part outcome is so different between the sites that it needs to be considered a new part. This is usually dependent on when the two different parts are diverging in Form-Fit-Function. Measures, characteristics or functionality then differ between the parts. The department of Product documentation have stressed that the action of issuing a new part number and the current way of working regarding separate part numbers is not sustainable. The IT-systems are not designed to manage multiple part numbers for the same part. Even if there are small differences between a Chinese produced part and a European produced part, there is still a need to know that they originate from the same part. Systematically in the IT-systems, there is not an easy way to know the connection between the two separated parts. A change made to one of the parts is not automatically updated to the other part and it have, in the IT-system, lost its connection to one another. Interviewees have even stressed that there are informal practices, that keep track of the connections between the separated parts. There are three different categories when traceability is essential; incoming material for production, spare parts for aftermarket and for product compliances. Product compliance means that the product does not comply with safety or quality commitments and are facing potential recall incidents.

4.3.1 Traceability of incoming material to production

In order to produce a car, the parts used have identification systems that directs the material to the right location at the right time. This identification can also be backtracked in order to provide data for improvements and to improve quality issues. Volvo Cars use part numbers as an identification system for their parts. This system has its compromises. In a single production plant, there can only be one part number for a produced part even if it is produced at multiple locations. In running production, there is not an easy way to mix the same produced part from different locations because of the variation and there needs to be an awareness of what the origin is of the incoming material. Earlier in the report it has been described that there is a need of a manufacturing project when introducing material from a different supplier in the production. The producer of car body parts, Olofström, have also requested the ability to forward information of changes made in their local processes when sending updated material to the assembly plants. Changes to the supplier's process could cause a change in the variation spread that potentially could cause problems at the assembly site. Even if the knowledge of the change exists, there is not an easy way to preventively tell the difference between the parts produce before and after a change in the manufacturing process, says a Manager in Olofström.

The Geometry department has stated that when issues occur in production, they need to be managed quick and efficient. With problems in production, the ramifications could potentially accumulate and produced components could become useless and needed to be scrapped. Thus, when the Geometry department gets involved in a critical situation, they tend not to ask "why", but "from where". With good knowledge about where the material origins there is a better chance of tracking down the source of the issue. With parts sourced globally and locally, which have been adapted to their different factories, the traceability of the parts is crucial.

The Purchasing department stated that Volvo Cars is mainly using one local supplier when a part is localized. The volumes have not been big enough to have multiple suppliers for a single part in one region. However, as the production volumes increases there are benefits in having two suppliers. The price can more easily be negotiated with multiple suppliers and the risk of becoming dependent on only one supplier decreases. Since two suppliers could have differentiating quality, there is however a need to know the origin of the material.

4.3.2 Traceability in aftermarket

According to employees at the Aftermarket department, the different regions' output from manufacturing will most likely vary. Aftermarket deals with the questions regarding spare parts and from where to source, regionally or globally. There are different scenarios as for when they can choose from what supplier to source from and when the previous action of separating part numbers will limit the sourcing options. The Aftermarket department states that it is beneficial to have local suppliers for the aftermarket in the different regions. However, since it is known that there might be differences in the outcome of the individual parts, complete interchangeability

between regions for components could be a problem. In the aftermarket, workshops have better possibilities to create a good fit between parts since they will have more time, resources and possibilities to make adjustments than in running production. The spare parts must be sourced with all of this in mind while assuring that there is a good level of traceability between the regions' parts.

4.3.3 Traceability for product compliance

Governments have high requirements on car manufacturers in order to protect customers in various ways. One of these requirements is the responsibility to take produced cars of the market, which does not fulfill safety and quality requirements. Without traceability of what cars that might be affected, the manufacturer must recall all the produced cars from the market until the problem is managed. Thus, the ability to trace parts used in cars is essential in order to prevent too extensive recalls that would affect the company negatively, financially as well as the customer satisfaction. In the future, regulations will probably become even stricter, according to a Senior Manager at the Product compliance department. Due to this, there is a need to provide even better solutions for quality, safety and traceability, to always improve and to be one step ahead.

Today, Volvo Cars has a specific department called Product compliance that work with issues of quality-defects and product recalls. The interviewees specified that Volvo Cars has good control over the quality issues in their cars. However, there is always room for improvement since if a quality issue occurs, there is an assessment of how many cars that should be recalled. The identified cars produced that is affected with the potential defect, and a span of additional cars produced before and after the incident, gets recalled in order to provide extra assurance. With full control and traceability, these additional cars that is a security margin, could become fewer, with lots of benefits both for the customers and financially for Volvo Cars.

The traceability aspect is essential for Product compliance and they want a stable system that contains information about different batches, which potentially could deviate. It is the same request that Olofström, the supplier of body parts, expressed. Product compliance does not specifically suggest the characteristics of a tracking system but stress the need of a stable system that incorporates a holistic view of the area that satisfies the needs of the whole organization.

