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TECHNOLOGICAL DEVELOPMENT AND ITS IMPACT ON THE AUTOMOTIVE INDUSTRY'S VALUE CHAINS

Master of Science Thesis

Examiner: Lecturer Risto Mikkonen
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ABSTRACT

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This Master's thesis studies the ways new technologies affect the automotive industry's value chains. The industry's revenues are shifting from hardware to software and from products to services, influencing the traditional players' roles, business models and operations, and attracting new players from other industries. The trends driving these changes are based on connectivity, infotainment, ADAS, autonomous driving, and new mobility services. This thesis also investigates what possibilities these changes can bring to Finland.

In this thesis, theory about value creation and value chains was studied from literature. Technology trends and changes in the industry's value chain structures were studied by getting information from literature and interviews, and by analyzing the traditional players' activity on acquiring capabilities related to new technologies.

Many of the new innovations will come from other industries, and especially the number of agile players entering the automotive market from the ICT-industry are likely to increase. These new technology suppliers and service providers have become a part of the automotive value chain, complementing it to help answer the customer demand and safety regulations. New technologies are shaping the value chain and forming a value network around the traditional tiered value chain. The traditional players need to gain internal and external software know-how and cooperate with the new entrants to succeed in developing intelligent vehicles and bringing new kinds of services to the customers.

The broad Finnish expertize on multiple areas can be transferred to answer the needs of the automotive industry on connected cars, autonomous driving and developing new services. However, Finland needs more companies, deeper understanding on how the automotive industry works, and raising awareness about Finland's innovative ecosystem in order to succeed in the automotive market and to attract foreign investments.

TIIVISTELMÄ

LAURA PITKÄAHO: Teknologinen kehitys ja sen vaikutus autoteollisuuden arvoketjuihin
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Tässä diplomityössä tutkitaan uusien teknologioiden vaikutusta autoteollisuuden arvoketjuihin. Autoteollisuuden rahavirrat muuttuvat raudasta ohjelmistoihin ja tuotteista palveluihin, vaikuttaen perinteisten pelureiden rooleihin, liiketoimintamalleihin ja toimintoihin, sekä houkutellen uusia pelureita toisilta teollisuuden aloilta.

Työssä tutkittiin kirjallisuudessa esiintyviä teorioita arvonluonnista ja arvoketjuista. Tietoa teknologiatrendeistä sekä muutoksista autoteollisuuden arvoketjuissa hankittiin tutkimalla kirjallisuutta ja haastatteluiden avulla, sekä analysoimalla perinteisten pelureiden aktiivisuutta uusiin teknologioihin liittyvän osaamisen hankinnassa.

Monet uusista innovaatioista tulevat muilta teollisuuden aloilta, ja erityisesti ICT-aloilta tulee uusia ketteriä pelureita enenevissä määrin mukaan autoteollisuuteen. Näistä teknologiatoimittajista ja palveluntuottajista on tullut osa autoteollisuuden arvoketjua, täydentäen sitä, ja auttaen vastaamaan muuttuvaan kysyntään sekä turvallisuussäädöksiin. Uudet teknologiat muovaavat arvoketjua luoden arvoverkoston perinteisen portaittaisen ketjun ympärille. Perinteisten pelureiden tulee hankkia ohjelmisto-osaamista sekä sisäisesti että ulkoisesti, ja toimia yhteistyössä uusien pelureiden kanssa onnistuakseen älykkäiden ajoneuvojen kehittämisessä ja tuodakseen uusia palveluita asiakkaille.

Suomalainen osaaminen on siirrettävissä useilta sektoreilta autoteollisuuteen, täten auttaen vastaamaan verkottuneiden autojen, itseohjautuvien autojen ja uusien palveluiden kehityksen tarpeisiin. Suomeen tarvitaan kuitenkin markkinoilla menestymiseksi ja ulkomaisten investointien houkuttelemiseksi lisää alalla toimivia yrityksiä, syvempää ymmärrystä siitä, miten autoteollisuudessa toimitaan, sekä tietoisuuden nostattamista Suomen tarjoamasta innovatiivisesta ekosysteemistä.

FOREWORD

This thesis was done for Finpro's Invest in Finland unit. The examiner for this thesis was Lecturer Risto Mikkonen and supervisors from Invest in Finland were M.Sc. Markku Lehikoinen and M.Sc. Teuvo Heikkinen. I want to thank you for your guidance. Special thanks goes to Kirsi Kokko from Finpro for providing me this opportunity. I am forever grateful.

There is a reason why the time spent during studies is said to be people's best time. I want to thank my friends from TUT and Skilta for all the fun times. I want to thank my parents and Matias' parents for all the support during our studies. You are priceless for us. Also, thank you Mari for providing us free accommodation during summer jobs.

Lastly, I want to express my gratitude for the endless support and love you have given me during these five years, Matias. Let's enjoy the journey there is still ahead of us!

Tampere, December 14th, 2016

Laura Pitkäaho

CONTENT

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LIST OF ABBREVIATIONS

5G	Next Generation Mobile Networks
ADAS	Advanced Driving Assistance System
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
BYOD	Bring-Your-Own-Device
DSRC	Dedicated Short-Range Communication
ECU	Electronic Control Unit
EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
GII	Global Innovation Index
GNSS	Global Navigation Satellite System
HMI	Human-Machine Interface
HUD	Head-Up Display
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IVI	In-Vehicle Infotainment
LTE	Long-Term Evolution, a standard for high-speed wireless communication for mobile phones and data terminals
M&A	Mergers and Acquisitions
MCU	Microcontroller Central Unit
NHTSA	National Highway Transportation Safety Administration
OBD	On-Board Diagnostics
OBU	On-Board Unit
OEM	Original Equipment Manufacturer
OTA	Over-the-Air
R&D	Research and Development
RSU	Road-Side Unit
SAE	Society of Automotive Engineers
SIM	Subscriber Identity Module
SME	Small and Medium-sized Enterprise
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VBO	Vehicle Brand Owner

1. INTRODUCTION

The automotive industry has gone through major changes in the past decades resulting in shifts in the responsibilities and value creation in the value chain. With advanced ICT-technologies, changing customer demands and steering regulations, the industry is evolving faster than before and facing new challenges. The traditional players race to keep up with the new innovations and to meet their customers' expectations. OEMs (Original Equipment Manufacturers) and suppliers need to restructure their competencies in order to avoid added-value and revenues moving to new entrants. The focus is also shifting towards services and new business models will be emerging. As new innovations are also coming from adjacent industries, all the players need to cooperate to succeed (figure 1).

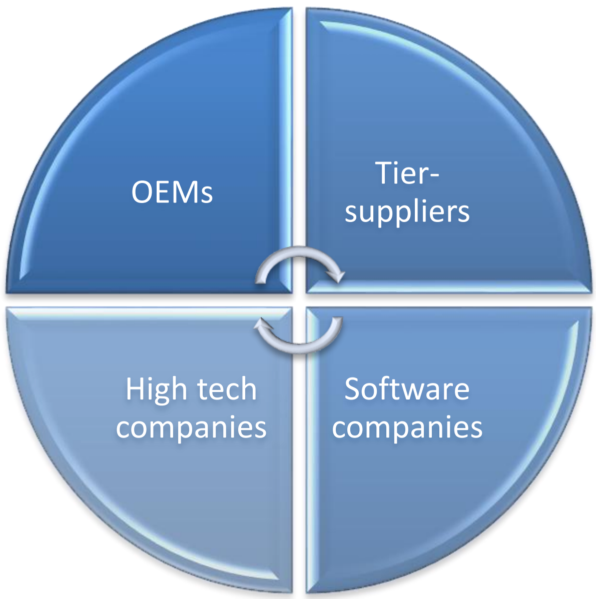

Figure 1 New and traditional players transforming the industry (author's view)

The purpose of this thesis is to study how the automotive industry is changing via technological development, and how this affects the industry's value chain. The disrupting trends are: connected cars, automated driving and new mobility services. We will also observe what possibilities this offers to Finland. Finnish experts from research sectors and companies are interviewed on their perspectives about the ongoing changes.

The objectives of this research are as follows:

1. How do the new technologies affect the automotive industry's value chain?
2. Do these changes offer new opportunities for Finland?

Firstly, we will examine literature about value creation and global value chains. We will also define the traditional automotive value chain and take a look at the history on how it has been transformed before. In the next section, we will go through the new technology trends disrupting the industry and legislation aspects are briefly overviewed as well. In the fourth section, we will examine how these trends are affecting the value creation and value chain structures. The fifth section contains results of the interviews and the next section continues to present the Finnish offering. Lastly, the findings of the study are presented in the conclusions.

2. VALUE CHAINS

Value chains can be used to present value-adding activities and roles of key players on product or service creation towards end use. The chains can be analyzed from a level of a single firm to containing the whole industry, and from a local level to global scope. In the next sections, value creation, global value chains and automotive industry's value chain are examined.

2.1 Value creation

Value is the difference between customer's evaluation of all the benefits and costs of an offering. The companies address customer needs by value proposition, which is a combination of products, services, information and experiences, that satisfy those needs. (Kotler and Keller 2012, p. 32, 146) Value chain is set of value-added activities linked together from handling raw materials to production and towards end customer.

A few decades ago the core expertise of many industrial companies was manufacturing. As only few had capabilities for manufacturing, it delivered a substantial part of the overall value of the product. Today, manufacturing capabilities are not a differentiating factor and it can be outsourced. This has led to increasing importance of the factors before and after manufacturing in value creation. To increase value, companies develop technologies, products, services and brand to create intangible assets. (Ali-Yrkkö, 2013, p. 5-22)

Global competition, changing markets and new technologies enable new ways to create value. With the new opportunities also greater risks appear when these changes open doors for new entrants from even previously unrelated industries. (Normann and Ramirez, 2000, p. 65)

According to Normann and Ramirez (2000), successful companies reinvent value instead of just adding it. The key strategic task to successfully create value is the reconfiguration of roles and relationships among different actors in value creating system (suppliers, partners, allies and customers) in order to mobilize the creation of value in new forms and by new players. Value creation is not only about the companies making their offerings more intelligent but making their customers and suppliers more intelligent as well. This is achieved by continuously redesigning their competencies and relationships in order to keep value-creating systems adaptable. The core competencies in value creation are the technologies, specialized expertise, business processes and techniques that the company has compiled and exploits them in the company's offering in a way that customers are willing to pay for them. Companies must invest in continuously broadening their competencies and to combine the gained resources of knowledge to their offerings. Normann and Ramirez (2000) point out that these investments can become so large that the company's offerings to existing customers base are no longer adequate to regain its investment. This leads to companies entering to new businesses and even outside their traditional industry in search for new customers.

Company's innovation capabilities are a key to higher value creation. However, the company's success in the market through its innovations depends on the accompanying changes in the whole ecosystem, both upstream and downstream the company's value chain. (Adner and Kapoor 2010) The upstream part of the chain includes segments from raw materials to final production and the downstream part segments from final production towards end customer and to the rest of the products life cycle. In technology-driven markets, no company can possess all the resources needed to create innovative products (Anderson et al. 2009, p. 141). This means that often other players upstream of the value chain face innovative challenges so their components will not limit value creation higher the chain, and also downstream the chain so that the customers' ability to benefit from the product won't be constrained. (Adner and Kapoor 2010)

As the customer expectations and demand for specific features and services change over time, the players in the industry need to meet these expectations and even be ahead of the customers by keeping track on the future trends. As the trends change, so can the part of the offering what customers value the most and thus changing the proposition of value added between different players and shaping the players' relationships.

2.2 Global value chains

Technological change has a major role in industries structural changes and in creating new industries. New technologies and innovations can erode the market position of well-entrenched companies and provide a path for others to the forefront. (Porter 1998, p. 164). Porter presents value chain as a tool to understand the role of technology as a competitive advantage. He states that technology is embodied in every activity of the value chain and that technological change can impact virtually any activity. Porter (1998) views value chain at a level of a single firm but the value chain aspects can be studied on an industry level as well.

Kogue (1985, p. 15) states that the value-added chain is the process by which technology is combined with material and labor inputs, and then processed inputs are assembled, marketed, and distributed. A single firm may consist of only one link in this process, or it may be extensively vertically integrated. The value chain can be defined in the terms of the contribution of each link to market value. This leads to a mapping of the product attributes upon the links of the value chain that are most strongly desired by customers. This means, that once the customers' desires on a product, and the value-added chains that generate those attributes to bring present and potential competitive advantage are identified, the implication for resource allocations is to shift investment from other links to the most value-added links in the chain.

Sturgeon (2000, p. 6-7) defines the term value chain as a particular, product based thread of activity that, at a given moment in time, runs through a larger constellation of activities and dynamic configurations embodied in a production network. He states also, that a value chain can be thought as a sub-set of a production network, a snapshot taken within the much more complex and dynamic set of activities encompassed by the network. The value chain is a tool that will allow the distillation of the steps taken to get a particular product to market and to clarify the concrete activities of the key players. In short, value chain can be defined as a sequence of value-added activities leading to end use.

According to Gereffi & Fernandez-Stark (2011), Global Value Networks framework helps us to understand how global industries are organized by examining the structure and dynamics of different actors involved in the specific industry:

> *"It examines the job descriptions, technologies, standards, regulations, products, processes, and markets in specific industries and places, thus providing a holistic view of global industries both from the top down and the bottom up."*

Gereffi & Fernandez-Stark also points out, that it is important to study the evolution of the industry and the trends that have shaped it in order to understand the entire chain.

Global value chain is based on four dimensions (Gereffi & Fernandez-Stark, 2011 and Gereffi, 1995):

1. A value-added chain of products, which describes the process of transforming raw materials into final products.
2. A geographical dispertion of production and marketing networks.
3. A governance structure of authority and power relationships between the firms that determines how financial, material, and human resources are allocated and flow within a chain; how the value chain is controlled.
4. An institutional framework that identifies how local, national, and international conditions and policies shape the industry.

The value chain structure represents the entire process of product's production from raw materials into final product. The main segments vary by industry, but usually they include R&D (research and development), inputs, production, distribution, marketing and sales. The segments of the chain illustrate how different value adding processes contribute to the product (Gereffi & Fernandez-Stark, 2011) and how they are involved in different activities through upstream and downstream linkages. The value chain's segments illustrate how identified players are positioned in the chain and their key characteristics.

The geographical analysis is helpful to identify the shifts in the geographical scope of global industries. Due to the globalization of industries, the value chains are globally dispersed and different activities may be carried out in different parts of the world. Developing countries usually offer low-cost labor for manufaturing and developed western countries have higly educated workforce available for R&D operations. (Gereffi & Fernandez-Stark, 2011)

Governance analysis helps one to understand how the chain is controlled and coordinated when some of the actors have more power than others. It also facilitates entry and development of the firms in the specific chain. With the analysis can be explained whose behaviour needs to change if different outcomes are emerging in the value chain. The form of governance can change as an industry evolves and a value chain can be characterized by multiple governance structures. (Gereffi & Fernandez-Stark, 2011 and Kaplinsky & Morris, 2001)

In the institutional framework global value chains are embedded within economic, social and institutional dynamics. Local economic conditions include the availability of key inputs, which are labor costs, available infrastructure and acces to other resources such as finance, social dynamics include the availability of labor and its skill levels, and institutions includes tax and labor regulations, subsidies, education and innovation policy that can promote industry growth and development. (Gereffi & Fernandez-Stark, 2011)

Aggording to Gereffi (1995, p. 113-118) the governance structure in global value chains can be divided into “buyer-driven” and ”producer-driven” value chains. *The buyer-driven structure* is typical in labor-intensive consumer goods industry such as footwear, toys and consumer elecronics. The core companies usually design, but do not make, the products or even own any production facilities. They are branded marketers who rely on complex overseas networks, which perform most of the product development, manufacturing, packaging and shipping. Their production networks are mostly located in the third world countries with low-cost workforce. *The producer-driven structure* is capital- and technology-intensive, and where large industrial enterprises control the production system. The geographical spread and the level of development of the countries in this structure is more varied as the production is based on flexible equipment, customized parts and relatively skilled workforce in industrial districs where cooperative networks form to facilitate innovation and adaption. An example of producer-driven structure is the automotive industry.

Recently, more detailed governance structures has been identified. The five structures has been determined by the complexity of the information between actors in the chain, how the information for production can be codified and by the level of suppliers competence (Gereffi et al., 2005 and Gereffi & Fernandez-Stark):

Market - The governance involves transactions that are relatively simple. The product is standard, or the supplier defines it without specific instructions from particular customers. The central governance mechanism is price rather than lead firms. The risks to buyers are low since the requirements are easy to meet and the cost of switching to new partners is low.

Modular – Suppliers make products to a customer’s specifications. The product is more complex than in market structure, but sufficiently modular in design that information regarding the product can be specified for clear product and quality guidelines. Suppliers take full responsibility for competencies surrounding process technology and make capital outlays for components and materials on behalf of customer. Relationships are more substantial than in market structure because of the high volume of information flowing between companies.

Relational – The governance includes complex interactions between buyers and sellers, which often creates mutual dependence and high levels of asset speficity. Here buyers and sellers rely on complex information that is not easily transmitted or learned and is resulted in frequent knowledge sharing between parties, requiring trust and generating mutual reliance. However, lead firms still specify what is needed, and they have the ability to exert control over suppliers. Suppliers are likely to supply differentiated products based on unique characteristics in these value chains. The linkages take time to build, so the costs and difficulties to switch to a new partner tend to be high.

Captive – Small suppliers are transactionally dependent on larger buyers. The capabilities of suppliers are low and detailed instructions and standards are required in order to deliver the level of quality required by lead-firms. These networks are characterized by a high degree of monitoring and control by lead firms and the suppliers face significant switching costs.

Hierarchy – Characterized by vertical integration and managerial control within lead firms that develop and manufacture products in-house. This kind of chain usually occurs when products are complex or highly competent suppliers cannot be found.

According to Kaplinsky and Morris (2001, p. 29-34), value chains are governed when parameters requiring product, process, and logistic qualifications are set and they have consequences up or down the value chain covering different activities, players, roles, and functions. Governance is important in the role of coordination, positioning the roles of different players along the value chain and in relation of the integration of components into the design of the final products, and the quality standards concerning the integration.

Under competitive pressures, the firms need to perform their activities more efficiently or change their activities. A key capability for the companies to increase their competitiveness and value proposition is through innovation. However, if the innovation rate is lower than competitors, it may result in declining value added and affect their market shares. This is why innovations and development cycles has to be compared to the ones of competitors. A process of moving to higher value activities through innovations can be referred to as *upgrading*. (Kaplinsky & Morris, 2001 p. 37) Humphrey & Schmitz

(2002) have identified four upgrading patterns to maintain or improve position in the global value chain:

1. Process upgrading – transforming raw materials into final products more efficiently by reorganizing the production system or introducing superior technology.
2. Product upgrading – increasing value in the product, moving into more sophisticated product lines.
3. Functional upgrading – increasing the overall skill content of activities by acquiring new functions or abandoning existing ones.
4. Chain upgrading – Horizontal movement into new sector, when a firm uses its competencies to enter new, usually related industry.

The governance and upgrading are linked together, as many chains are characterised by a dominant party who becomes responsible for upgrading activities within the chain and coordinating interaction between players. (Kaplinsky 1998, p. 13-14)

2.3 Value chains in the Automotive Industry

Automotive industry's value chain consists of tiered supply chain, manufacturing, sales and after sales functions. Traditionally, OEMs designed and assembled the vehicles, producing 60-70 % of the value of the cars in-house (Humphrey, 2003 p. 123). Tier-1 suppliers manufactured and supplied components directly to OEMs, Tier-2 suppliers produced simple individual parts directly to tier-1 suppliers and the next tiers supplied mostly raw materials (Veloso & Kumar, 2002 p. 12). However, the value chain structure has shaped as a result of globalization, outsourcing and modularization. Today, estimated 82 % of the value-added has been shifted to the suppliers (Statista, 2015). The trend of the value shift is presented in picture 1.

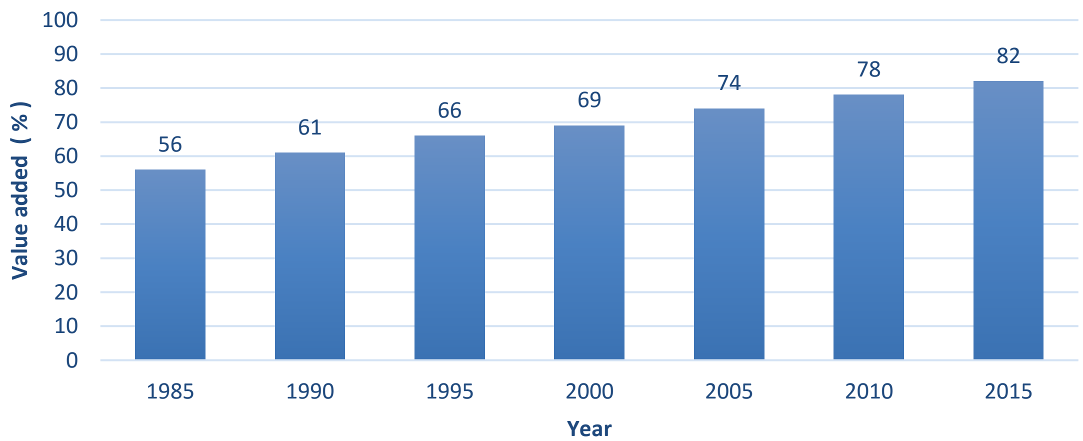

Figure 2 Proportion of value added to automotive manufacturing by suppliers from 1985 to 2015. Adapted from Statista (2015).

