CHALMERS

The diffusion of AUTOSAR in China

Master of Science Thesis
in the Management and Economics of Innovation Programme

LUKAS SUTER
MARCUS HARRYSON

Department of Technology Management and Economics
Division of Innovation Engineering and Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sverige 2015
Report No. E 2015:070

MASTER'S THESIS E 2015:070

The diffusion of AUTOSAR in China

LUKAS SUTER
MARCUS HARRYSON

Examiner, Chalmers: Christian Sandström
Supervisor, Chalmers: Anne Elerud-Tryde
Supervisor, Acme AB: Anonymous

Department of Technology Management and Economics
Division of Innovation Engineering and Management
CHALMERS UNIVERSITY OF TECHNOLOGY

Göteborg, Sweden 2015

The diffusion of AUTOSAR in China

LUKAS SUTER AND MARCUS HARRYSON

Master's Thesis E 2015: 070

Department of Technology Management and Economics
Division of Innovation Engineering and Management
Chalmers University of Technology
SE-412 96 Göteborg, Sweden
Telephone: + 46 (0)31-772 1000

Chalmers Reproservice
Göteborg, Sweden 2015

Abstract

In the diffusion process of a radical innovation, there are often several barriers that has to be overcome. These barriers often depend on several factors: market-forces, investment behaviour, and the innovation itself. This research aims to 1) identify what factors affect the diffusion of AUTOSAR in China, and 2) how these factors might be addressed. Initial hypotheses was formulated in close collaboration with AUTOSAR-experts at Acme, with focus on a scaled-down version of the AUTOSAR-implementation. These initial hypotheses was presented during interviews held with sixteen representatives operating in the Chinese automobile industry. However, the result of this study contradicts the initial hypotheses, especially the suggested scaled-down version. Instead, risk in various shapes was identified as a major hinder in the adoption of AUTOSAR, in many cases boiling down to lack of knowledge. This lack of knowledge exists among both Chinese OEMs and Chinese suppliers, which could result in unwanted results if AUTOSAR diffuse. This research presents means to decrease risk, both from a customer point-of-view, but also how AUTOSAR-products might be adopted to fit the needs of Chinese customers. Furthermore, being highly influenced by global OEMs, this research argues that AUTOSAR is likely to diffuse. As large OEMs operating in China start to require AUTOSAR products, suppliers are likely to follow.

Acknowledgements

This master's thesis was carried out at Acme's office in Gothenburg, Sweden between January 2015 and June 2015. The thesis is the final part of the master's degree programs Management and Economics of Innovation, and Computer Science - algorithms, languages and logic at Chalmers University of Technology and was carried out at the Department of Technology Management and Economics.

We would like to thank our supervisor at Chalmers, Anne Elerud-Tryde. She has continuously given us time and helped guiding us during this research.

We would also like to thank our supervisors and everyone who have supported us at Acme for both showing interest and providing crucial knowledge in order to perform this master's thesis. In addition, Acme provided us with the possibility to conduct the research in China, for which we are very thankful.

Lastly, we would like to thank all interviewees making this research possible.

Lukas Suter and Marcus Harryson, Gothenburg 08/06-2015

Contents

Abbreviations

AUTOSAR	AUTomotive Open System ARchitecture
BSW	Basic Software
E/E	Electrical/Electronic
ECU	Electronic Control Unit
EV	Electric Vehicle
JV	Joint Venture
MCAL	Microcontroller Abstraction Layer
MCU	Microcontroller Unit
OEM	Original Equipment Manufacturer
OS	Operating System
RTE	Runtime Environment
SWC	Software Component

1

Introduction

This chapter aims to introduce automotive E/E architecture, which will be followed by a problem analysis culminating in the purpose of this research. Lastly, the structure of the report is presented.

1.1 Background

After several economic reforms in the 1980s, China's economy has been growing in an impressive pace. Their gross domestic product (GDP) have almost twenty-folded from 1993 to today's GDP of $6800 per capita [18]. For reference, the United States (U.S.) two-folded their GDP over the same period [18].

Since the introduction of China's first car in 1956, the passenger car industry evolved slowly for the coming three decades. In 1985, China produced a total of 5200 cars [30]. The same year, China's import duty for vehicles amounted to 260 percent [30]. In spite of this, imports increased dramatically from importing 16,000 vehicles in 1982 to 354,000 in 1985 [30].

Since this starting point, the Chinese automobile industry has grown rapidly. In fact, China's automobile sales surges past the U.S. in 2009 [15]. As of 2014, more than 23M cars were sold in China [6], and the sales are expected to increase significantly in the years to come [1]. In sum, China holds the world's largest automobile market, which in turn pose various opportunities.

At the same time, issues in automotive Electrical/Electronic (E/E) architecture have grown. Mainly, this has been due to the increased importance of software in automobiles. Four decades ago, automobiles did not carry any software. As of today, automobiles carry as much as 100M lines of code [32]. Not only is the amount of software increasing, but the number of embedded platforms the software is deployed over are increasing too. For example, the BMW 7 series carries roughly 270 user-interactive functions which are deployed over 67 embedded platforms [34]. These functions sums to around 65 megabytes of binary code. However, for the next generation upper-class automobiles, Pretschner et al. [34] argues that software might require roughly one gigabyte in memory capacity.

Traditionally, hardware cost per unit have been important in the automobile industry [29]. This have lead to that focus often has aimed at reducing the amount of memory and computation power required by the software. In turn, this leads to that software is very closely tuned towards specific microcontroller unit (MCU)-characteristics. This results in increased difficulty in porting code between MCUs [34]. In fact, in many sub-domains, the functionality changed between car-models only account for 10 percent, while more than 90 percent of the software must be re-written [21]. In addition, changing parts of the code and fixing defects becomes increasingly hard.

In sum, the close dependency between software and hardware results in problems such as longer time-to-market, increased maintenance cost, and risk of not finishing development projects in time [34]. Another problem is that the automotive industry becomes highly vertical with the risk of concurrent engineering processes [34].

Based on this, Pretschner et al. [34] concludes that there is economical relevance in automobile software. A Merer study shows that the total value creation for automotive E/E in 2002 accounted for 127B euros [24]. This number is estimated to nearly threefold by 2015. In addition, software has gone from making up roughly 20 percent of this value in 2000 to 40 percent in 2010; 25 percent of these are entitled to software architecture, more specifically basic software (BSW) and operating system (OS) (see Chapter 4) [29]. Moreover, the total development cost of a vehicle is carried up to 40 percent by electronics and software [26]. In software/hardware systems, as much as 50-70 percent of the cost is carried by software [21]. In sum, software is becoming more and more important for the automobile industry, while simultaneously becoming increasingly complex.

A solution to these problems was initiated in 2003 by three major original equipment manufacturers (OEMs) – BMW Group, DaimlerChrysler and Volkswagen – and three major automotive system suppliers – Bosch, Continental and Siemens VDO. Together, these partners initiated the AUTOSAR (AUTomotive Open System ARchitecture) partnership and created an open standard for automotive E/E architecture. The objective with the AUTOSAR partnership is to simplify function integration and re-usability of software. In addition, Pretschner et al. [34] notes that clear interfaces – as a standard would provide – would make division of labor possible, and could lead to a more modular industry.

As the standard has matured over the years, many OEMs have become members to the AUTOSAR-partnership. Today, almost 80 percent of the car production in the world comes from AUTOSAR members [2].

1.2 Problem analysis and purpose

Despite the fact that 80 percent of the world's car production comes from AUTOSAR members, there are only four Chinese OEMs who have joined the AUTOSAR initiative as of 2014 [2]. However, several factors points to that the Chinese OEMs are experiencing similar problems as Western OEMs did in the early 2000s. First, the number of Chinese whose income-level allow them to buy a car increases rapidly [10]. The Chinese automobile market is predicted to reach over 30M cars in sales annually by 2020 [1]. This in combination with an increased demand on functionality by end-customers increases the importance on automotive E/E architecture (see

Chapter 1.1).

In addition, the influence from global OEMs and suppliers is steadily increasing. In spite of the 50 percent ownership-cap for global OEMs in China, the global OEMs accounted for 59 percent of the market in 2010, while accounting for 72 percent of the market in 2014 [3]. Furthermore, global suppliers are allowed to operate in China, and does not have any ownership-caps. These two factors combined results in a noticeable influence from the global automotive industry.

Moreover, as mentioned in Chapter 1.1, automotive E/E have traditionally suffered from concurrent engineering. As the labor cost have increased substantially in China the last couple of years [16], the problem with concurrent engineering increases. For reference, the average annual wages in manufacturing have increased by roughly 50 percent in the U.S. from 2002 to 2014. During the same period, Chinese average annual wages in manufacturing has almost five-folded [16][17].

However, the AUTOSAR standard is almost exclusively influenced by Western companies, as all of the initial six partners were Western. In 2014, the situation is similar, with only one non-Western Core Partner (see Chapter 4).

Based on the above problem description, this research aims to investigate the diffusion of AUTOSAR in China. This will be done by, firstly, identifying factors which affect the diffusion of AUTOSAR. After identifying these factors, the discussion will regard how these factors might be addressed in order for AUTOSAR to diffuse. These two steps are identified as important in order to increase the pace of the diffusion. Addressing this problem will be done by with the help of the two research questions (RQs) below, which will be answered in chronological order.

RQ1: ***What factors affect the diffusion of AUTOSAR in China?***

RQ2: ***How can these factors be addressed in order for AUTOSAR to diffuse?***

1.3 Structure of the report

This research paper starts by giving an introduction to the Chinese automotive industry and how automotive E/E architecture have evolved over time. The following chapter presents the theoretical framework used to analyse the gathered data. After that, a description of how the research have been conducted presented. This is followed by giving the reader an overview of AUTOSAR.

Chapter 5 presents the gathered data. In Chapter 6, the data is analysed using the theoretical framework. To conclude the research paper, a section discussing the findings are presented. Lastly, Chapter 8 presents a section with concluding remarks.

2

Theoretical Framework

The theoretical framework used in the analysis section (see Chapter 6) is presented in the Chapter below. This theoretical framework will help in understanding how already existing technology might diffuse in a new market, where there are many factors affecting such a diffusion.

2.1 Diffusion of innovations

The process of adopting new innovation has been studied for many decades. A popular model on the diffusion on innovation is presented by Rogers [35] in his book Diffusion of Innovations. Here, he defines the term innovation as "an idea, practice, or project that is perceived as new by an individual or other unit of adoption." Innovation is further elaborated by Tripsas [37], who defines radical innovation as replacing old technology rather than competing with it. Furthermore, she defines incremental innovation as where innovation compete with already existing technology. These definitions of innovation, radical innovation, and incremental innovation are the ones which will be used for this theoretical framework.

Rogers [35] continues, defining the term diffusion as: "the process by which an innovation is communicated through certain channels over time among the members of a social system." Whilst defining communication channels, where diffusion takes place, as ways in which information gets from the sender to the receiver, Rogers [35] notes that diffusion is a special kind of communication which includes first and foremost, an innovation. In addition, two individuals or units of adoption and a communication channel are included in the diffusion process.

These individuals are always a part of the social system in which the diffusion takes place. According to Rogers [35], a social system is “a set of interrelated units engaged in joint problem solving to accomplish a common goal."

Rogers [35] describes the process of adopting new innovation, as presented in Figure 2.1, whereby the process is divided into five stages: the knowledge stage (I), the persuasion stage (II), the decision stage (III), the implementation stage (IV), and the confirmation stage (V). He describes these five steps as an information-seeking process where individuals try to reduce uncertainty about the advantages and disadvantages of an innovation. These five steps are described below.

Knowledge stage (I)

In the *knowledge stage*, individuals search for knowledge about the innovation – how and why it works. This knowledge, Rogers [35] divides into three sub-categories: awareness-knowledge, how-to-knowledge, and principle-knowledge.

Awareness-knowledge refers to knowledge about an innovation's existence. This type of knowledge can motivate individuals to seek more information about the innovation and eventually to adopt it. This is followed by acquiring *how-to-knowledge*, meaning the knowledge of how to use an innovation correctly. Rogers [35] emphasises the importance of this step, as individuals who have sufficient knowledge prior to the trial are more likely to adopt the innovation. The last type of knowledge presented by Rogers [35] is *principle-knowledge*, which includes the knowledge about how an innovation works. Rogers [35] notes that innovations can be adopted without acquiring principle-knowledge. However, doing so results in increased risks, potentially leading to unforeseen problems.

Rogers [35] highlights how knowledge is important in a diffusion process. However, his research does not suggest how this knowledge is acquired. Gadde et al. [27] addresses this in their research on industrial networks, where they argue that a company's resources are dependent on other companies' resources, thus making them interdependent. This will be further elaborated on, in Chapter 2.2.

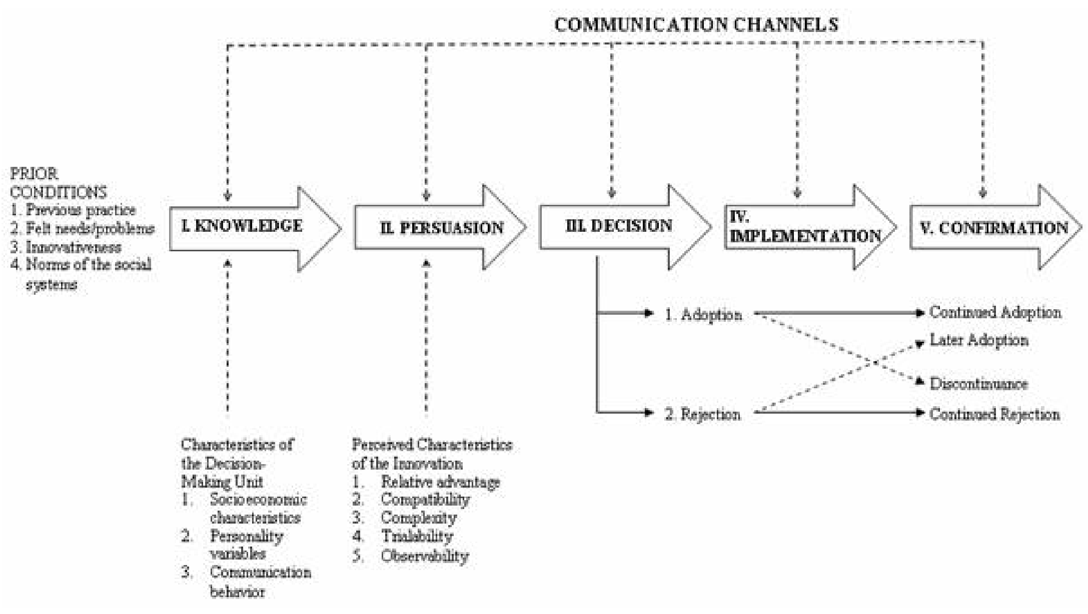

Figure 2.1: A Model of Five Stages in the Innovation-Decision Process [35]

Persuasion stage (II)

Similar to the knowledge stage, the *persuasion stage* is a social process where the interplay between companies affects outcomes. In this stage the individual must have already learnt about the innovation, and will shape his or her view accordingly. Rogers [35] notes that while the knowledge stage is more knowledge-focused, the persuasion stage is more feeling-focused. As such, parties' individual perception is of importance. The interplay between these parties is further examined in Chapter 2.2.

As seen in Figure 2.1, Rogers [35] presents five characteristics of the innovation perceived by users affecting the persuasion stage: relative advantage, compatibility, complexity, trialability, and observability.

Rogers [35] defines the first stage, *relative advantage*, as "the degree to which an innovation is perceived as being better than the idea it supersedes." Diffusion scholars have concluded that relative advantage is one of the strongest predictors of an innovation's rate of adoption [35]. Rogers [35] notes that economics and status are two factors supporting individuals in the adoption phase.

The significance of companies incentives to invest, and their investment behaviour can be inferred from the broad definition of relative advantage presented by Rogers [35]. Tripsas [37] argues that three factors ultimately affect the commercial performance of incumbent firms versus new entrants: investments, technical capabilities, and complimentary assets.

For the *investment* factor, Tripsas [37] makes a distinction between incumbent firms and new entrants, suggesting where and how they invest differs. Thus, they must differ in the way they adopt new innovation. It is therefore necessary to separate radical innovation from incremental innovation [37]. A radical innovation will replace old technology rather than competing with it. In contrast, incremental innovation refers to a series of small improvements which will often lead to improvements in companies' competitive positions. Generally, incumbent monopolists have less incentives to invest in radical innovation than new entrants do [37][20]. However, when it comes to incremental innovation, incumbents are in a better position and are more likely to invest than new entrants [37].

An alternative explanation to companies' investment behaviour is presented by Bower and Christensen [20] in their research on the disk-drive industry. In contrast to Tripsas [37], Bower and Christensen [20] suggest that customers are the main deciders in directing companies' investments. They use performance trajectories to describe this phenomenon.