4.4 Communication and collaboration

At Volvo Cars, communication is happening between departments and sites in order to introduce cars and to keep track off the running production. This communication is set up by recurring meetings and defined processes for communicating the running process, changes, deviations and incidents. Volvo Cars has a system called Volvo Quality Deviation Control, where issues in quality and deviation from specification, is communicated globally in a structured process. Multiple employees have mentioned that they also rely on personal contacts when dealing with issues

or retrieving knowledge or information. The reason for this has been stated as the mentality of having an engineering mindset of "solving problems here and now" and knowing the people personally that can be of help. This have been adequate way of working for a relatively small organization that operate only in Europe. However, issues with the informal communication channels will grow as Volvo Cars is expanding and more operations are based globally. As this is ongoing, interaction between personnel that is based on relationships instead of structured processes, can be problematic. One example, is the communication at the Geometry department between Sweden and China, which have been working well because the interviewees knew each other and could connect through informal communication channels. An employee at the Geometry department state that; "as people get relocated or replaced and new personnel are hired, much information and knowledge face the risk of being lost". To access certain existing information, employees needs to know their way around the informal procedures in order to know who to contact and where the information can be retrieved. There is a need for standardized ways of handling communication, especially when Volvo Cars will be producing in the US, Asia and Europe.

A Launch Leader in Chengdu stated that exchanging experiences regarding learnings from conducting a project is important to avoid repeating the same mistakes in other projects. One way Volvo Cars is sharing knowledge today, is through "Lessons learned", which is a process to present information gained so it is accessible for other parts of the organization. When launching the recent car model globally, there was a gap of six months between the introduction in the Swedish plant and the Chinese plant. This was done in order to focus effort to introduce the car in one plant first and to allow for knowledge reuse for the second plant. This was helpful but some learnings were not communicated quickly enough for the second plant to avoid making the same mistake, said a Project Manager in China. The reasons for this was due to short time span between the incidents and low priority for the communication. The process of sharing knowledge in those situations can be of great value for colleagues abroad.

According to all interviewees, the collaboration is generally working well between Volvo Cars' operations in Sweden and China. However, as the business is growing, more things will be on the agenda at the headquarter, meetings with the counterpart in China receives less attention. Several employees highlight the problem with the time difference of six hours between Sweden and China. This allows only a few hours that are suitable for Skype-meetings and the need for meetings across the regions is increasing. Coordinating with the upcoming US plant will add additional complexity to Volvo Cars' communication channels.

Volvo Cars' choice of having a lead factory that develops processes and material six months before the second plant is introducing the same car model is working well. However, an engineer from R&D, states that there is room for improvement regarding feedback and communication from the second plant, back to the first one. As the second plant start from a more developed state, they often have the possibility

to take the process and material one step further in the development. Another point for this is the current quality levels for the plants where the Chengdu plant is the one with the highest performance in general (Söderholm, 2014). Therefore, it could be beneficial to carry back the results from the second plant as soon as the production have stabilized. Potential improvements could be found and cases of this have been presented during interviews. To improve the coordination between the sites even further, it has been expressed that the project teams responsible for launching the same car model in the different factories could work even more closely. It would allow for more information exchange and more involvement in each other's decisions, which is important as they affect one another. Both interviewees in China and in Sweden expressed that the Swedish organization have more focus towards their own operations and sometimes the Chinese operations can be disregarded to some extent. A Chinese R&D Manager says that this can have major consequences as the production volume in China is increasing and there is more development towards the Chinese market. An example is the speed of which TV-drawings are updated, since it is not the highest priority in Sweden, but is rather made when there is time. This leads to the Chinese operations are not being able to adapt to changes as quickly, as updates in Gothenburg are only made locally until the formal update in the IT-system. When there is a delay in updating drawings, the subsequent plant, are working towards an older version of TV-drawing than the lead plant. Several Managers and Directors have stated that there is more freedom for the lead plant to adjust the car model to their processes but the changes have got to be communicated immediately through the formal processes that are in place. Volvo Cars use a system that is called Volvo Part Concern (VPC) whenever adjustments are made on parts, to communicate the changes globally. The defined processes need to be used in order to communicate to the subsequent China operations. A VPC is only made when there is a substantial update or change. A Senior Project Manager in Chengdu suggested that even smaller changes within the tolerance of a specification should also be communicated to a greater extent. Maybe not with the rigorous process of a VPC, but in order to keep parts from deviating between plants, communication needs to be improved between the regions.

4.4.1 Supplier communication

The R&D functions in China and Sweden often have weekly meetings to maintain the communication between the different regions. Coordinating suppliers however, have been mentioned to be harder in the global setting. There are several possibilities for how Volvo Cars is sourcing their parts. They can have a global supplier that ship parts worldwide, one supplier that have separate plants depending on what region to cover or Volvo Cars can choose multiple suppliers that are competitors to supply different regions. The different alternatives are visualized in Figure 4.1.

When sourcing parts locally, it is important that the different plants have the same outcome from its production. During the interviews, it was exemplified how one supplier delivered different quality on parts supplied from their plant in Europe compared to their Chinese plant, despite having gotten the same drawing and speci-

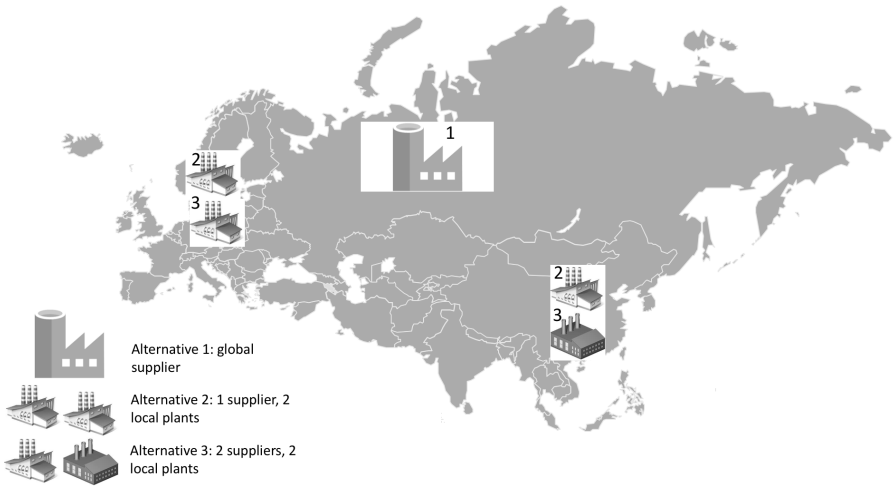

Figure 4.1: Illustration of the three alternatives of suppliers.