According to Veloso and Kumar (2002, p. 12-22), the old configuration of the chain structure is not valid today since the suppliers have new roles with more responsibility on design, engineering, manufacturing and assembly. The new supplier roles can be divided as follows:

1. *System Integrator* – Supplier who designs and integrates components, subassemblies and systems into modules.
2. *Global Standandizer* – Systems manufacturer that sets the standard on a global basis for a component or system. Supplier who designs, developes and manufactures complex systems. They supply straight to OEMs or through System Integrators.
3. *Component Specialist* – Supplier that designs and manufacturers a specific component or subsystem for a car or platform. These suppliers can also have additional capabilities sucs as machining and assembly. They supply to system integrators and standardizers.
4. *Raw material suppliers* – Supplies raw materials to OEMs or other suppliers. Some raw material suppliers are moving into component specialists to add value to their products.

By combining these roles to the tiered value chain structure (Humphrey and Memedovich, 2003 p. 21-22), the players in the automotive industry can be defined as follows:

OEM – Automakers, final assemblers. Core competencies lie in vehicle design, branding, finance and manufacturing.

Global mega-suppliers – Suppliers for major systems, such as complete seating solutions, to the OEMs. Also referred as Tier-0.5 suppliers when they work closer with the OEMs than the tier-1 suppliers and they might even have capabilities to build a car on their own. These companies need global coverage, in order to follow their customers to various locations. They need design and innovation capabilities in order to provide solutions required by their customers by using their own technology to meet the performance and interface requirements.

Tier-1 – Modules suppliers, standardizers and system integrators. Usually mega-suppliers who offer large assortment of products and systems directly to OEMs and they have a global presence. These suppliers can also be SMEs (small and medium-sized enterprises) with specialized offering. They need to have design and innovation capabilities.

Tier-2 – Component specialists. These suppliers design and manufacture components for higher-tier companies and OEMs. They require process-engineering skills in order to meet cost, quality and flexibility requirements. These are usually local companies.

Tier-n – Component specialists who provide basic products. They compete on price and only basic engineering skills are required.

Raw materials – Suppliers of raw materials for other suppliers and OEMs.

The players mentioned above combine the upstream value chain, linking the players and activities needed for production of the vehicle.

Operations located in the downstream involves the ones from final assembly towards end customer. The downstream operations are: distribution, sales and marketing, and after sales services. The automotive after sales services include all the functions that take part after the car purchase, such as repair, maintance, spare part sales, and car rental. The automotive industry's value chain is presented in picture 2.

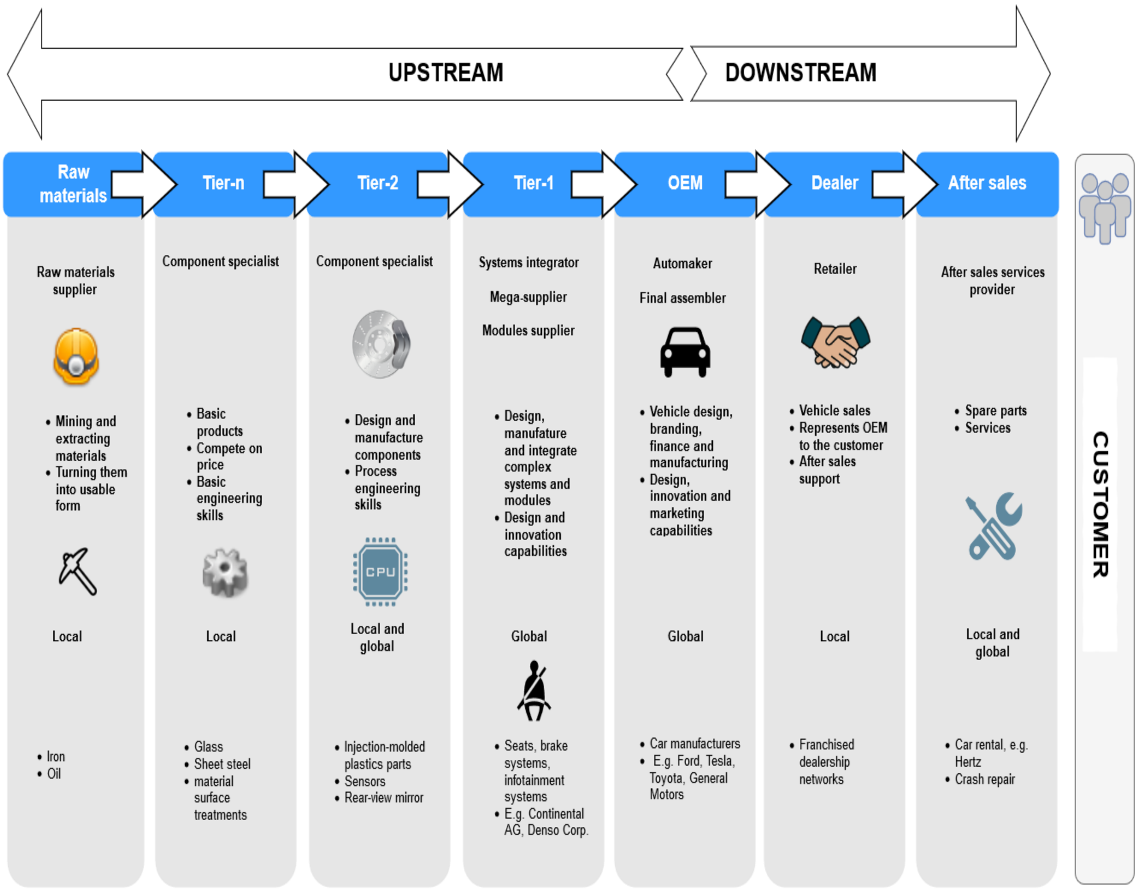

Figure 3 Value chain of the automotive industry (author's view).

In this study, we will concentrate in the downstream chain only on the after sales services and on some aspects of the changes in dealership. This is why we won't process other downstream operations in more detail. Also from the upstream value chain raw materials and lowest Tiers are excluded, eventhough there is progress in materials development especially on new light-weight materials. We concentrate only on the parts of the value chain where we believe the new technology trends affect mostly.

2.4 Changes in the Automotive value chain

During the past 30 years, the automotive industry has changed from a series of discrete national industries to a integrated global industry (Sturgeon et al., 2008 p. 302). Since the late 1980s, competition in the industry was reshaped due to the pressure on OEMs to become global manufacturers, to improve the quality of products, and to reduce production costs (Sturgeon et al., 2008 and 2009). Globalization, increased outsourcing and moving to sourcing modules and systems instead of individual parts affected the value chain structure.

Due to globalization, the OEMs faced increasing competition. They had the pressure and power to drive lower prices and they started to look for certain components on a world basis from the same supplier. OEMs established final assembly plants near their major market areas and emerging markets for local production, and large suppliers had to follow them in order to gain contracts and to be able to deliver systems and modules on-time and at low cost. (Sadler, 1999) Major changes have taken place in the structure of supplier base where has occurred significant reduction in the number of supplier companies, formation of mega-suppliers, and a shift in design responsibilities resulting change in power relations between OEMs and suppliers.

The outsourcing boomed in the automotive industry in the 1990s when OEMs moved design and assembly responsibilities to the supply base. Instead of individual and re-designed parts, Tier-1 suppliers provide completely assembled and tested systems. (The Boston Consulting Group, 2004). Modularization, which means outsourcing larger units in subassembly, has led to increasing responsibility and role as system integrators for suppliers. The assembler provides overall performance specifications and information about the interface with the car, and the Tier-1 supplier designs a solution, usually adapting basic design with it’s own technology to match customer’s requirements. (Humphrey 2003, p. 124) The outsourcing has led to car manufacturers becoming more of a vehicle brand owners (VBO) than OEMs, as they are becoming increasingly responsible primary for managing, marketing, and maintaining their brands (International Trade Administrator, 2005 p. 4).

Since the mid 1990s, auto suppliers’ prices have fallen annually around 3 percent. The intense competition for contracts and constant cost pressure severely eroted suppliers’ financial performance and some have been pushed to the brink of bankruptcy. (The Boston Consulting Group, 2014). Due to cost pressure and competition between suppliers driven by OEMs, suppliers were forced to broad their capabilities through mergers, acquisitions and joint-ventures to gain complementary assets and geographical footprint.

These trends have led to a significant decrease in the number of suppliers and to the formation of global mega-suppliers with major role in design, production and foreign investments. Mega-suppliers deliver complete vehicle systems and they acquire smaller suppliers with complementary capabilities of their interest to gain competitive advantage. Overall, the responsibility of innovation and cost of R&D has shifted to the suppliers, and the changes offered them various possibilities for upgrading.

Due to the consolidations, the choice of suppliers has reduced especially in the leading-edge areas of electronics and mechatronics. This is why it is important for the OEMs to develop strong relationships and engage in exlusive R&D partnerships with the most innovative suppliers to ensure sufficient level of product differentiation. On the other hand, OEMs will have to keep on eye on the trends and suppliers also beyond traditional supply base to identify the best innovators and include them in their supply base in order to produce innovative and high-quality cars and to avoid too narrow supplier base. (The Boston Consulting Group, 2004)

Although there has been changes in the value chain structure, the business models and overall structures have been remained mostly unchanged. The biggest changes have been in that the value creation capabilities and managing control has moved down the value chain. The value chain is still strongly controlled by a small number of lead firms which are the OEMs. As the suppliers have gained bigger scale and larger roles in design, production and foreign direct investments, also the need for co-design has become more important, and resulted in captive and market governance structures shifting towards more relational structures. The relational structure between OEMs and suppliers provide the best innovative capabilities (Willis, 2014) and enable further structural changes in the value chain through new technological developments.

3. TECHNOLOGY TRENDS SHAPING THE INDUSTRY

Consumer demand is shifting as more and more people are starting to think cars as transportation machines and the emotional tie towards owning a car is waning. The percentage of persons with driver license has been decreasing, especially among young people (University of Michigan, 2016) This affects how much people are willing to pay for a car. Historically, vehicles have been designed based on customer demand for vehicle performance and reliability, but now the focus is on safety, environmental impact, and features unrelated to the operation of the vehicle. There has been a general increase in the car quality throughout the industry, and OEMs need to find ways to differentiate their products. Customers are expecting more sophisticated infotainment systems at low price, and high-end safety features to be a standard. Safety technologies are seen as the most important features in new vehicles, but high-level autonomy of the car isn't desired yet, as customers have doubts about their safety. Sensors and telematics systems in new vehicles produce vast amount of data and information about vehicle usage and driver behavior. All players across the automotive value chain are interested in the data, but it is still uncertain how it will be used. (Strategy&, 2015)

There is an ongoing transition from mechanical-based industry to a software-based industry. Today, electronics and software contribute more than 90 % of innovations in the industry, which is transforming through three main areas of technological development: computational technologies, wireless technologies and sensing technologies. (Strategy&, 2016) Figure 4 illustrates the development of the cost of electronics per vehicle from the 1990s. In 2009, it was estimated that software development contributes about 15 % of the cost of electronics. (Charette, 2009 and Statista, 2016a)

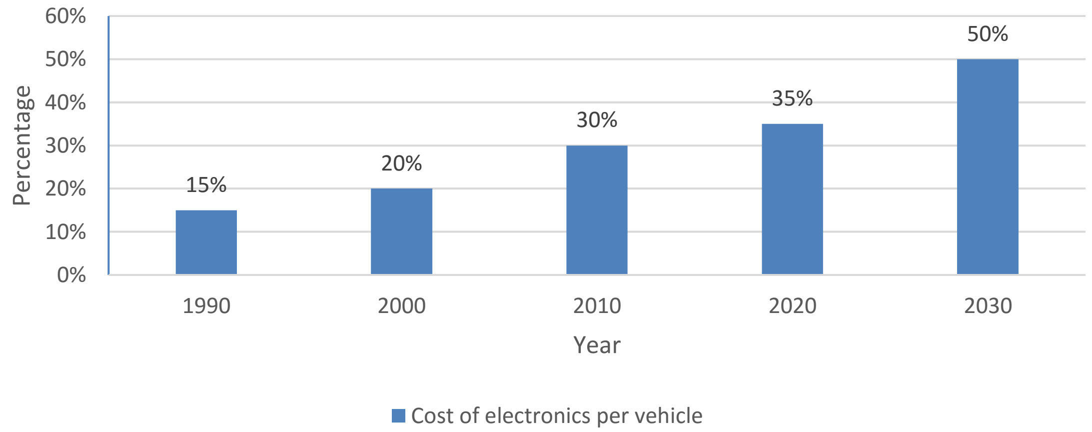

Figure 4 Growth trend of the amount of electronics per vehicle 1990-2030, adapted from Statista (2016a)

The growth trend of software and electronics used in vehicles is due to three technology trends driven by shifting in consumer demand, regulatory constraints and advancements in ICT technologies. The three technology trends are connected cars, automated driving, and new mobility services. These trends are presented in more detail in the next sections.

3.1 Connected cars

Connectivity enables new services inside and outside the car, providing better safety and convenience to customers. Connected cars have access to the Internet and variety of sensors, ability to send and receive signals, sense environment around them, and interact with other vehicles and surroundings (Strategy&, 2016). In this section, we will go through how connectivity is implemented in connected cars, advances in infotainment technologies, and connectivity enabled applications.

3.1.1 Connectivity

Car connectivity features are already a critical purchasing factor for over a half of new-car buyers (McKinsey & Company, 2014). The amount of vehicles with built-in connectivity functions will increase from 10 % in 2013 to 90 % by 2020. Almost three-quarters of the new-car buyers considered the safety and diagnostics as the most important features, and they were also interested in navigation features that have more functionalities than present systems. (Telefonica, 2014)

Car connectivity comprises a set of functions that digitally links the car to the driver, services, infrastructure and other vehicles (McKinsey & Company, 2014). Connected car can be defined with capabilities as follows (Frost & Sullivan, 2014a, p.2 and Qualcomm, 2016):

- Vehicle-to-Vehicle (V2V): Communication between vehicles. Vehicles exchange information regarding their relative position and speed. The information can be used to avoid collision and to enable auto-cruise.
- Vehicle-to-Infrastructure (V2I): Vehicle is able to communicate with infrastructure such as traffic lights, toll booths, hospitals and parking lots. The information can be used to traffic management, electronic tolling and emergency services.
- Vehicle-to-Everything (V2X): Vehicle is able to communicate with other vehicles, infrastructure and pedestrians, making them part of Internet of Things.

Connectivity can be implemented by embedded solutions, tethered solutions, integrated solutions, or hybrid solutions:

1. *Embedded solutions* are build-in modules enabling the vehicle to perform all the data transactions and they are used to high-reliability and high-availability needed

applications. The module consists of a modem and a Subscriber Identity Module (SIM).

2. *Tethered solutions* are BYOD (bring-your-own-device) based connectivity, which are usually smartphones. Applications run in the vehicle, while external SIM is used to provide connectivity. These solutions are used for infotainment services, as it enables the customer to directly manage and pay the costs of used services.
3. In *integrated solutions* the connectivity is provided by the smartphone, where also applications run. The vehicle hardware is solely used for HMI (Human-Machine Interface).
4. *Hybrid solutions* use both embedded and tethered or integrated solutions, where applications are hosted on the vehicle to provide better integration with various features, and communication is provided with smartphone connectivity. This allows OEMs to provide better personalization capabilities of a user's smartphone.

Embedded solutions are needed to keep the intelligence and applications in the car for offering various services, but the management of data costs can be a barrier for using embedded SIM for features with unpredictable data consumption. (NTT data, 2015, Frost & Sullivan, 2014a)

Flexible architectures are the key to answer the accelerating pace of innovations and evolving technologies. The development process of the vehicles in the era of connected cars will have to be implemented in three sections. Firstly, the traditional vehicle hardware development process can be carried out mostly in the same manner and timeframe as before. Secondly, the development process of the IT hardware at the HMI needs to be separated and carried out in shorter cycles. This is enabled with modular structure of all the components used. Modularity gives possibility to add and change components flexibly. Lastly, software features for additional functionalities must be separated from the previously mentioned processes. As these features need to be updated immediately, the best solution is the introduction of OTA updates. (KPMG, 2015a p. 24) For example, Audi has approached the short development cycles of consumer electronics industry by developing modular infotainment platform. The modular architecture allows hardware and software to be upgraded independently as newer solutions come available, and it has enabled to cut down the development cycle to just one year from up to seven years. (Automotive News Europe, 2015) As new innovations are emerging more rapidly, vehicles that can be constantly updated bring much greater value to the customers compared to investing large amount of money to a product that will be soon outdated.

Vehicular environments impose new requirements for wireless communication systems. In order to function safely, V2X systems need security and communication infrastructure to enable reliable communication between vehicles and environment.V2X applications cannot tolerate long connection establishment delays or latencies to communicate with other vehicles and infrastructure. Two main V2X communications technologies are dedicated short range communications (DSRC) and cellular networks.

V2X systems use DSRC devices to provide local-area, low-latency network connectivity to support broadcasting messages between vehicles and infrastructure. DSRC is a two-way, short-range wireless communication technology designed for the automotive industry (Denso Dynamics, 2012). Radar, lidar, cameras, and other sensors, as well as GPS is used to provide information about vehicles location, predicted path, speed and braking status.

The DSRC is achieved over reserved radio spectrum bands and the standards differ geographically. In North America, Institute of Electrical and Electronics Engineers (IEEE) have defined IEEE 802.11p standard, also known as wireless access for vehicular environments (WAVE). In Europe, DSRC has been developed by European Telecommunications Standard Institute (ETSI), and in Japan by the Association of Radio Industries and Businesses (ARIB). (Delgrossi and Jiang, 2008, Zishan et al., 2016, Abboud et al., 2016) Vehicles equipped with DSRC on-board units (OBUs) can communicate with each other and with the road side units (RSUs) (Zishan et al., 2016). The standard's performance is sensitive to larger vehicle densities, traffic load, and vehicle speed. (Hameed and Filali, 2014)

Cellular technologies such as the LTE (Long Term Evolution) provide superior performance in terms of throughput and lower latencies. Cellular networks have high network capacity to support high bandwidth demand, wide cellular coverage range and mature technology. The LTE standard promises a truly broadband experience to users and enables mobile network operators to deliver sophisticated services. The existing LTE infrastructure can be exploited to support vehicular networking applications either through vehicle's LTE-enabled on-board unit or using smartphones with LTE connectivity. However, its performance is sensitive to available network load and the number of cellular network users. (Hameed and Filali, 2014, Abboud et al., 2016) In the future, 5G will enable the next generation of connected and automated driving and new services. 5G is the next generation of mobile communication technology providing improved performance in terms of reduced latency, increased reliability and higher throughput under higher mobility and connectivity density (5G-PPP, 2015).

To achieve efficient and reliable V2X communications, both DSRC and cellular technologies can be used as a hybrid solution. The use of these technologies in an urban environment is illustrated in figure 5.

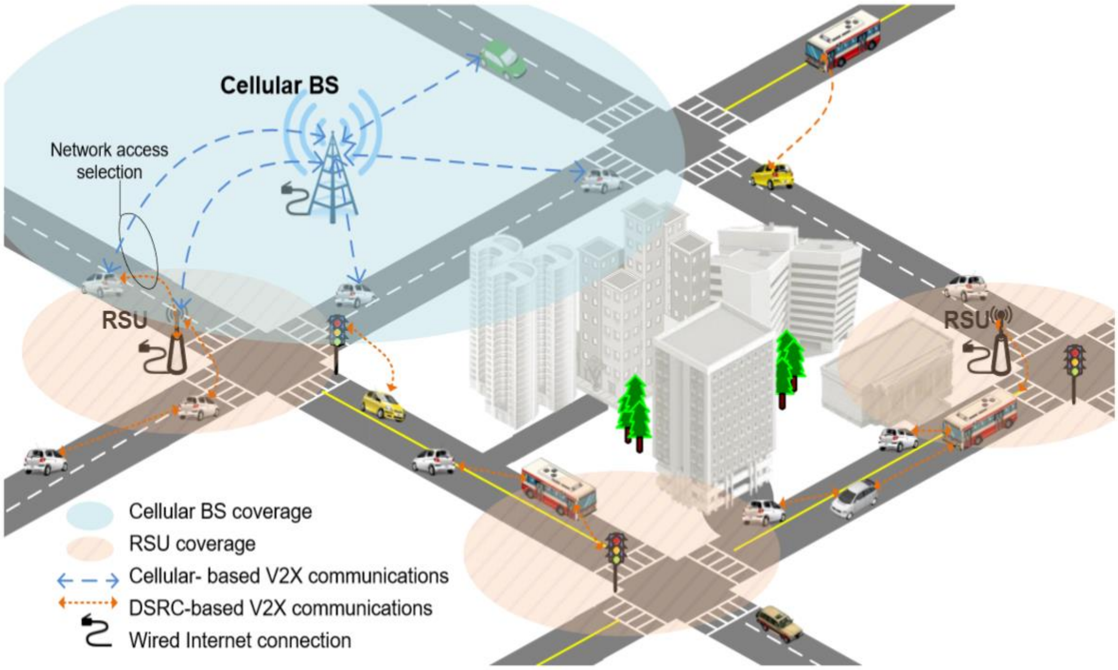

Figure 5 V2X communications using DSRC and cellural technologies (Abboud et al., 2016)

One of the most critical components of a connected vehicle is the connectivity platform. The platform includes hardware and the operating environment to perform required functions. Communication with users is established through human-machine interface, and with outside world or other vehicle components through telecommunication network, Bluetooth, Wi-Fi, or a combination of them. Frost & Sullivan research firm (2014a) suggests that the automotive industry is likely to adapt modular approach towards connectivity platform development. In this approach, the platform is composed of basic components, non-critical components and critical components. Basic components are architectures and software modules which are non-differentiating parts of the platform and they will be governed by standards set by communities such as GENIVI to reduce development costs, facilitate hardware and software development, and reduce time-to-market. Non-critical components are in-vehicle infotainment (IVI) applications, software, and related hardware, which interact directly with users and control vehicles' non critical functional features. These modules provide differentiating features and they are developed in collaboration with partners with related special capabilities. Critical components are software and hardware modules that manage critical functionalities in vehicles, such as technologies which provide automatic features. Critical software is developed with strategic partnerships and they will be primarily managed in-house by OEMs to ensure safety and security.