The research result of Bower and Christensen [20] on the disk-drive industry is presented in 2.2. Notably, in all cases, what is demanded by the users is substantially less than what is provided. This phenomenon does Bower and Christensen [20] describe as technology overshoot. Ultimately, technology overshoot leads to companies creating products with higher capacity than what is asked for. Assuming increased capacity results in increased investments, technology overshoot would lead to companies to spend more money, whilst not adding value to the product for the end-customer.

Where radical innovation is introduced, Tripsas [37] suggests that *technical capabilities* also play an important role. She notes that technological progress is usually characterized by incremental innovations over a long period of time, ending when a radical innovation is introduced. Similarly with the investment factor, incumbents technical capabilities are an advantage

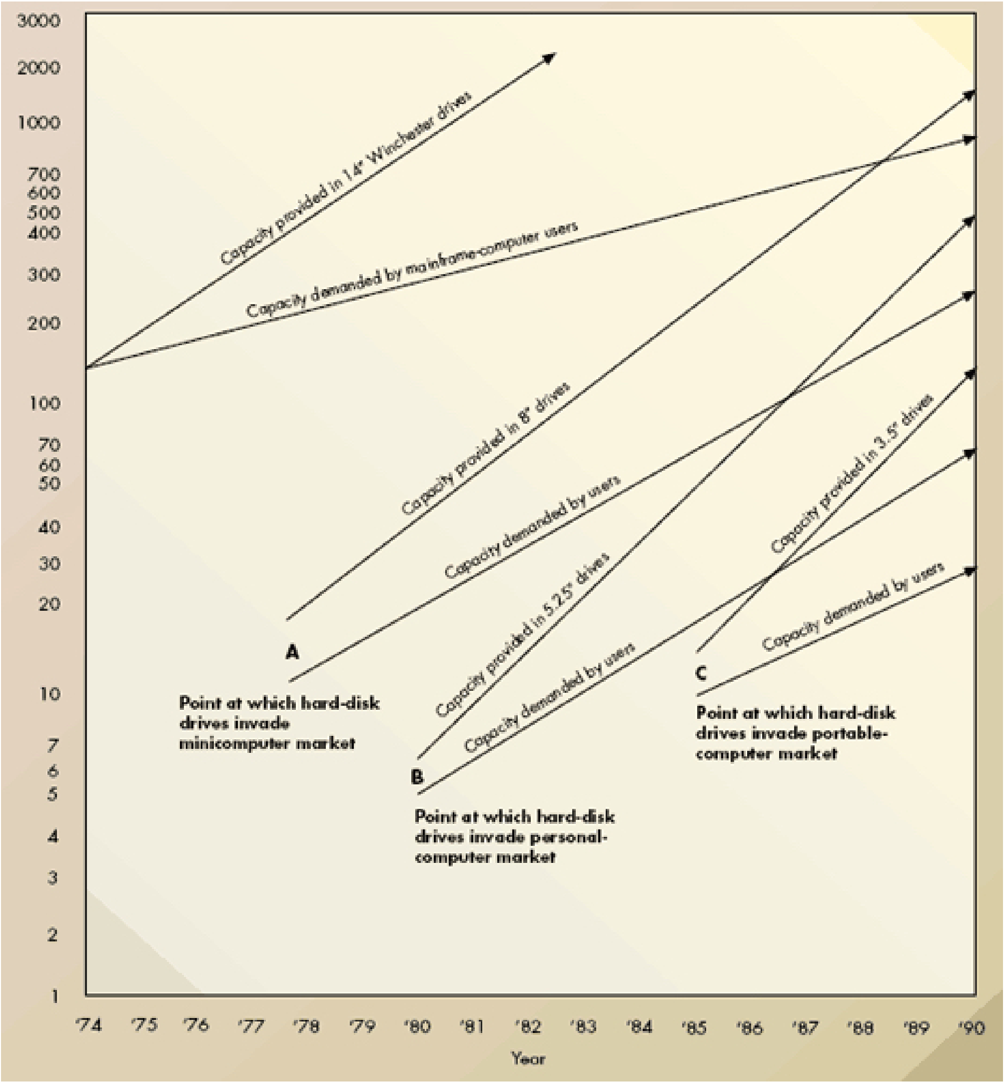

Figure 2.2: How disk-drive performence met market needs [20]

in a period of incremental innovation. Nonetheless, during radical innovation, incumbents have a disadvantage; Tripsas [37] notes that core competencies have the potential to become core rigidities. Moreover, Tripsas [37] highlights that architectural innovations could also destroy the value of existing products, as they change the interface between components.

Furthermore, Tripsas [37] suggest *complimentary assets* to have an important role in incumbents versus new entrants. Complimentary assets could refer to manufacturing capabilities, distribution channels, service network and complimentary technologies. These could provide a buffer for incumbents towards new entrants [37]. However, technological innovation can also destroy the value of these assets. Examples of this is presented by several scholars [36][28]. Sandstrom [36] presents research on how mechanical calculators was replaced by electronic calculators. In the case of the Swedish company Facit, they held large inventory of mechanical calculators while sales declined. In addition, Facit had 90 sales offices in Sweden and strong customer relations, which was a sales model designed for small sales volumes with high margins. With the shift to electronic calculators – which was cheap in contrast to mechanical calculators – it made little sense selling them through Facit's sales channels. Glasmeier [28] research on the Swiss watch industry present similar results.

Another motivating factor in the persuasion stage, Rogers [35] argues, is *compatibility*. He defines compatibility as "the degree to which an innovation is perceived as consistent with the existing values, past experience and needs of potential adopters."

Linking to the compatibility-factor is *complexity*, which Rogers [35] defines as "the degree to which an innovation is perceived as relatively difficult to understand and use." He notes that complexity is an important obstacle in the adoption phase.

The next factor affecting the adoption is *trialability*, which is defined as "the degree to which an innovation may be experimented with on a limited basis." He also notes that trialability enables reinvention, meaning that innovation might be changed or modified by potential adopters. This might lead to faster adoption [35].

Additional research by Holmström and Stalder [31] has shown similar results. They have designed a framework addressing why specific information technologies often need to be changed during their adoption phase. More specifically, Holmström and Stalder [31] have performed a case study on the diffusion of the Swedish cashcard. In this case, the banks had a predetermined view on what the end-customers – the merchants and the card users – expected from the cashcard. However, the banks' predetermined view differed from what the end-customers expected, resulting in resistance from end-customers in the adoption phase.

The cash card study is an example of communication diffusion in accordance with Rogers [35]. That is to say that, the innovation is not changed in accordance with the two units of adoption, it aggravates diffusion, which in this case resulted in the cash cards being rejected.

Moreover, in a system where sociology and technology are involved in an interplay, it is important to reflect the interest of both parties, in order for the system to stabilize [31]. If the parties do not adapt to each other, Holmström and Stalder [31] describes the diffusion as a "hit-or-miss situation" where the technology is either adopted or rejected. They emphasises the importance that both technology and its potential users adapt to each other respectively, stating that it is "crucial for the successful development and implementation of technology."

Moreover, Rogers [35] notes the importance of *observability*, which he defines as "the degree to which the results of an innovation are visible to others." This is typically done by witnessing a peer or role model use the innovation and showing its benefits.

Decision stage (III)

Whether the innovation is adopted or not is decided in what Rogers [35] defines as the *decision stage*. The adoption of an innovation depends on the potential users and their preferences. This, Rogers [35] demonstrates in a diagram (see Figure 2.3) where the adopters are placed in broad categories depending on how they respond to new innovation. Mainly, these categories are based on individuals level of innovativeness. As seen in Figure 2.3, these categories are: innovators,

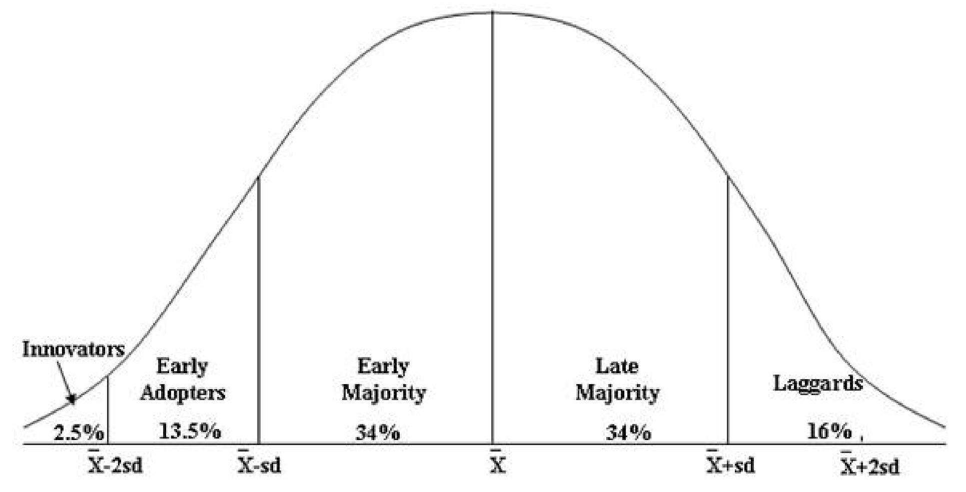

Figure 2.3: Adopter Categorization on the Basis of Innovativeness [35]

early adapters, early majority, late majority and laggards. These categories will be elaborated on below.

The *innovators* are actors who are willing to cope with risk. They must cope with both potential unprofitably and with potentially unsuccessful innovations. Rogers [35] also notes that they are gate-keepers in a social system, meaning that they bring new innovation into a social system. Thus, innovators often must have complex technical knowledge enabling them to adopt new innovation and displaying it to other members of the social system.

As for the *early adopters*, they act more in-line with the social system and its boundaries. Early adopters are often leaders and role-models whom other members of the social system approach in order to get advice [35]. Thus, early adopters and their subjective evaluation are important in the diffusion process. Consequently, interpersonal contacts are important in this stage of the diffusion. Rogers [35] notes that the early adopters acceptance equals them putting "their stamp of approval" on the new innovation.

In contrast to the early adopters, the *early majority* are rarely individuals with leadership roles. They do, however, have good interaction with other members of the social system. In addition, their interpersonal network plays an important role.

The *late majority* is categorised by Rogers [35] as those who adopt innovation later than most peers do. Individuals in this category tend to be more sceptical about an innovation's benefits and necessity. They are, however, often more sensitive to peer pressure than individuals in other categories. Rogers [35] also notes the importance for the late majority to feel safe in the adoption stage. Thus, close peers should persuade individuals in the late majority to adopt the innovation to reduce uncertainty.

The final category, *laggards*, is the most sceptical category described by Rogers [35]. They are the most localized group where much of their interaction take place with people among the same social system as themselves. This leads to that they often acquire awareness-knowledge late. As laggards tend to be sceptical, it is important for them to observe previous users to see whether the innovation is successful before adopting it.

Implementation stage (IV)

At the *implementation stage*, the innovation is put into practice. Uncertainty might still be a problem at this stage. Thus, implementers might need technical assistance to reduce this uncertainty and overcome technical barriers. Rogers [35] also notes that reinvention often happens at the implementation stage, where an innovation might be changed or modified. He also notes that the more frequently reinvention takes place, the faster the diffusion.

Confirmation stage (V)

In the final stage, the *confirmation stage*, the decision to adopt the innovation has already been taken. The decision can still be revised, but Rogers [35] argues it is very unlikely. Rather than looking for conflicting messages about the innovation, the user tends to seek supportive messages confirming the decision to use the innovation. There are two types of discontinuances: replacement discontinuances and disenchantment discontinuances. The former refers to a situation where a new, better innovation is introduced. The latter refers to the user not being satisfied with the outcome of the innovation where the perceived relative advantage is smaller than the actual relative advantage.

2.2 Industrial networks

As described by Rogers [35], diffusion is a social process where two parties affect each other. However, Rogers [35] does not describe in depth how these parties affect each other. Thus, research on the interplay between parties is added to the theoretical framework. Gadde et al. [27] present research on industrial networks, which they describe as a context in which companies have interconnected business relationships. These relationships, in turn, affect the outcome of actors' actions [27]. They note that, in an industrial network, co-evolution and interdependence are significant factors, while the competitive aspect becomes less important [27]. More specifically does the research, presented by Gadde et al. [27], concern strategies in industrial networks, which is based on three paradoxes.

The first paradox is based on that actors' close relationships are the heart of their survival. Gadde et al. [27] argue that this goes both ways. At the same time as resources are accessed through these relationships in order to develop the actor further, they also ties an actors' ways of operating and thus restricts actors' ability to change.

The second paradox steams from the understanding that a company's relationships are one of their primary means to influence other parties in the network - suppliers, customers, partners, etc. In this view, a company influences their present and potential partners, while simultaneously the potential partners influence the company. The paradox, Gadde et al. [27] argue, is that the company itself is a product of those relationships. These are in turn a product of their relationships, and so on.

The third and last paradox concerns a company's ability to control the network surrounding them. Gadde et al. [27] argue that the paradox lies in that the more successful a company is in doing so, the less innovative the network becomes.

According to Gadde et al. [27], it is important to form a strategy to control the level of involvement in these three paradoxes presented above. That is, controlling a company's resources (I), activities (II), and actors (III). These will be elaborated on below.

The resource dimension (I)

The first dimension Gadde et al. [27] suggest it is important to control is the *resource dimension*. The initial assumption, based on the industrial network approach, highlights the significance of business relationships. These could include relationship to suppliers, customers, etc. A company's resources are thus tied to the resources of other companies, where every company becomes a part of a larger entity - the network.

Developing the relationships to a company's partners thus becomes important. Via exchanges, companies are able to utilize other companies' resources, which would not have been possible without these relationships. However, building strong relationships might not only be resource contributors. Gadde et al. [27] note that in order to maintain these relationships, substantial investments are required and they are costly to handle. Furthermore, high-involvement relationships are strongly interdependent, which might give rise for lock-in effects [27]. History suggests that being interdependent in times of technological discontinuities could result in disorganisation and disintegration [28]. Glasmeier [28] presents research on the Swiss watch industry giving an example of this. Lock-in effects is argued by Gadde et al. [27] to appear when development of relationship-specific assets narrows a company's potential to develop alternative relationships.

Gadde et al. [27] also notes the importance of acquiring an information-rich position in the network. By doing so, companies learn to utilize their complementary resources brought by external actors. This enhance the value of the resources, as compared to deploy them in isolation.

Last, Gadde et al. [27] emphasise the importance in not perceiving resources as given. Resources always have unexploited dimensions which can be explored through interaction with new business partners. It is through these that new resources are further developed. This means that the relationships are not only an important resource in itself, but it can also be used to change how other resources are deployed.

The activity dimension (II)

Similar to the resource dimension, the *activity dimension* includes exchanges between parties in the industrial network. However, in this view, it refers to exchanges of products and services. These form chains of interdependent activities in which several companies are involved. By relating activities to other companies, it is possible to utilize these interdependent activities which might extend beyond ownership boundaries. As such, Gadde et al. [27] suggest that activities of individual firms are not isolated. In addition, productivity and efficiency are directly related to how these relationships are maintained.

In contrast to the industrial network view, mainstream strategy differ in some aspects. Mainstream strategy is dominated by the value chain model presented by Porter [33]. In contrast to an industrial network approach, this model provides a too narrow view where too few companies are included. In the network approach, a single chain is determined by how resources and activities are related to those in other chains. Here, the value chain model by Porter [33] is limited.

The actor dimension (III)

In order to perform activities, there has to be actors doing so. Below, the *actor dimension* is described in detail. In the industrial network view described by Gadde et al. [27], there is no central governing. Rather, relationships are established between parties for different purposes. Thus, networks are actors with connections to each other where no single party can rule fully. However, Gadde et al. [27] note, networks and how they are formed are not random. Rather, actors in possession of resources direct these to other individual actors in order to influence them. This influence-process goes both ways. Gadde et al. [27] argue that this is important in driving network dynamics. They continue arguing that the more effective a single company get in doing so, the less innovative the network as a whole will be. This, since the network will be more centrally controlled which limit the entire network.

2.3 Reflection on theory

The theoretical framework presented above is influenced by research on diffusion theories aimed to address the diffusion of an existing technology in a new market. Rogers [35] defines a five-step guide to how innovation diffuses. His model is linear in the sense that it implies that these five steps are adopted in chronological order. This implies that adopters go through these steps fairly isolated from other adopters (while of course being affected by external factors during the whole adoption process). However, this might not be the case when companies adopt an innovation. As Rogers [35] describes, the innovation-decision process is characterised by potential adopters trying to reduce uncertainty. However, in the context of a company, more than one phase or subphase could be engaged simultaneously. In addition, all these steps might possibly not have to be addressed by all members of a company, but rather, division of labour could take place within the model presented by Rogers [35]. For example, in the knowledge phase, decision-makers might only need principle-knowledge, while technical experts might need how-to-knowledge.