fications. One of the supplier's plants had a better quality outcome from its production even though it can be assumed that the supplier could easily communicate and coordinate internally in order to achieve similar quality levels at the different plants. This exemplifies the issues of coordinating suppliers even though there is only one supplier that has multiple sites for the different regions. Thus, the communication is not always shared internally at the supplier.

The communication channels go from one supplier plant in one region, to the contact at Volvo Cars who communicate with their Volvo Cars counterpart in the other region, and from there, to the local supplier plant, see Figure 4.2. The lead time for exchanging knowledge is a concern for Volvo Cars and it could be good to coordinate and facilitate so that suppliers exchange more information internally. If Volvo Cars choose to have suppliers that are competitors in different regions, the communication and coordination directly between them would however not be possible. Another concern with these communication arrangements is the potential risk of losing information along the way and not get the correct message through.

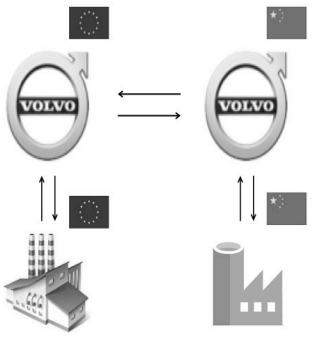

Figure 4.2: Supplier communication.

4.4.2 Early phase involvement

During several interviews, the possibility of improving ways of working with diverging output between sites have been discussed. Today, Volvo Cars is aiming towards the nominal value initially and are striving towards the same output globally. They are also communicating between the sites in order to share lessons learned and to update the corresponding department how the work is progressing at each site. The communication can however be improved, which have been discussed earlier in the report. Another aspect to the communication is not what is shared, but when it is shared and how early departments get involved in the process. Designers at the R&D department have stated that in order to reach an improved result with less diverging output between sites, communication and collaboration between the different sites have to happen earlier. If not, the relevant information cannot be exchanged when there is still a chance to make changes to the car model in the project. Then there is a risk that more components will be developed locally and diverge from their indented specification. If parts are diverging from specifications, or other complications occur at the site producing the first car, that information needs to be communicated to the other site. Today, this is of course happening, but it has been expressed at multiple interviews that this can be done better and information can be shared even earlier. Thus, earlier involvement, especially from the subsequent site, could improve the diverging output by observing and participating in the launch process at the leading site. However, if complications occur at one site, the focus lies on solving the problem locally and not set up meetings with its international counterpart. An example is the TV-drawings that are not updated early enough so the subsequent plant is aiming towards a nominal value, but at the leading plant, a new target value has already been set. In order to reduce the diverging output between the sites, the right information needs to get distributed to the right people, at the right time.

4.5 Stakeholder responsibility

The situation today at Volvo Cars is resulting in situations where it is reasonable and motivated to have diverging outcome and separate part numbers. This is due to the fact that processes in general will produce varying and potentially diverging outcome when produced in different locations. The effort of trying to keep parts from diverging will in some cases eventually be constrained by time and money. At that point in the development process, there will come a time when there is not enough resources to try to keep parts with the same part numbers and thus, they will be separated. The decision to separate parts is made based on local factors and in a case by case situation. It might be well motivated in the short term and with the information available at the time being. The decision is usually made in collaboration between different departments during DRM-meetings where it is a strive for a consensus decision. This process is sufficient with the goal of producing the car locally and getting the car ready for production as quickly as possible. However, it has been expressed that this way of working does not always evaluate the holistic, long term implications of separating part numbers and it will

for example lead to differences in outcome between plants. A part with separate part numbers, will lead to increased costs in the aftermarket, problems in reusing the part in other models, and issues when aiming towards flexibility of the production of cars. The connection between parts have also digitally been lost, which has been described earlier. The decision to separate parts should be made with this in mind and there needs to be a global function that surface these considerations when the decision is made. Quality Directors in China have specifically expressed that there might be a possible need for a Commonality Manager with mandate for these types of issues and questions. Other interviewees from R&D have also specifically requested a determined governance process since the decision to separate parts is made with local focus and the aggregated results of many separate parts is a big concern. Running production will not get this aggregated view of the separated parts but will rather be occupied with producing cars. However, other departments such as Product documentation and Aftermarket will experience the long-term complications of the decision.

5
Analysis

In the following chapter, the analysis is using the theoretical framework as a lens for assessing Volvo Cars' situation. In order to answer the first research question, Volvo Cars' global part management and how it is affected by their manufacturing network, will be presented and analyzed.