3.1.2 Infotainment

In-vehicle infotainment is a combination of software and hardware products which deliver information and entertainment to enhance driver and passenger experience. Earlier

IVI systems have been closed systems with predefined set of functions and analog instrument clusters, but now they are transforming into more open and differentiated systems through the possibilities brought by connectivity, advanced display technologies and HMI development.

Today, instrument clusters are becoming fully digital or hybrid in which analogue and digital components are combined (Frost & Sullivan, 2015b). Infotainment system can have digital displays on the dashboard and rear seats to provide interface for the passengers to exchange information with the vehicle and to enjoy entertainment. HMI needs to be intuitive and easy to use to minimize driver's distraction off the road. In addition, the increasing amount of media and other content provided through infotainment can distract driver from observing the surrounding.

The driver can control the IVI system through touch screens, voice control and hand gestures. Voice recognition can be embedded or provided through a cloud for advanced services. Voice control enables the driver to answer phone calls, control climate or read text messages hands-free with text-to-speech services. Gesture control can be implemented with sensors recognizing hand movements and for example volume can be controlled by making a circular movement with your hand. (Just-auto, 2016) One solution to bring visual information is head-up display (HUD), where information is projected to an additional glass partition or windscreen using AR (augmented reality) technology. HUD enables the driver to see for example navigation instructions, speed limits and ADAS warnings without taking his eyes off the road. (Continental, 2016)

Figure 6 An augmented reality HUD and fully digital instrument cluster (Texas Instruments, 2016).

Infotainment applications can be embedded or brought-in. Embedded applications are integrated into the main program of the IVI system and they are usually navigation, basic media, hands-free phone services and connectivity applications. To enhance in-car experience, wider media and service content, and control functionalities are provided through smartphone and app integration. Leading smartphone connectivity technologies are MirrorLink, Apple CarPlay, and Google's Android Auto, respectively. These technologies provide smartphone screen projection to the vehicle's head unit for example through USB or Bluetooth, and the user is able to control the smartphone applications through the head unit's touch screen, voice control or steering wheel controls. (MirrorLink, 2016 and Fortune, 2015)

Applications can also be provided with an on-board diagnostics port (OBD-II) dongle. OBD-II has been mandatory in vehicles for over a decade. It allows external developers and other third parties to access vehicle data for application development. Applications using dongles typically run entirely on mobile device, in the cloud or on a computer, instead of the vehicle's infotainment system, and they can't be used to control the vehicle. External developers can also use OEM development platforms. In order to foster innovation many OEMs have established own development environments for third-party applications, which are reviewed and offered to customers via app stores. These software development kits include guidelines and specific tools to help third-party providers develop vehicle-adapted versions of their apps. However, some OEMs still keep all of their development in-house or use solutions licensed from suppliers. (NTT Data, 2015)

Infotainment operating system is a vital part in infotainment systems managing computer hardware and software. They are divided into proprietary and open source operating systems. QNX and Microsoft are both proprietary and the most widely used operating systems with 74 % market share in 2015. IHS' forecast estimates that by 2022 Microsoft will be leaving the infotainment OS market, and QNX and open source based Linux systems will share the market. (IHS, 2015) Open source operating systems are gaining larger market share as they allow greater differentiation for OEMs through broader control of their software platforms, the ability to tailor different features (Wired, 2012) and they offer a robust developer community to bring more apps tailored for vehicles.

3.1.3 Applications and services

Connected cars enable a wide range of applications in the fields of navigation, safety, remote telematics, diagnostics, insurance, car sharing and infotainment. Examples of these applications are presented in table 1. (AutoScout24, 2014)

Table 1 Applications enabled with connected cars and examples of use cases

Navigation	• Live traffic information • Intermodal route planning • Intelligent parking, e.g. available parking slots shown on a map
Safety	• Automatic emergency calls in case of a crash • Driver health monitoring • Warning of wrong-way-driver • Intersection movement assistance
Remote telematics	• Stolen vehicle recovery • Remote control, e.g. honking to find car in a parking lot • Fuel efficiency analysis
Diagnostics	• Self-diagnosis • Automatic data transfer to repair shops • Check-up for used cars
Insurance	• Pay-as-you-drive • Additional services, e.g. breakdown calls
Car-sharing	• Private car-sharing without physical key exchange • Ad hoc car-pooling
Infotainment	• In-car Wi-Fi • Synchronizing smartphone content, e.g. playlists and contact lists • Media applications

Connected cars produce, gather and exchange data from their own operation, other vehicles, sensors on infrastructure, and even drivers' and passengers' personal data from their mobile devices connected to the vehicles. Since vehicles have requirements of small-size and low-cost hardware systems, they have limited computational and storage resource resulting in low data processing capability. To support enabling all operations and applications, connected cars need cloud solutions. The clouds in vehicular network consists of central cloud, which is established among a group of dedicated servers in the Internet, and local clouds, which can be established among roadside units or a group of cooperative vehicles. The cloud architecture fully utilizes the physical resources in an entire network, and the computational and storage resources are merged in to the cloud. The architecture is flexible and compatible with DSRC and cellular communication technologies. With cloud computing, new services and applications are made possible for the customers. (Yu et al., 2013) As the vehicle development cycle is measured in years and software development cycle in months, over-the-air updates (OTA) ensure that customers are provided the latest technology. OTA updates can quickly deliver new connected car features and for example update instantly display screen graphics or voice recognition software (Frost & Sullivan, 2015a p. 30).

In real-time navigation, resources in the central cloud is utilized for traffic data mining. Real-time navigation application provides dynamic three-dimensional maps and it adaptively optimizes routes based on the real-time traffic information (Yu et al., 2013). In addition, information about weather conditions, such as black ice on the road, or about a wrong-way driving vehicle can be captured and stored in the cloud from other vehicles' sensor data and used to send a warning to specific vehicles based on their locations. Vehicles equipped with surroundings sensing systems and on-board parking cameras can determine the size and location of an empty parking slot by driving past, and this information can be distributed via central cloud, allowing the creation of real-time overview of city parking spaces (European Parliament, 2016). As an another example of cloud-enabled services, information about nearby gas stations and their real-time prices can be shown on the infotainment when the sensors send data about low gasoline level in the vehicle. Similarly, targeted advertisements and offers can be shown in-vehicle based on location and preferences evaluated from driver's personal data.

3.2 Automated driving

In automated driving, perception, decision making and operation is partially implemented by electronics and computers in the vehicle, while the human driver remains in charge. With advances in technological development, the amount of control gradually shifts from the human-driver to the computer, leading to fully autonomous vehicles. Autonomous features increase road safety as they exclude the possibility of human-error, decrease the amount of traffic jams and emissions with optimized routing, and provide convenience with freed time from the driving task.

3.2.1 ADAS

Vehicles' safety systems are divided into passive and active safety systems. Passive safety refers to solutions helping reduce the effect of an accident (e.g. airbags and seatbelts), and active safety to helping avoid the accident. Active safety solutions include anti-lock braking systems (ABS), Electronic Stability Control (ESC) and Advanced Driver Assistance Systems (ADAS). ICT based ADAS systems are the newest addition to active safety solutions and they have a major role in enabling the future of autonomous driving. In this section we will concentrate on different ADAS applications.

ADAS applications help the driver avoid accidents by assisting the driver continuously in their driving task, and enhance the comfort and efficiency of driving. Below are presented some of the ADAS functionalities:

- In-vehicle navigation system
- Forward collision warning
- Adaptive Cruise Control
- Lane Departure Warning System
- Intelligent speed adaption
- Night vision
- Pedestrian protection system
- Traffic sign recognition
- Blind spot detection
- Parking assistance / Automatic parking
- Driver drowsiness and inattention detection

The functionalities are enabled by radar, lidar, camera, and other sensor technologies. Sensors gather information on their immediate environment and they have a limited measurement range. Their signal bandwidth is also limited, which affects sensors' reliability. Most of the sensors have problems in challenging weather conditions, such as fog or rain, as well as at high speed. ADAS applications can be implemented by combining different sensors with complementary capabilities to address these challenges.

The data gathered from various sensors is processed in ECUs (Electronic Control Unit). The processors contain software algorithms that synthesize the input information in real-time and provide output as a warning to the driver or specify how the system should react and intervene in vehicle control. The warnings can be audible, indicated by vibrating the steering wheel or seat, or visual through HMI. (Shaout, A. et al. 2011)

Adaptive cruise control is a system that adjusts the speed of the vehicle with automatic braking and acceleration based on the distance of the vehicle ahead in order to maintain safe distance. The systems use radar and lidar technologies to measure the relative speed and distance to other vehicles. The technological advances of vision processing have allowed the introduction of camera based adaptive cruise control systems. With the vision systems relative acceleration can be calculated by using change in the image size of the forward vehicle. The system can also recognize the other vehicle's braking lights. The same kind of technology is also used in collision avoidance systems. (Mobileye, 2016 and Shaout, A. et al. 2011)

Pedestrian protection system detects people on or near the road ahead, or crossing the road. If the system detects a pedestrian in front of the car, the driver will receive audible and visual warnings. If the driver does not react on time, the system will control the brakes. The vehicle has forward looking cameras and the image data is processed on onboard ECU. Machine learning enables the system to recognize objects from the background based on edges, colors and shapes. The system may also include radars to ensure avoiding collision. Camera technologies are also used in traffic sign detection, lane departure assistance and night vision systems. Night vision systems are implemented by infrared cameras to highlight animals and pedestrians on the road when they might not be visible to the naked eye. (Autoliv, 2016 and Ford, 2014)

The parking assistance is based on ultrasound sensors integrated on the side of the vehicle. The sensors scan the surroundings of the vehicle and identify suitable parking spaces. The system electronics calculate the most favorable steering maneuvers, but the driver controls the braking and acceleration. In automatic parking, the system takes full control of the vehicle and the driver can activate parking outside the car by using for example smartphone. (Bosch, 2016)

In-vehicle navigation systems support the driver by providing information about their vehicle's location and giving visual and audible instructions how to get from one point to another. The system performs map-matching to estimate the vehicle's location by comparing the information from GNSS (Global Navigation Satellite System) receiver and digital map. To provide better accuracy in urban environments where surrounding buildings and objects block or reflect the signals, systems also use information from multiple onboard sensors such as accelerometers, gyroscopes and odometers to perform dead reckoning. With dead reckoning the acceleration, speed and direction information can be matched to the digital map information when GNSS signal is lost. (Skog and Händel, 2014) The ADAS systems and their sensors placement and reach is illustrated in figure 7.

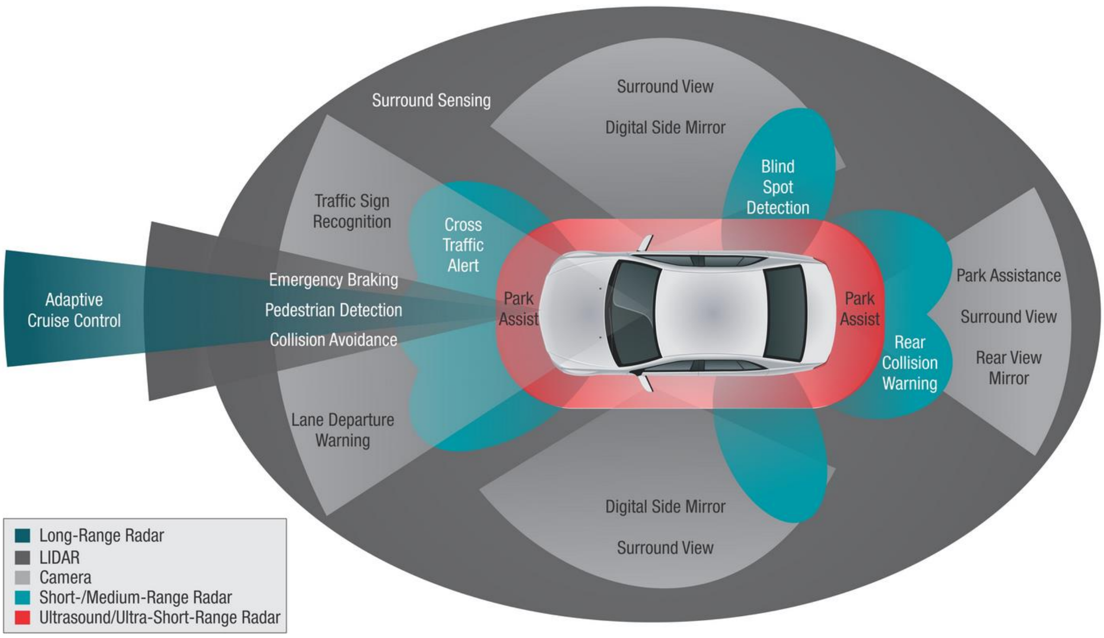

Figure 7 Illustration of ADAS (Texas Instruments, 2016).

3.2.2 Autonomous driving

Advanced ADAS systems and connectivity technologies are enabling the development of fully autonomous vehicles. SAE International (Society of Automotive Engineers) has published standard J3016 as a common terminology for autonomous driving. In the standard six levels of autonomous driving are identified from "no automation" to "full automation". The six levels are presented in table 2.

Table 2 Six levels of autonomous driving (SAE, 2014).

	Level	Name	Definition
Human driver monitors the environment	**0**	No automation	Full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems
	1	Driver assistance	Driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task
	2	Partial automation	Driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that human driver perform all remaining aspects of the dynamic driving task
Automated driving system monitors the environment	**3**	Conditional automation	Driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene
	4	High automation	Driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene
	5	Full automation	Full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver

Functions of autonomous vehicles are based on integration of ADAS systems, V2X communications, connected intelligent transport systems, integrated sensing systems and management of collected data (Liikenne- ja viestintäministeriö, 2014). As the driving tasks are shifting away from the driver to the in-vehicle computer, this will free the travelling time from watching the road to other activities, and new comfort functionalities and services will be introduced to customers. Unlike today, powertrain won't matter anymore when purchasing a new vehicle and differentiation comes from the size, interior and non-driving related functionalities. When fully autonomous vehicles become common, even owning a car is not necessary as you can summon one to your doorstep when needed.

In order to achieve fully autonomous level for vehicles, vehicular, computing, networking and data management technologies need to improve and work at all times securely. Today's sensors are not reliable in every situation, especially in challenging weather conditions. Sensor fusion needs to improve, enabling coherent combination of data from multiple sensors. On the software side, especially combination of image and non-image data is challenging. Developments in sensor fusion are shifting from embedded software running on single ECUs to software platforms running on centralized ECUs or MCUs (Microcontroller Central Units). (McKinsey & Company, 2016) Autonomous vehicles need high-performance in-vehicle and cloud computing for reliable perception and planning. Fully autonomous vehicles need to be able to understand their surroundings as well as humans can. For example, the vehicles need to understand police officers' signs to stop. Artificial intelligence (AI) based on deep learning architectures is needed to enable vehicles to recognize and understand the world they operate in through a process of turning data into decisions of a computer program. The difference to algorithm-based systems is that once the basic model is established, the deep learning system learns on its own how to fulfill the intendent tasks, emulating the way the human brain learns about the world. AI is required for development of more sophisticated ADAS, and to pave the way for autonomous driving. (Langenwalter, 2016) As the amount of data will grow drastically, data management capabilities will be a key challenge. Also real-time navigation based on GNSS, high-definition mapping, and sensing systems need to develop in order to provide wide reach and high accuracy on a centimeter level to enable self-localization, routing, obstacle detection, and parking (Heiko and Xiaolong, 2016).

Since the human driver isn't needed in fully automated vehicles when the computer takes care of the driving tasks, the possibility for different apps, services and advertising will grow as there won't be restrictions concerning driver distraction and safety. This will free the time spent on travelling to working or relaxing. The vehicle interior is likely to change, comprising of for example comfortable seats for taking a nap, a desk and screens for working or entertainment and a coffee machine for morning coffee while commuting.

The technologies to enable autonomous driving already exist. Many OEMs have semi-autonomous vehicles available for the customers, and almost all of them are developing fully autonomous vehicles. In addition, tech companies like Google and Baidu are developing their own models and entering the competition. (Business Insider, 2016) However, fully autonomous vehicles are still on a research and piloting phase, and it will take at least until 2020 for them to be available on the market and much longer until they are widely adopted. Legislation allowing autonomous driving on the public roads and consumers' willingness to give up control to the computers are the biggest obstacles before we see them widely on the roads. As the renewal of car fleets is slow, there will be a mixture of different kinds of vehicles on the roads with different states of intelligence for a long time, posing challenges to the traffic.

3.3 Mobility

Mobility is a user-centric concept where transportation products and services must be responsive to the needs, habits, and preferences of travelers and society. New mobility solutions are enabled by emerging technologies and wireless connectivity that allow more convenient, efficient, and flexible travel, and also offering easier options for payment. (CAR, 2016 p. 1-3) The development of autonomous vehicles and environmentally friendly solutions will drive the adoption of new solutions with cost-savings and convenience.

3.3.1 New mobility solutions

The center of new mobility solutions is the concept of shared-use mobility. Shared-use mobility enables users to have access to different transportation modes for a short-term and on an on-demand basis. (CAR, 2016 p. 1) Urbanization opens markets for new mobility services as especially among young people there is a decline in willingness to own a car, and dense population causes difficulties on traffic, parking and air quality due to high number of vehicles in cities.

People increasingly use multiple modes of transportation to travel and demand for fit-for-purpose mobility solutions is rising. Instead of using one car for all purposes, car-sharing gives an opportunity to choose optimal mobility solution for each specific purpose. Mobility services – car-sharing and ride-hailing – are likely to decrease the need for owning a car but unlikely to affect car sells as the usage rate of cars will remain the same or even increase; there will be less cars on the roads in cities but they will be more fully utilized as travelled kilometers per vehicle will increase resulting in faster replacement. New mobility services also offer travel options for persons without driving license, elderly, and disabled, which in turn creates more travel. (McKinsey, 2016)

Cars are one of the biggest investments for households and still they are mostly unused, waiting in garages and parking lots throughout the day. In Intelligent Energy Europe's report (2010) on state of car-sharing in Europe, the biggest reasons for joining car-sharing were occasional need for car, cost savings, and environmental aspects. In car-sharing, smaller and newer vehicles are used than in average household. Small cars are popular because they are convenient for short trips within the city, as an average car-sharing trip is 7,5 kilometers (Boston Consulting Group, 2016) and they have cheaper usage prices. Providers also have a wider selection of vehicles available to be chosen according to comfort level and purpose of the trip (Intelligent Energy Europe, 2010 p. 69-70). In the future, there will be a wide selection of vehicles for specific needs, such as camper vans for long family trips, autonomous electric minicars for commuting and fancy premium cars for business needs. These cars can also be further customized for each customer's preferences, such as seating adjustments, based on data from their smartphones. Smartphones will also act as a key to enter rented vehicles, excluding the need to pick up and return keys, to search and book the rides, and to make payments.

Emerging trends in mobility technology are ride-hailing and car-sharing services. *Ride-hailing* services rely on smartphone apps to connect customers with drivers who provide rides on their private vehicles for a fee. Companies offering ride-hailing services design and operate online platforms and link these self-employed drivers with customers and collect a fee for making the connection. The most well-known ride-hailing company is Uber. The term ride-hailing can be confused with ride-sharing which indicates that the driver and passengers share their destination. However, the distinction with these concepts is becoming less clear and many companies are offering services combining these two when customers share a ride with others while the driver still do not share the destination. (CAR. 2016 p. 3-4)

Car-sharing is a short-term car rental. It includes B2C (business-to-consumer) offerings and peer-to-peer arrangements. All costs, including gasoline and insurance are included in car-sharing. Car-sharing can be implemented in two kinds of business models. Round-trip car-sharing requires reservation with a beginning and an end time, and the car must be returned to its starting point. In flexible car-sharing, the car can be rented for one way trips and on demand. The vehicles can have a “home area”, where the vehicle must be parked on the street or any legal parking space after use, or the vehicles must be parked only on designated garages, parking lots or at electric vehicle charging stations. (CAR, 2016 p. 5) In contrast to car rental, vehicles can be quickly booked online after registration without any paperwork. Vehicles can be located around the city and they have keyless access through a smartphone app or a membership card, thus supporting on-demand needs. (DriveNow, 2015)

Autonomous vehicles will lead to a new level of car-sharing and bring further cost-savings and efficiency to mobility. Shared autonomous vehicles can be summoned by customers using mobile phone applications, much like in ride-hailing. Several auto manufacturers, technology companies, and new mobility companies are developing autonomous vehicles to offer shared services. (CAR. 2016 p. 7)

3.3.2 eMobility

Here we define eMobility as an ecosystem of utilities, services, mobile devices and software which focuses on serving mobility needs under the aspect of sustainability using electric vehicles.

Electric vehicles use electricity as their primary fuel or to improve the efficiency of conventional drivetrains. There are four types of electric vehicles (Chan, 2007 and Canadian Automobile Association, 2016):

- *Battery electric vehicles* run entirely on a battery and electric drivetrain, without internal combustion engine. The vehicle is powered by electricity from external source, which is usually public power grid. Batteries can recharge overnight plugged into a household outlet or by using rapid charging stations in 30 minutes. The electricity is stored in onboard batteries. They have typically range between 100 and 160 km. Today, some vehicles' range can exceed even 400 km.
- *Plug-in hybrid electric vehicles* run mostly on a battery but it is also equipped with an internal combustion engine, that can recharge the battery and to replace the electric drivetrain when the battery is low. Range in electric mode is between 30 and 60 km.
- *Hybrid electric vehicles* have two complementary drive systems. The vehicle's gasoline engine and electric motor can simultaneously turn the transmissions. Hybrid electric vehicles cannot be recharged from the power grid as their energy comes entirely from gasoline and regenerative braking. Range in electric mode is between 5 and 10 km.
- *Fuel-cell electric vehicles* create electricity from hydrogen, instead of storing and releasing energy like a battery. Hydrogen production, storage, and the technical limitations of fuel-cells still limit the availability of fuel-cell vehicles to the general public.