In sum, this suggests that the theory on diffusion presented by Rogers [35] might not be adopted for diffusion of businesses, but rather of end-customers. However, if the company is seen as an entity in the diffusion phase, the same premises goes for that entity as for sole individuals adopting innovation. Nevertheless, the diffusion process might be slightly more complex when the diffusion concerns companies or groups due to internal activities which does not exist in the case of sole individuals adopting innovation.

Moreover, in some cases, the theories of Rogers [35] on diffusion might need compliments in order to understand the diffusion of innovation in an industrial context where there are many interdependencies. For example, in the first stage – the knowledge stage – Rogers [35] describes what kind of knowledge must be acquired in order for innovation to diffuse. However, how this information should be retrieved is not addressed adequately. Thus, has the research presented by Gadde et al. [27] on industrial network been included in the theoretical framework, to address interplay between companies. More specifically, they discuss how exchanges shape the way firms operate. As new knowledge to an organization is retrieved from external actors through exchanges, the behaviour of industrial networks, as presented by Gadde et al. [27], is of importance addressing the knowledge stage defined by Rogers [35]. More specifically, the resource and activity dimension proposed by Gadde et al. [27] can add to the knowledge stage in the diffusion process.

During the persuasion stage, diffusion scholars are under the impression that relative advantage is one of the strongest factors affecting the pace of diffusion [35]. This is discussed briefly by Rogers [35], who notes that relative advantage is about whether an innovation is perceived better than the one it supersedes. However, according to industrial network scholars, such as Gadde et al. [27], this is a complex process defined by companies' interdependence on a macro-level. Gadde et al. [27] argue that handling these dependencies are of importance for companies. This is something which the research of Rogers [35] does not cover.

In addition, the relative advantage factor is addressed by both Bower and Christensen [20], Tripsas [37] who discuss investment behaviour of companies. In contrast to Gadde et al. [27] research on industrial networks – addressing industries on a macro-level – Bower and Christensen [20], Tripsas [37] address investment behaviour on a micro-level. More specifically, what factors affect companies' investment behaviour. As Bower and Christensen [20], Tripsas [37] analyse relative advantage from a different perspective than Gadde et al. [27] do, both are important to include in the theoretical framework.

The decision stage defined by Rogers [35] is a social process where interpersonal contacts are important. In order to give a more in-depth view on how these interpersonal contacts are structured, industrial network, as presented by Gadde et al. [27], is considered important to the theoretical framework.

As politics is a part of creating a social system, which Rogers [35] discuss, politics affect diffusion of any technology as it shapes the individual operating in that industry. This is a complex process and might be briefly addressed in the theoretical framework as it affects the relative advantage factor. However, as the focus of the research has been on AUTOSAR and its diffusion, studying the political factors has not been the main focus.

3

Methodology

This chapter will introduce the methodology used in this research. The research topic has been defined and specific research objectives have been chosen. Based on these objectives, a research design has been chosen accordingly. This is followed by a presentation of how data has been collected and analysed. Lastly, a chapter with reflections on the quality of the research is presented.

3.1 Research problem

The decision to have the diffusion of AUTOSAR in China as research topic was taken after holding initial interviews with Acme. More specifically, Acme was interested in how AUTOSAR is perceived in China. Acme's interests combined with meetings at Chalmers University of Technology helped in forming three initial research questions (RQs):

1. What factors affect the diffusion of AUTOSAR in China?
2. How do OEMs and suppliers perceive AUTOSAR?
3. How might an AUTOSAR value proposition look like for the Chinese automobile market?

These initial RQs have served as a starting point in the collection of data and resulted in initial hypotheses. However, over time, these initial RQs have been evaluated, resulting in new, more accurate RQs which are presented in Chapter 1.2. These, in combination with held interviews have resulted in that the initial hypotheses have been re-evaluated along with the initial RQs, resulting in new market, customer and product hypotheses.

3.2 Research design

As diffusion is a social process influenced by subjective views [35], a qualitative approach was chosen to acquire knowledge to answer the RQs. The research procedure was inspired by Blank

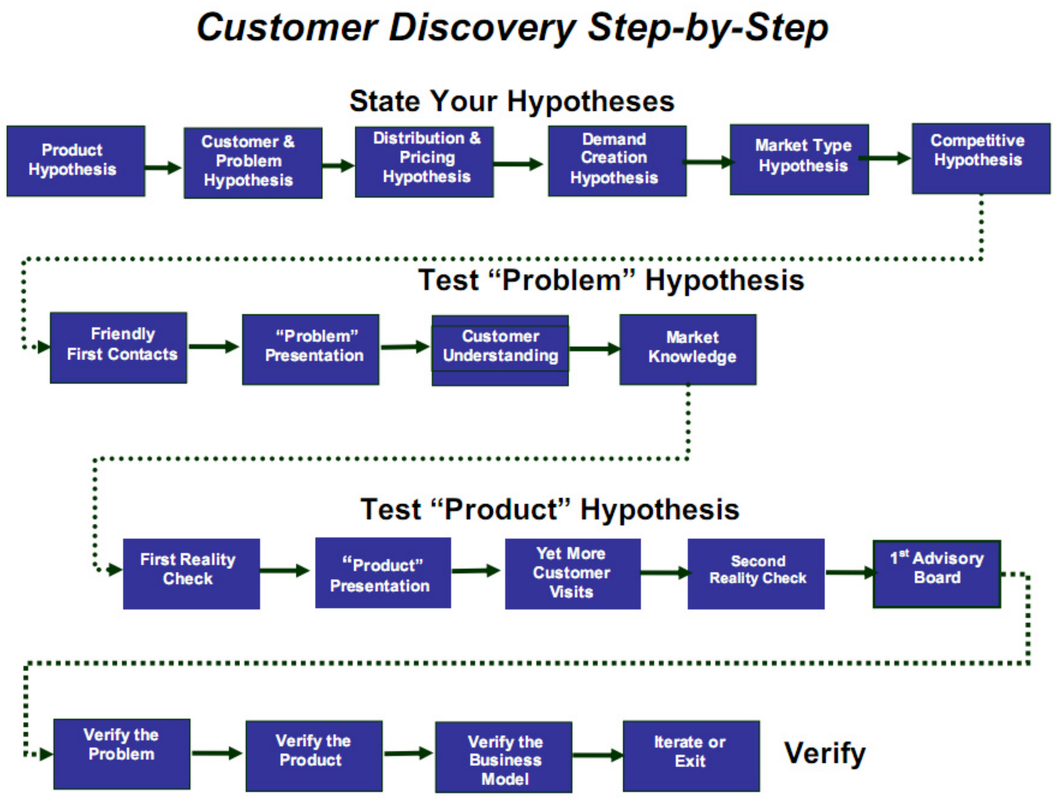

Figure 3.1: Customer Discovery Step-by-Step [19]

where initial customer, product and market hypotheses was constructed, which could later be tested (see Figure 3.1). More specifically, in order to understand how affected parties perceive AUTOSAR, a case study has been conducted. The case study approach helps capture opinions which may be used to draw conclusions and test hypotheses [25].

The interviews have focused on identifying potential customers and their needs, which Blank [19] notes as important. He continues adding the importance in meeting potential customers to learn about their problems. In addition, an understanding of how the offered product might solve these problems must be studied too. In this phase, it is important to understand who end up using the product as well as what forces affect the buying decision, and what power these forces have. All these factors have been thoroughly considered and incorporated in held interviews.

Furthermore, the interviews were conducted with a semi-structured approach, which according to Bryman and Bell [22] allows the interviewee to elaborate on topics of relevance. In order to avoid pointing the interviewee in any direction, the questions were asked as openly as possible. During these interviews, the hypotheses could be presented to the interviewee. Based on the result from these interviews, the hypotheses could be revised and a prototype of how an AUTOSAR-product more easily can reach the Chinese market has been constructed.

3.3 Data collection

In order to understand how an AUTOSAR value proposition for the Chinese market could be constructed, three research questions were initially addressed. The data collection was based on qualitative research, where the collected data was both of the qualitative and quantitative type. The first part in the data collection process was to collect primary and secondary data in order to be able to formulate the initial hypotheses. In the first part, primary data was gathered from Acme, while secondary data was mainly gathered from industry reports and papers from academic databases.

The second part of the data collection process was conducted by a case study which originate from the above mentioned hypotheses. According to Eisenhardt [25], the empirical study, which the case study approach provides, enables to test the hypotheses. As the case study research typically contains both interviews and secondary data [25], it provides a way to triangulate the collected data and hence a way to evaluate the validity of the hypotheses. In addition, to ensure that the hypotheses are valid through the process of collecting data, analytic induction method was used to analyse the data. This method is highlighted by Bryman and Bell [22] as a strategy to use previously collected data as a basis for future data collection. This iterative method is also in line with Blank [19] model of re-evaluating the hypotheses. Moreover, the sample for this case study was categorised in three groups: OEMs, suppliers and AUTOSAR implementers. Nine OEMs were interviewed, four suppliers, and one AUTOSAR implementer.

3.3.1 Formulating the initial hypotheses

The aim of the first step of the data collection process was to acquire knowledge to formulate an initial product, customer and market hypotheses. For this, in depth knowledge about AUTOSAR and a broad understanding of the Chinese automotive industry was gathered. Information about the Chinese automotive industry was acquired by collecting secondary data from annual reports, industry reports, industry journals and scientific reports retrieved in academic databases. Moreover, in order to understand the Chinese automotive market's relation to AUTOSAR, in-depth knowledge on AUTOSAR was acquired. This was done in several steps. Firstly, literature on AUTOSAR was studied. However, as AUTOSAR is a concept recently introduced, the literature available was limited. As supplement, free-form interviews as well as semi-structured interviews were held with AUTOSAR experts at Acme. These interviewees have all worked with AUTOSAR for more than 10 years. In addition to this, a two-day AUTOSAR course was attended. The course included both information on what AUTOSAR is and how to implement it.

Name	Company	Title	Date	Location
Interviewee1	Acme	Product Manager	28/1-2015	Gothenburg, Sweden
Interviewee2	Acme	AUTOSAR Expert	3/2-2015	Gothenburg, Sweden
Interviewee3	Acme	Team leader	10/3-2015	Gothenburg, Sweden

After acquiring this knowledge, initial customer, product, and market hypotheses could be formed. These hypotheses have all been inspired by earlier mentioned experts, as they have profound knowledge about AUTOSAR and about the automobile industry as a whole. These hypotheses are the result of the first part of the data collection, which thus has served as a basis in the second part of the data collection. Furthermore, the knowledge obtained in the first part of the data collection process has been fundamental for having the interviews. The acquired secondary data has made it possible to formulate the interview-guide and ask relevant supplementary questions.

3.3.2 Empirical study

In the second part of the data collection process, a case study was conducted to test the initial hypotheses. The secondary data acquired in the first part of the data collection together with the knowledge acquired from Acme was vital to formulate an interview-guide with relevant questions. The interview-guide contained a set of core questions, and a set of questions tailored according to the interviewee's area of expertise. For more details on this, see Appendix A. The sample of interviewees from the second part of the data collection process was chosen so that the interviewees had expertise in either electrical architecture, AUTOSAR, or strategy. In addition, interviewees knowledge was always relevant for the Chinese automotive market, working for either an OEM, supplier or AUTOSAR-implementer operating on the Chinese automotive market. Interviewees with this knowledge are together with Acme assessed to be in a position to give relevant input to the hypotheses.

Before the interviews, the interviewee was informed that this research was conducted in cooperation with Chalmers University of Technology and Acme. The interviewee was also given the chance to decide upon what data should be considered confidential and what information could be included in the paper. This included the possibility to keep the the interviewees' name and their company's name anonymous.

The intention with the interviews was to present the hypotheses and get the interviewees' perception of them. To do so, Blank [19] suggests that a friendly first contact must be established. In this step, Acme among a few other industry contacts were very helpful, as they had contacts suitable for the field studied. In turn, some of these interviews resulted in new contacts and interviews. The fact that the initial contact was made with help of Acme did not affect the interviews significantly.

The interview-form consisted of a semi-structured interview approach, and have always been conducted in person. This is, according to Bryman and Bell [22], the best way of extracting an interviewee's individual ideas and opinions, as it provides for more elaborate answers. In addition, topics of relevance unknown to the interviewers are more often addressed by the interviewee, which has been of importance as the interviewee often was in a position of greater knowledge than the interviewers.

During the interviews, in-detail notes were taken to avoid missing out on important information. Directly after the interviews, these notes were discussed and the interview-guide for coming interviews was re-shaped. The interviewees were also asked if would be possible to come back with complimentary questions, which all interviewees agreed to. To be able to ask questions in more than in one occasion is something which Bryman and Bell [22] mention is typical for a qualitative interview.

Beneath follows a table of the interviewed companies. The interviews will be discussed more in details in Chapter 5.2.

In-text Reference	Interview topic	Title	Date	Location
Supplier1	Market	Global R&D Manager	4/3-2015	Sweden
AUTOSAR Implementer1	Market	Business Developer	18/3-2015	China
AUTOSAR Implementer2	AUTOSAR	Vice GM Automotive Electronics	19/3-2015	China
OEM1	Market	Management of Dealership	21/3-2015	China
OEM2	Market	Management of Dealership	22/3-2015	China
OEM3	AUTOSAR	Electrical Architecture	26/3-2015	China
OEM4	Market	Product Planning	31/3-2015	China
Supplier2	AUTOSAR	Technical Expert	1/4-2015	China
Supplier4	Market	R&D Department Manager	2/4-2015	China
OEM5	AUTOSAR	Basic Software Team Leader	7/4-2015	China
OEM6	Market	Expert in Strategy & Marketing	8/4-2015	China
Supplier3	AUTOSAR	Product Management	9/4-2015	China
OEM7	AUTOSAR	Responsible for Battery Control	9/4-2015	China
OEM8	AUTOSAR	Control Development of the Automotive Electronics Department	13/4-2015	China
OEM9	AUTOSAR	Electrical Architecture	30/4-2015	Sweden

3.4 Data analysis

The data analysis has been conducted with an analytic induction approach. The initial hypotheses were formulated based on secondary data as well as input from earlier mentioned AUTOSAR experts. These hypotheses have been presented for the interviewees during the case study. The response to the initial hypotheses in addition to other information acquired from the interviews has been analysed afterwards. In accordance with the analytic induction approach the collected data has been compared to the hypotheses, and given that the analysis shows that the data from the case was not in-line with the hypotheses a reformulation of the hypotheses was conducted. This has been done in iterative steps when new collected data has been acquired and analysed. During this iterative process the initial RQs have also been reformulated due to new insights. Bryman and Bell [22] note that one of the advantages with analytic induction is to start in existing theory and move back and forth between it and collected data. This analysis continues until no case is found being inconsistent with the hypotheses.

3.5 Reflection of quality

The research of this study could be viewed as a two-part study, where the first part of the research was to formulate hypotheses – market, customer, and product hypotheses – for why AUTOSAR was not as diffused in the Chinese market. These hypotheses as well as the interview-guide were formed together with Acme and Chalmers University of Technology. In addition, studied literature has given useful insight in formulating hypotheses. However, limited input from actors operating in the Chinese market has affected the initial hypotheses. The research questions was formulated according to this first part of our study, which in turn helped formulating an interview-guide. Thus, the data collected in the interviews was based on the first part of the study as well.

The second part of the research has consisted of holding qualitative interviews with actors affecting the diffusion of AUTOSAR. Again, in order to understand the diffusion of AUTOSAR one must not only know about AUTOSAR, but an understanding of the Chinese automobile market is of importance. As the Chinese automobile market – the largest automobile market in the world – is a complex market, with many forces affecting it, limitations in knowledge about the market and what forces affect the diffusion of AUTOSAR will also affect the result of the research.

Moreover, studying a market externally – the way in which most part of the study has been conducted – there will always be limitations. An example for this research are language barriers, which might have affected the result of the data. Another factor affecting the result of this research is the size of the interviewed companies. Many interviewees' notes that the views within the company differ. As such, the views of the company as a whole might not be represented fully with the interviews that have been held. A mean to increase the quality of the data have been to triangulate data from the two parts of the study.

In addition, Bryman and Bell [22] highlight two criteria as means for evaluating the quality of qualitative research: trustworthiness and authentication. Two central criteria for trustworthiness are credibility and transferability. These have been used in the reflection of this research's quality.

To ensure the research's credibility, the aim has been to use a tape recorder for every interview. In the cases where the interviewees has declined careful notes has been taken to avoid misinterpreting the interviewee. This has been especially important in this research as the language used in interviews was neither the interviewees nor the interviewers mother tongue. In order to ensure that the collected data has been interpreted correctly, the interviewee have afterwards been given the data collected to validate its correctness. Bryman and Bell [22] says that this respondent validation is popular to ensures that the research data is in-line with the interviewee's view.

Other threats of validation are the validity of the secondary data that was acquired before the case study. Limitations in knowledge about the market and what forces affect the diffusion of AUTOSAR will also affect the result of the research. The initial hypotheses was mostly formulated according to this data. Hence the questionnaire and the data collected in the interviews was also partly guided by this.