The analysis is conducted by using the framework of Friedli, Mundt and Thomas (2014) for evaluating global manufacturing networks. The layers of strategy, configuration and coordination needs to be assessed and developed with a strategic fit together with the business objectives of Volvo's expansion strategy, where operations are established in China and the US. Volvo Cars has an ambitious goal of reaching 800,000 sold cars until 2020 (Volvo Cars, 2016), which is an increase by approximately 49% from 2016 year's sales (Volvo Cars, 2017c). The growth demands a transformation in the setup of the manufacturing network and an understanding how it affects the global part management. The strategy is already set by Volvo and creates the preconditions for the manufacturing network. Thus, will the analysis of the strategy layer be limited and more focus directed towards the configuration and coordination layers. An illustration of how the theoretical framework and the empirical data was combined is shown in Figure 5.1.

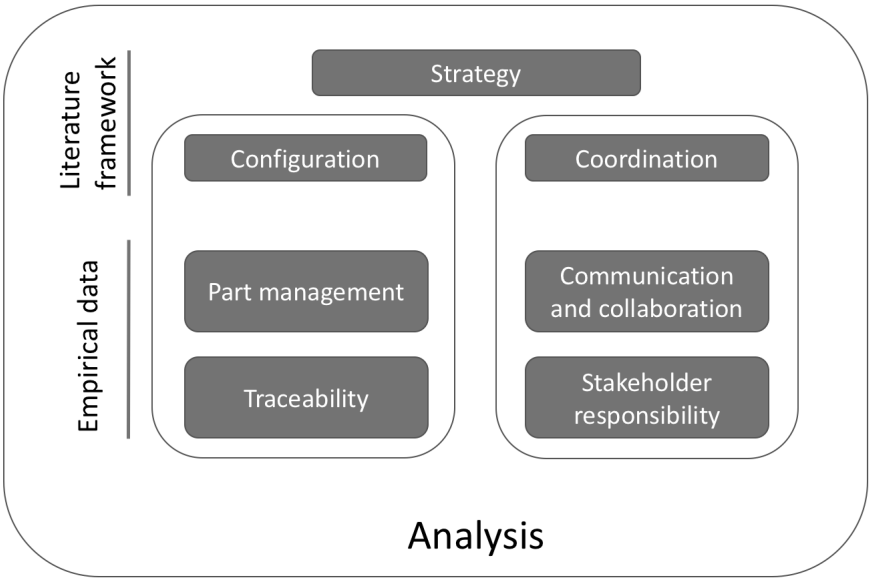

Figure 5.1: Matching theoretical framework with empirical data.

5.1 Strategy

Volvo Cars can be considered a small car manufacturer compared to bigger players such as Toyota, Ford or Volkswagen. Previously, Volvo Cars mainly had production sites in Europe and therefore has little experience of global operations. Their relative small size and the closeness between production and R&D facilities, has allowed for a high level of flexibility. Because of the less complex setup, the Manufacturing department had the possibility to solve issues together with the R&D department. This was a competitive edge for Volvo Cars, which is aligned with how Skinner (1969) argued that the manufacturing strategy should be used as a competitive weapon. Skinner (1969) also discussed how manufacturing should be derived from the business objectives and situation of the company. With the transformation of Volvo Cars' situation and global expansion, new conditions apply for how the strategy should be set up, which will affect the whole organization.

When Geely acquired Volvo Cars from Ford in 2010 (Volvo Cars, 2010), the transition towards the global market increased dramatically. Production in China was set-up without previous experience of producing cars globally to the same extent. The Chinese car market is currently one with the highest growth potential (PwC, 2014) and Volvo Cars has high ambitions for the Chinese market. The newly acquired knowledge from producing cars in China, will be applied in the US where a new plant is being built. This will enable Volvo Cars to produce cars where they are sold to a higher extent. The local production plants allow for local responsiveness to the markets, which is stressed by Miltenburg (2009) as an argument for having global production.

The first cars introduced to the Chinese production plants have been mature car models that Volvo Cars had previous knowledge about launching into production. However, as the Chinese organization has developed, Volvo Cars has chosen to introduce new car models in China and Europe almost simultaneously. The development is sound and performed in order to launch newer models into the targeted Chinese market. Friedli, Mundt and Thomas (2014) states that part of the network strategy, concerns how the network should be set up in order to access targeted markets. However, the expansion puts another dimension of complexity to Volvo Cars' operations. The simultaneous introduction and production of car models enables the presence in new markets and growth possibilities. This is aligned with the business goals, but the layers of configuration and coordination needs to be assessed, updated and aligned in order to reduce the risk for Volvo Cars to experience growing pains in their operations.

5.2 Configuration

Volvo Cars' manufacturing network is being re-configured in order to achieve the main strategic objectives of establishing a second home market in China and reaching a significant growth in sales. Multiple plants have therefore been established in

China in a short period of time. How the plants are positioned is influenced by multiple of factors and will not be analyzed, but rather what the configuration will imply for Volvo Cars. The design of Volvo Cars' manufacturing network will affect their part management and ability to trace components.

5.2.1 Part management

Rugman and Collinson (2004) states that car manufacturers struggle with establishing significant sales in multiple markets. They argue that there are many barriers for this, among them are key supplier relationships, which will prevent the Chinese and European plants to act independently. Components are today partly sourced from global suppliers where the material needs to comply with locally sourced parts in the fitting process. The global parts will become the steering parts since they will affect multiple processes. Thus, a hierarchy exist between different parts. Rudberg and West (2008), suggest a categorization of parts depending on how crucial and complex they are. Complex parts will need more attention and developed relationships with the suppliers. The assessment of the procurement should also be made holistically according to Friedli, Mundt and Thomas (2014). Hence, Volvo Cars needs to identify its complex parts and make a comprehensive assessment of their suppliers when localizing parts.