Today, the high cost of batteries, insufficient charging infrastructure and short travel ranges slow down the penetration of electric vehicles. The speed of adoption of electric vehicles will be driven by total cost of ownership and regulatory push. The obvious advantage of electric vehicles is that they cut down the emissions caused by city traffic. The shift to electric cars changes the mechanical complexity of a car as a number of the moving parts are reduced drastically. This makes building a car easier, and lowers entry barriers to become a car manufacturer. The reduction in number of moving parts also reduces the need for maintenance and increases reliability with fewer points of potential malfunction. Combined with the possibility to upgrading the car's features or fixing the car online through OTA-updates, the need for new model launches to drive new car sales aren't necessary. (Forbes, 2015)

Autonomous vehicles will likely be electric in the future. The simplicity of electric motor and battery pack compared to combustion engine makes it easier to implement autonomous features on them for testing and development. The possibility of wireless charging is also an advantage to be used on autonomous electric vehicles as the car will be able to drive to an open parking spot and self-charge itself. Once fully charged, the car can drive itself to another spot or continue to its driving duties, freeing the charging spot to other vehicles thus increasing charging efficiency. (Lux Research, 2016)

Autonomous vehicles combined with car-sharing and electrification bring the greatest benefits for the society. The three factors will reinforce each other for faster adoption as autonomous vehicles makes it easier to share vehicles and reduce the number of vehicles, improves road safety, and electric vehicles are preferred by both customers and policy makers to cut emissions in cities.

3.4 How legislation may steer the development

Legislation and regulations have an impact on the technological development. Recently, OEMs have been forced to dedicate R&D resources to powertrain development in order to meet the emission targets. EU (European Union) has set mandatory emission reduction targets for new cars sold on the European market. The legislation is a cornerstone to EU's strategy to improve the fuel economy and to encourage eco-innovation (European Commission, 2016a). Similar emission standards have been set worldwide (EPA, 2012 and Delphi, 2015). The emission regulations contribute to development of more efficient internal combustion engines and encourage to develop electric vehicles.

In 2015, European Parliament set eCall regulation which requires all new cars to be equipped with eCall technology by April 2018. The technology automatically calls nearest emergency center in case of a crash. If the passenger is not able to speak, minimum set of data is sent, which includes the exact location of the crash site. The in-vehicle system can be an embedded module with integrated network access or a phone-based solution. (EUR-lex, 2015) The eCall technology will promote adoption of connected cars and accelerate introduction of related services such as tracing a stolen car.

The European Commission monitors technical developments for realizing new safety features becoming mandatory for every new vehicle. In the Commission's latest final report about benefit and feasibility of a range of new technologies and unregulated measures in the field of vehicle occupant safety and protection of vulnerable road users (2015), multiple active safety applications were recognized suitable for application in legislation. The technologies are:

- enhanced autonomous emergency braking with collision mitigation
- intelligent speed adoption
- lane keep assist

- reversing detection and reversing camera systems
- emergency brake light display

The report finds, that also pedestrian detection systems may be cost beneficial in the future as system costs come down. Driver distraction and drowsiness systems were seen possible to be considered for further legislative development noting that further work is required to determine how to define and test the effectiveness of the systems. Since 2015, all new trucks and buses need to be equipped with advanced emergency braking systems as well as lane departure warning systems. As the EU aims to achieve reduction in road fatalities in the EU by 50 % compared to 2010, active safety regulations are likely to reach also passenger cars in the near future. (European Commission, 2015) In 2016, the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) and the Insurance Institute for Highway Safety announced a commitment of 20 OEMs to make automated emergency braking systems a standard in all new cars by 2022 (NHTSA, 2016). By voluntary agreement, NHTSA is able to provide these new safety features to the consumers in the U.S. faster than through formal regulation but there is no guarantee that minimal standards for the systems are met.

The EU has established The High Level Group GEAR 2030 to debate the main challenges for the automotive industry in the next 15 years and to make recommendations to reinforce the competitiveness of the European automotive value chain. The objective is to address the new global challenges in the value chain so European suppliers could remain ahead and reinforce the technological leadership that has been challenged by rapidly evolving geographical and product markets. In particular, it will consider a roadmap for the rollout of autonomous vehicles. (European Commission, 2016b)

The Vienna Convention of Road Traffic of 1968 is an international treaty designed to facilitate international road traffic and to increase safety by establishing standard traffic rules among the contracting parties. Article 8 in the Convention states that every vehicle must have a driver, and that every driver must at all times be able to control his vehicle. All EU members, with exception of the UK and Spain, are signatories of the Convention. USA is a signatory of the earlier, 1949 Geneva Convention, which makes it easier to allow autonomous vehicles. In 2014, amendment to the Vienna Convention was approved saying that: "systems which influence the way vehicles are driven' are deemed to be in accordance with Article 8." The amended convention still demands that every vehicle must have a driver, but the driver may take the hands of the wheel if he is at all times able to take over the driving functions. Systems with high or full automation are mostly compatible with the amended convention, but further amendment process is still necessary to permit driverless vehicles. (European Parliament, 2016) The current legislation in Finland allows testing of autonomous driving, since the law on road traffic doesn't have a specific definition about the driver of a vehicle. However, the law is based on an assumption that human is responsible of the vehicle in every situation. (Liikenne- ja viestintäministeriö, 2015)

NHTSA proposed a creation of a new Federal Motor Vehicle Standard to require V2V communication capability for light vehicles and to create minimum performance requirements for V2V devices and messages. The mandate is believed to facilitate the development and introduction of a number advanced vehicle safety applications and to promote market penetration. The proposition was released in 2014 and it is still waiting for the approval. (NHTSA, 2014)

Legislation to protect personal privacy of consumers in connected vehicles is seen as necessary. Connected vehicles have capability to generate, store and transmit users' personal data, such as route to work, time of travelling and appointments. Third parties can access and use this sensitive data if the connection between the in-vehicle system and the OEM's central server is not secure. Besides unwanted use of personal data, hackers accessing into vehicle can control its basic functions via the entertainment and navigation software thus causing great danger to passengers and the surroundings. (European Parliament, 2016)

In addition, liability issues are unclear regarding autonomous vehicles. Currently, there is no framework in place regarding harmonizing the rules of liability for damage caused by accidents in which vehicles are involved. Regulations of liability of the holder of the vehicle or of the driver differ between the EU member states. When on higher levels of the automation, it is difficult to prove if the accident was caused due to a defect with the automated vehicle or the behavior of the driver. (European Parliament, 2016)

Legislation offers both incentives and barriers for new technologies. Regulations and policies are made to promote innovation and to ensure public safety. Local and international acts need to be made in order to speed up market penetration of new safety applications and connectivity technologies. Formal and voluntary standards are also needed to set common definitions in order to ensure that technologies function together seamlessly. However, it can be hard for policy makers to keep up with the technological development as formal processes can take years resulting regulations been outdated.

4. HOW TECHNOLOGICAL DEVELOPMENT AFFECT VALUE CHAINS

The shift towards more and more intelligent vehicles is combining the traditional automotive industry and software professionals in design and development. There is a conflict in meeting these industries, as car companies design their product once in a five-to-seven-year development cycle, and software companies fix their products in much shorter cycles. As some of the technologies necessary for the development of intelligent cars, such as networking, sensors, and software, are not core competencies for traditional automotive players, new players especially from high-tech industry are joining the competition.

Connectivity and new mobility solutions enable new value-adding services for the customers. Especially when the technologies and regulations on autonomous driving enable their market penetration, automakers need to make a move from product manufacturers towards service providers. All of the companies in the value chain need to rethink their strategies and business models to capture value in the evolving markets.

4.1 Upstream value chain

In the upstream value chain, the companies struggle to keep up with the technological development which is accelerating due to new innovative and cash-rich players entering the competition. The growth in revenues from different technologies are driven with regulatory and customer demands for better safety and digital services.

As many innovations are likely to come outside the automotive industry, OEMs and traditional suppliers will need to work closely with the new players coming from non-traditional industries. As the value is shifting from mechanical components to software and electronics, the traditional players need to acquire these capabilities in order to keep their presence.

4.1.1 New players entering the industry

New players coming from different industries, such as giant tech companies, high-tech start-ups, telecommunication and consumer electronics companies, are disrupting the automotive value chain.

The entry barriers to automotive industry are high due to economies of scale, tight supplier relationships, and customer brand preferences. Electric vehicles have partially paved the way for the tech companies to enter the automotive industry. The simpler design of electric motors has made it easier to center their designs around them. The shift from internal combustion engines to electricity also shifts the value from motors to batteries. Consumer electronics manufacturers are familiar dealing with battery life and power optimization, but their biggest advantage is the ability to build an entire technology system around the electric vehicles. (Pakman, 2015)

Companies coming from consumer electronics industry have also capabilities in communications, display technologies and user experience. Especially Tier-1 companies tend to acquire companies with these kinds of complementary capabilities from adjacent industries to expand their offering and to gain competitive advantage. However, the recent acquisition of HARMAN, the market leader in connected car solutions and a Tier-1 company, by Samsung Electronics (Samsung, 2016) shows that the newcomers aren’t the only targets or just potential partners for product development, but real competitors who are after even bigger positions in the industry’s market shares and value chains.

Tech companies, such as Google and Apple, are driving the development of autonomous vehicles. Giant tech companies are used to following the customer desires and know how to utilize customer data effectively. Their investment capacity is significantly higher than OEMs, and they can devote their R&D budgets on the latest ICT technologies as they don’t need to concentrate also on the maintaining of vehicle platforms and powertrain efficiencies. These companies think the car as “the ultimate mobile device” and their focus is on the generated data and its utilization on the aftermarket services. Google has experience and capabilities to manage vast amounts of data and to use it to train their algorithms, giving them advantage in developing self-driving cars. In addition to autonomous vehicle technologies, Google is developing in-car software platform and operating system for connected vehicles. Connected cars and ultimately autonomous vehicles free up time for passengers from driving tasks and open revenue possibilities on in-car services. As most of Google’s revenues come from advertising, they can gain huge benefit from a wide use of their Android platforms and from the development of new technologies enabling creating better customer profiles and new advertising channels (PCMag, 2012).

Tech companies are unlikely to start manufacturing vehicles themselves but instead to utilize their core competencies on data management and software, selling platforms to established manufacturers. Both tech companies and OEMs have noticed, that they won’t be able to succeed on their own but they need to cooperate to benefit from both parties’ competencies to be able to develop truly intelligent vehicles (Bloomberg, 2016, VentureBeat, 2015). Tech companies aren’t familiar with the car business which is an obstacle for them but it can be seen also as an advantage as they have the ability to think outside the box and do things differently. This mindset combined with the fact that the customers are already accustomed to using their solutions can lead to great success in gaining tech-savvy consumers’ attraction and in creating demand for new kinds of features and services.

One of the latest competitors in vehicle manufacturing is Tesla with its luxury electric cars. Behind Tesla's success from startup to well-known player are its compelling cars and new business model. Unlike most of the other car manufacturers, Tesla doesn't have dealers and it sells its cars directly to customers through online stores and company-owned showrooms. Tesla has direct customer-relationship also through its service centers and mobile technicians which you can call to your home to service your vehicle. The biggest advantage for Tesla is their OTA-updates. Some of the problems can be fixed by online technicians wirelessly uploading data. OTA-updates also gives the ability to offer new features to the vehicle, such as adding autonomous features or boosting up the engine. The owner of a Tesla can update his vehicle without buying a new car or going to maintenance, and pay only for the features he desires. Tesla makes most of its components in-house thus producing bigger share of value itself and gaining advantage with better ability to innovate. (Investopedia, 2015, Hanfield, R., 2016)

Many new players have realized opportunities for revenue sources from demand for ADAS systems which is expected to increase over the next decade, driven by regulatory and customer demand for safety applications. Semiconductor companies that didn't earlier have a presence in the automotive sector are now pursuing after ADAS opportunities related to sensors, processors, systems, and systems on a chip. Semiconductor players can have competitive advantage if they have experience from adjacent industries, and are able to adapt their products for automotive sector. In addition, they can capture value by expanding their offering into software and algorithms and attempt to provide modules or integrated solutions instead of single components. (McKinsey & Company, 2016)

Also many high-tech start-ups and SMEs are entering the competition, specializing for example in image processing and computer vision. To be able to stay competitive in the ADAS market, OEMs need to collaborate with these companies, and both Tier-1 and Tier-2 companies to pursue mergers and acquisitions to gain all the capabilities needed for ADAS development. (McKinsey & Company, 2016)

In addition, the traditional players in the automotive value chain need to work with telecom and wireless companies to create a comprehensive infrastructure supporting demand for customer access, accurate navigation, and the vast amount of data from different sources (KPMG, 2015b p. 24). Automotive players need to connect their value chain with wireless service providers, potential clients, fleet management companies, car rental and car-sharing services, infotainment content providers and developers of location-based services to capture value from opportunities created from connectivity (5G-PPP, 2015).

4.1.2 The supply base

The supply base is under constant cost pressure and technological development is creating new challenges for the suppliers. In order to adapt to these changes, the supply base continues its restructuring and consolidations may even accelerate. Emerging technologies are driving M&A (mergers and acquisitions) activity, as both traditional and non-traditional players are acquiring innovative startups to gain innovative capabilities and competitive advantage (PwC, 2016).

Consumer expectations for individualization and latest technology has led to increasing product differentiation. Over the past two decades the number of car models has increased dramatically. The consumers have also more power to select specifications to their vehicles from variety of colors to different add-ons. With increased demand for customization, OEMs are decreasing the design effort and costs by platformization. This means that they use the same basic platform for various vehicle models. The platform may include for example rolling chassis, braking system engines and transmissions. The parts are usually invisible to consumers and the visible ones remain model-specific. (Sturgeon et al., 2009 p. 20) Due to the use of shared platforms and modules, the physical differentiations of vehicles across all market segments is smaller and the car manufacturers are adopting new technical solutions that can improve car performance, comfort or safety (Veloso and Kumar, 2002). The continuing of platformization and modularization will futher drive the consolidation of suppliers, leading to a smaller number of large global suppliers. For example Ford has stated that it is reducing its supplier base from 1150 to 750 suppliers (Strategy&, 2015). Suppliers will outsource their hardware production to subsuppliers in order to concentrate on software and integration to increase their profits (Frost & Sullivan, 2015c). The Tier-1 suppliers are providing larger pieces of the cars and gaining even higher percentage of the value-added in each vehicle. Some of the Tier-1 suppliers are already capable of manufacturing complete vehicles themselves and more of them are becoming more like Tier-0.5 than Tier-1 companies. Those suppliers that won’t be able to provide extensive modules or keep up with the innovations are likely to become lower tier suppliers or exit the industry.

As the recent development of ADAS technologies pushes OEMs to collaborate with innovative Tier-2 suppliers, this gives them a more critical role and offers them upgrading possibilities. In contrary to traditional straight-forward tier structure where OEMs do business directly with Tier-1 companies and they manage the lower tiers, the lower tier companies can now directly deal with the car manufacturers passing the Tier-1s, if their offering is innovative and brings an asset to the OEM.

In addition to outsourcing low value-adding parts of their operations, the Tier-1 suppliers are actively partnering with and acquiring companies with innovative products and complementary capabilities. By examining the acquisition and partnering activity (Appendix A) of 10 biggest Tier-1 companies (Automotive News, 2016) from 2011 to October in 2016, the importance of acquiring capabilities for new technology development can be observed, as figures 8 and 9 shows.

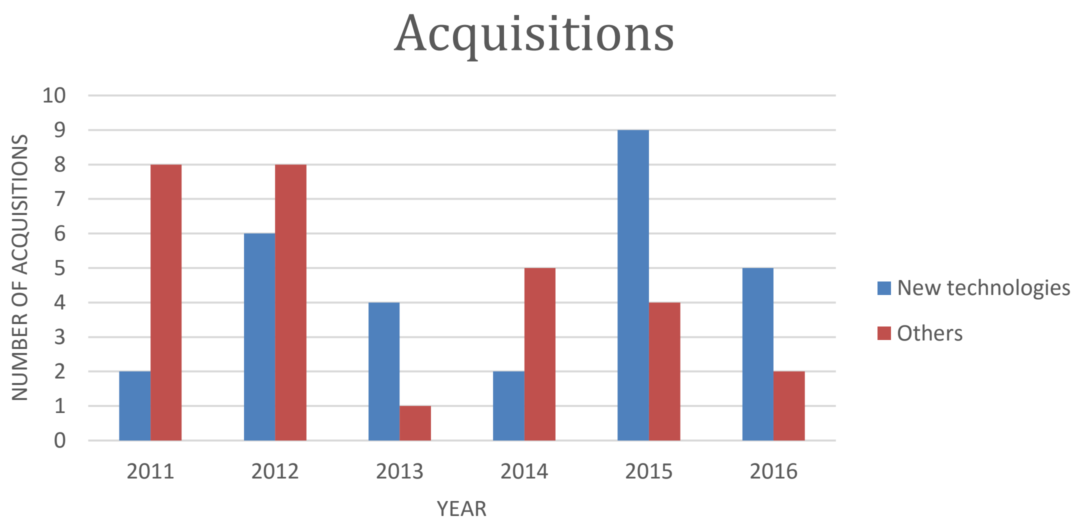

Figure 8 Acquisition activity of 10 biggest Tier-1 companies from 2011 to 2016

From 2011 to 2016, acquisitions on companies developing other technologies, such as basic components, chassis, stamping and conventional power trains, have been decreasing. During the last two years, the activity on acquiring companies working on new technologies have been already more than twice larger than on other technologies.

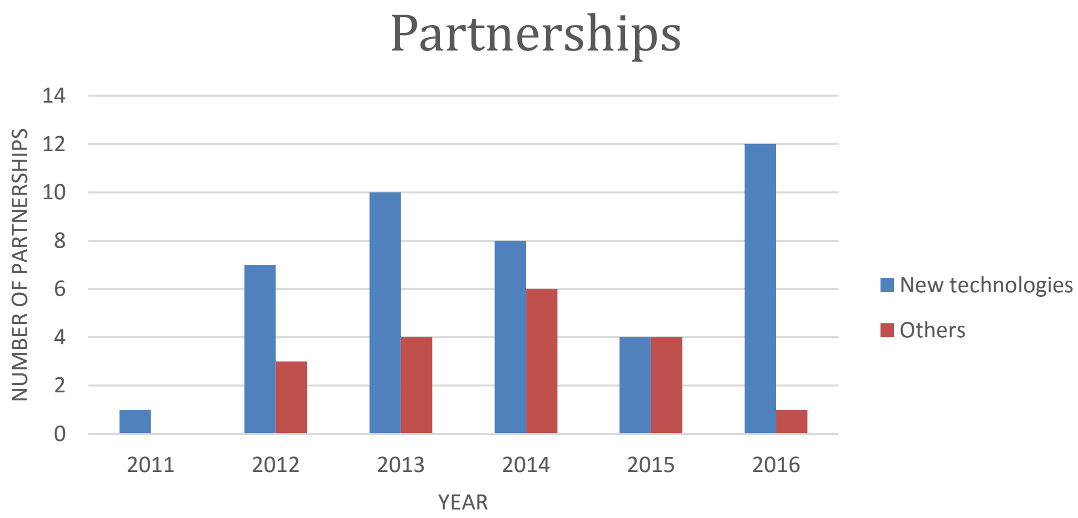

Figure 9 Partnering activity of 10 biggest Tier-1 companies from 2011 to 2016

The importance of partnering on new technologies is clear. Throughout the analysis period, the number of partnerships on new technologies is bigger than the number of other partnerships, except in 2015, when the numbers are even. Notable here is the clear increase on new technology partnerships in 2016, taking into account that the period is only from January to October. The trends are examined in more detail based on technology types and by year in figures 9 and 10.