To ensure that the secondary data acquired in the first part of the data collection process was valid, this data has been triangulated with the primary data acquired in the interviews. To further increase validity, the questions have been, as far as possible, asked open-ended. To either verify or dismiss the secondary data, the data from more than one interview has been used in the triangulation. This, since the interviewee may have different interpretations. According to Bryman and Bell [22] triangulation is a good way to crosscheck data from different sources to ensure its validity.

With regard to that a qualitative research has been conducted on a complex market as well as on a complex technology, thick description have been used to put the result into a context. The thick description provides transferability by giving rich details of the context, this provide a possibility to evaluate if the research can be used in a different situation Bryman and Bell [22].

4

AUTOSAR

Automobile-software has traditionally been strongly coupled with the underlying hardware. As software has become an increasingly integral part of automobiles (for more information on this, see Chapter 1), the need for standardized software architecture has increased.

In 2003, a joint collaboration was initiated by large OEMs – BMW Group, DaimlerChrysler and Volkswagen – and automotive system suppliers – Bosch, Continental and Siemens VDO. The goal was to develop a standardized open software architecture, AUTOSAR. From its initial six members, the AUTOSAR partnership has grown to over 160 members and 80 percent of all cars sold worldwide is produced by AUTOSAR-partners [2].

4.1 Benefits

There are several advantages with AUTOSAR: It enables transferability, scalability and simplifies integration of functional models from multiple suppliers [23]. Transferability refers to simplifying moving functions between ECUs and between platforms, resulting in that functionality can be re-used in coming car-models. Scalability refers to the possibility to add and remove functions without having to configure the code mapped to the hardware. This also enable OEMs to use SWCs from different suppliers, since the SWCs are not hardware-dependent.

However, all these models defined by the AUTOSAR standard comes with a cost: footprint on the hardware. This is something which has been discussed both in initial interviews with Acme, and with many interviewees. Providing abstraction layers, such as the three layered architecture provided by AUTOSAR, always implicate a larger hardware-footprint.

A larger hardware-footprint result in increased requirements on the hardware [23], which will impact hardware-costs. In addition, software costs are not initially decreased by using AUTOSAR. Rather, learning how AUTOSAR works initially is costly. However, there have been research on a scaled-down AUTOSAR-model which would only include certain functionality. For example, the most demanding functionality could be excluded assuming that this functionality is not critical for the end-user. However, as there is not enough research on the matter, what functionality could be excluded can not be specified.

4.2 Commercial model

In the AUTOSAR partnership, there are various levels of memberships: Core Partners, Premium Partners, Development Partners, Associate Partners, and Attendees. The memberships gives different rights and obligations. The Core Partners manage the development cooperation of AUTOSAR. The Premium Members have to contribute with 1.5 full-time equivalent (FTE) and 17,500 euros annually. In return, they get leading roles in the continued development of AUTOSAR. The Development Partners are required to contribute 0.5 FTE, while Associate Partners are required to contribute 10,000 euros. Last, Attendees do not have to contribute by FTE nor any annual fee. However, Attendees are the only category which is not allowed to use AUTOSAR royalty-free for automotive applications [2]. Thus, in order to use AUTOSAR-products commercially, one must be a member of the AUTOSAR partnership.

4.3 AUTOSAR architecture

Today, a luxury car's E/E architecture consists of a network of roughly 80 electronic control units (ECUs) [32]. An ECU has many properties like a personal computer: It contains a MCU, flash memory, RAM, etc. However, ECUs need to have certain properties to be suited for the automotive industry. For example, the ECUs interact with sensors and actuators. In addition, ECUs used in the automotive industry are connected to vehicle networks. There are various vehicle networks; the most predominantly used is CAN, but in various domains, FlexRay, LIN, and MOST are used. Moreover, ECUs often have limited computing power.

Traditionally, automotive software has been configured and optimized specifically for each ECU. Consequently, automotive software often suffer from strong coupling between the software and the hardware. As a result, re-using the code is difficult, which becomes an increasing problem with an increased amount of software.

As mentioned, AUTOSAR was initiated to tackle this problem, and provide independence between the MCU and the Application Layer [23]. In Figure 4.1 a representation of the AUTOSAR's layered architecture is presented. These layers include the Application Layer, the AUTOSAR Runtime Environment (RTE), and BSW. These are all configured to simplify the communication with the MCU.

First, The Application Layer consist of a number of Software Components (SWCs), which are interconnected. They also implement an interface enabling communication with the RTE. The RTE is responsible for handling communication between the Application Layer and the BSW. The top-layer of the BSW, the parts connected to the RTE, also provides an interface, communicating signals from the BSW to the SWCs. The BSW is structured into three main-categories: Services Layer, ECU Abstraction Layer and Complex Drivers, and Microcontroller Abstraction Layer (MCAL). These categories, in turn, consist of various sub-categories. However, these will not be elaborated on in this chapter.

The Service Layer have various tasks. Primarily, providing specific services for the ECUs

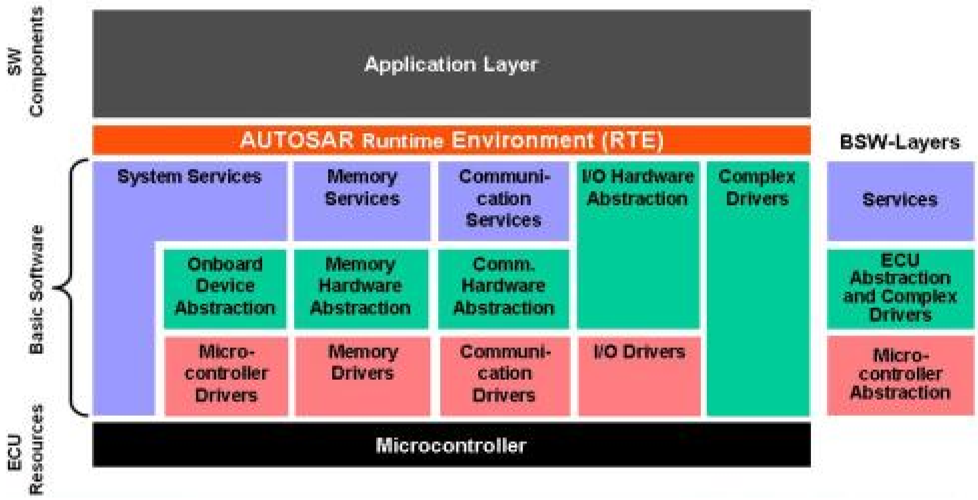

Figure 4.1: Autosar Layered Architecture

as well as specifying standardized properties, such as OS and timers. As demonstrated in Figure 4.1, these functions are available for the other layers in the BSW.

The ECU Abstraction Layer operates as an interface for higher level software, making it independent from the MCAL. The Complex Driver spans over the three layers of the BSW - from the RTE to the MCU. In the Complex Driver Layer, drivers for devices which do not have AUTOSAR specification is contained. More specifically, functionality which do not have any standardize Service. The signals for these functions are directly communicated between the MCU and the Application Layer.

Lastly, the BSW contains a MCAL, which is an abstraction layer to the MCU. This is the only layer that is MCU-dependent (excluding Complex Drivers).

5

Empirical data

In below chapter, the data gathered during this reserach is presented. Firstly, the initial hypotheses are presented. After that, a section containing the data gathered during held interviews are presented. Lastly, a section presenting the hypotheses based on all data gathered during this reserach is presented.

5.1 Initial hypotheses

The initial hypotheses were formed based mainly on literature on the Chinese automotive industry and interviews with Acme. In the literature, much useful information could be acquired regarding the automotive industry. Acme, on their hand, has given an increased understanding of AUTOSAR-products and their views on the Chinese automotive industry.

5.1.1 Market hypothesis

The market hypothesis has been addressed mainly based on initial interviews held at Acme. They argued that stricter regulations and the growth of the EV market often lead to the need for more complex software. This, in turn, leads to a growing need for a standardized architecture where larger investments would have to be spend on software.

Initially, the mere fact that the automobile sales have steadily increased in the past years, and are expected to increase significantly in the years to come [1], shows that there is a great potential for AUTOSAR products. In addition, the number of cars sold by global OEMs have increased in the past few years, making up 72 percent of China's light-weight vehicle sales 2014 [3]. Moreover, global OEMs must form a joint venture (JV) with a local OEM in order to be able to operate in China. In these JV, global OEMs have a 50 percent ownership-cap. These could be seen as a mean for knowledge-transfer in both directions, which include technological know-how. Furthermore, in contrast to global OEMs, global suppliers have no ownership-cap in China. Thus, global suppliers are allowed to set up subsidiaries in China without cooperating with a local Chinese supplier. These global OEMs and suppliers affect what products are sold in China.

Political

The Government has a department called NDRC, which is responsible for formulating and implementing macroeconomic policies. For example, they decide upon the building of new car-manufacturing plants. There are indications that the Government encourages global OEMs to develop indigenous brands together with its JV partner [12].

Moreover, the Government are faced with congestion issues in majors Chinese cities resulting in several new policies. First, stricter emission standards were introduced recently. In 2015, the Corporate Average Fuel Consumption (CAFC) is set to 6.9L/100km, which can be compared to Europe's 5.6L/100km [13]. For 2020, China's CAFC is set to 5.1L/100km [13]. Second, the Government is trying to spur the electric vehicle (EV)-market by having EV's accounting for 0L/100km of OEMs' CAFC, multiplied by five [13]. In addition, when buying an EV, end-customers can expect subsidies of up to 60,000 RMB and free license plates in cities with ownership-caps [8]. The Government is also said to invest 100B RMB in EVs and its infrastructure [4]. In sum, this have lead to that the production of EVs in China have five-folded between 2013 and 2014 [7]. Third, ownership-caps were introduced in eight major cities recently, which have affected sales in these cities. In Beijing, the ownership-caps was introduced in 2010. From selling 790,000 cars in 2010, the sales decreased to 173,000 in 2011.

Demography

Often, Chinese cities are divided into coastal regions and inland regions. Many inland regions have had an increase in GDP recently, making it possible for residents to buy their first car [9].

As mentioned, 28 percent of the sold cars in China are sold by Chinese OEMs [3]. Recently, however, Chinese OEMs struggle to compete along the coastal areas in cities such as Shanghai and Beijing, which might be a consequence of the introduced ownership-caps [11]. As GDP generally is higher in these regions, people tend to be less price-sensitive.

5.1.2 Customer hypothesis

As AUTOSAR is something which is adopted by the software industry as a whole, defining in what stages customers are involved is of importance. In the case where OEMs order AUTOSAR-implemented software, the suppliers must have the knowledge on how to implement AUTOSAR. However, OEMs can also develop software themselves making it AUTOSAR-compatible. Whether software development is outsourced or developed in-house varies between OEMs. However, regardless, OEMs must be able to integrate SWCs with each other. This require them to have AUTOSAR-knowledge. In order for AUTOSAR to diffuse, both these interests must be seen to.

As for the customer hypothesis specific to the Chinese market, some factors were identified when formulating the initial hypotheses. The predominant factors are that they have price-sensitive customers which requires them to keep costs low, resulting in low component cost among other expenses. Generally, as mentioned in the market hypothesis (see Chapter 5.1.1), the spending among Chinese OEMs in R&D have traditionally been low. However, many Chinese OEMs have JVs with global OEMs where knowledge is to some extent shared among the partners. Western technology is also brought to Chinese OEMs by acquisition. For example, Geely acquired Volvo Cars in 2010; Dongfeng acquired 14 percent of PSA Peugeot Citroen in 2014.

In sum, the customer hypothesis argue that Chinese OEMs generally target a price-sensitive customer segment, but are realizing the importance of R&D by increasing these investments in various ways.

5.1.3 Product hypothesis

In interviews held with AUTOSAR experts at Acme, the advantages of AUTOSAR was highlighted. However, the footprint of AUTOSAR is larger than that of traditional software for the automobile industry, where RAM and flash memory on the ECU was emphasised as most prominent. As Chinese OEMs generally have produced low-cost cars to meet price-sensitive customers, it has been of importance to keep component-cost low. A slight increased cost per car would increase the total cost of producing that car model significantly. In sum, the common perception was that Chinese OEMs would unlikely invest in AUTOSAR unless it could meet their hardware-demands.

This resulted in an initial product hypothesis: a scaled-down version of AUTOSAR which would be able to run on less complex ECUs. This, while still be able to enjoy the benefits of AUTOSAR. However, in a scaled-down version, some functionality naturally have to be reduced.

5.2 Mini cases

Below, mini cases based on held interviews are presented. In total, 15 interviews have been held with representatives from 14 companies operating in China. Nine of them were held with OEMs: one global OEM, two JVs, and six Chinese OEMs. In addition, three suppliers were interviewed: two global suppliers and one JV supplier. Lastly, one Chinese AUTOSAR-implementer was interviewed.

The structure of the mini cases below is as follows. Firstly, depending on the interviewees areas of expertise, either the market or product hypothesis was in most cases addressed. As such, the interviews are categorised accordingly. Furthermore, in most interviewees, the customer hypothesis have been addressed and will if so be presented.

Furthermore, all interviewees' names and company names are held confidential. Instead, acronyms are used: OEMs will be referred to OEM1, OEM2, etc.; suppliers will be referred to as Supplier1, Supplier2, etc.; and the AUTOSAR implementer will be referred to as AUTOSAR Implementer1. For all interviews, the number of interviewees have ranged between 1-3 interviewees.

Supplier1

Below interview was held held with Supplier1, **Global R&D Manager** at a global supplier.

The initial discussion regarded the importance for companies in the automotive industry to operate in China as it is the market with the highest growth. Supplier1 noted that strategy differ between Chinese OEMs and global OEMs. The local OEMs have historically used more local suppliers to produce a more cost-effective car. Often, however, the quality of the cars have suffered due to this. Supplier1 drawed a parallel to the history of other countries' automotive industry that have been in the same phase as the Chinese are now: the South Korean and the Japanese automobile industry. Both these countries' OEMs went through a phase of producing cost-effective cars where quality have suffered. Since then, they have evolved towards quality similar to cars produced in the West. However, as for the future, Supplier1 argued that the local OEMs want to increase the quality of their products to be acknowledged internationally. A step in this process would be to buy more from global suppliers [Supplier1].

Next topic addressed was EVs. Supplier1 spoke about how the EV market is to grow significantly. The Chinese government are interested in addressing environmental issues. However, the EV market is still small [Supplier1]. In addition, the Governments are tightening fuel-consumption restrictions to give incentives to both OEMs and suppliers to invest in new technology. According to Supplier1, this is one of the main drivers in the technological development forward.

OEM2

Below interview was held held with OEM2, **Dealership Manager** at a JV OEM.

The market hypothesis was first addressed by OEM2, who emphasised the importance of the car as a status-symbol in China. He broadly categorized customers based on price-sensitivity. Chinese OEMs tend to focus on the more price-sensitive customer-segment, whereas global OEMs often focus on less price-sensitive customers, where they dominate the market. In the latter, attributes such as brand-image are of importance [OEM2]. If an OEM's brand is not linked to either of these categories, sales would most likely suffer [OEM2].

For Chinese customers, OEM2 emphasised three parameters of importance when deciding upon a car: price, brand and roominess. Furthermore, He notes that despite its lacking importance today, the environmental awareness is growing in China and with the Chinese customers. Noticeable, the Government are investing heavily in EVs and its infrastructure. However, OEM2 did not seem too optimistic about this.

OEM1

Below interview was held held with OEM1, **Dealership Manager** at a JV OEM.

Initially, OEM1 categorised customers in two groups, addressing the market hypothesis. These are customers searching for an affordable car, in contrast to those searching for more recognized brands, often a global brand.

In addition, demography was discussed. OEM1 noted that some Chinese OEMs are forced to shut-down in the Chinese coastal areas. Instead, many Chinese OEMs move inland focusing their sales on Tier 3 and Tier 4 cities.

Last, EVs and the Governments investment efforts was discussed. These investments, OEM1 was very pessimistic about.

OEM6

Below interview was held with OEM6, **Expert at Strategy and Marketing** at a global OEM.

Initially, China's demography was discussed. OEM6 argued that there is a trend among OEMs to move in-land in China. In addition, the Government are in various ways encouraging this development [OEM6]. The interviewee was under the impression that global OEMs are dominating the coastal regions, forcing local OEMs to move in-to more mainstream markets such as Tier 3 and Tier 4 cities. However, several global OEMs are trying to enter the low-price automobile market with their JV partners [OEM6].

The next topic addressed was EVs and suppliers. Regarding the former, OEM6 seemed to be under the impression that this is just a phase as many households have problems getting access to private charging stations. Regarding the latter, quality was argued differentiate global and local suppliers. OEM6 argued that many Chinese suppliers do not have the capacity, technology or knowledge to provide complex components.