When producing cars in multiple continents and using key global suppliers, the supply chain becomes a critical aspect. Employees at Volvo Cars have expressed the problems with the lead time of three months between Europe and Asia. In addition to that, the tied-up capital becomes significant in such a capital-intensive industry. It is however a clear trend that more parts are being localized to regional suppliers. Volvo Cars will benefit from this by avoiding trade barriers, improved supply chain responsiveness and more local collaboration between the production sites and suppliers (Abele et al., 2008).

When Volvo Cars produce cars in multiple regions, they need to decide which car models that should be produced in the different regions. To produce where the cars are sold are only motivated when the production volumes provide enough profitability compared to the investment cost of establishing the production for the car model. There is a trade-off between reaching economies of scale and producing cars locally where they are sold. In 2003, 90% of cars produced were sold where they were made (McKinsey Quarterly, 2003). Volvo Cars is also following this industry trend, but needs to regard the potential low volume car models that needs to reach economy of scale in order to be profitable. Thus, there is a need of a combination of a market-oriented strategy and a product-oriented strategy for setting up the product mix in the production plants (Friedli, Mundt and Thomas, 2014). The level of specialization needs to be assessed, since a focused factory will outperform a plant with a broader product mix (Skinner, 1974). In order for the newly established plants to become successful, a lower level of complexity in the product mix have been necessary. The factories can reach economy of scale and establish a significant knowledge about producing cars before increasing the complexity in the product mix.

In addition to choosing the type of product mix, which will affect the specialization level of the plant, it is essential to evaluate the impact of potential differences in production processes. These are assessed when choosing how to direct resources, which Friedli, Mundt and Thomas (2014) identifies as an important aspect when evaluating the configuration for the manufacturing network. Volvo Cars has actively chosen to have different manufacturing processes in their plants that are producing the same cars. It is due to multiple reasons, among them are the wage levels in different regions, which will impact the return of investment in automation technology. Newer plants are also set up with more updated equipment and older plants' tools are not always updated in the same pace. The choice might be well motivated, but will increase the level of differentiating outcome from production, which contradicts Volvo Cars' ambition to strive for a uniform output. Hence, Volvo Cars has made its investments mainly based on financial calculations and has chosen not to act on the risk of different processes causing differentiating output. Even if the choice was made with or without assessing the long-term risk of diverging output, the implications are that Volvo Cars need to manage other aspects such as traceability, coordination and communication in order to mitigate the situation of diverging output.

Sharing parts interchangeably between plants will give production and Purchasing department more flexibility regarding their sourcing options. Capacity problems could be solved and prices could be more easily negotiated. However, the Manufacturing department states that it is essential to be prepared by performing projects when introducing new material. In addition, there is a need for more extensive traceability in order to be able to share parts between plants. Every situation will need to be evaluated case by case, where financial benefits are held against other factors such as, time spent, lead time changes and initial quality issues when introducing a new supplier into production.

5.2.2 Traceability

The traceability aspect is fundamental in order to achieve a flexible and stable global manufacturing network. An alternative way could be to make production only regional and supply the individual local markets. In that case, the Manufacturing department could focus in their own processes and try to get the right fit and finish between local parts and supplied parts from global suppliers. However, since Volvo Cars is producing cars in multiple continents, ships them to targeted markets, and occasionally even changes the production site of a car model to another one, traceability becomes essential.

Volvo Cars has tracking systems for their cars and parts but when producing in multiple locations the identification system needs to be improved and adapted to the more complex environment. All departments have stated that the traceability aspect is one of the most essential in order to achieve a successful production that is flexible and global. Using local suppliers which produce the same component in multiple locations will improve the responsiveness in the supply chain, but will

also add complexity (Friedli, Mundt and Thomas, 2014). In order to manage this increased complexity, the right data needs to be available in order to make well founded decisions, which requires a highly functioning traceability system.

An interviewee from the Geometry department stated that it is crucial to know the origin of material in order to make improvements and correct errors in production. The way of issuing separate part numbers to manage some complex situations, where material is produced in multiple locations, will provide the material with the traceability information about the origin. However, several other aspects will be affected with this procedure. The connection to the original part is lost in the IT-system and updates to one of the parts with split part numbers will not be done automatically on the other part. Interviewees from the R&D department have also specifically stated that the procedure of splitting part numbers is not sustainable, since the IT-systems are not designed to manage multiple part numbers for the same part. Thus, another process of keeping track of diverging parts is needed. In addition to the need of a good way to keep track of parts produced in multiple locations, both production in Olofström and the department Product compliance have stressed the issue of increased traceability between batches of material. They have experience that there might be fluctuation in quality between batches of the material produced. This variation might even be known and the information held within the company, but it is not easily communicated. Thus, an improved process of traceability between batches have been expressed.

Today, the issue of traceability mainly includes the localized parts in different regions and the need to improve a tracking system between batches. In addition, the Purchasing department have also stated that the IT systems need to be updated to better manage multiple suppliers to a single factory for a single part. By using multiple suppliers of a component, price could be negotiated and the dependence of a single supplier would decrease. The IT-systems need to be revised in order to comply with Volvo Cars' expansion goals. Production volumes could soon reach levels where multiple suppliers of a single part, to a plant is well motivated but could be limited by pre-existing systems.