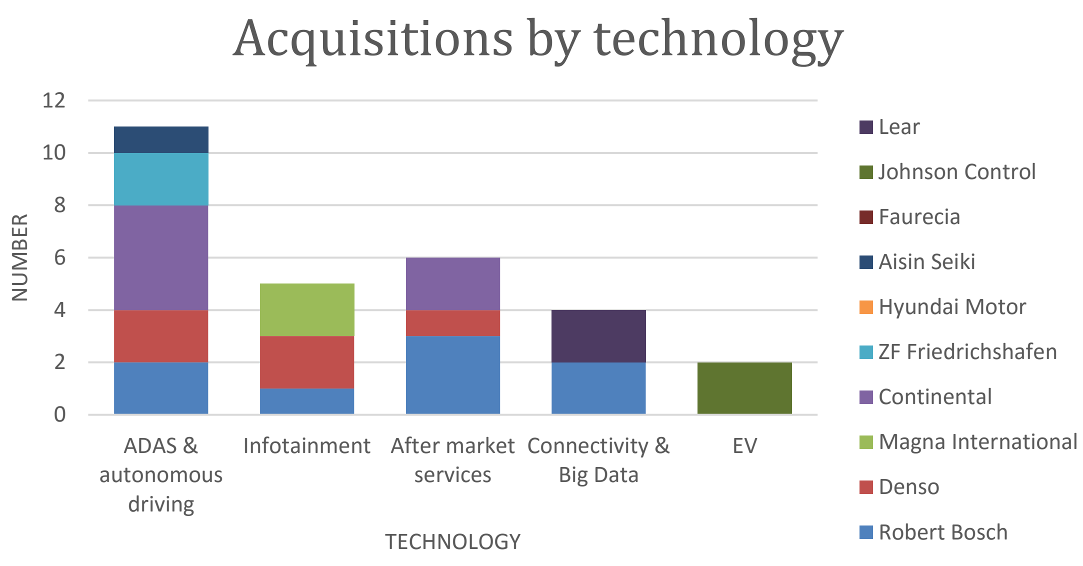

Figure 10 Acquisition activity on different technologies in 2011-2016

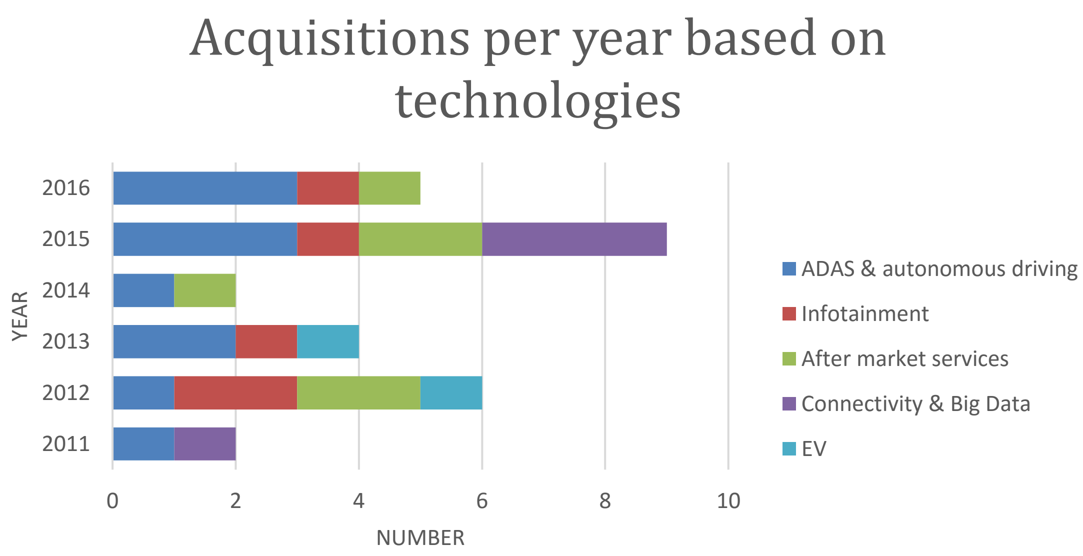

Figure 11 Acquisitions based on different technologies by year

The focus has been in ADAS and autonomous driving technologies throughout the observation period. ADAS related capabilities have the biggest share of acquisitions and by looking at the figure 11 we can see that the number of these acquisitons has been slightly growing. The second largest target is aftermarket services, which includes diagnostics and telematics products and services. The number of acquisitions on after market services and infotaiment have been quite steady, but on connectivity and big data there is a clear peak from 2015. During the analysis period, there has been only two acquisitions on electric vehicle technologies.

On partnering, the trends divided by technology types and by year are shown in figures 12 and 13.

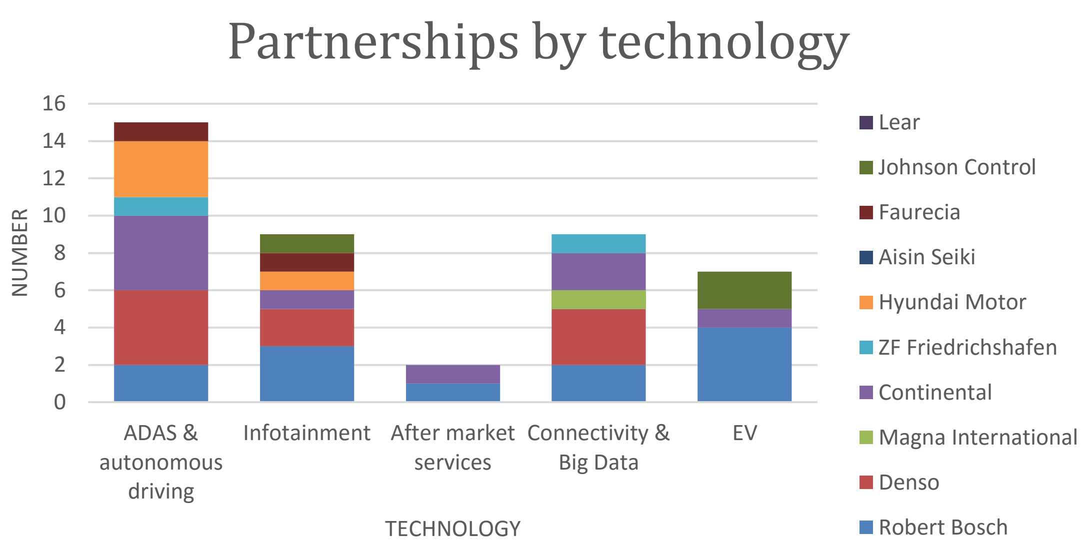

Figure 12 Partnering activity on different technologies in 2011-2016

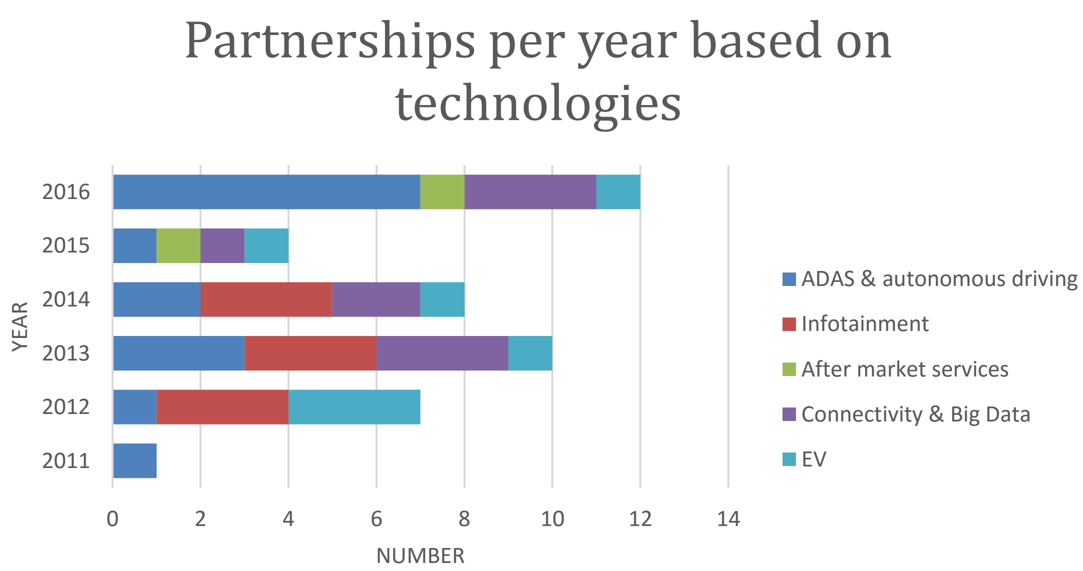

Figure 13 Partnerships based on different technologies by year

ADAS and autonomous driving technologies are the biggest driver also on partnerships and there has been a substantial growth during 2016. On the contrary to acquisition data, aftermarket services are not seen as relevant sector for partnering. Connectivity and electric vehicles technologies related capabilities are more commonly seeked through partnerships than acquisitions.

To specify what kind of capabilities the Tier-1 companies are after through acquisitons and partnerships, the competencies of the target companies or partners were identified to software (SW), electronics (ELE), data management (Data), electric vehicles (EV, including electric motors, battery technologies and charging), and to companies with core competencies on both software and electronics or unclear witch one (SW+ELE). The share of these capabilities is shown in figure 14.

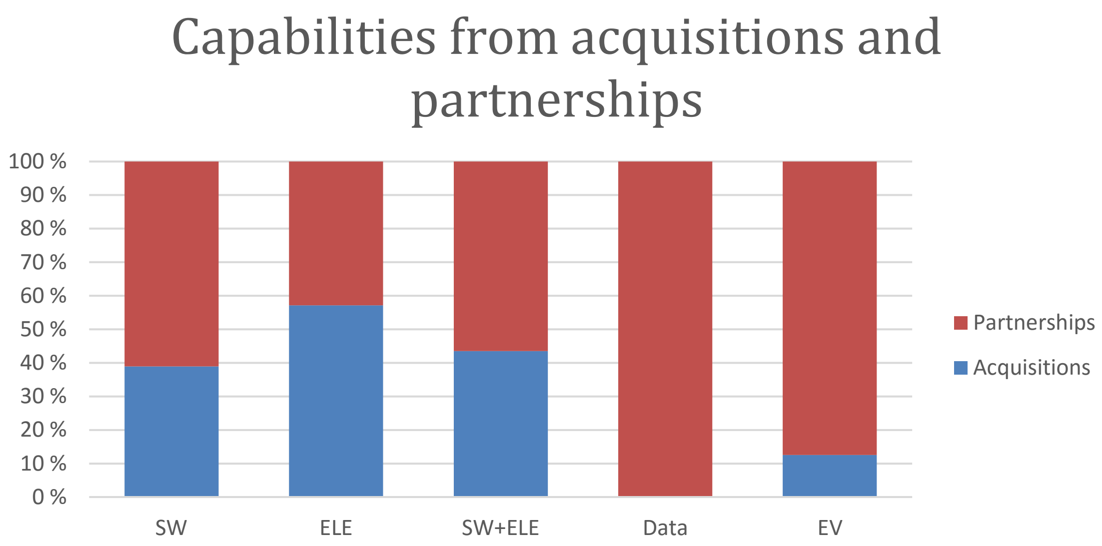

Figure 14 Capabilities acquired through acquisitions and partnerships

Figure 14 shows that data capabilities and the ones needed for electric vehicles development are mostly acquired through partnerships. These are the kind of capabilities that are usually posessed by companies so large, that they are out of reach to acquire, or the acquisitions will not be reasonable, for example if the related competencies are only a minor part of the target company's business areas.

4.1.3 Challenges facing OEMs

OEMs have been focusing their R&D on power train, interior design, and chassis components, which have been differentiators for them traditionally. Today, the differentiation factors have shifted to connectivity and ADAS features, in which expertise lies with Tier-1s. This is why it is essential for OEMs to establish effective partnerships with these suppliers to build long-term advantage and capture innovation. They also need to determine which areas of innovation will remain in-house and on which areas they will rely on suppliers and in co-development from external sources. (Boston Consulting Group, 2014)

OEMs ability to innovate isn't fast enough to keep up because they are mainly system integrators. Instead of developing components, they are mostly outsourcing them from Tier-1 suppliers, resulting in a lack of key engineering leadership to quickly produce innovations not available to their competitors. As an opposite, many new entrants in the industry produce proprietary innovations in some areas where neither OEMs nor their suppliers have core capabilities. (Pakman, 2015)

Some manufacturers are waking up and approaching the tech companies' way of building the car around technology instead of layering the tech on top of the car. Recently, Volvo and Geely presented a new car brand called Lynk & Co, which is said to be born digital. It has an open API (Application Programming Interface), sharing services, permanent connection to the cloud, and the first dedicated app store for cars. The brand is also following Tesla's footsteps with direct customer relationships as the vehicles will be sold online and delivered to the customer's doorstep. Even their website states that "the car is not a car" – it's like a smartphone and a platform with endless opportunities. They also state, that they are not just trying to sell a car, but you can buy, lease, subscribe or borrow one. (Lynk & Co, 2016) This is an example of the future business models where the traditional revenues coming from one-time purchases are turning into revenues coming along the vehicle's lifecycle and towards direct customer relationships.

OEMs may take lead role in ADAS development since the systems in autonomous vehicles must work together effortlessly. Taking charge of the ADAS development gives them better change of differentiating themselves for autonomous driving functions and freedom to select the best subsystems so they can avoid relying on a single Tier-1 supplier. (McKinsey & Company, 2016) To keep up with the development, the OEMs need to collaborate with innovative companies. As the development of autonomous vehicles offer them differentiation opportunities and they are also critical features needing high safety and security, the OEMs need to keep most of the critical software development in-house. The importance of this aspect can be seen in their activity on recruiting software engineers. Here are a few examples of this activity from 2016:

- General Motors hires 1000 software engineers in Canada to develop autonomous driving software.
- Volvo hires 400 engineers in Sweden to develop safety technology, autonomous driving and electrification.
- Tesla hires 1600 software engineers in Silicon Valley to develop Autopilot.
- BMW plans to increase number of software engineers to 50 % from 20 % to compete with the likes of Google

However, one of the obstacles facing OEMs is to secure new talent. Traditional automotive companies aren't seen as places where the most talented young people dream of working and at the same time, the companies' knowledge base is shrinking as older talent retire. (KPMG, 2015b p. 28) The increasing value of software and electronics can also be seen in the rise of software engineers' salaries. In 2013, starting annual salaries were already at least two-thirds higher than five years earlier, according to staffing firms in Michigan. As companies from multiple industries are competing for the same talent, OEMs need to redouble their recruiting efforts and in addition to offering competitive salaries, pitch their image and attractiveness of the area they are recruiting in. (Reuters, 2013)

Today, to keep up with the technology trends and to attract talent, OEMs are seeking innovators from hubs such as Silicon Valley or Israel. All the major auto manufacturers, Mercedes-Benz, BMW, Ford, Honda, Nissan, Volkswagen, General Motors, Hyundai, and Toyota, have already established offices and research labs in Silicon Valley (Automotive News). According to Statista's and LSP Digital's research, 55 % of connected car technology startups are located in the USA and only 4 % in Germany despite being a traditional automotive stronghold (Statista, 2016b).

The OEMs have a need for new partnerships and ecosystems to strengthen their positions. Earlier this meant finding the best suppliers but now it's moving to finding the best allies and establishing partner networks. In figure 15, the accelerating activity on forming partnerships can be seen (Appendix B).

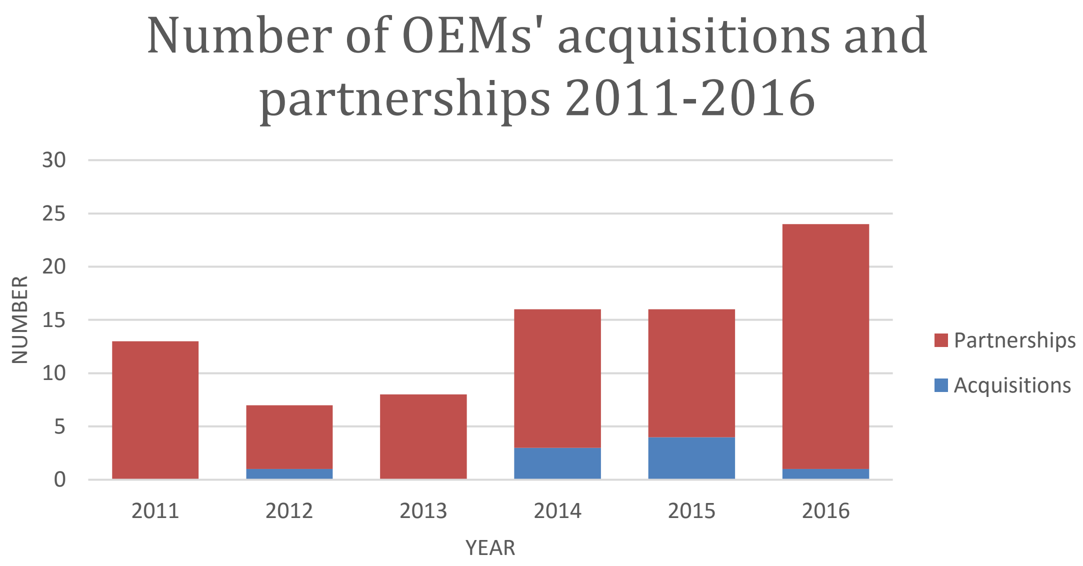

Figure 15 OEMs' activity on acquisitions and partnerships from 2011 to 2016

The data in figure 15 includes only the deals related to new technologies, as presented in figure 16. The OEMs had also formed partnerships related to materials development and charging infrastructure, but they were excluded from the research and were negligible part of the overall partnering.

Compared to suppliers' activity, there is an enormous difference on the number of the partnerships. During the observation period, while activity of 5 biggest car manufacturers was researched, OEMs acquired only 9 companies and signed 75 partnerships. The same numbers for suppliers were 28 and 42, respectively, and the research scope on suppliers was 10 companies instead of only 5.

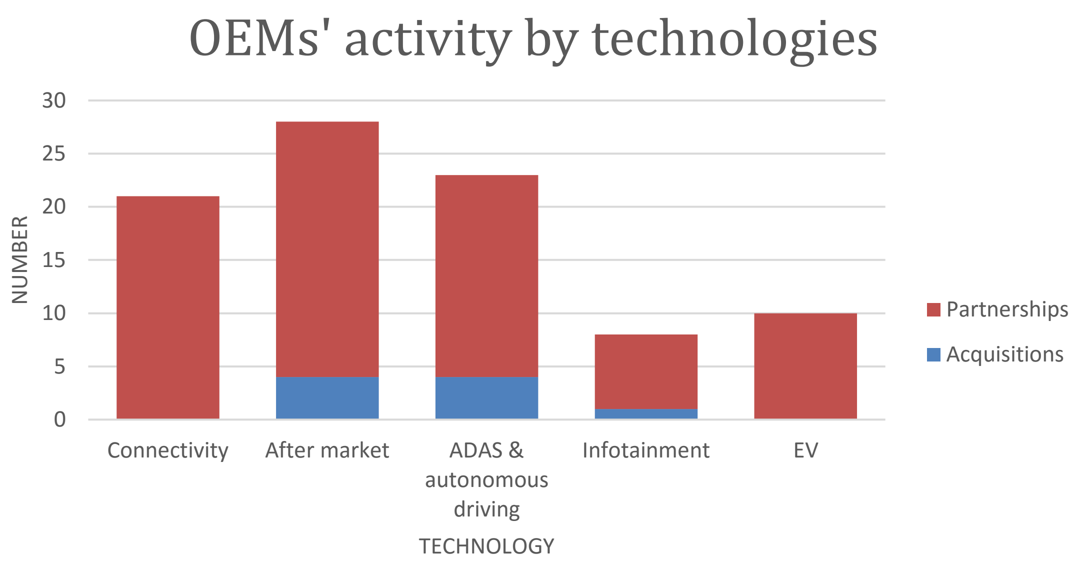

Figure 16 OEMs' acquisition and partnering activity on different technologies

As with suppliers, ADAS, autonomous driving and connectivity technologies are seen important sectors for partnering. However, OEMs have a clear focus on the aftermarket services, which in their part includes ride-hailing, car-sharing and apps. The partnering companies were mostly technology companies, mobility companies and research institutes, except on electric vehicles, where the OEMs mostly partnered with each other. They see electric powertrains as non-differentiating factors, and partnering on their development with competitors to share technology and costs is beneficial.

4.2 Downstream value chain

The new technologies enable new services, such as new mobility services, connectivity services, and feature updates, which could expand automotive revenues by 30 % (McKinsey & Company, 2016). With new service offerings, there will be new kinds of business models and ecosystem around them, and the value chain could be better described as a value network.

A network has the potential to create additional value for end customers when it brings together a set of differentiated partners with complementary capabilities and different economies. It requires a lead firm to create a structure to align partners with different roles and manage possible conflicts between them. Partners in the network can act as an important source of technology and competence or market and customer knowledge for the lead firm. Partners can also act as market makers when their operations or reputations may help to gain acceptance of the technology or service in the market and simulate additional demand. (Williamson and De Meyer, 2012)

Diversification strategy into services gives new sources for growth and value creation, even in markets that don't pledge great expansion potential due to their maturity. Services enlarge the skills and capabilities of firms and creates competence platform for more sophisticated product-related services. (Kessler et al., 2010)

4.2.1 Data-enabled services

The increasing focus on customer data can lead to a completely new and scalable revenue streams throughout the entire customer lifecycle. OEMs need to find a way to manage separate production cycles that operate at different paces in order to keep pace with the competitors coming from fast-paced high-tech industries, as in the upstream chain discussed above. KPMG's study (2015a) even shows an exaggerated alternative that OEMs could become suppliers themselves, producing vehicles which would be seen as mobile data rooms for companies such as Google. The other alternative for OEMs is to evolve and expand their business model beyond creating vehicles. However, OEMs have been shifting closer to the customers for a while now, since they have been outsourcing their design and production operations to suppliers, and taking a bigger role in sales, marketing and after sales services. Besides vehicle-depended services such as predictive analytics about vehicle operations, OEMs need to develop their business models towards vehicle-independent, customer behavior-oriented services. If OEMs manage to possess data on their customers' behavior, they will be able to provide tailored services matching every customer's specific needs. This is why it is surprising, that according to KPMG's study (2015a, p. 14), only 18 % of automotive companies have developed a strategy for the realization of big data measures.

The big question is, who will own the data. Is it the customer, OEM, or third party? Premium car manufacturers with strong brands have an advantage as their customers place greater trust in them to manage their personal data than technology companies. In particular, car manufacturers in Europe could have an additional advantage on account of the countries strict regulations on data security. To succeed, in addition to data security aspects, OEMs need to use informational engineering to intelligently combine the various data streams so that the resulting benefits for the customer form a unique selling point compared with the third parties. (KPMG, 2015a) The data ownership is likely to be based on an agreement on which parties the vehicle owner is willing to give his information to, and these can be multiple parties.

New services will be based on data generated from vehicles, infrastructure and passengers' mobile devices, and the value creation will be based on new revenue streams, cost reduction, and increased safety. Examples of creating value from data is presented in table 3.