Supplier2

Below interview was held held with Supplier2, **Software Integrator** at a global supplier.

In the interview with Supplier2, AUTOSAR was discussed in-detail in order to address the product hypothesis. Firstly, Supplier2 mentioned three major factors hindering the diffusion of AUTOSAR in China: price, an underdeveloped maturity of the tool-chain, and lack of technical capabilities among both suppliers and OEMs. Furthermore, the OEMs' lack of technical capabilities results in them posing vague requirements to their suppliers [Supplier2]. The OEMs specify more broad requirements, and leave much to the suppliers. In addition, the safety-standard ISO 26262 was discussed, with its various ASIL-levels. These are common demands which the suppliers must comply to [Supplier2]. However, as the OEMs rarely require their suppliers to implement in specific ways, the reliability of the product ends up on the suppliers [Supplier2].

Addressing the product hypothesis further, Supplier2 elaborated on AUTOSAR's commercial model. Supplier2 argued that managers are used to be able to re-use software, which is not possible with most AUTOSAR licenses as they are often both hardware- and project-specific [Supplier2]. Without giving any concrete examples, Supplier2 was under the impression that the commercial model in an AUTOSAR value proposition would benefit from being modified. Moreover, Supplier2 noted that good service/support is of importance when choosing supplier.

OEM7

Below interview was held held with OEM7, **Battery Control Unit Manager** at a Chinese OEM.

Initially, OEM7 noted several hinders the Chinese OEMs faced in the adoption of AUTOSAR. Firstly, the price of licenses for both the tools and the MCAL is too high for Chinese OEMs as of now.

Secondly, managers views might differ from the engineers views, where managers often think of short-term profit. As AUTOSAR is a concept which is not intended to be profitable short-term, this could pose a hinder in the diffusion of AUTOSAR. The price-factor has lead to that own tools are being developed, trying to avoid the high licence-costs. OEM7 was under the impression that a few additional Chinese OEMs were doing the same.

Thirdly, the maturity of the tool-chain was mentioned as a hinder for adoption. For OEMs, it would be preferable being able to use the tools of different AUTOSAR-implementers, which is not feasible today [OEM7]. Furthermore, Chinese OEMs tend to invest in labor to develop software believing that this is the most cost-efficient way [OEM7]. However, OEM7 was under the impression that if the diffusion increase in the West and are more recognized there, China will follow.

Furthermore, the large AUTOSAR-implementers are trying to fill in knowledge-gaps by holding AUTOSAR-courses, and by giving out trial licenses to potential customers [OEM7]. Last, OEM7 argued that the affect on hardware in implementing AUTOSAR was not major.

AUTOSAR-Implementer1

Below interview was held held with AUTOSAR-Implementer1, **Business Developer** at a Chinese AUTOSAR implementer.

As AUTOSAR-Implementer1 area of expertise is the Chinese automobile market, this was discussed in detail. First, AUTOSAR-Implementer1 argued that the car is a status-symbol in China, where customers are either price-sensitive or looking for a more luxurious car. An example was given: Government officials are all driving an Audi A6, which is considered a luxurious car.

In addition, the EV industry was discussed. AUTOSAR-Implementer1 argued that it is fundamental for the EV industry that a standard for the charging stations is agreed upon. Furthermore, the situation is complex, as oil companies would probably oppose to the development of EVs [AUTOSAR-Implementer1].

Moreover, AUTOSAR-Implementer1 noted that hardware-cost is important in China. In addition, software is relatively cheap in China due to low wages [AUTOSAR-Implementer1]. This decreases the incentives to invest in a standard such as AUTOSAR [AUTOSAR-Implementer1]. When asked for an estimate of how much cost of an ECU is carried by software, AUTOSAR-Implementer1 suggested that it is substantially less than for most global OEMs, but notes that it is hard to give an exact number.

Lastly, AUTOSAR-Implementer1 noted that the Government is a key-factor in the diffusion of AUTOSAR. The Government could give more incentives for companies to adopt AUTOSAR by, for example, give subsidies for AUTOSAR-adopters [AUTOSAR-Implementer1]. Furthermore, a decision on the use of AUTOSAR from the Government would definitely increase the diffusion of AUTOSAR [AUTOSAR-Implementer1].

Supplier4

Below interview was held held with Supplier4, **R&D Department Manager** at a global supplier.

Initially, Supplier4 stated that the price-sensitive market segment is growing. Chinese OEMs typically target this segment, giving them an overhand against global OEMs. However, global OEMs are increasingly targeting these customers, too, by producing cars able to compete in this price-range. The strategy is often to decrease production cost. Supplier4 argued that this was part of the reason to why the local OEMs' market share have decreased in reason years. At the same time, local OEMs tries to increase their quality by buying from global OEMs [Supplier4].

Supplier4 argued that global OEMs have more knowledge, and notice a trend where Chinese OEMs buying more from global OEMs. This was very unusual for a couple of years ago [Supplier4]. This trend is something Supplier4 argued beneficial as they sell high-quality product to a slightly higher price. Part of the reason is to learn from global suppliers during the implementation phase [Supplier4].

Supplier4 continued saying how there are more electric vehicle in the bigger cities. There exist more incentives to do so in the cities with restrictions.

Moreover, Supplier4 noted that many Chinese OEMs are aware of AUTOSAR and have basic knowledge about it. However, not enough to use if for implementation. When asked about the initial product hypothesis, Supplier4 started noting that hardware cost will not be a problem. As OEMs start focusing on complexer ECUs the suppliers will produce more and the cost will decrease [Supplier4].

Last, AUTOSAR's complex driver was addressed where Supplier4 argued that when adopting AUTOSAR, there might be several functions that do not suit the defined functional groups, but is instead placed in complex drivers.

OEM4

Below interview was held held with OEM4, **Product Planner** at a private owned Chinese OEM.

First, OEM4 discussed the Government's role in the Chinese automobile industry. In China, the Government plays an important role for the automobile industry [OEM4]. The macroeconomic management agency NDRC is responsible for approving the construction of new manufacturing plants. OEM4 mentioned two criteria of importance in the approval process: the location of the manufacturing plant and what cars are planned to be produced there. In the former, the Government is trying to encourage OEMs to build manufacturing plants inland China. In the latter, the interviewee was not very clear. However, some are under the impression that the Government encourage JVs to develop cars tailored for the Chinese market [OEM4].

The Government is also giving substantial subsidies to end-customers who buy new energy vehicle [OEM4]. Despite that, OEM4 argued, the market for EVs is still relatively small, mainly due to lack of infrastructure for EV charging stations. Both public efforts as well as chargers for private households are struggling [OEM4]. In the former, parties of influence seem to disagree upon a standard for the charging station. The latter regards the large number of people who live in apartments, which makes it impossible for all residents to charge their car near their home in a feasible manner.

Moreover, the discussion regarded their possible entry to the Western market. OEM4 mentioned that many Chinese OEMs have a hard time meeting the requirements of the Western market. Instead, the majority of the export has its destination in the BRIC (Brazil, Russia, India and China) countries [OEM4]. However, they intend to export to both the American and the European market in a foreseeable future. Their way of approach is technology transfer from the Western market and increased expenses on components [OEM4].

These components are only available at a small set of suppliers, often global suppliers. Furthermore, OEM4 was under the impression that most high-technology components are sold by global suppliers, whereas components such as chassis often are sold by Chinese suppliers. OEM4 argued that there is a trend in that global OEMs buy more and more of these components from Chinese suppliers; a way to cut cost for global OEMs, so that they are able to compete in more price-sensitive customer segments.

Supplier3

Below interview was held held with Supplier3, **Product Manager** at a JV supplier.

Initially, the Chinese automobile industry was discussed in general terms. Supplier3 noted that Chinese customers often are either price-sensitive or choose more luxurious, recognized brands. These price-sensitive customers often consume cars produced by Chinese OEMs who produce low-cost cars, thus often with slightly lower quality than its global competitors. Furthermore, addressing demography, Supplier3 was under the impression that these cars are typically sold in Tier 3 and Tier 4 cities. The increasing demand in these cities have not only been recognized by Chinese OEMs, however, but also by global OEMs who are trying to enter this low-price segment by cheaper configuration of the cars produced in China [Supplier3].

However, Supplier3 has seen a difference in the Chinese OEMs behavior recently. He suggested that Chinese OEMs are willing to and understand the importance of R&D, giving examples in large Chinese SOE. Thisoften done by acquiring technological know-how [Supplier3].

Moreover, when asked about suppliers, Supplier3 was under the impression that Chinese suppliers often had limited technological knowledge. This, in contrast to global suppliers who often possessed a more advanced and complex product portfolio with more in-depth knowledge about automotive parts.

Furthermore, Supplier3 suggested that more and more OEMs started demanding AUTOSAR. This affect suppliers, which has lead to that many suppliers are ready for AUTOSAR [Supplier3]. Furthermore, Supplier3 shared that part of their product portfolio will be using AUTOSAR software. This meant that all units of this specific product will carry AUTOSAR-implemented software. As such, tailoring of that product towards customers requiring non-AUTOSAR solutions will not be offered. Supplier3 further noted that software is considered a one-time cost, not accounted for as a per-unit price.

OEM3

Below interview was held held with OEM3, where two employees from a JV OEM participated, with titles: **Manager for Electrical Architecture and Functional Development** and **Manager Vehicle Electrical Systems**.

First, AUTOSAR was discussed on a macro-level. OEM3 noted that as more OEMs are requiring AUTOSAR, their suppliers will eventually have to follow. Thus, many suppliers are in the AUTOSAR-collaboration in order to be ready for this possible paradigm shift. By being in the collaboration, they do not only acquire knowledge, but they are also part of shaping the AUTOSAR standard continuously. OEM3 added, lastly, that if the Government would decide upon AUTOSAR as a standard for the Chinese automobile industry, the diffusion of AUTOSAR increase rapidly. OEM3 believed there is a collective action problem for the Chinese OEMs using AUTOSAR today, where being an early adopter would not be beneficial.

Moreover, OEM3 noted that they invest heavily in safety, with good grades in various crash-tests. In addition, they have invested in AUTOSAR, which is used in one of their safety domain nodes. OEM3 also noted that even though they do not use AUTOSAR in more than one node, their network management are AUTOSAR-ready, meaning that implementing AUTOSAR on further nodes would be possible as of today. However, hinders such as lacking knowledge from suppliers is common [OEM3]. This results in that the cost of development is high, as knowledge about AUTOSAR on the supplier-side must be acquired first. Furthermore, some suppliers cannot fulfill all requirements asked for [OEM3]. In addition, OEM3 mentioned that for the non-AUTOSAR nodes, they buy the operating system which is provided to their suppliers. This simplifies integration for [OEM3], as all nodes have the same operating system.

OEM5

Below interview was held held with OEM5, **Basic Software Team Leader** at a Chinese OEM.

As OEM5 has profound knowledge on AUTOSAR, this was discussed in detail. First, technical capabilities was addressed where OEM5 noted that many Chinese OEMs find difficulties in specifying clear requirements, which was highlighted as a key-element. Chinese OEMs focus more on functions rather than the underlying architecture [OEM5]. The fact that AUTOSAR is costly without reflect any difference in functionality decreases the incentives to invest in the technology [OEM5]. As for the price, it is yet too high both for them and for Chinese OEMs in general. They are able to develop software themselves to a lower price, OEM5 argued.

However, OEM5 emphasised that they have a keen interest in learning about AUTOSAR. Furthermore, the advantages of AUTOSAR is already identified, where migration of functionality to coming platforms was mentioned. These views might not be reflected by management, however [OEM5]. OEM5 argued that the managers focus more on functionality, whereas software architecture is not as prioritised. The decision of the managers is of great importance in China [OEM5]. In spite of this, AUTOSAR is used on one of their nodes. Moreover, often when software is ordered from suppliers, requirements on the software are set and specification for the network specified. However, what BSW the supplier use is not specified, but rather up to the supplier.

Last, OEM5 highlighted two things of importance in the case of AUTOSAR. First, the hardware-cost is not a key-factor for why AUTOSAR has not diffused yet. Second, some functionality is not complex enough to enjoy the benefits of today's implementation of AUTOSAR.

OEM8

Below interview was held held with OEM8, where three employees from a Chinese OEM participated, with titles: **Control Development for the Automotive Electronic Department** and two **Software Engineers**.

Initially, OEM8 noted that in order to use AUTOSAR, broad knowledge about AUTOSAR is a necessity, where lack of knowledge would be a great hinder. OEM8 noted that in their case, they give broad functional requirement without very specific details. In this way, the responsibility for the software ends up on the suppliers, which OEM8 emphasised the importance of.

Furthermore, AUTOSAR is used in R&D [OEM8]. In addition, they have also developed their own IDE for generating embedded software. However, OEM8 noted that they are not in need of AUTOSAR today as the amount of software in their cars is not enough to enjoy the benefits of AUTOSAR. AUTOSAR has, however, been considered for two of their more software intense ECUs.

Moreover, OEM8 noted that risk is an important factor for Chinese OEMs. AUTOSAR's objective is to decrease the development costs for coming car platforms. However, OEM8 expressed concern over this. In addition, concerns over the tool-chain was expressed. OEM8 argued that different AUTOSAR-implementers tool is not compatible enough, which was argued an additional risk. Furthermore, many Chinese OEMs are price-sensitive, where AUTOSAR tools and licenses might be too costly for them [OEM8].

In the case of suppliers, OEM8 argued that local suppliers tend to develop high-quality products. These are more costly than products offered by their local competitors. As of today, his company use mostly local suppliers [OEM8].

Lastly, the product hypothesis was addressed briefly where a scaled-down version of AUTOSAR was discussed. On the matter, OEM8 argued that there would be additional hardware cost in implementing AUTOSAR. In their case, this would be expensive.

AUTOSAR-Implementer2

Below interview was held held with AUTOSAR-Implementer2, **Vice GM Automotive Electronics** at a Chinese AUTOSAR implementer.

Initially, AUTOSAR-Implementer2 shared that several Chinese OEMs uses the OS-part and the MCAL of AUTOSAR. On top of that, many Chinese OEMs develop their own BSW with these components integrated. However, much indicate that the automobile industry will be increasingly dependent on software [AUTOSAR-Implementer2]. For example, more and more Chinese OEMs have started cooperating with Internet providers, which was described in detail. Another concrete example given was parking systems and the need for identifying cars in big parking lots.

These two examples, among many others, will increase the amount of software in cars, which leads to higher likelihood of adoption of AUTOSAR [AUTOSAR-Implementer2]. However, as of today, AUTOSAR-Implementer2 argued that the amount of software in Chinese OEMs' cars is substantially less than in most Western cars.

Moreover, AUTOSAR-Implementer2 has worked in several AUTOSAR-projects, where many of these gets subsidies from the Government. He says that project members are often subsidised by 1/3rd or 2/3rd of the project costs. These subsidies are given to OEMs, suppliers and AUTOSAR-implementers.

Furthermore, suppliers and EVs were discussed. AUTOSAR-Implementer2 compared global and Chinese suppliers saying that global suppliers tend to be more reliable. In addition, AUTOSAR-Implementer2 commented on the EV market saying that many companies try to develop their own EV-charger standard, which is not good for the EV-market as a whole.

Lastly, factors to why AUTOSAR has not yet diffused was discussed. AUTOSAR-Implementer2 mentioned that knowledge on AUTOSAR is important. However, to solve this, AUTOSAR-Implementer2 mentioned that they are considering to develop and IDE with less parameters, which would be easier to configure AUTOSAR-compatible software with. This due to that AUTOSAR contains too many parameters today, which makes AUTOSAR more complex than it has to be. Furthermore, unit cost is more important than the cost of software development as of today [AUTOSAR-Implementer2]. Another factor to why AUTOSAR has not yet diffused is that small amount of code has to be re-written between different ECU-architecture [AUTOSAR-Implementer2].

OEM9

Below interview was held held with OEM9, **Module Team Director** at a Chinese OEM.

First, technical barriers to AUTOSAR was discussed. Technical barriers in this case refers to the lack of knowledge about AUTOSAR, and the already possessed knowledge in how to develop software traditionally, which is often preferred by suppliers. The suppliers are then able to give a more accurate time assumption. In addition, there are less development costs for suppliers as they already possess this kind of knowledge. Moreover, OEM9 suggested that more and more OEMs have started developing their own software due to responsibility issues. Suppliers do not want to take full responsibility when they have not developed the BSW themselves [OEM9].

Furthermore, OEM9 was asked about Chinese suppliers and how they differ from global suppliers. Global suppliers tend to offer products of higher quality, to an increased price. OEM9 argued that few OEMs order complex ECUs from Chinese suppliers. OEM9 also noted that future functionality will increase requirements on software, giving autonomous driving as an example.

Moreover, the product hypothesis was addressed in detail. Firstly, OEM9 listed the advantages with AUTOSAR: standardized architecture and portability of functionality. In addition, AUTOSAR makes the tool-chain more modular, making it easier than it traditionally have been to change parts of the tool-chain [OEM9]. Traditionally, few players have possessed much power in the implementation of BSW. With AUTOSAR, this problem is addressed [OEM9].