According to employees from the Aftermarket department, it is beneficial to have a rapid supply chain with local suppliers for the aftermarket because of the three months in lead time between China and Sweden. The potential of reaching economy of scale with a single supplier for the aftermarket is secondary after a rapid supply chain. In addition, cars are produced continuously where supplier relationships are ongoing with the current production and the aftermarket department are utilizing the same suppliers for spare parts.

A problem occurs when cars are shipped to other markets than where it is originally produced. For example, a car model could be shipped from both China and Europe to the US. In this case, there is a need to decide from which supplier to source from. As parts are varying between production plants, there is a risk that a European part would not fit on a car produced in China. However, the aftermarket workshops have

more time and resources to get the right fit and finish between parts compared to the production line.

As the situation of producing the same car in two different locations and shipping the cars to a joint market is a new venture, the full ramifications of the complications of diverging output between sites have not yet been experienced. Aftermarket operations is increasing during the life cycle of a car and since the cars are produced today, the full extent of the situation have yet to come.

The department of Product compliance deals with how the produced car comply with commitments made to the customer and regulations set up by governments. They have stressed that regulations and customer demands are only moving towards more strict rules and higher standards set by customers. The traceability becomes essential down to batch sizes when a potential recall is issued. A system where traceability is lost because of IT-systems' shortcomings of handle production of the same car in multiple locations is not acceptable. In addition, a potential recall affect customer satisfaction dramatically. All unnecessary recalls should therefore be avoided. Since both customer satisfaction and financial factors could be improved, an extensive traceability system is well motivated.

5.3 Coordination

Volvo Cars is replicating their organizational structure from Europe and applying the same concept in China, but as a scaled down version. Friedli, Mundt and Thomas (2014) mention that the structure of the organization is influencing the distribution of responsibility. However, the formal hierarchical structure is much more rooted in the Chinese organization than in the Swedish one, which has both pros and cons. The culture in China was stated to be of the nature of "doing what they were told" to a high degree, and employees tend not to perform tasks outside the specified work description. Interviewees stated that the result of this cultural difference can be seen in the higher quality output (Söderholm, 2014) from the Chinese factories. However, there are many aspects that must be considered when comparing quality levels for the different plants. The cultural contrasts might be a big part of the differences in quality. However, many employees in the Chinese organization added factors for the higher quality output such as; less complex product-mix, better production layout, newer equipment and that more man-hours are put into the production of each car. The structure of an organization would, according to Friedli, Mundt and Thomas (2014), determine the mandate for decision making on an individual basis. There are however more factors influencing this, despite replicating the organizational structure from one region to the other.

The level of centralization regards how much authority is given to the single site in relation to what decisions are made in the central unit. More centrally made decisions is deemed to be of great importance when producing complex parts, which are aimed to be interchangeable. However, the centralization leads to less freedom in the single sites (Hayes et al., 2005). Volvo Cars' current direction of increasing

operations globally puts even more strain on the central unit to keep parts and processes aligned because of the outspoken agenda of having the same outcome in terms of quality on all cars worldwide. The highest priority for each factory is to produce the best possible cars, but when decisions are made locally, the holistic view can sometimes be neglected. Problems are solved by logical decisions locally (Hayes, 1985), but they could in the long run turn out to be bad for future development projects. An example is the trade-off between having to make big investments to change sheet metal stamping processes versus changing a less complex plastic component's specification. The financial aspect of the business case points in one direction, but the implications of what the changed plastic component will have in the future is unclear. If the plan is to utilize the plastic part in other car models, a small change could potentially have a big negative impact. A connected topic to centralization, is the level of standardization in the network regarding methods and practices, which are necessary to sustain to a great extent. Even though standards and rules are limiting sites' autonomy, the upside is the possibility to more easily cooperate between sites (Friedli, Mundt and Thomas, 2014).

5.3.1 Communication and collaboration

When establishing production in China as a premium brand, the quality requirements are essential to be maintained or improved, in order to uphold the credibility for high quality cars. The pressure on Chinese factories to surpass the European in regard to quality, is one of the reasons for why the Chengdu plant has better overall outcome than European plants. Other factors for this was the maturity of the product and the production processes, fewer car models in each factory but the strive to outperform each other remains. Gnyawali and Park (2011) states that having a well managed coopetition, both a cooperative and a competitive environment, is highly beneficial. Volvo Cars deals with the coopetition aspect through knowledge, information and practice exchange while comparing the different plants' performance levels in multiple areas. This is aligned with the coopetition perspective presented by Friedli, Mundt and Thomas (2014).

Several interviewees have brought up that the intensity of the information exchange decreases if there is a temporary increase in workload. Sharing knowledge, practices and information at Volvo Cars has however been presented to be done in both formal and informal ways. There is a risk when relying too much on informal communication since employees, for example, can get replaced or simply change roles, which in the worst case could cause information to get lost. The informal communication relies on personal contacts, but since the organization is expanding, it could be hard to induce the necessary knowledge exchange. There are however benefits regarding the existing informal communication, since it quickly and easily can solve many problems just by knowing to whom to talk to. The formal process concerning updating parts (VPC), is good for ensuring that all substantial changes are communicated globally. This pace of knowledge development is rather slow and requires quite a lot of effort from both the transmitter and the recipient. The suitable transfer mechanism for this type of knowledge is through "Manuals or databases", just like Volvo