Table 3 Value creation models. Modified from (McKinsey & Company, 2016 p. 12)

VALUE CREATION MODEL	EXAMPLES
INCREASING REVENUES	Map updates Directions to nearest repair shop Location-based promotions Streaming In-car purchases Selling data for insurance Targeted advertising Feature updates, e.g. to increase horsepower
COST REDUCTION	Predictive maintenance Driving style monitoring Optimization of materials costs on R&D based on sensor data Pay-as-you-drive insurance Cost reductions based on purchases
SAFETY	Real-time warnings Emergency and breakdown calls Driver distraction monitoring

Collecting and analyzing data creates opportunities for new revenue streams. New services, features and targeted advertises can be delivered to the customers through infotainment. Car sensor data can be utilized to gather information about the vehicle’s condition and location to give directions to the nearest repair shop or gas station. In the same manner, location-based offers can be delivered. For example, if the vehicle’s gas level is getting low or the driver has driven for a long time and it would be good to have a break, the system can show advertisement about free coffee if he wants to stop by the near gas station. OTA updatability enables selling updates to maps and control features, and change the car’s functionalities. OTA updates give the possibility to for example increase horsepower or add autonomous features, permanently or temporarily. The data owner can also sell the data to third parties such as insurance companies or shops. Luxury shops may be interested in premium car owners’ preferences for targeted advertisement purposes, location-based promotions and in-car purchases, utilizing in-vehicle spent free time for increasing sales. In this value creation model, the player who has the access to all the data and is able to process and sell it, will be acting as a gatekeeper. The player will have to be highly trusted by the end customers and is responsible for ensuring data security. This position is natural to be possessed by the OEMs with trusted brand image and the ability to coordinate security issues throughout the value chain. (McKinsey & Company, 2016) However, third parties can convince customers to install OBD-II dongles to have straight source to car condition data. Multiple players will enjoy increased revenues and the end customers will value increased convenience.

Value will be also delivered by cost reductions. In-vehicle sensors can help predict breakages of specific components and notify the driver before they happen. As mentioned earlier, directions and discounts can be offered to the customer based on location data. The sensors enable monitoring the driver's driving style and give instructions to help save fuel. This data can also be used to offer pay-as-you-drive insurances which reduces insurance costs. As much of the car's lifetime costs come after the purchase, these services bring huge value to the customer. On the other hand, vehicle sensor data can also be utilized in the upstream chain on R&D. The sensor can give information for example about how many times the back doors of the vehicle have been opened in the vehicle's lifetime. If the door mechanism is measured to last 10 000 times and it is opened and closed only 7000 times, cheaper materials can be used in the future. One big benefit is the possibility to save on costly recalls. If there has been noticed a failure in some component, instead of calling back all the vehicles which are using it, the drivers' can be notified real-time to drive to replacement or the issue can be even handled OTA.

Third value-adding aspect is safety. As we know, safety features are highly demanded by both customers and the regulators. Data from ADAS systems and infrastructure offers huge benefits on safety with real-time warnings about hazards concerning other vehicles, driver distraction, road works, and road conditions. If an accident or a breakdown happens, the system is able to send valuable data to emergency responders to speed up getting help.

Different content providers, app developers, advertisers, insurance companies, and others will be sharing the new revenue streams with OEMs. As most of these services are yet to come, early entrants will gain advantage.

4.2.2 Mobility services

New mobility services are making a change in customer preferences – away from vehicle ownership and towards vehicle usership. The increasing adoption of these services and the success of companies like Uber and Lyft have already made car manufacturers rethink their business models. Many OEMs have already partnered, invested in, or started R&D projects with new mobility and technology firms, and included in-house mobility services for their offerings. Companies like BMW, Daimler and General Motors, have announced changes in their strategies and aiming to become service companies instead of plain vehicle manufacturers. Car-sharing and ride-hailing companies give OEMs the opportunity to turn those companies into reliable customers and they can influence in potential losses in private sales. Mobility companies using their vehicles is also an advertisement for their brand. In addition, companies offering car-sharing and ride-hailing are potential customers specifically for electric and luxury vehicles as the higher cost of these vehicles could be more rapidly offset due to intense use of the vehicles. There is also an opportunity to gain revenues from these companies' driver-partners through financing, leasing, or renting vehicles for them. (CAR, 2016 p. 29-32)

In addition to OEMs activity on mobility services field, their strategies are also focusing on connectivity, autonomous driving, and electric vehicles. All these trends are linked together, complementing each other and driving to a broader change in transportation. Deloitte's analysis (2015, p. 19) estimates that shared mobility will shift value from asset ownership and driving performance to software and driving experience. Autonomous cars and shared mobility will lead to the rise of mobility management providers and autonomous drive operating system players. There will also be a wider range of vehicle designs to meet needs for every occasion. Ultimately, customer will enjoy rides on-demand, exactly appropriate for their need at the time, customized for their preferences, and at lower cost than owning a vehicle of their own.

4.3 The main impacts

The technological development is opening doors for new companies coming from non-traditional industries. As many of the capabilities needed for the development of new technologies are not core competencies for the traditional players, they need to cooperate with innovative companies in order to differentiate, and to acquire software know-how.

The traditional supply base keeps restructuring as consolidations continue. Tier-1s outsource low value-added parts, increase their software capabilities, and deliver even larger modules to increase value. Some Tier-1s would be able to build vehicles on their own and also completely new companies are starting to build cars around new technologies. The OEMs are also increasing their software know-how to be able to keep critical parts of the autonomous driving development in-house. Some are also changing their business models towards direct customer relationships and services. OEMs are facing competition on multiple fronts and they need to adjust their strategies to keep their presence.

The increasing acquisition and partnering activity on new technologies shows the growing importance of the new entrants in the value chain. The Tier-1s' activities are concentrated on ADAS and autonomous driving development and OEMs' on connectivity, autonomous driving and new services. Technological development brings possibilities for companies that are innovative and able to adapt their offering for the automotive sector. The new entrants have become an important part of the value chain and they bring value for multiple players. Instead of straight-forward tiered chain, the value chains are now complemented with multiple new players and transforming into value networks.

5. INTERVIEWS

To obtain the views of the actors in the automotive field regarding changes in the automotive industry, 4 experts from companies and 2 experts from research sectors were interviewed. All the representing companies offer software-based products or services to the automotive industry, such as engineering and consulting. The interviewed researchers are working on projects in the automotive field. The interviews included questions about value creation, industry trends, and Finnish competencies. Detailed information about the interview structures can be found in Appendix C. This chapter contains results of the interviews combined together.

The value chain is seen to differ from the traditional one. The companies' revenues come mostly from Tier-1s and OEMs, and from the revenue point of view the companies can be viewed as Tier-2 or Tier-1 companies. However, as Interviewee 3 points out, they are a technology supplier and they approach the new value chain from a different angle. The word 'tier' is associated with integration and taking the overall responsibility forward. In contrast, technology suppliers can supply to everyone along the chain and they can be viewed as being positioned alongside the upper part of the tiered chain. The differentiating factors and competitive advantage of the companies is seen as being brought by comprehensive product range, value brought to the whole value chain, product readiness and agnosticism. Interviewee 2 believes there is also a shift in the value chain's power relations. In decisions related to new technologies, OEMs are more and more the decision makers and this influences the power position of Tier-1 companies. Therefore, the Tier-1s themselves are becoming more of integrators than decision makers. However, most of the revenue streams still come through Tier-1s and especially deals related to traditional components go through Tier-1s as before. Of course, there are a lot of differences and extremities in these roles. Tier-1s are strong players and they are building software and intelligence, so they might even some day announce that they will not be supplying to manufacturers anymore but build their own car around software.

The researchers were also interviewed about the changes they see arising in the downstream side of the value chain. Interviewee 4 sees Tesla's business model with direct sales as the future. Internet will be an important channel not only for vehicle sales, but for different kinds of services and features to be installed in the vehicle. "Googles" will be part of the ecosystem as they have strong operating system knowledge and they already have ongoing pilot projects. New technology companies, service providers, app developers and all big software companies will be entering the market. The traditional players need to open their code to create added value for their products and to stay competitive.

Open source will bring new ideas to the market through the increased amount of developers. It was also seen likely that some company will enter the market as a “Wild card” with a completely new offering.

The different development cycles in software and automotive industry is seen as a huge challenge, but most of the companies see themselves in their part helping to solve it. The amount of software and electronics in vehicles, in terms of cost and perceived value, increases all the time. In addition to in-vehicle systems, the new mobility service models are also implemented with software, and together these can lead to a tenfold increase in the amount of software. Interviewee 5 sees that the car will become a platform with possibilities for mass differentiation through apps. Ultimately, it will become an extension of the living room. Today, the operations in software and electronics are highly fragmented as the needed pieces are gathered from multiple players. This results in high costs. Structures must be simplified and consolidations will emerge, said most of the company interviewees. As 90 % of the vehicle development can be software development, it is natural that companies with software expertise will enter the automotive industry. Interviewee 3 put together the enormous change that the automotive industry is going through:

> *“The mobile industry had 15 years to develop from hardware into a modern software business, but in the automotive industry, in addition to moving from hardware to software, also new forms of travelling, such as electric cars and drones, and new service models, all come in a 5-year window. The transition was hard in the mobile industry and then even the 15 years felt short.”*

Different opinions arose about whether or not some of the traditional OEMs will survive, but it is certain that new ones will continue to come into the market. The newcomers are seen as faster innovators, and they see opportunities in software and electronics to differentiate them from the traditional OEMs. Technology firms entering the industry prepare the software and build a car around it, as traditional OEMs build the car and put software in it. These two approaches are in a collision course. When asked about how competition will change, increasing competition between big players and consolidations were often mentioned. New entrants are going to be companies working on AI, service providers, consulting firms, sensor manufacturers, software suppliers, and new car manufacturers, such as Tesla. Overall, ICT industry and all the players coming from agile world have a lot of potential. Tesla was used as an example multiple times when talking about newcomers, electric vehicles, updatability, or user experience. The interviewed companies also brought up cooperation with competitors as being important. As Interviewee 1 phrased, everyone wants their part of the big money, and this creates not only competition but also synergy.

Some of the companies build all their core competencies themselves, and some use partners to complement each other to be able to implement ready-made solutions that would not be possible to do alone by either one. Partners are also seen as a source for learning and improving products through their knowledge. In addition to different firms, many companies cooperate with universities and universities of applied sciences, which can provide talent with education targeted for the companies' needs. Companies also provide internships and projects for students. Interestingly, there is a difference in how companies and research sectors see the universities' state of education. One of the companies sees that universities are up to date with the future software needs of the automotive industry and in contrast from the research sector rose an opinion on how the education is lagging behind.

Along with the new technologies, the amount of data is going to be huge and the relevant information must be shown to the driver. Many of the companies brought up the fact that autonomous driving won't come overnight, but in small sections as separate features. As the vehicle takes charge of some of the driving-related decision, what will be shown on the displays will change a lot:

> *"The operating system's role will be increasingly to provide the sense of control to the driver. As an example would be a metro, which wouldn't provide information about where you are and when is the next stop. More pleasant is that it tells you that such-and-such stop is in three minutes. The passenger wants the information even though he is not in control, in order to achieve the sense of control."*

Instead of tachometer, information such as weather conditions, traffic, and free parking spaces are demanded. On the other hand, one of the interviewees speculated if the evolution of ADAS systems will lead to cars being used for entertainment only or will there be interaction left between the vehicle and the driver. It is certain, that the amount of displays in cars will increase. Challenge brought by the new technologies is the uncertainty; what will the future vehicles look like and what will be the demand? The companies need to be agile to keep up and to maintain skilled workforce.

When asked about the advantages that Finland has in the automotive industry, the Nokia's heritage was mentioned by almost all of the interviewees. Along with Nokia, Finland has gained an excellent and solid base of skills in extensive engineering know-how covering coding, graphics, sensors, cameras, embedded software, and others. People have also learned how to work in global projects. It was also mentioned, that now that there is not one major company, where all the talent wants to work, it can be easier for other companies to attract this skilled workforce. However, the automotive business is very different from the mobile business, and Finland needs to gain more understanding on how it works. Finnish automotive players need to develop customer oriented approach, productization, and conceptualization. It is not enough to have superior tech, but one needs to show what it can do. In addition, Finland needs to strengthen embedded know-how with cloud know-how and to produce comprehensive solutions instead of components. If the automotive industry starts using open source, this opens also opportunities for Finland to enter the market. Alongside with the automotive business models, the funding in Finland is seen as a challenge. In contrast to many other industries, it takes much more time to realize a return. However, Finland's broad technical know-how is likely to bring investments to Finland, especially in R&D where the determinative factor is not the unit cost but value creation.

Getting into the automotive business is seen as being hard. More and bigger Finnish companies are needed to get in to building relationships and then also the other companies can benefit through different forms of partnerships. The legislation is seen as an advantage as it allows testing in the actual traffic, which is quite rare. However, even though we have excellent possibilities for winter testing, Interviewee 4 tells that the OEMs do not see the snow conditions as a primary problem to solve in autonomous driving, since only 2-3 % of vehicles are sold to be used in winter conditions and even then the problem is present only for a few months a year. The interviewees from the research sector see that Finland needs more "do attitude" and to put an effort to getting into the automotive software R&D site. Regarding the new services, Finland has competencies in the gaming industry and mobile applications, which can be transferred to being used in the automotive industry. In addition, 5G development was mentioned as an advantage.

In summary, the results of the interviews confirm that the new companies coming to the automotive industry can bring value for multiple players along the traditional value chain. They are part of the industry's value chain but they can be better viewed positioned along the traditional one as technology suppliers. The new technologies also affect the traditional players' roles as OEMs can work directly with the technology suppliers, and traditionally only Tier-1s have had the direct supply relationship and they have been the decision makers. The interviewees saw that consolidations will continue as discussed in chapter 4. Finland has possibilities to succeed in the automotive industry due to deep technical know-how in areas that benefit the automotive sector. However, we need more Finnish companies in the industry, or foreign investments to get a better foothold, and to commercialize our products better.

6. OPPORTUNITIES FOR FINLAND

Finland has a reputation of creating user-driven solutions and sought-after technologies. Finland has dynamic ICT clusters in gaming, industrial internet of things, big data, financial technology, ecommerce, digital health, digital learning, mobility-as-a-service, photonics and mobile application development. (Finpro, 2016) Many of these sectors have competencies that can be easily transferred to future vehicles and mobility services development.

As in the interviews came up, Nokia has been the biggest influencer in shaping the Finnish offering and bringing advantages that continue long after the golden days. The Nokia cluster has created a strong inheritance of wireless communications and mobile device know-how, and has helped to create development experience, from standardization to system on silicon and full-fledged products (Finpro, 2016).

In addition to skilled professionals, education continues to be the main engine behind Finland’s digital success with having one of the world’s best education systems in the world based on the PISA rankings. Finland also has efficient innovation systems that encourage collaboration between research institutes and companies and has the highest ratio of labour productivity to cost in the world. Finland is used as a testing ground by international companies due to highly receptive market to new technologies and services. Finland has a flourishing Silicon Valley-inspired start-up culture and the number of software firms in Finland has risen by 40 % in six years. (Finpro, 2016) The software industry survey shows that while the global software market grew by 5-8 % a year in 2014, the growth in Finland was 20,6 % and the trend has been similar in 2015 (Software industry survey, 2015). One of the factors behind this is the growth of Internet as a marketing and distribution channel. Finland has a lot of know-how in this area and in creating new kinds of software businesses. (Finpro, 2016) This expertize can be used in bringing new automotive aftermarket services to the consumers.

Finland was one of the earliest adopters of mobile telephony and internet connections. Today, Finland has an extensive 2G, 3G and 4G network coverage, and is a forerunner in mesh networks and 5G technology with highly advanced test network capabilities for new applications. The 5G opens possibilities for multimedia content delivery and data sharing services in the wireless domain for connected cars and autonomous driving. Several global companies are already developing new technologies with VTT Technical Research Centre of Finland and Finnish Universities. VTT is working on wireless sensor networks, wireless data management, vehicle communications and autonomous vehicles ecosystem., and helping automotive companies for example to solve the difficulties related to the technologies’ function in challenging weather conditions. Finnish universities have expertise in electric vehicles, wireless communication, sensors, location technology, image recognition, machine learning, software engineering, and data analysis, among others. (Finpro, 2016)

ADAS and autonomous driving technologies need to be tested under different environmental and operational conditions to ensure their safety. Finland has several test beds for architecture and device testing, such as the Aurora test ecosystem for intelligent transport and automated driving in the Finnish Lapland (Liikennevirasto, 2016). In Finland there is a strong mindset to permit testing and introduction of autonomous vehicles, and the Finnish Transportation Agency recommends to improve informing the local and foreign companies about the possibilities brought by the Finnish regulation. The Agency also recommends better utilization and promotion of the strong Finnish expertize in organizing and managing field tests. Finland has an opportunity to specialize as versatile test environment for winter conditions and our permissive legislation would act as the basis. To reach this vision, the local actors need to be networked together effectively, so the whole country could become an arctic test environment where all the actors can concentrate on their core competencies. The goal is to attract foreign actors to Finland with joint marketing efforts. Since 2015, Trafi (The Finnish Transport Safety Agency) has offered guidance and assistance in planning and organizing automated driving experiments. (Liikennevirasto, 2015) Finland also has a road map to make MaaS (Mobility-as-a-Service) concept a working reality by 2025 and hosts the first MaaS ecosystem in the world (Finpro, 2016). The concept brings together all the means of transport, including car-sharing and ride-hailing, combining different options from different transport providers into a single mobile service (MaaS Global, 2016). A survey conducted by Green Business Development GmbH (GBD) shows that Helsinki is seen as one of the new mobility hotspots in Europe (GBD, 2016).

As the amount of data will explode along connected cars and new services, Finnish companies' competencies on big data analytics provides competitive advantage through deeper understanding of consumer behavior and ability to manage networks effectively, automatically leveraging business intelligence into relevant and timely actions that boost customer experience. In addition, our country is a leading digital weather data provider, and for example Foreca is providing forecast data for BMW to be used in its connected car services (Foreca, 2015). The connected cars are part of the IoT, and Finland has companies involved in every aspect of the IoT value chain, from sensor manufacturing to analytics and visualization. According to the Eurostat study from December 2014, Finland has the highest take-up of cloud services in Europe. With data usage, also security issues arise. Finnish key competences in the cyber security area are virus protection, identification and identity control, firewalls, situational awareness systems and testing as well as data and cyber security services. There's also high quality expertise in cryptology, mobile security, and vulnerability analysis. The Finnish value proposition for development of intelligent vehicles is presented in table 4.

Table 4 The Finnish offering in intelligent vehicles sector (Finpro, 2016)

Improved and secure connectivity	• Cloud-based infotainment systems (e.g. maps, traffic conditions) • Wireless communication systems • Integration between cars and smartphones
Optimized data usage	• High precision sensors for acquiring e.g. acceleration, inclination, rotation, temperature data • Powerful data aggregation and analysis solutions, bespoke for automotive industry
User-centric service design	• Proven development frameworks for native applications and highly-performing hybrid solutions • Expertize in creating compelling user interfaces • World leading experts delivering iterative software development for quick product launches
Value adding applications for customer satisfaction and retention	• Leveraging app development know-how for delivering in-car smartphone experience • Improved traffic safety with embedded software
Test environments	• Arctic winter testing for automotive industry • Public infrastructure in Lapland enabling smart traffic and autonomous vehicles testing in real arctic road environment • 5G open test networks • Authorized test labs
Vision leaders in Cyber security	• One of the strong cyber security clusters in Europe • Core expertise in encryption, data privacy, threat prevention and identity management solutions

During the last 10 years, the innovation activity has become a key point for start-ups in Finland and more of them are after a significant growth internationally, although still in small numbers. However, half of the start-ups face challenges with regulations and legislation, and especially the growth-oriented companies have difficulties in receiving funding. One of the challenges linked to the entrepreneurship was also the low number of foreign investments. With systematic development, Finland has the opportunity to build a start-up ecosystem up to the international level. One of the corner stones is to deregulate regulations that are harmful and outdated. In a report by Valtioneuvosto, the new Transport Code is given as a good example. (Valtioneuvoston kanslia, 2016 p. 137-142) In the Transport Code, transport market regulations are brought together in a unified act. The aim is to create preconditions for new business models and entrepreneurship, and to enhance implementation of technology and digitalisation (Liikenne- ja viestintäministeriö, 2016).

Foreign direct investments (FDI) are driven by global development and investors are generally attracted to large and growing markets. There are also country-specific location drivers, such as a stable business environment, a light corporate tax regime, high quality infrastructure and support from local investment agencies. In addition, sector-specific factors influence the FDIs. Low wages attract FDI in labour-intensive sectors and companies with a need to secure special competencies and skills tend to locate in countries with those skills. (European Commission, 2016c) The motives to invest in Finland and in the automotive sector are to gain skilled labour and technological capabilities and this way improve the quality of existing products as well as innovating new ones. When comparing multiple countries as potential FDI locations with equal resources, the cost, language capabilities, location, and regulatory framework can be determinative factors. In addition to the advantages mentioned earlier in this chapter, Finland has one of the lowest corporate taxes in Europe and lower salary expenses than in traditional automotive countries, such as Germany, or innovation hubs, such as the United States and Israel. The comparison of labour costs of software development centre with 20 employees is presented in figure 17.