OEM9 also noted that OEMs handle AUTOSAR in different ways. Some tries to keep the number of AUTOSAR-implementers low in order to avoid integration-problems, especially a few years ago when AUTOSAR was less mature. Others buy from several AUTOSAR-implementers in order to increase bargaining power. In their case, they use AUTOSAR for most of their nodes on the platform that they are building [OEM9].

The adoption of AUTOSAR is a long-term investment not always recognized by managers who sometimes lack knowledge to see the advantages with AUTOSAR [OEM9]. In addition, AUTOSAR is developed by several OEMs and suppliers, many companies have views on what should be included in the standard, which have resulted in that AUTOSAR suffers from too many parameters [OEM9]. OEM9 was under the impression that this list of parameters should be decreased.

When discussing our initial product hypothesis, the scaled-down AUTOSAR version, OEM9 argued that hardware cost is not the main decider. However, several ECUs would benefit from an AUTOSAR version with a smaller footprint [OEM9]. Software for simpler ECUs are not in need of everything provided by the AUTOSAR BSW [OEM9].

5.3 Hypotheses

Below, a summery of both primary and secondary data affecting the three initial hypotheses are presented. This include the market, customer and product hypotheses.

5.3.1 Market hypothesis

First, the trend of more complex functions and stricter requirements will consequently mean more investments in software. When it comes to general investments in R&D, global OEMs have traditionally invested more money than Chinese OEMs [14]. However, in the last few years, Chinese OEMs have realized the importance of R&D [OEM7, Supplier3], which is also reflected in the increased investments [14]. In addition, technological know-how has also been retrieved by acquiring global OEMs, global suppliers, global platforms, etc.

Four interviewees have emphasised the importance of China's demography, where inland regions are target-markets for many OEMs. This applies especially for Chinese OEMs, as the competition and regulation are too high in the coastal areas, where the customers are more brand-aware. In China, the customers are either price-sensitive or brand-aware, preferring cars which are considered luxurious [OEM1, OEM2, OEM6, Supplier3, AUTOSAR-Implementer2].

The Chinese government has a department, NDRC, which is responsible for approving the building of new car-manufacture plants. According to OEM4, NDRC have two main criteria for doing so: location and type of car. OEM4 continued mentioning that the Government is trying to spur development of cities inland, where part of their strategy is to set-up car-manufacturing plants inland. As for the type of car, some are under the impression that the Government encourage JVs to develop indigenous cars tailored for the Chinese market [12].

Moreover, the Government are trying to spur the EV-market by big investments, mainly to the end-customer [8]. In spite of this, four interviewees are negative towards the EV-market, especially the charging stations and its potential. OEM4 argued that as most people live in apartments, it is not possible to in a feasible manner install charging stations at these residences.

However, the end-customers are not the only ones benefiting from the development of EVs; the OEMs does too. When producing EVs, these decrease an OEM's CAFC significantly [13]. Recently, these fuel-consumption requirements have been increasing, and are set to be increased significantly in 2020 [13].

Lastly, AUTOSAR-Implementer2 shared that they have received subsidies for AUTOSAR-projects.

Summary

The market hypothesis argued above consists of several factors. First, a growing perceived importance of acquiring technology for Chinese OEMs is shown in various ways. There is also the case of customers, where there is a wide customer-segmentation between typical low-price customers and the more brand-aware customers. Demography also affect the market hypothesis, where inland regions seems to be catching up with coastal regions in terms of GDP. In addition, for the development of cars, the boom is expected to be inland where an increasing number of car-brands tailored for the Chinese market will be developed. Moreover, despite barriers, there are indications that the EV-market will grow in the coming years. However, to what extend is hard to estimate. Lastly, subsidies giving incentives for AUTOSAR adopters are given by the Government as of today.

5.3.2 Customer hypothesis

Below, data acquired affecting the initial customer hypothesis is presented. First, two OEMs interviewed mentioned that OEMs are afraid of taking responsibility for software development, and would thus rather trust a supplier for implementation [OEM8, OEM9]. Furthermore, four interviewees argued that the suppliers have their own routines when it comes to software development, where some have indicated that this includes them developing their own BSW. Two Chinese OEMs argue that both OEMs and suppliers lack knowledge on AUTOSAR. On the OEM-side, many does not have the knowledge to set requirements detailed enough towards the suppliers [OEM5, OEM8], where focus is more on functions rather than architecture [OEM5]. On the supplier side, many are not able to provide complex requirements which are asked for by some OEMs [OEM3, OEM6]. In addition, for suppliers agreeing to implement AUTOSAR, the initial cost is high, due to lack of knowledge [OEM9].

Moreover, many of the technical experts that were interviewed suggests that the managers' views and the engineers' views often differ [OEM5, OEM7, OEM9]. Managers, they argue, tend to focus more on functions rather than underlying architecture. OEM5 emphasised that the managers' decision is of great importance in China. In addition, the fact that an architectural innovation is not reflected in the end-result makes the investment harder to justify towards end-customers, as they would not see the benefit with AUTOSAR [OEM3, OEM5, OEM9].

In spite of these barriers, AUTOSAR is used by five Chinese OEMs today. Out of these, two are, or have decided to use it in mass-production [OEM3, OEM5]. The rest use the AUTOSAR

OS and the AUTOSAR MCAL. In addition, at least five Chinese OEMs are also using it in R&D. In fact, some are even developing their own tools to configure their own BSW [OEM7, OEM8].

In addition, OEM3 mentioned that despite that most of their nodes does not carry AUTOSAR-software, their network management system is ready to coop with AUTOSAR nodes. OEM3 continued mentioning that they buy the operating system to their suppliers, for them to develop the application layer onto. This to ensure that they have the same BSW on all ECUs. Two of the interviewees noted that several large OEMs have started requiring AUTOSAR when ordering software [OEM3, Supplier3]. This leads to that suppliers are likely to follow in order to keep these customers, as they have big influence [OEM3, Supplier3]. However, as OEM7 notes, this decrease the number of suppliers possible to buy from, as all suppliers are not yet AUTOSAR ready.

Moreover, Supplier3 noted that they are AUTOSAR ready, and that several more large suppliers are too. He continues saying that as their product adopt AUTOSAR, it will do so for all its customers. This means that the product will not be adopted for certain customers, and that everyone in need of that specific product would have to use AUTOSAR BSW for that node. In addition, eight interviewees all made a quite clear distinction between global suppliers and local suppliers. The greatest difference according to them is how technologically advanced they are, where they argues that most local suppliers lack in knowledge and technological know-how to provide complex components. OEM9 argued that they do not buy complex ECUs from Chinese suppliers at all. However, Chinese suppliers, OEM8 argued, are generally cheaper.

As such, price-sensitive Chinese OEMs' strategy often is to buy from Chinese suppliers to keep costs low [OEM8]. Many Chinese OEMs have problems entering Western markets [OEM4], often failing crash-tests etc. [5]. OEM4 mentioned that they are interested in increasing their exports to Western countries. One mean to do so is to increase the quality of the components [OEM4]. However, their exports are mainly to BRIC countries today. In addition, most Chinese OEMs are focusing on the growing car-segment in Tier 3 and Tier 4 cities, which is a price-sensitive customer-segment [OEM1, OEM6, Supplier3]. Regardless, Chinese OEMs are trying to enter the mainstream market by acquire knowledge and increase quality [OEM6, Supplier3]. At the same time, many argue, global OEMs are trying to lower costs to meet the growing customer-segment in Tier 3 and Tier 4 cities [OEM6, Supplier3]. In sum, the interviewees seemed to be under the impression that Chinese OEMs and global OEMs are converging price-wise.

Summary

The customer hypothesis differs depending on who in the adoption phase is referred to. In the case of the OEMs, managers are suggested to either: 1) lack knowledge on the benefits of AUTOSAR, or 2) not perceive AUTOSAR as beneficial as other adopters suggest. There is also a knowledge-gap in integrating (and possibly implementing) software among OEMs. Many suppliers also suffer from lack in knowledge on how to implement AUTOSAR-specific knowledge. However, as described by interviewees working for suppliers, they are asked by OEMs to use AUTOSAR rather than actively choose to do so themselves. In their description, the decision is almost already taken for them. This is a strong indicator in the case of AUTOSAR diffusing in China – the power of these OEMs. In addition, the number of Chinese OEMs buying from global suppliers are suggested to increase. This further spur the diffusion of AUTOSAR. However, cost is a growing concern for both global and Chinese OEMs, trying to meet demand from price-sensitive inland.

5.3.3 Product hypothesis

Below, interviewees' views on AUTOSAR and on the product hypothesis is presented. Firstly, a scaled-down AUTOSAR version was discussed during all interviews. Three interviewees representing Chinese OEMs were under the impression that the hardware-cost is not the main decider in whether AUTOSAR is adopted or not [OEM7, OEM9]. However, [OEM8], on the contrary, notes that hardware is one of the factors affecting their decision in whether to adopt AUTOSAR or not. AUTOSAR-Implementer1 also noted that hardware cost is important, without commenting on its affect on AUTOSAR. In contrast to hardware-optimizing, two interviewees have suggested a stripped AUTOSAR-IDE [AUTOSAR-Implementer2, OEM9], which would be simpler to use.

In addition, three interviewees have expressed concerns regarding the maturity of the tool-chain [Supplier2, OEM7, OEM8]. They were under the impression that different AUTOSAR-implementers' tools does not synchronise in a feasible manner. Many have also expressed dissatisfaction with the prices of AUTOSAR licenses and tools. OEM8 also expressed concern that cost, as intended with AUTOSAR, might not decrease over time. In addition, Supplier2 suggested that the commercial model many AUTOSAR-implementers are using today would benefit from changing.

Moreover, additional services are provided by AUTOSAR-implementers, which also concerns the product hypothesis. For example, OEM7 shared that the major AUTOSAR-implementers provides both training sessions in which knowledge about AUTOSAR and how it is implemented is conveyed. The AUTOSAR-implementers also provide trial-licences, which too can be seen as part of the product. As knowledge is identified as a major hinder, these two are important elements in a product hypothesis. By providing a good training to customers, providing knowledge about why AUTOSAR should be used and how, the risk of doing so would decrease significantly. In addition, providing trial-licenses simplifies significantly in bringing in views from new customers.

Summary

The initial hypothesis has been rejected by most interviewees, where knowledge has been presented as a much greater hinder in the adoption of AUTOSAR. For this, a stripped version of AUTOSAR was suggested where the number of parameters are reduced, simplifying for the customer. As such, the knowledge-gap are decreased by the help of AUTOSAR-implementers. Then there is also the case of training, which too decreases the knowledge-gap. Providing training meeting the Chinese customers' demands will be an important area of improvement in the diffusion of AUTOSAR. Having a strategy for handling trial-licences could also help in meeting new customers' demand. Lastly, price and maturity of the tool-chain are two factors which also affect the decision of adopters.

6

Analysis

Before starting the analysis, terms frequently used should be defined. Below, unless otherwise stated, the adopters is defined as representatives either from OEMs or from suppliers as they are both customers and users of AUTOSAR. This should not be confused with what is referred to as end-customers below, i.e. consumer of the vehicles produced by OEMs.

The structure of the chapter is as follows. Firstly, Chapter 6.1 presents how AUTOSAR is defined in the context of the theoretical framework (see Chapter 2). This is followed by Chapter 6.2, which identify factors affecting the diffusion of AUTOSAR in China (*RQ1*) and suggest ways to overcome these barriers for each factor (*RQ2*). Lastly, Chapter 6.3 contrasts the implications of being an *innovator* and a *laggard*.

6.1 Defining properties of AUTOSAR

In order to be able to apply the theoretical framework presented in Chapter 2, AUTOSAR must be defined in the context of some of these key-expressions.

Firstly, the terms innovation, radical innovation, and incremental innovation will be used as defined in Chapter 2. In the case of AUTOSAR, there are some traits implying that AUTOSAR is an incremental innovation, while other traits imply that AUTOSAR is a radical innovation. First, AUTOSAR does compete with the traditional way of developing software, suggesting incremental innovation. In contrast, AUTOSAR requires knowledge which companies previously is not in a possession of, suggesting radical innovation. However, AUTOSAR is not fully radical since those having previous knowledge about embedded development have a head-start in AUTOSAR development. The knowledge-gap between implementing AUTOSAR-compatible software and develop software the traditional way is described by many interviewees as large.

Considering the above, most facts suggest that AUTOSAR should be categorised as a radical innovation. However, one significant difference from Tripsas [37] definition of radical innovation is that AUTOSAR is rather adopted first and foremost by incumbents, and not by new entrants. In Tripsas [37] definition of radical innovation, this is indeed an example conflicting with her views in radical versus incremental innovation. However, for the six founders, AUTOSAR might not be all radical after all. These six companies all had technical capabilities and knowledge which probably directed them in their development of AUTOSAR.

In this view, AUTOSAR is rather an incremental innovation, but influenced by these six major companies. However, for adaptors of AUTOSAR not familiar with the way these six companies operate, AUTOSAR might be conceived as a radical innovation. In sum, whether AUTOSAR is an incremental or radical innovation is suggested to depend on whose view it is defined. In the case of the six founders, AUTOSAR is argued being incremental with a very high rate of adoption among these companies. In addition, companies tightly linked to the founders will be more likely to adopts AUTOSAR as these companies would possess more resources from the founders than companies less linked to the founders. And for firms not very closely linked to the founders – in different markets, for example – the innovation will be perceived as more radical than among the founders. In the case of AUTOSAR, this implies that there is a scale ranging between the two extremes radical and incremental innovation. Furthermore, on such a scale, Chinese OEMs would be likely to perceive AUTOSAR as rather radical.

6.2 Factors affecting the diffusion

During an adoption process, the adopter seeks to reduce risk [35]. This clearly applies to both OEMs and suppliers in the Chinese automobile industry, which will be exemplified below.

6.2.1 Knowledge

Firstly, knowledge is a factor which decrease risk and thus affect the diffusion of innovation [35]. In the case of AUTOSAR, all interviewees working with automobile E/E architecture was familiar with AUTOSAR, having awareness-knowledge of the innovation. They are aware that the technology exists, and are positive to learn more about it.

The second kind of knowledge Rogers [35] refer to is how-to-knowledge, which is knowledge about how to use an innovation correctly. The common perception is that most Chinese OEMs and suppliers seem to lack how-to-knowledge. Eight interviewees argue that neither Chinese suppliers nor OEMs have enough knowledge. The OEMs do not have enough knowledge to give requirements specific enough [OEM5]. On the other hand, for those who do, most Chinese suppliers do not have enough knowledge to make their software AUTOSAR-compliant [OEM3]. However, many AUTOSAR-implementers have acknowledged this and provide trainings where they teach customers about AUTOSAR and how to implement it [Supplier2].

Lastly, principle-knowledge is emphasised by Rogers [35], which is knowledge about how and why an innovation works. He suggests that innovation can be adopted without having principle-knowledge, but describes that this might not be optimal. In China, the leaders decision is of great importance [OEM5]. Thus, principle-knowledge is important for high-ranking managers. They must understand why they should adopt AUTOSAR, and how implementation should be handled.

6.2.2 Perception

Apart from knowledge about an innovation, the adopters have perceptions of what to expect from an innovation. Rogers [35] divides how adopters perceive innovations in five categories: relative advantage, compatibility, complexity, trialability, and observability. These factors will be elaborated on in an AUTOSAR-context, to understand how adopters perceive AUTOSAR and how they affect each other during this phase.

Relative advantage

Relative advantage is to what degree an innovation is perceived as better than its predecessor [35]. In the case of AUTOSAR, most interviewees are aware of the benefits of AUTOSAR. However, some concerns have been expressed where the interviewees believe that the Chinese automobile market differs from the Western market [OEM4]. For example, an interviewee stressed that Chinese OEMs' cars generally carry less software than those produced by global OEMs [OEM8]. Some also argue that there are only small changes in functionality between different platforms [AUTOSAR-Implementer2, OEM5]. In addition, one interviewee noted that Chinese labor is relatively cheap and hence the need for re-usability of functionality is not valued as high as for global OEMs [AUTOSAR-Implementer2].

Four interviewees also noted that as many Chinese OEMs are still targeting price-sensitive customers, unit-price is still important. With AUTOSAR, the unit-price would increase slightly. However, the views on unit-price differ between interviewees. Most interviewees actually argued that the unit-price is not a key decider in the adoption of AUTOSAR [OEM7, OEM9]. One interviewee also mentioned that Government subsidies are given for AUTOSAR-projects [AUTOSAR-Implementer2]. This, Rogers [35] argues, is a relative advantage which he defines as financial payment incentives. In spite of this, six interviewees believe that the tools and the license-cost of AUTOSAR-products are too high. Several interviewees have also argued that most Chinese OEMs have a short-term focus, which conflicts with the adoption-process in adopting AUTOSAR [OEM5, OEM7, OEM9].