Cars use (Ferdows, 2006). The downside of relying too much on formally updating databases is the speed of which explicit knowledge reach the intended recipient. Ferdows (2006) instead suggests cooperating through "Joint developments" for explicit and fast paced knowledge development when necessary. Volvo Cars is mainly conducting their research and development at their head office in Gothenburg and the knowledge is distributed to sites globally. The manufacturing sites applies one of Ferdows (2006) suggested approaches of "Joint developments" to a higher extent. This is done since the launch of new car models into production is done almost simultaneously. Thus, there is a need for Volvo Cars to improve their communication between regional departments to manage producing the same car models and to launch them into production. By comparing experiences and transferring back locally gained knowledge about components and manufacturing processes, the overall quality could be improved. The global perspective needs to be prioritized by the individual sites since both the sites and the central organization could benefit from it. To address tacit knowledge exchange, Volvo Cars is moving people within the organization globally as well as conducting projects worldwide, which is aligned with Ferdows' (2006) transfer mechanisms for slow and fast knowledge development. It might be sufficient to encourage or instruct more collaboration, but a complementary solution could be to have more incentives on a global level in order to reach improved collaboration (Luo, 2005).

Stimulating information and knowledge exchange within an organization could be difficult enough but managing communication with and between suppliers in a global manufacturing network is even harder. The different supplier setups providing a specific part for Volvo Cars are as mentioned; one global supplier, supplier with regional factories or competitive suppliers in the separate regions. Ensuring that manufacturing processes are uniform so that the output will be as similar as possible from separate factories has proven to be difficult. It is hard even when collaborating with one supplier that are meant to supply two regions. When having competing suppliers in different regions, cooperation between them is not possible, which complicates things for Volvo Cars. The incoming parts should be within specifications, but if suppliers would share manufacturing processes and other information, it could ease the situation. When localizing a part, it is a business case that decides from what supplier the part will be sourced from. In addition to the financial factors, communication aspects could be taken into consideration to a higher extent. Another reason that might lead to having suppliers for different regions that are competitors, is that a supplier does not have the capability to supply both regions. The implication for Volvo Cars is that the lead times for communicating from one supplier, through Volvo Cars' both sites, and to the other supplier, is quite long and information could also be lost in the process.

Volvo Cars is introducing cars in a project organization and as any project, the possibility to influence the outcome is biggest in the beginning. In the early phase of a project, the least amount of resources are needed in order to make a big impact. During the project of launching a new car, it is therefore essential to share information at the right time in order to be able to take action. Since cars have

been launched in a leading factory, the subsequent plant becomes highly dependent on the first plant. The information exists within the organization but are not prioritized to share when workload is increasing during intense phases of the launching process. In order for the subsequent plant to adjust their target values and refine its processes, the information needs to be shared about corrections made in the leading plant. The local focus of getting cars produced in time with the right fit and finish will create problems for the organization as a whole. Problems later then occur at the subsequent plant which will cause components to deviate. In order for Volvo Cars to improve their manufacturing network and global part management, earlier involvement and communication is essential.

5.3.2 Stakeholder responsibility

As Volvo Cars is producing the same car models in multiple parts of the world and since diverging outcome will be a recurring problem for production, clear guidelines and distribution of responsibility for the situations are needed. During the launch process of a car, there are deadlines to fulfill and a targeted launch date that needs to be reached. In addition to that, the car needs to be produced with high quality and the right fit and finish. If a situation occurs where a component diverges outside of its specifications, but the right fit and finish on the car is achieved anyway, there are situations when the part is still accepted. Time and money are constrained and production needs to choose between two options. To dedicate even more resources than planned to make the component fit within specifications or make the decision of accepting the diverging component outside its specification. However, the decision is mainly based on local and short-term factors, which will make the cars produced at each site meet the standards in time. The long-term ramifications of diverging product lines may not have been taken into account as much as necessary. Friedli, Mundt and Thomas (2014), states that the standardization in the network together with the distribution of responsibility needs to be assessed in order to coordinate the manufacturing network. Since this process is rather unstandardized and the decision is mainly based on local factors, the complexity of the global production is increasing. Quality Directors and other interviewees from R&D have requested clear guidelines and delegation of responsibility regarding these questions, which will surface during the launch process. A Commonality Manager, or another function where there is a clear mandate for these questions is needed. The responsibility should include the decision of allocating more resources in order to try to make the component fit within its specification in order to reach a more global compliance to the initial drawings. The second possibility is to separate the locally produced part from its original drawing and set up new specifications. Volvo Cars does not have a clear process for these questions, but is rather solving the problem locally when it occurs and may not assess the holistic perspective of the situation. With an increased global production and a rapid expansion in multiple continents, these situations needs to be standardized and delegated. Functions with the ability to analyze the holistic situation in combination with the mandate to make the right decision are needed.

6
Conclusion

In order to answer the second research question, areas that a car manufacturer needs to consider in order to improve their global part management will be presented. For the case investigated in this study, Volvo Cars has clear goals about their expansion and how the company should evolve strategically in the future. Expansion in both sales and number of manufacturing plants is currently ongoing in China and the US, which is currently progressing well. The obstacles of producing cars in multiple locations have been few since each factory has had the ability to mainly focus on their car models. Today, Volvo Cars is introducing and producing the same car models in different parts of the world and this venture will continue to expand. The situation of producing the same car model simultaneously in three continents is not an unrealistic situation and might happen sooner than the internal systems are developed in order to cope with the global operations, unless proper actions are taken.