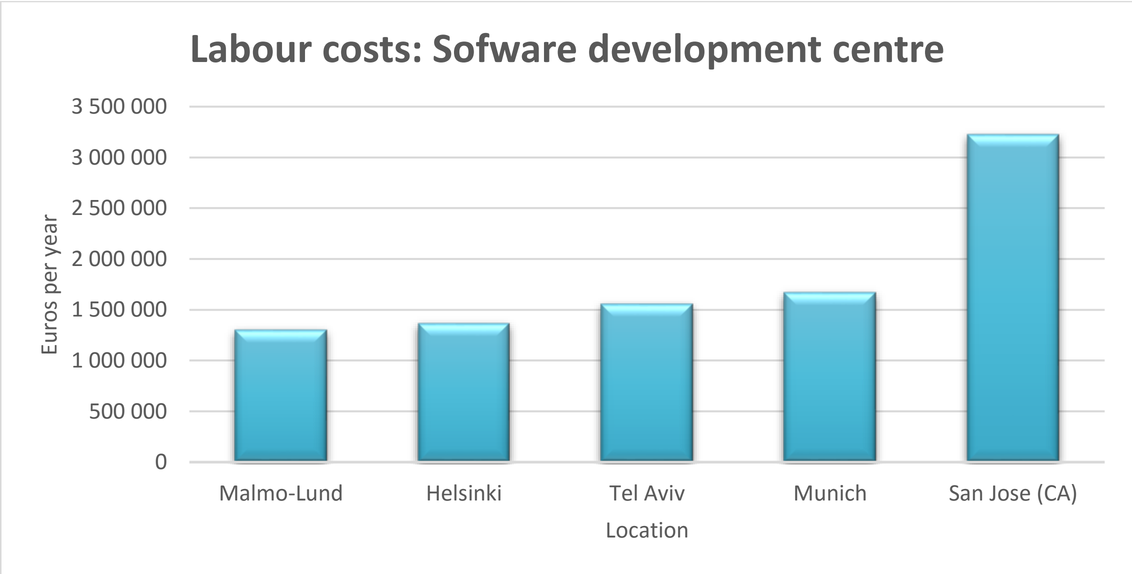

Figure 17 Labour costs of 20 persons' software development centre by location (Finpro 2016).

Finns have good language skills and English is commonly used in business. Finland has been ranked among the world's most innovative countries for years and placed 5th in 2016, according to Global Innovation Index (GII, 2016). In the EU, Finland is ranked as the 3rd most innovative country (European Commission, 2016d). In addition, Finland is currently ranked as the most attractive country for foreign direct investment in the EU in European Commission's comparative analysis (European Commission, 2016c). The study revealed that Finland has the most attractive political, regulatory and legal environment in the EU, as well as the highest knowledge and innovation capacity.

The Finnish ICT technology base, unique conditions for winter testing, and education system create an excellent environment for future vehicle and mobility services development. The strength for Finland is the small circles, that allow effective networking and collaboration to build an ecosystem around intelligent vehicles (Liikennevirasto, 2015). Multiple companies in Finland have already spotted the possibilities brought by the disruption in the automotive industry and have been able to successfully get in by adapting their competencies in the mobile industry to the automotive sector. Finland is a highly innovative country and an ideal location for foreign direct investments, offering special competencies in software and electronics development, permitting legislation, innovative ecosystem, and attractive political environment.

7. CONCLUSIONS

The automotive industry is evolving from being solely a product-based industry into services. The disruptive trends behind this transition are connected cars, automated driving and new mobility services. Software and advanced electronics are the main drivers behind these trends and they open doors for new entrants coming from different industries.

The major changes that the automotive industry is going through can be reflected to the ones other industries, such as the mobile industry, have gone through in the past. However, the digitalization and value shift to software from hardware is happening in a lot faster pace and from multiple directions in the automotive industry. OEMs and Tier-1 companies have challenges to keep up with the innovations and to acquire software know-how, which has not traditionally been their core competence. Today, as 90 % of all innovations in the industry are coming from software and electronics development, it is natural that companies from adjacent industries with strong software competencies are entering the competition to gain their share of the automotive market's revenues.

In the upstream value chain, connectivity, infotainment, ADAS, autonomous driving, and alternative propulsion are main technologies creating value. In order to keep up with the technological development, the acquisition and partnering activity is accelerating as traditional players are seeking for complementary competencies. Also the newcomers are starting to acquire the traditional players to gain bigger foothold in the market. Neither the traditional players nor new entrants will be able to succeed on their own and creating new partnerships and ecosystems is a must to stay competitive.

The aftermarket revenues can increase 30 % with the introduction of new services. Connectivity enables selling apps for entertainment purposes and buying new features to a car thus allowing one to modify their vehicles according to their preferences and needs. The car will also become a new channel for targeted advertising and location-based offerings. New mobility services will increase vehicle usage rates through ride-hailing and car-sharing, and the usage will futher increase after the introduction of shared electric vehicles. In addition to tech companies, service providers, content developers, and other new entrants, OEMs are also after these new revenue streams and rethinking their business models.

Besides the industry's ability to innovate, the pace in which connected cars, autonomous vehicles and the genuine shift from car ownership to car usership will be largely seen in our daily lives, depends on the customer demand, customer readiness to adapt the new technologies, and legislation.

Traditionally, the automotive industry's value chain has been tier-structured, where each tier produces larger pieces towards the car manufacturer, integrating the lower tier's components or materials to theirs and increasing the value after each tier. The lower tier suppliers usually supplied directly to the next tier and Tier-1 companies directly to the OEM. The OEMs have been increasingly outsourcing their operations to Tier-1 companies and expecting them to make even larger modules and sub-systems, which led to consolidations and formation of mega-suppliers. Some of the mega-suppliers can be referred to being Tier-0.5 suppliers as they are able to produce vehicles on their own. This might even happen in the future as they continue to acquire complementing capabilities. OEMs are also threatened by new companies that build cars around new technologies. Many new entrants come from agile industries and are able to innovate faster than the traditional players. Now the innovations and value is seeked from different industries and also smaller companies with innovative products and software competencies can even work directy with the OEMs. Along the traditional value chain there are now new suppliers with ICT-based offerings who can work with multiple players in the traditional chain. New actors are increasingly joining also the downstream value chain as new service models are formed, combining a value network, as shown in figure 18.

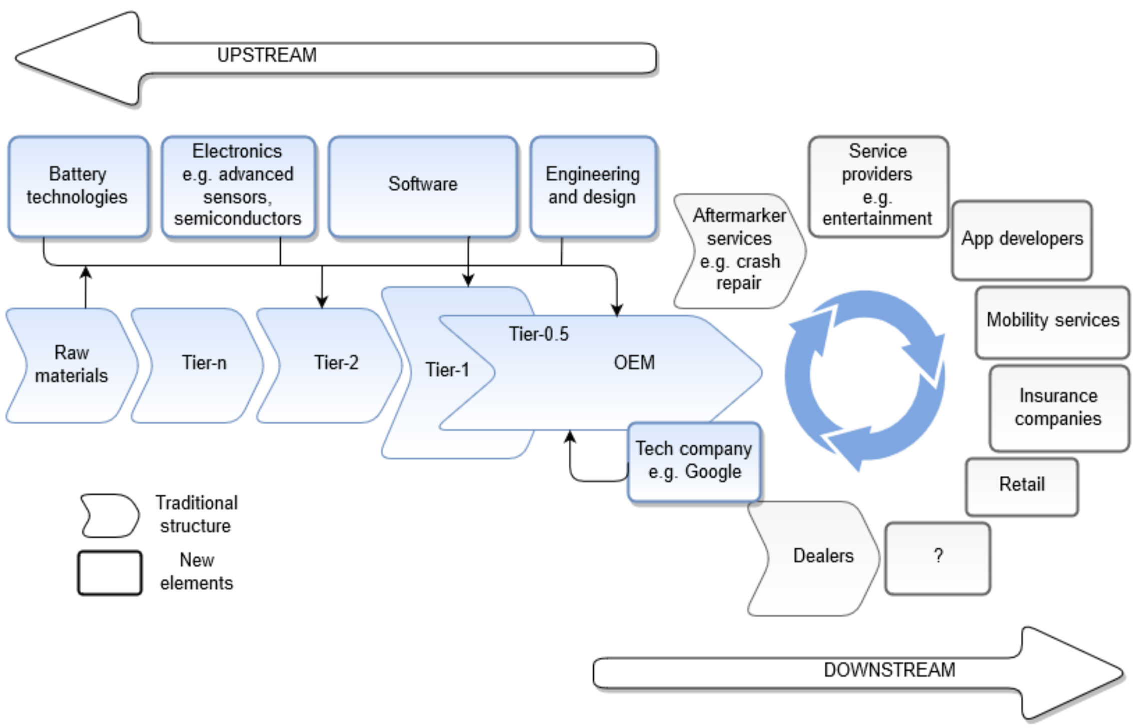

Figure 18 The new value chain (author's view).

As most of the new elements in the value networks are based on ICT technologies and on the areas where Finland has competencies, Finland has a lot of potential to succeed in the new technology and service driven automotive markets, and to attract foreign direct investments into the country. Finnish competencies and offerings have been gathered to table 5 under connected cars, autonomous driving and new services. Finland needs to enhance its marketing internationally and promote its winter testing possibilities, innovative ecosystem, and legislation which allows testing autonomous vehicles in real world conditions. Finnish companies working in the automotive industry see that Finland needs more companies to the industry and to better understand how the industry works. Partnering is also seen important as a way to enter the market and to provide an ecosystem to attract foreign companies.

Table 5 Some of the Finnish offerings in the fields of disruptive trends

Connected cars

- **Data management** and integration of multiple data sources
- **Cyber security** expertice
- **Cloud**-based solutions
- **Integrated in-vehicle computers**
- The most advanced **5G test network** in the world
- Next-generation **user interfaces**, e.g. touch tracking, electrostatic haptic feedback
- **Connectivity** solutions
- **Agile software** development

Automated driving

- **3D data analysis** for automatic scene understanding by gathering data from the environment using video and depth cameras, stereo cameras and other sensors
- **Algorithms** that process sensor data
- **Wireless sensors** and wireless data management protocols
- **Context detection**, computer vision
- **AR & VR** technologies
- **Winter testing**
- **Autonomous driving testing**

New services

- **Mobile applications** development
- **Mobile payment** systems
- The first **MaaS** ecosystem in the world

Finnish companies can adapt their expertize to answer the needs of the automotive industry, benefiting from the possibility that has come with the disruption to enter the market, and to become a part of the new value chain. Finnish companies could also increase their chances to succeed through different kinds of partnerships with each other to be able to provide larger offerings and to gain size.

Overall, Finland has huge potential to succeed in the automotive domain through ICT, as the traditional players are seeking innovations and looking for software expertise. However, marketing, networking and supporting startups and SMEs to join the market through funding needs to be improved.

REFERENCES

5G-PPP. (2015) 5G Automotive Vision. 5G-PPP White papers, 67 p. Available (accessed on 17.11.2016): https://5g-ppp.eu/wp-content/uploads/2014/02/5G-PPP-White-Paper-on-Automotive-Vertical-Sectors.pdf

Abboud, K., Omar, H. and Zhuang, W. (2016) Interworking of DSRC and Cellular Network Technologies for V2X Communications: A Survey. IEEE Transactions on Vehicular Technology, vol.PP, no.99, 15 p.

Adner, R., & Kapoor, R. (2010) Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. Strategic management journal, 31(3), pp. 306-333.

Ali-Yrkkö, J. (2013) Mysteeri avautuu – Suomi globaaleissa arvoverkostoissa. Taloustieto Oy (ETLA B257), Helsinki, 135 p. Available (accessed 15.9.2016): https://www.etla.fi/wp-content/uploads/mysteeri_avautuu_low_res.pdf

Autoliv. (2016) Night vision technology. Company web page. Available (accessed 19.9.2016): http://www.autolivnightvision.com/technology/

Automotive News Europe. (2015) Audi speeds up infotainment and driver assistance innovation. News article. Available (accessed 25.10.2016): http://europe.autonews.com/article/20151110/ANE/151109936/audi-speeds-up-infotainment-and-driver-assistance-innovation

Automotive News. (2016) Top 100 global suppliers. Available (accessed 15.10.2016): https://www.autonews.com/assets/PDF/CA105764617.PDF

Automotive News. Guide to Silicon Valley's auto corridor. Available (accessed 15.10.2016): http://www.autonews.com/article/20140616/OEM/140619948/guide-to-silicon-valleys-auto-corridor

AutoScout24. (2014) Connected car business models – state of the art and practical opportunities. AutoScout24 GmbH, Technical report, 28 p. Available (accessed 1.12.2016): http://obd2.autoscout24.com/wp-content/uploads/2014/07/Connected_Car_Business_Models.pdf

Bird. (2015) Windows' share of infotainment OS set to decline faster than expected. IHS market insight. Article. Available (accessed 9.12.2016): https://www.linkedin.com/pulse/windows-share-infotainment-os-set-decline-faster-than-colin-bird

Bloomberg. (2016) How Apple scaled back its titanic plan to take on Detroit. Article. Available (accessed 1.12.2016): https://www.bloomberg.com/news/articles/2016-10-17/how-apple-scaled-back-its-titanic-plan-to-take-on-detroit

Bosch. (2016) Systems in detail – fully automated parking. Company web page. Available (accessed 19.9.2016): http://www.bosch.com/en/com/boschglobal/automated_driving/technology_for_greater_safety/pagination_1.html

Business Insider. (2016) These 19 companies are racing to put driveless cars on the road by 2020. Online article. Available (accessed 29.10.2016): http://www.businessinsider.com/google-apple-tesla-race-to-develop-driverless-cars-by-2020-2016-7?r=US&IR=T&IR=T/#tesla-is-aiming-to-have-its-driverless-technology-ready-by-2018-1

Canadian Automobile Association. (2016) Types of electric vehicles. Available (accessed 20.11.2016): https://www.caa.ca/electric-vehicles/types-of-electric-vehicles/

CAR. (2016) The impact of new mobility services on the automotive industry. CAR – Center for Automotive Research, Transportation Systems Analysis Group, CAR research paper, 56 p. Available (accessed 13.11.2016): http://www.cargroup.org/assets/files/new

_mobility_services_-_white_paper.pdf

Chan, C. C. (2007) The state of the art of electric, hybrid, and fuel cell vehicles. Proceedings of the IEEE, 95(4), 704-718.

Charette, R.N. (2009) This car runs on code. IEEE Spectrum, online article. Available (accessed 20.9.2016): http://spectrum.ieee.org/transportation/systems/this-car-runs-on-code

Continental. (2016) Company website. Available (accessed 16.9.2016): http://continental-head-up-display.com/

Delgrossi, L. and Jiang, D. (2008) IEEE 802.11p: Towards an International Standard for Wireless Access in Vehicular Environments. Vehicular Technology Conference, 2008. VTC Spring 2008. IEEE, Singapore, pp. 2036-2040.

Deloitte. (2015) The future of mobility – How transportation technology and social trends are creating a new business ecosystem. Deloitte University Press, 25 p. Available (accessed on 13.11.2016): https://www2.deloitte.com/content/dam/Deloitte/br/Documents/manufacturing/Future_of_mobility.pdf

Delphi. (2015) Worldwide Emission Standards – Passenger and light duty vehicles. Available (accessed 30.9.2016): http://delphi.com/docs/default-source/catalogs/delphi-worldwide-emissions-standards-pc-ldv-15-16.pdf

Denso Dynamics. (2012) All about V2X: Talking car technology. Online article. Available (accessed 23.9.2016): http://www.densodynamics.com/all-about-v2x-talking-car-technology/

DriveNow. (2015) Difference between car sharing and renting a car. Blog article. Available (accessed 9.11.2016): https://www.drivenow.com.au/blog/difference-between-car-sharing-and-renting-a-car/

EPA United States Environmental Protection Agency. (2012) Fact sheet: EPA and NHTSA set standards to reduce greenhouse gases and improve fuel economy for model years 2017-2025 cars and light trucks. Available (accessed 20.10.2016): https://www3.epa.gov/otaq/climate/documents/420f12051.pdf

EUR-lex. (2015) Regulation (EU) 2015/758. Available on: http://eur-lex.europa.eu/eli

/reg/2015/758/oj

European Commission. (2015). Benefit and feasibility of a range of new technologies and unregulated measures in the field of vehicle occupant safety and protection of vulnerable road users – Final report. Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, European Commission, Unit G.3, 470 p.

European Commission. (2016a) Reducing CO2 emissions from passenger cars. Available on: http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm

European Commission. (2016b) Commission launches GEAR 2030 to boost competitiveness and growth in the automotive sector. Available on: http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8640

European Commission. (2016c) Towards a foreign direct investment (FDI) attractiveness scoreboard. Directorate – General for Internal Market, Industry, Entrepreneurship and SMEs. ISBN: 978-92-79-58882-2. p. 201

European Commission. (2016d) Innovation performance compared: How innovative is your country? Press release. Available: http://europa.eu/rapid/press-release_IP-16-2486_en.htm

European Parliament. (2016) Automated vehicles in the EU, Briefing, 12 p. Available on: http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/573902/EPRS_BRI(2016)573902_EN.pdf

Finpro. (2016) Finland – the land that makes digital difference. Unpublished report, 90 p.

Forbes. (2015) Tesla's business model highlights what the shift to electric means for the auto industry. Available (accessed 1.11.2016): http://www.forbes.com/sites/greatspeculations/2015/09/01/teslas-business-model-highlights-what-the-shift-to-electric-means-for-the-auto-industry/2/#5e7d4328dde7

Ford. (2014) New Ford pre-collision assist with pedestrian detection technology will help drivers avoid some frontal crashes. Company News. Available (accessed 19.9.2016): https://media.ford.com/content/fordmedia/fna/us/en/news/2014/10/23/new-ford-pre-collision-assist-with-pedestrian-detection.html

Foreca. (2015) Foreca launches premium connected car weather services in over 40 countries, Press release. Available (accessed 29.11.2016): http://corporate.foreca.com/en/news/20/61/Foreca-launches-premium-connected-car-weather-services-in-over-40-countries

Fortune. (2015) The Google-Apple connected car battle has begun. Article. Available (accessed 23.10.2016): http://fortune.com/2015/05/27/google-apple-connected-cars/

Frost & Sullivan. (2014a). Connected vehicle value chain, unpublished report, 20 p.

Frost & Sullivan. (2014b). Connected Industry Insight Series – ICT Opportunities in the Global Connected Car Market, unpublished report, 54 p.

Frost & Sullivan. (2015a). Cloud and the car – Use cases, business models, and impact analysis – Autonomous vehicles and connected cars will bolster adoption, unpublished report, 58 p.

Frost & Sullivan. (2015b). Rise of virtual cockpits in the car, unpublished report, 47 p.

Frost & Sullivan. (2015c). Competitive benchmarking of key tier 1 suppliers in connected car market, unpublished report, 16 p.

GBD. (2016) GBD’s European new mobility survey 2016. Green Business Development, 2016 survey summary datasheet. Available (accessed 25.11.2016): http://tuup.fi/wp-content/uploads/2016/09/GBDs_European_New_Mobility_Survey_2016.pdf

Gereffi, G. (1995) Global Production Systems and Third World Development. In B. Stallings (Ed.), Global Change, Regional Response: The New International Context of Development, Cambridge; New York and Melbourne: Cambridge University Press, pp. 100-142.

Gereffi, G. and Fernandez-Stark K. (2011) Global Value Chain Analysis: A Primer. Center on Globalization, Governance & Competitiveness (CGGC). Duke University, Durham, North Carolina, USA, 40 p.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005) The governance of global value chains. Review of international political economy, 12(1), pp. 78-104.

GII. (2016) Global Innovation Index 2016. Available (accessed 28.11.2016): https://www.globalinnovationindex.org/media-press-releases

Hameed, Z. and Filali, F. (2014) LTE and IEEE 802.11p for vehicular networking: a performance evaluation. EURASIP Journal on Wireless Communications and Networking 2014:89, 15 p.

Händel, P. and Skog, I. (2014) State-of-the art and future in-car navigation systems – a survey. IEEE Transactions on Intelligent Transportation systems, p. 13

Hanfield, R. (2016) Supply chain view from the field - Outsourcing: Tesla is bucking the trend. NC State University, The supply chain resource cooperative. Available (accessed 2.11.2016): https://scm.ncsu.edu/blog/2016/04/04/insource-outsource-cost-trade-decisions-have-lasting-impact-at-tesla/

Heiko G. S. and Xiaolong H. (2016) Autonomous Driving in the iCity—HD Maps as a Key Challenge of the Automotive Industry. Engineering, Volume 2, Issue 2, ISSN 2095-8099, pp 159-162.

Humphrey, J. and Memedovich, O. (2003) The global automotive industry value chain: What prospects for upgrading by developed countries. Sectoral studies series. United nations development organization, Vienna, 50 p.

Humphrey, J. and Schmitz, H. (2002) How Does Insertion in Global Value Chains Affect Upgrading in Industrial Clusters? Regional Studies, 36 (9), pp. 1017-1027.

Intelligent Energy Europe. (2010) The state of European car-sharing. Momo car-sharing project, Final report D 2.4, Work package 2, 129 p.

International Trade Administration. (2005) The American Automotive Industry Supply Chain – In the Throes of a Rattling Revolution. 12 p. Available (accessed 15.9.2016): http://ita.doc.gov/td/auto/domestic/SupplyChain.pdf

Investopedia. (2015). What makes Tesla’s business model different? Available (accessed 9.9.2016): http://www.investopedia.com/articles/active-trading/072115/what-makes-teslas-business-model-different.asp

Just-auto (2013) Connected Vehicle technologies – forecasts to 2031 – 2016 Q3 Edition: In-Vehicle Infotainment (IVI). Unpublished report.

Kaplinsky, R., and Morris, M. (2001) A handbook for value chain research. Vol. 113, Ottawa: IDRC, 113 p.

Kogut, B. (1985) Designing global strategies: Comparative and competitive value-added chains. Sloan Management Review (Pre-1986), 26(4), 15 p.

Kotler, P. and Keller, K. L. (2012) Marketing management. 14th global ed., Harlow: Pearson, England, 674 p.