Furthermore, one interviewee stressed that technical support and technical barriers are potential hinders in adopting innovation [Supplier2]. Supplier2 emphasised the importance in good service/support during the implementation phase.

Additional factors concerning the perceived relative advantage which was mentioned was that the cost of software development for the Chinese OEMs will not decrease, as expected to with AUTOSAR [OEM8]. Interviewees also highlighted the tool-chain, which many interviewees argue must mature before adoption among Chinese OEMs can take place [OEM7, OEM8, Supplier2].

Compatibility

Compatibility is defined as to the degree an innovation is compatible with existing values, past experience and needs of adopters. There are many factors which are not fully compatible shifting to an AUTOSAR BSW. For example, AUTOSAR is not compatible with the past experience of the software developers, as it is a new BSW, which requires new ways of implementing. In addition, the importance of software have been growing constantly since it was introduced (see Chapter 1), where software is becoming an integral part in automobile E/E [34][24][29][26][21]. Even though this is a change over time, many interviewees still does not perceive software as important as these scholars.

Moreover, there is also the case of risk, where both OEMs and suppliers do not seem keen on being responsible for the software and its consequences. Depending on which part of the software is at fault, the consequences could cause great problem to great cost. Furthermore, as AUTOSAR is often implemented by a third party, either the OEM or the suppliers must take responsibility for the software.

The primary reason for not wanting to take responsibility seem to be lack of knowledge to assure that the software is working correctly. Four interviewees describe that they prefer to let the supplier provide both the software and the BSW, as this puts the responsibility on the suppliers. The suppliers, on their hand, often take responsibility if they are in control of both the software and the BSW [OEM8]. In the case of AUTOSAR, they are often assigned to use AUTOSAR, where they can choose an AUTOSAR-implementer, but they often do not create an AUTOSAR BSW, which is the reason for them not wanting to take responsibility for AUTOSAR-compliant software.

The commercial model has also been argued incompatible. Supplier2 argued that many customers believes that they should be able to use software over several projects/developers over a non-extended time-frame, which AUTOSAR-providers does not provide.

Complexity

As for the complexity parameter, it links to knowledge as discussed in Chapter 6.2.1. However, one mean to decrease the complexity of AUTOSAR could be to decrease the complexity of AUTOSAR, rather than teaching adopter about AUTOSAR as it is today. AUTOSAR-Implementer2 argued that this could be done by introducing a stripped AUTOSAR-IDE. This would mean that less parameters needs to be configured and the configuration-process would thus be simplified [AUTOSAR-Implementer2, OEM9]. This would result in that AUTOSAR - the technology - is tailored towards its users, rather than that the users must fill the whole knowledge-gap. A stripped AUTOSAR-IDE would imply an adoption from both parties, which is emphasised as important by Holmström and Stalder [31].

Trialability

Trialability must be defined in the context of AUTOSAR before addressing it. Trialability in the sense that it is possible to try implementing software according to the AUTOSAR-interface is possible. Furthermore, most AUTOSAR-implementers offer a trial-license over a 30-day period which customers are allowed to use to implement BSW of their preference [OEM7]. However, the trial-period could, in the case of AUTOSAR, be argued to be much longer than this. In fact, the trial-period could be the whole period from the first implementation in R&D to that there are no longer cars running with that same AUTOSAR-implemented software, as this is the life-cycle of an AUTOSAR-product. In the latter, no one have experience.

However, defining trialability as the former, the trialability of AUTOSAR-related products is considered good. After this trial-period expires, customers are able to comment on the product, making re-invention possible. This, in turn, speeds up the diffusion-process [35].

Observability

In addition to try AUTOSAR, there is also the factor observability, which concerns seeing predecessor use the innovation. In the case of AUTOSAR, some interviewees actually argued that the mere fact that global OEMs are adopting AUTOSAR increase the likely-hood of adoption in China [OEM7, Supplier3]. In addition, two Chinese OEMs have already adopted AUTOSAR, which other actors on the market will notice and the results of these adopters can be observed.

6.2.3 Investment behaviour

In contrast to the factors described in Chapter 6.2.2, the chapter below presents factors which are less about perception, and rather concerns attributes companies possess affecting their investment behaviour.

There are three factors which is emphasised by Tripsas [37] to affect the investment behaviour of a company: technical capabilities, incentives to invest, and complimentary assets.

Technical capabilities

Technical capabilities have many attributes which is similar to how Rogers [35] describes how-to-knowledge. Lacking technical capabilities, Tripsas [37] argues, could lead to less incentives to invest in a new technology. Many interviewees describe that they possess knowledge in how to develop software as they always have. This is, according to them, a cheaper and safer way of developing software [OEM5, OEM9]. Tripsas [37] continues on technical capabilities talking about core competencies which might become core rigidities during a period of disruptive innovation. Disruptive and radical innovation hold many similarities. With AUTOSAR being defined as a radical innovation, these conceived core competencies might become core rigidities in the case of a shift towards AUTOSAR. However, during time of incremental innovation, these core competencies are often preferable and often enhance the end-result [37]. This means that as long as AUTOSAR is not diffused to affect enough companies, these core competencies will be enhanced all the way until they might become core ridgeties instead.

Investment factor

In addition to technical capabilities, Tripsas [37] notes the investment factor as important. Tripsas [37] argues that for a radical technological change, incumbents are less likely to invest than new entrants. In contrast, for incremental innovation incumbents are more likely to invest than new entrants. In the case of AUTOSAR in China, R&D requires a substantial input in order for there to be decent output. The automobile industry is an industry with high barriers to entry, making it harder for new entrants. Furthermore, AUTOSAR was developed by incumbent firms as a way to tackle existing problems. As such, the founders would naturally be the earliest adopters of AUTOSAR. In spite of incumbents being the earliest adopters, AUTOSAR is still defined as a radical innovation (for elaboration on this, see Chapter 6.1).

Another view on the investment factor is given by Bower and Christensen [20] who argue that companies should invest according to what end-customers want. During the interviews, many have addressed this. Some interviewees argue that as AUTOSAR does not add any functionality for end-customers, they would not have the incentive to pay for it [OEM3, OEM5, OEM9]. Similarly, managers are important in decision-making. Many interviewees have described a scenario where the engineers perceive the advantages and need for AUTOSAR differently in contrast to how managers perceive it. Similar to end-customers, managers focus more on functionality rather than architecture according to many interviewees [OEM5, OEM7, OEM9].

Complimentary assets

The third factor defined by Tripsas [37] is complimentary assets, which includes manufacturing capabilities, distribution channels, service network, and complimentary technologies. In the case of AUTOSAR, the first two does not apply as the shift to AUTOSAR does not affect neither the manufacturing capabilities nor the distribution channels. However, it might affect the service network improving the process of changing or enhancing the software in cars as AUTOSAR makes it possible to change part of the software on an ECU. Complimentary technologies for incumbent firms might also exist, such as various IDEs, which have been used to develop software.

6.2.4 Interconnections

Neither the perception of AUTOSAR, nor the investment behaviour of adopters fully cover how AUTOSAR is diffused. Interconnections and interdependencies does, too, affect the diffusion of AUTOSAR, which will be elaborated on below.

In the research presented by Rogers [35], these adopters are categorized according to their innovativeness (see Chapter 2.1). Early adopters are generally more willing to cope with risk, acting as gate-keepers in bringing new technology into the social system. In the context of AUTOSAR, these are the global OEMs, or more specifically the founders of AUTOSAR. Since the introduction of AUTOSAR in 2003, diffusion have taken place among global suppliers and OEMs, inspired by the early adopters. As role-models such as large OEMs - Volvo, Volkswagen - adopt AUTOSAR, more companies see that it is actually possible and feasible.

In the context of China, though, one must keep in mind that global OEMs have much influence. However, that does not imply that Chinese OEMs will adopt AUTOSAR in the same pace, nor in the same way. As the Chinese automobile market - OEMs, suppliers, etc. - looks different, there will be different business relationships and resources will be exchanged differently, as discussed by Gadde et al. [27]. This must be taken into consideration when applying the theories of Rogers [35] on AUTOSAR's diffusion in China. Actually, several criteria for Chinese OEMs who have adopted AUTOSAR are in-line with what Rogers [35] defines as innovators/early adopters. These OEMs must cope with an increased risk, as compared to those who have chosen not to adopt AUTOSAR yet.

The research by Gadde et al. [27] on industrial networks adds an understanding on interconnectedness between these adopters categorised by Rogers [35]. In the case of the Chinese automotive industry, companies operating there are definitely dependent on both Chinese companies as well as global companies. Firstly, there are several JVs between global OEMs and Chinese OEMs. This makes them interconnected. In addition, suppliers are, as mentioned earlier, allowed to set up a subsidiaries in China where they have no ownership-cap, in contrast to the OEMs. There are several global suppliers operating in China, and consequently affect what resources Chinese customers end-up with.

This phenomena result in that companies are able to develop further. On the other hand, Gadde et al. [27] notes, they might restrict companies' ways of operating creating lock-in effects. Especially so during times of technological discontinuities. As AUTOSAR have some traits suggesting that it is a disruptive innovation, these lock-in effects should not be ignored. In high-involvement relationships where companies are strongly interdependent, lock-in effect might take place.

As mentioned, one Chinese OEM buys the operating system for their suppliers [OEM3], controlling not only their business relationships, but their suppliers' business relationships too. There have been suggested that this is a common phenomena in the automobile industry. Another example of this is OEMs such as Volvo and Volkswagen adopting AUTOSAR more and more in the West, where one interviewee mentioned that as they do, suppliers will have to follow [OEM3, Supplier2]. An interviewee with a Chinese supplier noted that as they adopt AUTOSAR for a certain product, the product package of hardware + AUTOSAR-software will be sold exclusively and it will not be possible to order that product without AUTOSAR [Supplier3]. This is another example Gadde et al. [27] would explain as resources being interconnected with each other. As customers buy this AUTOSAR-product, they will be restricted in their way of choosing BSW due to their business relationships. One interviewee shared that as OEMs request for AUTOSAR-products, the range of hardware is decreased [OEM7].

This can be viewed in two ways using the framework for industrial networks presented by Gadde et al. [27]. On the one hand, the OEMs requesting AUTOSAR-products decrease their range of hardware, decreasing their potential partners and their potential business relationships. On the other hand, the companies (or products) which is not offered as AUTOSAR-compatible runs the risk of not acquiring technical capabilities which could be important in a potential trend-shift to AUTOSAR.

6.3 AUTOSAR-laggards

With increased adoption of the AUTOSAR standard - both in the Chinese market but also globally - the late majority and laggards will lack technical capabilities in the case of a trend-shift. There are several Chinese OEMs that have adopted AUTOSAR already. For example, one Chinese OEM are using AUTOSAR at one of their nodes [OEM3]. In addition, the creation of a platform using AUTOSAR nodes almost exclusively is being introduced in the Chinese market in one or two years time [OEM9]. There are also at least five OEMs who use part of the AUTOSAR standard, such as the AUTOSAR OS and the AUTOSAR MCAL. In another interview, a Chinese supplier suggested that they are to have AUTOSAR-compatible products in part of their product portfolio [Supplier2].

Furthermore, many interviewees suggested that they and many with them are ready for a shift to AUTOSAR, as they have seen the growing trend. One of our interviewees mentioned that their network management system would be able to cope with AUTOSAR nodes [OEM3]. In addition, many Chinese OEMs use AUTOSAR in R&D whereas some are working on their own tools giving them possibility to generate AUTOSAR-compatible software [OEM7, OEM9]. In sum, this all adds to an increasing loss for those who are not ready for a potential trend-shift. However, more companies seem ready for AUTOSAR as to those who use it in production.

Moreover, Gadde et al. [27] emphasise the importance of acquiring an information-rich position in a network. They note that by doing so, companies learn how to make best use of resources brought by external actors, and is preferable in contrast to deploying them in isolation. Since the introduction of AUTOSAR, companies have steadily adopted the AUTOSAR standard. If this continues, the companies who does not adopt the AUTOSAR standard might end-up deploying resources in isolation. However, as mentioned previously, many have realised this and have acquired information-rich positions describing that they are ready for a shift to AUTOSAR. In fact, four Chinese OEMs - First Automobile Works (FAW), Dongfeng Motor (DFM), SAIC Motor, and Great Wall - are already in the AUTOSAR collaboration, giving them frequent information about the AUTOSAR standard and its development. In addition, at least two Chinese suppliers are in the collaboration too [2].

7

Discussion

Below chapter presents a dissuasion based on the three hypotheses presented in the previous chapter.

7.1 Market hypothesis

There are macro-trends indicating a fastening of the diffusion of AUTOSAR. Firstly, the AUTOSAR collaboration was initiated by the major Western OEMs and suppliers, suggesting that these companies intend to use AUTOSAR. In turn, this might spread to smaller OEMs and suppliers being dependent on these companies, as suggested by Gadde et al. [27]. For example, Supplier3 argued that they are heavily influenced by the choices of large OEMs. When Western OEMs and suppliers adopt AUTOSAR, many interviewees have argued that this will lead to adoption of AUTOSAR in China too [OEM3, Supplier3].

In addition, several interviewees argue that Chinese OEMs are realizing the importance of investing in new technology [OEM7, Supplier3]. This is clear when looking at the changed R&D-spending among Chinese OEMs [14]. In addition, many acquisitions of Western technology have been made recently. Nothing indicates that these investments will lessen. Also, as discussed in Chapter 1, the amount of software have steadily increased. In the case of software, there are no indications that the amount of software in cars are decreasing. Rather, much point in the opposite direction where emission standards are increasingly tightened, autonomous driving is on the verge of being introduced, etc. This trend is something which have been picked-up on the Chinese market, where Supplier3 describe that many are ready for a shift to AUTOSAR.

Moreover, OEM7 argued that by adopting AUTOSAR, the range of hardware decrease. However, soon, the case might be different. Instead, the nature of the industry might change where those companies not providing AUTOSAR-solutions might have a decreased number of customers. These companies resisting AUTOSAR would end-up lacking technical capabilities, potential core competencies turning to core rigidities, as described by Tripsas [37], might be the case for these laggards. This could result in terrible losses, as several scholars indicate [28, 36].

7.2 Customer hypothesis

The general impression of the collected data is that the largest concern for Chinese OEMs and suppliers in the adoption phase of AUTOSAR is risk. This is clear in various ways. For example, many OEMs are afraid to take responsibility for the software, which often have been done by suppliers [OEM8, OEM9]. Many express the lack of technical capabilities, which are costly to acquire [OEM5, OEM8].

This problem must be tackled on various levels. High-ranking managers, for example, seem less positive to AUTOSAR than the engineers. However, these engineers who work with E/E architecture on a daily basis should naturally have more knowledge than high-ranking managers. In China, where the leaders decision is of great importance [OEM5], persuading these leaders will be critical. For high-ranking managers, principle-knowledge is important. They must understand why they should adopt AUTOSAR, and how implementation should be handled. This would surely decrease risk among high-ranking managers. As Rogers [35] notes, interpersonal contacts are of great importance here. In order to persuade these high-ranking managers, influence-makers must reach them to share their principle-knowledge. This knowledge must reach high-ranking managers in order for AUTOSAR to diffuse.

In addition to lacking principle-knowledge, most Chinese OEMs and supplier lack how-to-knowledge. This is another prevalent factor, which might influence high-ranking managers in their decision: they are aware of the high-cost linked to acquiring this knowledge.

There are other aspects, too, where knowledge-gaps must be addressed. For example, being responsible for that the software runs correctly and does not cause any errors will most likely end-up on the OEMs. Suppliers are not likely to take on that responsibility, as they have not produced themselves. Similar reasoning goes for AUTOSAR-implementers. It has been indicated that traditionally, the suppliers took responsibility for the software. By not doing so anymore, another risk-factor is added, which most likely have to be addressed by OEMs.

Moreover, there has been a shift in how cost is estimated in automotive E/E. Traditionally, hardware cost has been the greatest carrier whereas today software is carrying an increasingly large cost of automotive E/E [24]. This has not been realised by all members of the industry [OEM5, OEM7, OEM8]. Realizing the importance of software would benefit the diffusion of AUTOSAR.

7.3 Product hypothesis

Furthermore, most interviewees had a keen interest in AUTOSAR. Despite that, their technical capabilities and knowledge about AUTOSAR are lacking [OEM5, OEM8]. In the trainings which most AUTOSAR-implementers already have, there is a great opportunity to convey implementation-specific information regarding AUTOSAR. Focusing on this will be important for AUTOSAR-implementers entering the Chinese market; to fill in the how-to-knowledge-gaps described by Rogers [35]. In addition, knowledge about AUTOSAR from the AUTOSAR-collaboration could be presented clearer. They, too, have incentives to have additional members to the AUTOSAR-collaboration. As of today, there are mostly specification files available, which are not easy to learn from.