The business strategy is aligned with the manufacturing and network strategy, but the layers of configuration and coordination needs to be assessed further and improved. In order to produce cars globally, there is a need to know factors such as the origin of parts and if the parts deviate so much they cannot be used interchangeably. It is also necessary to improve the way of managing connections between localized parts that have separated part numbers. These challenging factors, in combination with a lack of clear stakeholder responsibility in the decisive processes, requires distinct directions for future actions. In addition to this, clear communication channels that can handle a dispersed manufacturing network are needed for the growing organization.

Only when a well-configured network accompanies the strategy and it is coordinated with the goal to fulfill the overall business objectives, an efficient and effective manufacturing network can be achieved. Volvo Cars needs to create awareness on how their actions will affect their global part management when they are re-designing their manufacturing network. In order to successfully fulfill the current strategy, their systems need to be improved regarding the areas of traceability, communication and stakeholder responsibility. The identified areas could differ between car manufacturers, but the areas have been identified as vital for a well-functioning global part management.

In the automotive industry, the alignment between the three layers are essential. If there are discrepancies between the different layers, it creates complications for companies and the overall performance will be affected negatively, especially when

there is a global ambition and the complexity of the operations increases. The efforts and resources needed to align the layers of configuration and coordination with a high set global strategy, could with a less ambitious strategy be directed elsewhere. However, since automotive manufacturers could access global markets and that production is generally happening where the products are sold, an ambitious global strategy will probably set the tone for the industry. In that case, automotive manufacturers needs to assess the configuration and coordination layers of their global manufacturing networks.

In conclusion, a well-functioning manufacturing network in the automotive industry needs to be aligned in the layers of; strategy, configuration and coordination and the areas of; traceability, communication and stakeholder responsibility are essential for managing parts in a complex global setting.

7
Recommendations

In order for car manufacturers to improve their part management, they need to assess and possibly improve the areas of traceability, communication and stakeholder responsibility. Car manufacturers are recommended to do this, by evaluating the strategic goals for the company, acknowledging the situation of today and identifying future requirements on the internal systems and processes.

Volvo Cars' is producing high quality cars that are sold in a premium segment, which sets high demands on Volvo Cars' manufacturing abilities. Producing the same car models in multiple continents puts even tougher requirements to manufacture within specifications in order to have the same output globally. In the launching process, there is a need to aim more towards the nominal metric value in the specifications and not do local adaptations. However, the right local fit and finish cannot be compromised with, which means that Volvo Cars needs to set even higher demands on their own manufacturing processes and suppliers.

The traceability aspect is highly dependent on current IT-systems and their potential to be improved. Car manufacturers have very complex enterprise resource planning systems to manage the information needed to organize one of the most advanced industries there is. The new global venture for Volvo Cars puts new requirements on the systems and ambitious investments are needed to manage the more complex environment.

As a smaller car manufacturer, Volvo Cars had close collaboration between R&D and Manufacturing, which enabled a competitive edge. The global expansion requires the communication to be enhanced to collaborate better between sites in different continents. Obstacles such as time, culture and languages differences need to be overcome by more intense and richer communication. In addition to that, the communication needs to happen earlier in order to act on the available information. Since the global setting is putting higher demands on coordination and requires more effort in order to communicate within the organization, a higher degree of standardization is needed. If complying with the set guidelines and specifications, the coordination can become more efficient.

Volvo Cars' global part management is today not fully coordinated and standardized, which leads to problems being assessed locally and potentially without a holistic view. Clear guidelines are needed, together with a governance process that evaluate the ramifications of local decisions. By acknowledging the current situation that

the global expansion is causing, Volvo Cars need to reconfigure their practices. The holistic situation needs to be assessed and managed through a governed process that has mandate to make long term decisions, which are in line with Volvo Cars' expansion.

Global car manufacturers that face the same expansion and alignment challenges as Volvo Cars, need to address the identified areas in the study, which otherwise could affect their performance negatively. The situation of each company is unique and a thorough assessment of what the critical aspects in the manufacturing network and part management that are relevant for them needs to be understood when setting new directions. However, traceability, communication and stakeholder responsibility are identified as critical areas for part management in global manufacturing networks within the automotive industry.

7.1 Future research

The conducted study has assessed how a car manufacturer should reconfigure and coordinate certain areas of their manufacturing network to be in alignment with a global expansion strategy. The main findings of traceability, communication and stakeholder responsibility are likely to be applicable to other companies in the automotive industry. It could also be relevant for other industries, such as the aircraft industry. However, it is based on the prerequisite that they operate in similar conditions of producing products globally as in the studied case. Future research is suggested to evaluate how other manufacturers manage aligning a global strategy with their manufacturing network's configuration and coordination.

In addition, a longitudinal study is suggested to address how a centrally decided strategy affects a manufacturing network's configuration and coordination in terms of alignment in a globally dispersed network. The research can provide better understanding of how a global manufacturing network complies with centrally made decisions.

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Appendix 1

Interview guide

Structure and management

- Describe your role?
- Tell us about the department you are working on.

Parts management today

- How do you and your department work with [Volvo's] global parts?
- When do parts get separate part numbers?
- How is the process of global parts governed?
- What strengths and weaknesses are there with the system of today?
- How do you and your department work with China/Sweden regarding [Volvo's] global part management?

Future considerations

- How would, an ideal, global part management look like, from your perspective?
- Are there any obstacles or constraints to reach an ideal part management process?

In addition, department specific questions were asked.