Moreover, to address this knowledge-gap during the implementation phase, the importance of good support has been mentioned [Supplier2]. From that, the assumption that customers would feel safer knowing that an AUTOSAR-implementer provide good support was made. Conveying that is not an easy task. As employees of AUTOSAR-implementing companies would be perceived as biased, this information must come from elsewhere. Possibly, an interactive interface at AUTOSAR-implementers website could be developed where customers are encouraged to add reviews. This would decrease uncertainty in such a transaction. In addition, it would give incentives for the AUTOSAR-implementers to provide high-quality support. Conveying this information could also be done mouth-to-mouth. However, as relatively few Chinese companies use AUTOSAR today, this might not be very effective. Moreover, many have shared that lacking knowledge on AUTOSAR has been a hinder [OEM5, OEM8]. In addition, AUTOSAR-Implementer2 mentioned that a stripped AUTOSAR-version could help addressing this adjusting the technology towards its customers, as described by Holmström and Stalder [31], rather than the other way around.

To further meet customers' needs, Rogers [35] suggest re-invention as a mean to do so. When AUTOSAR-implementers issue a trial-license, this is the first step in interaction with potential customers. This opportunity must be seized and the information they provide should in some way be captured. Creating a systematic way of handling these licenses would benefit re-invention, which Rogers [35] argues is a way to increase the pace of diffusion.

Three interviewees also mentioned the tool-chain as a problem of adoption in China. They argued that different AUTOSAR-implementers' tools did not sync with each other. This could either be knowledge-gaps, or a flaw in the tool-chain of AUTOSAR; the answer probably lies in both. The former have been experienced by global OEMs too: the tools of AUTOSAR-implementers was not mature enough. The latter could be addressed by AUTOSAR-implementers cooperating to make sure their tools sync. However, this research does not have enough data to make claims on this matter.

Last, six interviewees have argued that the cost of AUTOSAR tools and licenses are high. As the adoption of AUTOSAR increase, the price might decrease as supply might exceeds demand.

8

Conclusion

The purpose of this research has been to investigate the diffusion of AUTOSAR in China. More specifically, what diffusion-factors that hinders the adoption of AUTOSAR and how these can be addressed. The Chinese market's automobile sales account for more than 23M cars annually, where most of the Chinese OEMs are not using AUTOSAR-implemented software in mass-production today. In order to identify these diffusion-factors, understanding how above mentioned parties perceive AUTOSAR is critical. Thus, a case study was conducted, where interviews were held with representatives from these affected parties. The data gathered during these interviews have been analysed with the theoretical framework in order to understand the diffusion process of AUTOSAR in China.

Furthermore, this research conclude factors affecting the diffusion of AUTOSAR and discuss how these could be addressed. There are macro-factors which suggests that AUTOSAR are likely to diffuse in China. Firstly, since AUTOSAR was initiated by major Western OEMs and suppliers it is likely that they will adopt the standard. As stated earlier, AUTOSAR has many traits suggesting it is a radical innovation. As such, in this thesis, AUTOSAR is considered a radical innovation. Furthermore, in the case of AUTOSAR, incumbent firms - the six major Western OEMs and suppliers - are likely to adopt the standard first, which contradicts Tripsas [37] theory on firms' investment behaviour. In contrast, AUTOSAR does have traits suggesting that it is an incremental innovation too. As AUTOSAR was initiated by incumbents, it indicates that AUTOSAR might not be that radical after all. This, since the AUTOSAR-standard is based on the knowledge of the incumbents initiating AUTOSAR, it is based on these incumbents' previous knowledge, which could be argued an incremental innovation.

Regardless of categorization, AUTOSAR is suggested to have an increasing influence in the Chinese automotive industry. As the world is becoming more and more interconnected, where Chinese OEMs and suppliers are increasingly dependent on resources of the global automotive industry. This is something which Gadde et al. [27] would refer to as an industrial network with increased range, including more parties where parties' influence are changed over time. Moreover, Chinese OEMs have started realizing the importance of investing i R&D, paving way for investing in AUTOSAR. There is also an increase in acquisitions of Western companies and, as such, their technology. Lastly, software will be an increasingly integral part of cars.

However, on a micro-level, there are factors which must be addressed in order for AUTOSAR to diffuse. The most prevalent factor identified is risk, which refers to the risk of being accountable for potential errors in the software and its implication. Firstly, the responsibility of software is a risk many OEMs are resisting to take-on. However, adopting AUTOSAR, this is something OEMs must learn to take-on. This has its roots in knowledge-gaps, which Rogers [35] defines as how-to-knowledge, which Rogers [35] argues in an important hinder in a diffusion process. Furthermore, how-to-knowledge in how to implement software with a new BSW must be acquired. Similarly, principle-knowledge about AUTOSAR and its advantages is generally lacking, which Rogers [35] argues is another element to increased risk during the adoption phase of new innovation. This must be addressed, too, in order for AUTOSAR to diffuse. Often, these various types of knowledge must be acquired in different hierarchies in an organisation. Principle-knowledge about benefits of AUTOSAR will be important to convey to decision-makers, whereas how-to-knowledge is more important among engineers. Last, software-cost is of increased importance for actors in the automotive industry. However, this increase is not recognized by all industry members. This must be carefully considered by affected parties in the diffusion process.

Furthermore, the initial product hypothesis suggested a scaled down version of AUTOSAR, which would have less of a footprint on the hardware, would increase the rate of the diffusion. However, the case study showed that it was rather the knowledge-gap than the hardware-cost that was most essential.

The major AUTOSAR-implementers all hold training courses where implementation-specific knowledge is taught. In these training courses, the knowledge-gaps presented in above section should be addressed. Another party in a position to spread in-depth knowledge on AUTOSAR is the AUTOSAR-collaboration itself. In addition, providing good support/services is important for AUTOSAR-implementers. Conveying this to lower the risk further in the adoption stage would further decrease risk and increase the rate of adoption. AUTOSAR-implementers product could also be adopted addressing knowledge-gaps. This by providing a stripped version of AUTOSAR where certain parameters are excluded. Doing so, the knowledge-gaps are addressed from both the product and the customer perspective.

Another way of meeting customers' needs is re-invention. Most AUTOSAR-implementers provide trial-licenses for a shorter period. One way to increase the rate of adoption is to create a strategy for handling these, acquiring the Chinese customers' views, which would be a way to perform re-invention. Two additional factors affecting the diffusion of AUTOSAR have been identified. First, the maturity of the tool-chain is identified as a problem. Second, the price of AUTOSAR tools and licences is high. Unfortunately, this research does not contain data to suggest how to resolve these problems.

These recommendations are not only important for Acme, but also for Chinese OEMs and suppliers. As a whole, the Chinese automotive industry might benefit from the result of this research.

Last, this research presents a theoretical framework addressing the diffusion of AUTOSAR in China. As such, the theoretical framework is adopted for diffusion of software in a B2B-context. Similar problems could be addressed using this framework in the future. However, the researches using it must take into consideration that a diffusion process is a highly social activity with many elements of complex interdependencies which must be studied.

8.1 Limitations

First limitation to this study is that the Western market is not analyzed thoroughly. This would increase the significance of the results as they have big influence in the Chinese automobile market. In addition, there are several other forces such as end-customers and politicians whom have not been interviewed nor their views have been taken into account much. Studying how these forces affect each other and which is most significant would better the result of this study.

Another limitation to the presented research is how AUTOSAR should be defined in the context of the framework which have been used. As argued earlier, AUTOSAR has traits suggesting that it is a radical innovation, and traits which suggest it is an incremental innovation. To gain an understanding in this would help when applying the theoretical framework on the gathered data.

8.2 Future research

After concluding this research, several topics of interest have been found.

Firstly, diffusion is a complex process, especially so in markets where several external forces affect the studied innovation's diffusion. As AUTOSAR still is relatively immature, and in China relatively few use AUTOSAR. This results in that the gathered data could only be used to address the early phases of diffusion, where phases such as the implementation and the confirmation stage defined by Rogers [35] has not been studied. This could be a mean for future research as the standard matures and more Chinese customers adopt it.

Firstly, defining whether AUTOSAR is a radical innovation or an incremental innovation has been complicated, as described in Chapter 8.1. In order to give more relevance to the theoretical framework presented in Chapter 2, knowledge about how to define AUTOSAR would help significantly.

In addition, research on how cost is accounted for in the automobile industry would add to the research on automobiles and would increase the knowledge on what cost-carriers cars have today.

Moreover, not many seemed to think that a scaled-down AUTOSAR version the main decider in the diffusion of AUTOSAR. However, this might still be interesting as many both Western and Chinese OEMs have some ECUs in their vehicles which are less software-intense. Similarly, many OEMs argue that it is preferable if all nodes use the same BSW. In this sense, a scaled-down AUTOSAR-version could be needed and thus, research for how this could be performed more in-depth than this research provide is needed.

In addition, as mentioned above, the lack of knowledge in AUTOSAR is clear. To tackle this, a stripped version of AUTOSAR – where the interface basically is the point of improvement – could reach customers. Instead of them learning, the software could be simpler and easier to configure. However, how this stripped version of AUTOSAR might be designed still needs research.

Lastly, this research argues that interplay between various actors on the Chinese market strongly affect how AUTOSAR is diffused. However, the interviews have only provided slight indications on how this interplay is affected in the diffusion of AUTOSAR. A starting point to this could be to contrast the number of OEMs to the number of suppliers, which would give an indication of how these parties affect each other.

Bibliography

[1] China's automotive market. [Online]. Available: http://www.accenture.com/sitecollectiondocuments/pdf/chinas-automotive-market-cosumer-digital-marketing-insights.pdf

[2] Autosar. [Online]. Available: http://www.autosar.org/

[3] Not even chinese state tv can make people buy local cars. [Online]. Available: http://www.bloomberg.com/news/articles/2015-03-18/not-even-chinese-state-tv-can-make-people-buy-local-cars

[4] China said to consider $16 billion ev-charging fund. [Online]. Available: http://www.bloomberg.com/news/articles/2014-08-26/china-said-to-consider-16-billion-ev-charging-funding

[5] Crash test: Here's why chinese cars are not ready for primetime. [Online]. Available: http://www.businessinsider.com/chinese-cars-crash-tests-2011-11?IR=T

[6] The sales and production of automobiles kept a steady growth. [Online]. Available: http://www.caam.org.cn/AutomotivesStatistics/20150114/0905144504.html

[7] New energy vehicles enjoyed a high-speed growth. [Online]. Available: http://www.caam.org.cn/AutomotivesStatistics/20150416/1305155133.htmlhttp://www.caam.org.cn/AutomotivesStatistics/20150416/1305155133.html

[8] Opportunities and challenges in china's electric vehicle market. [Online]. Available: http://www.chinabusinessreview.com/opportunities-and-challenges-in-chinas-electric-vehicle-market/

[9] China's provincial gdp figures in 2012. [Online]. Available: http://www.china-briefing.com/news/2013/05/16/chinas-provincial-gdp-figures-in-2012.html

[10] Automotive industry. [Online]. Available: http://www.export.gov/China/doingbizinchina/leadingsectors/eg_cn_081019.asp

[11] Inpact on beijings license quota system on the chinese automotive industry. [Online]. Available: http://www.ey.com/Publication/vwLUAssets/Impact_of_Beijings_license_quota_system_on_the_Chinese_automotive_industry/$FILE/Auto_Beijing.pdf

[12] China's indigenous brand policy backfires. [Online]. Available: http://www.ft.com/intl/cms/s/0/02756814-cc5a-11e3-9b5f-00144feabdc0.html#axzz3b2hCNt2M

[13] China phase 4 passenger car fuel consumption standard proposal. [Online]. Available: http://www.theicct.org/sites/default/files/publications/ICCTupdate_ChinaPhase4_mar2014.pdf

[14] Can chinese car companies finally succeed in 2015? [Online]. Available: http://www.mckinseychina.com/can-chinese-car-companies-finally-succeed-in-2015/

[15] China car sales top u.s. [Online]. Available: http://www.reuters.com/article/2010/01/11/us-autos-idUSTRE60A1BQ20100111

[16] China average yearly wages in manufacturing. [Online]. Available: http://www.tradingeconomics.com/china/wages-in-manufacturing

[17] United states average hourly wages in manufacturing. [Online]. Available: http://www.tradingeconomics.com/united-states/wages-in-manufacturing

[18] Gdp per capita (current $us). [Online]. Available: http://data.worldbank.org/indicator/NY.GDP.PCAP.CD

[19] S. Blank, *The four steps to the epiphany*. K&S Ranch, 2013.

[20] J. L. Bower and C. M. Christensen, *Disruptive technologies: catching the wave*. Harvard Business Review Video, 1995.

[21] M. Broy, "Challenges in automotive software engineering," in *Proceedings of the 28th international conference on Software engineering*. ACM, 2006, pp. 33–42.

[22] A. Bryman and E. Bell, *Business research methods 3e*. Oxford university press, 2011.

[23] S. Bunzel, "Autosar–the standardized software architecture," *Informatik-Spektrum*, vol. 34, no. 1, pp. 79–83, 2011.

[24] J. Dannenberg and C. Kleinhans, "The coming age of collaboration in the automotive industry," *Mercer Management Journal*, vol. 17, no. 88-94, p. 66, 2004.

[25] K. M. Eisenhardt, "Building theories from case study research," *Academy of management review*, vol. 14, no. 4, pp. 532–550, 1989.

[26] S. Fürst, "Challenges in the design of automotive software," in *Proceedings of the Conference on Design, Automation and Test in Europe*. European Design and Automation Association, 2010, pp. 256–258.

[27] L.-E. Gadde, L. Huemer, and H. Håkansson, "Strategizing in industrial networks," *Industrial Marketing Management*, vol. 32, no. 5, pp. 357–364, 2003.

[28] A. Glasmeier, "Technological discontinuities and flexible production networks: The case of switzerland and the world watch industry," *Research policy*, vol. 20, no. 5, pp. 469–485, 1991.

[29] B. Hardung, T. Kölzow, and A. Krüger, "Reuse of software in distributed embedded automotive systems," in *Proceedings of the 4th ACM international conference on Embedded software*. ACM, 2004, pp. 203–210.

[30] E. Harwit, "The impact of wto membership on the automobile industry in china," *The China Quarterly*, vol. 167, pp. 655–670, 2001.

[31] J. Holmström and F. Stalder, "Drifting technologies and multi-purpose networks: the case of the swedish cashcard," *Information and Organization*, vol. 11, no. 3, pp. 187–206, 2001.

[32] J. Mössinger, "Software in automotive systems," *IEEE software*, no. 2, pp. 92–94, 2010.

[33] M. E. Porter, *Competitive advantage: Creating and sustaining superior performance*. Simon and Schuster, 2008.

[34] A. Pretschner, M. Broy, I. H. Kruger, and T. Stauner, "Software engineering for automotive systems: A roadmap," in *2007 Future of Software Engineering*. IEEE Computer Society, 2007, pp. 55–71.

[35] E. M. Rogers, *Diffusion of innovations*. Simon and Schuster, 2010.

[36] C. Sandstrom, "Facit and the displacement of mechanical calculators," *Annals of the History of Computing, IEEE*, vol. 35, no. 3, pp. 20–31, 2013.

[37] M. Tripsas, "Unraveling the process of creative destruction: Complementary assets and incumbent survival in the typesetter industry," *Strategic Management Journal*, vol. 18, no. s 1, pp. 119–142, 1997.

A

Interview-guide

- In your opinion, what car-segments (price-wise) exists in China and how do you see volume growth in these segments?
  - In which segment do you consider yourself and where do you strive to be?
- What is the biggest difference buying from local vs. global suppliers?
- What are your views of Autosar?
- Why do you think Autosar is important – both for OEMs and suppliers respectively?
- What would be your gain by implementing Autosar?
- Does your cars have any ECUs carrying Autosar software, or are to in the coming years?
- How does the software development process look like for you - In house/buying software from suppliers?
  - When buying from a supplier, do you have requirements on what OS/BSW that is used?
  - Apart from the OS/BSW, do you set any other requirements? If so, what are these?
- Why do you believe a standard such as Autosar is not yet widespread in China? Which parties affect whether a standard such as Autosar is spread or not? What must happen in order for it to spread?
- Do you have any perception of how much cost of an ECU is carried by software? If so, what would you estimate this number to be?
- How much functionality is re-used in the coming car models (or coming ECU architectures) and how much code has to be re-written?

- Is it possible to estimate the price-difference for an ECU able to carry Autosar and one who is not? If so, could you specify your estimate?
- From our understanding, hardware cost-per-unit is very important within the automobile industry. As Autosar demands much from the hardware, we have been thinking in terms of a scaled-down version of Autosar.
  - Is cost-per-unit the biggest hinder in an adoption of Autosar?
  - What are your views on a scaled-down Autosar version? You think that could help the diffusion of Autosar in the Chinese market?