KPMG. (2015a) Metalsmith or Grid Master: The automotive industry at the crossroads of a highly digitalized age. KPMG International, 28 p. Available (accessed 10.9.2016): https://assets.kpmg.com/content/dam/kpmg/pdf/2015/11/metalsmith-or-gridmaster.pdf

KPMG. (2015b) The clockspeed dilemma – What does it mean for automotive innovation? KPMG LLP, USA, 40 p. Available (accessed 10.9.2016): https://assets.kpmg.com/content/dam/kpmg/pdf/2016/04/auto-clockspeed-dilemma.pdf

Langenwalter, J. (2016) Artificial Intelligence in Autonomous Driving, Automotive EETimes, Design Center articles. Available (accessed 4.10.2016): http://www.automotive-eetimes.com/design-center/artificial-intelligence-autonomous-driving

Liikenne- ja viestintäministeriö. (2015) Robotit maalla, merellä ja ilmassa – Liikenteen älykkään automaation edistämissuunnitelma. Liikenne- ja viestintäministeriön julkaisuja 7/2015, 49 p.

Liikenne- ja viestintäministeriö. (2016) Transport Code progresses, a solution found. Press release. Available (accessed 7.12.2016): https://www.lvm.fi/en/-/transport-code-progresses-a-solution-found

Liikennevirasto. (2016) E8 – Aurora. Project website. Available (accessed 28.11.2016): http://www.liikennevirasto.fi/web/en/e8-aurora#.WD1TleZ95hE

Lux Research. (2016) Six reasons why electric vehicles and autonomous vehicles will inevitably merge. Research summary. Available (accessed 15.10.2016): http://blog.luxresearchinc.com/blog/2016/09/six-reasons-why-electric-vehicles-and-autonomous-vehicles-will-inevitably-merge/

Lynk & Co. (2016) Company website. Available (accessed 10.11.2016): www.lynkco.com

MaaS Global. (2016). MaaS as a concept. Available (accessed 29.11.2016): http://maas.global/maas-as-a-concept/

McKinsey & Company. (2014) Connected car, automotive value chain unbound. Advanced industries, McKinsey & Company. 54 p. Available (accessed 21.9.2016): https://www.mckinsey.de/files/mck_connected_car_report.pdf

McKinsey & Company. (2016) Advanced driver-assistance systems: Challenges and opportunities ahead. Article. Available (accessed 15.10.2016): http://www.mckinsey.com/industries/semiconductors/our-insights/advanced-driver-assistance-systems-challenges-and-opportunities-ahead

Mirrorlink. (2016) Website. Available on: www.mirrorlink.com

NHTSA. (2014) U.S. Department of Transportation Issues Advance Notice of Proposed Rulemaking to Begin Implementation of Vehicle-to-Vehicle Communications Technology. Press Release. Available (accessed 20.10.2016): http://www.nhtsa.gov/About+NHTSA/Press+Releases/2014/NHTSA-issues-advanced-notice-of-proposed-rulemaking-on-V2V-communications

NHTSA. (2016) U.S. DOT and IIHS announce historic commitment of 20 automakers to make automatic emergency braking standard on new vehicles. Press release. Available (accessed 28.9.2016): http://www.nhtsa.gov/About-NHTSA/Press-Releases/nhtsa_iihs_commitment_on_aeb_03172016

Normann, R and Ramírez, R. (1993) From value chain to value constellation: designing interactive strategy, vol. 71, Harvard Business School Press, United States, pp. 65-77.

NTT Data. (2015) Connected Car Report, 34 p. Available (accessed 1.10.2016): https://emea.nttdata.com/fileadmin/web_data/country/de/documents/Manufacturing/Studien/2015_Connected_Car_Report_NTT_DATA_ENG.pdf

PCmag UK. (2012) Will Google make money off the self-driving car? Online article. Available (accessed 2.11.2016): http://uk.pcmag.com/cars-products/60193/news/will-google-make-money-off-the-self-driving-car

Porter, M. E. (1998) Competitive advantage: Creating and sustaining superior performance, with a new introduction. New York (NY): The Free Press. 559 p.

PwC. (2016) PwC deals – Automotive M&A deals insights – First half of 2016. Online report, 8 p. Available (accessed 15.11.2016): http://www.pwc.com/gx/en/automotive /pdf/automotive-insights-2016.pdf

Qualcomm. (2016) Leading the world to 5G: Cellular Vehicle-to-Everything technologies, Qualcomm Technologies Inc., 39 p. Available (accessed 14.9.2016): https://www.qualcomm.com/media/documents/files/cellular-vehicle-to-everything-c-v2x-technologies.pdf

Reuters. (2013) Calling all ‘codaholics’: Automakers vie for tech talent, online article. Available (accessed 7.11.2016): http://www.reuters.com/article/us-autos-engineers-idUSBRE96S0DL20130729

Sadler, David. (1999) Internationalization and Specialization in the European Automotive Components Sector: Implications for the Hollowing-Out Thesis, Regional Studies, vol. 33/no. 2, pp. 109-119.

SAE. (2014) Automated driving – levels of driving automation are defined in new SAE International’s standard J3016. Information report. Available (accessed29.9.2016): http://www.sae.org/misc/pdfs/automated_driving.pdf

Samsung. (2016) Samsung Electronics to acquire HARMAN – Accelerating growth in automotive and connected technologies. Press release. Available: https://news.samsung.com/global/samsung-electronics-to-acquire-harman-accelerating-growth-in-automotive-and-connected-technologies

Shaout, A., Colella, D., & Awad, S. (2011) Advanced driver assistance systems – past, present and future, Computer Engineering Conference (ICENCO), 2011 Seventh International, IEEE, pp. 72-82.

Sivak and Schoettle. (2016) Recent Decreases in the Proportion of Persons with a Driver’s License across All Age Groups, University of Michigan, Transportation research institute, study abstract. Available (accessed 17.11.2016): http://www.umich.edu/~umtriswt/PDF/UMTRI-2016-4_Abstract_English.pdf

Software industry survey. (2015) Available (accessed 28.11.2016): http://www.softwareindustrysurvey.fi/softwareindustrysurvey.fi/SlidesFinland2015.pdf

Statista. (2015) Automotive suppliers proportion of value added to worldwide automobile manufacture from 1985 to 2015, statistics report. Available (accessed 11.9.2016): https://www.statista.com/statistics/269619/automotive-suppliers-share-of-worldwide-automobile-manufacture-since-1985/

Statista. (2016a) Automotive electronics cost as a percentage of total car cost worldwide from 1950 to 2030, statistics report. Available (accessed 11.9.2016): https://www.statista.com/statistics/277931/automotive-electronics-cost-as-a-share-of-total-car-cost-worldwide/

Statista. (2016b) Connected car startups, Statista Digital Market Outlook and LSP Digital, statistics chart. Available (accessed 2.12.2016): https://www.statista.com/chart/4472/connected-car-start-ups/

Strategy&. (2015) 2015 Auto industry trends, Industry perspectives, industry perspectives, online report. Available (accessed 2.12.2016): http://www.strategyand.pwc.com/perspectives/2015-auto-trends

Strategy&. (2016) Connected Car report 2016: Opportunities, risk, and turmoil on the road to autonomous vehicles, industry perspectives, report, 63 p. Available (accessed 1.10.2016):http://www.strategyand.pwc.com/media/file/Connected-car-report-2016.pdf

Sturgeon, T. (2000) How do we define chains and production networks? Massachusetts Institute of Technology, Background paper prepared for the Bellagio Value Chains Workshop, Rockfeller Conference Center, Bellagio, Italy, 23 p. https://www.ids.ac.uk/ids /global/pdfs/vcdefine.pdf

Sturgeon, T., Van Biesebroeck, J., & Gereffi, G. (2008) Value chains, networks and clusters: reframing the global automotive industry. Journal of economic geography, nro: 8, pp. 297–321.

Sturgeon, T.J., Memedovic, O., Biesebroeck, J.V. & Gereffi, G. (2009) Globalisation of the automotive industry: main features and trends. Int. J. Technological Learning, Innovation and Development, Vol. 2, Nos. 1/2, pp. 7-24.

SWExperts. (2016) Software engineer salaries by country. Available (accessed 29.11.2016): http://swexperts.com/news/software-engineer-salaries-by-country/

Texas Instruments. (2016) Advanced Driver Assistance Systems (ADAS). Company web page. Available (accessed 3.10.2016): http://www.ti.com/lsds/ti_de/automotive/processors/adas/overview.page?DCMP=adas_tda3&HQS=adas

Texas Instruments. (2016) Head-display solutions with TI DLP technology. Company web page. Available (accessed 2.10.2016): http://www.ti.com/ww/en/dlp/automotive/hud .html

The Boston Consulting Group. (2004) Beyond cost reduction – Reinventing the automotive OEM-supplier interface. BCG Report, 52 p. Available (accessed 10.9.2016): http://www.bcg.com/documents/file14316.pdf

The Boston Consulting Group. (2014) Accelerating innovation: New challenges for automakers. BCG Perspectives, industry report. Available (accessed 2.11.2016): https://www.bcgperspectives.com/content/articles/automotive_innovation_accelerating_innovation_new_challenges_automakers/#chapter1

The Boston Consulting Group. (2016). What's ahead for car-sharing? – The new mobility and its impact on vehicle sales, 13 p. Available (accessed 23.11.2016): http://www.bcg.de/documents/file206078.pdf

Valtioneuvoston kanslia. (2016) Startup-yritysten kasvun ajurit ja pullonkaulat. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 30/2016, ISBN: 978-952-287-289-0, 204 p.

Veloso, F., & Kumar, R. (2002) The automotive supply chain: Global trends and Asian perspectives. Asian Development Bank, Economics and research department, ERD working papers series no. 3, 55 p.

VentureBeat. (2015) Car giant Daimler mulls joint ventures with Apple and Google. Online article. Available (accessed 22.10.2016): http://venturebeat.com/2015/08/21/car-giant-daimler-mulls-joint-ventures-with-apple-and-google/

Williamson, P., & De Meyer, A. (2012) Ecosystem Advantage: How to Successfully Harness the Power of Partners. California Management Review, Vol. 55, No. 1, pp. 24-46.

Willis, J. S. (2014) Governance and Innovative Capabilities in Global Value Chains: A Conceptual Framework. University of Manchester, Manchester Business School, 18 p. Available (accessed 2.9.2016): http://druid8.sit.aau.dk/acc_papers/6ege9sdsr6ennidhoj1151qqlkf8.pdf

Wired. (2012) The next big OS war is in your dashboard. Online article. Available (accessed 22.10.2016): https://www.wired.com/2012/12/automotive-os-war/

Yu, R, Zhang, Y, Gjessing, S, Xia, W & Yang, K. (2013) Toward cloud-based vehicular networks with efficient resource management. IEEE Network, vol. 27, no. 5, pp. 48-55.

Zishan Liu, Zhenyu Liu, Zhen Meng, Xinyang Yang, Lin Pu & Lin Zhang. (2016) Implementation and performance measurement of a V2X communication system for vehicle and pedestrian safety. International Journal of Distributed Sensor Networks September 2016, vol 12, nro: 9, 14 p.

APPENDIX A: SUPPLIER ANALYSIS TABLES

Company	Year	New technology acquisitions	Description	Capabilities	Technology		Other acquisition	Description		New technology partnerships	Description	Capabili	Technology		Other partnerships	Description	
Robert Bosch GmbH	2011	Inubit AG	Software specialist on IoT and services for connected world	SW	Connectivity & Big Data	1	Unipoint Group	Starters, wiper blades and other	1					0			0
	2012	SPX Corporations service division	Diagnostics tools and software for auto dealers and repair shops	SW+ELE	After market services				0	Chery Automobile, JV	Develop and produce instument clusters and infotainment systems	SW+ELE	Infotainment	2			0
		Atech's division	Instrument clusters and infotainment systems	ELE	Infotainment	2				Daimler, collaboration	Develop eletric motors		EV				
	2013					0			0	GS Yuasa and Mitsubishi Corporation, JV	high energy-density lithium ion batteries for electric and hybrid vehicles			1			0
	2014	ZF Lenksysteme	Electric steering development, core technology for automated driving	ELE	ADAS & autonomous driving	1			0	MongoDB	Big Data solutions for IoT	Data	Connectivity & Big Data	5			0
										General Motors	Connectivity applications for infotainment systems	SW+ELE	Infotainment				
										Hillcrest Labs	Sensor Hub solution for Head-mounted displays and wearables	SW	Infotainment				
										TomTom	Map data for ADAS	Data	ADAS & autonomous driving				
										BMW	Fast EV charger development		EV				
	2015	ProSyst	Software for connectivity	SW	Connevtivity	3	Seeo Inc.	Electric vehicles	1	Mercedez-Benz and car2go	development of smartphone-enabled, fully-autonomous parking service	SW+ELE	After market services	1			0
		TTA International	Software and engineering for diagnostics	SW	After sales services												
		Re'flekt	Augmented reality for diagnostics	SW	After sales services												
	2016	ITK Engineering	Software and systems development for ADAS, automated driving, powertrain systems, electrification, and connectivity.	SW+ELE	ADAS & autonomous driving	1			0	Nokia and Deutche Telekom	Local cloud development for V2X	SW+ELE	Connectivity & Big Data	3			0
										Borgward, SAP, LG Electronics	Electric mobility		EV				
										Autoglass	ADAS windshield calibration solution	SW+ELE	ADAS & autonomous driving				
Total #		8					2			12					0		
Denso Corporation	2011					0			0					0			0
	2012	I-Net Corporation's 3D	Display technologies	SW	Infotainment	1			0	Intel	Technology for next-generation In-vehicle information and communication systems	SW+ELE	Infotainment	2			0
										Appcelerator	Development solution for in-car applications that are fully integrated with vehicle information systems	SW	Infotainment				
	2013	ADASENS	Image recognition technology	SW	ADAS & autonomous driving	2			0	Sharp	New technologies that improve the comfosrt, safety and convenience of vehicles by integrating vehicle technologies with home electronics technologies	SW+ELE	Connectivity & Big Data	1			0
		Pricol	Instument clusters	ELE	Infotainment												
	2014	EASE Simulation Inc.	Vehicle diagnostics and telematics	SW+ELE	After market services	1	Conditioner Co., Ltd.	Compressor manufacturer	1	Thai ITS Association	V2X technologies testing, data gathering and analyze information systems.	Data	Connectivity & Big Data	1			0
	2015					0			0	Morpho	Image recognition technology	SW	ADAS & autonomous driving	1			0
	2016	Trilumina	Semiconductor laser technology focused on improving LiDAR and driver-monitoring technologies	ELE	ADAS & autonomous driving	1			0	Toshiba	Artificial Intelligence technology for next-generation image recognition systems	ELE	ADAS & autonomous driving	4			0
										eSOL and NEC Communications, JV	Software development for high-speed data communication and security to advance in-vehicle systems for automated driving	SW	ADAS & autonomous driving				
										Toyota Tsusho	Develop software to improve ECU development	SW	ADAS & autonomous driving				
										NTT	Mobile phone carrier company, V2X connectivity	SW+ELE	Connectivity & Big Data				
Total #		5					1			9							

Company	Year	New technology acquisitions	Description	Capabilities	Technology		Other acquisitions	Description		New technology partnerships	Description	Capabilit	Technology		Other partnerships	Description	
Magna International Inc.	2011					0	BDW	Aluminum casting	3					0			0
							Grenville Castings	Casting									
							Thyssenkrupp Automotive systems	structural components and modules									
	2012					0	Ixetic	Pumps	2					0	Zoltek	Materials development	1
							STT Technologies	Pumps									
	2013					0			0					0			0
	2014					0	TechCom companies	Basic components	1					0	Ford	Ligh vehicle components development	2
															TaTa, JV	Seating systems	
	2015	Philips & Lite-On Digital Solutions	Head-up Display and electronic components business unit	ELE	Infotainment	1	Getrag	Transmission	2	Argus Cyber Security Ltd.	Develop solution for the automotive industry that addresses vehicle security concerns related to cyber attacks in the car	SV	Connectivity & Big Data	1			0
							Stadco	Stampings									
	2016	Telemotive AG	Engineering service provider in the field of automotive electronics, expanding product portfolio in the fields of connectivity, HMI and infotainment	SV+ELE	Infotainment	1	BOCO Group of companies	Basic components	1					0			0
Total #		2					9			1					3		
Continental AG	2011	Magna International	Radar engineering unit	ELE	ADAS & autonomous driving	1			0					0			0
	2012	Omitec Group	Diagnostics products and services	SV+ELE	After market services	1	Parker Hannifin	Air-conditioning business	3	SK Innovation	Battery technology			1			0
							Sim Tyre Malaysia	Tires									
							Freudenberg	Molded brake components									
	2013	ASL Vision	Technological solutions for 360-degree 'surround-view' camera detection systems	SV+ELE	ADAS & autonomous driving	1			0	Cisco	Demonstrated a car supporting Cisco software that could switch between 3G, 4G and other wireless networks	SV	Connectivity & Big Data	5			0
										IBM	Big data and cloud solutions for connected vehicles	SV	Connectivity & Big Data				
										Google	Self-driving cars development	SV+ELE	ADAS & autonomous				
										BMW	Co-pilot development for automated driving	SV+ELE	ADAS & autonomous				
										Texas Instruments	Microcontrollers for ADAS	ELE	ADAS & autonomous				
	2014					0	Emitec	Drivetrain technologies	3	HERE	Map data for ADAS	Data	ADAS & autonomous driving	2			0
							Magna International Inc.	Composites operations		Airbiquity	Develop global connected car solutions to vehicle manufacturers, infotainment platform and solutions	SV	Infotainment				
							Zytek	Chassis, interior and powertrain									
	2015	Elektrobit Automotive Group	Software and system development for automated cars	SV	ADAS & autonomous driving	1			0					0	Fallbrook technologies Inc.	New transmission solutions	1
	2016	Zonar systems	Fleet management and remote diagnostics	SV+ELE	After market services	2	Hoosier Racing Tire Corporation	Tires	1	TomTom Telematics	Development of data archiving for fleet management	Data	After market services	1			0
		Advanced Scientific Concepts Inc.	A division making imaging sensors and 3D LiDARs used in autonomous	ELE	ADAS & autonomous driving												
Total #		6					7			9					1		

Company	Year	New technology acquisitions	Description	Capabilities	Technology		Other acquisitions	Description		New technology partnerships	Description	Capabilities	Technology		Other partnerships	Description	
ZF Friedrichshafen AG	2011					0			0					0			0
	2012					0			0					0			0
	2013					0			0					0	GenShock	Chassis	1
	2014					0			0					0	BAIC, JV	Chassis	1
	2015	HDLE GmbH	Development department of ADAS	SW+ELE	ADAS & autonomous	2			0					0			0
		TRW Automotive	Active and passive safety	SW+ELE	ADAS & autonomous												
	2016					0			0	doubleSlash	Vehicle networking	SW	Connectivity & Big Data	2			0
										Ibeo	LIDAR technology	ELE	ADAS & autonomous				
Total #		2								2					2		
Hyundai Mobis	2011					0			0	Takata	Automotive safety systems, active seat belt development related to ADAS	ELE	ADAS & autonomous driving	1			0
	2012					0			0	Samsung LED	LED headlamps to be used in ADAS related Adaptive Front Lighting systems	ELE	ADAS & autonomous driving	1			0
	2013					0			0	Wind River	Infotainment systems development	SW	Infotainment	1			0
	2014					0			0					0			0
	2015					0			0					0			0
	2016					0			0	Mobileye	Chips and algorhitms used in ADAS	SW+ELE	ADAS & autonomous	1			0
Total #										4							
Aisin Seiki Co.	2011					0			0					0			0
	2012	Hiji High Tech	Product differentation from downsizing ECUs and sensors	ELE	ADAS & autonomous driving	1			0					0			0
	2013					0			0					0			0
	2014					0			0					0			0
	2015					0			0					0			0
	2016					0			0					0			0
Total #		1															
Faurecia	2011					0	Angell-Demmel	Aluminum trim	2					0			0
							Amminex A/S	ASDS gaseous system									0
	2012					0	Sore Composites	Composite body parts	2					0	Mitsubishi Chemical	Bioplastics for interiors	2
							Ford/AHC	Interiors business unit							Howa Textile Industry Co. Ltd,	Interior systems	
	2013					0			0	Magneti Marelli	To design, development and manufacturing of HMI interior products, Magneti Marelli brings exppertice in displays and electronics	ELE	Infotainment	1			2
															FAW Foundry	Magnesium alloy seat frames	
															Suzhou PowerGreen Emission System	Emission control systems	
	2014					0			0					0	Interval, JV	Materials development	1
	2015					0			0					0	WKW Automotive Parts Co. Ltd., JV	Interior aluminum decoration parts	2
															Dongfeng Hongtai Holdings	Interior components	
	2016					0			0	Hoana Medical Inc.	Active Wellness set to enhancing the well-being of drivers and their driving experience	SW+ELE	ADAS & autonomous driving	1			0
Total #							4			2					7		

Company	Year	New technology acquisitions	Description	Capabilities	Technology		Other acquisition	Description		New technology partnerships	Description	Capabilit	Technology		Other partnerships	Description	
Johnson Controls Inc. (Automotive business spun off into a new publicly traded company called Adient in 10/2016)	2011					0	KEIPER	Metal components	2					0			0
							Spumotim	Foam									
	2012	A123	Electric car batteries		EV	1			0	PolyPlus	Battery development			1			0
	2013	MAC	Automotive batteries		EV	1	Tata Johnson Controls, JV	Automotive seat systems	1	General Motors	Development of instrument cluster	SW+ELE	Infotainment	1	Hitachi, JV	Air conditioning	1
	2014					0			0					0	Shanghai Yanfeng Industry, Commerce Co., Ltd. and Anhui Yansheng Automotive Trim	Fabrics	2
															Fraunhofer-Gesellschaft	Cooling systems for vehicle	
	2015					0			0	Lawrence Technological University	Test and develop advanced battery systems in vehicles		EV	1	SAIC's Yanfeng Automotive Trim Systems Co. Ltd.,	Interior systems	1
	2016					0			0					0			0
Total #		2					3			3					4		
Lear Corporation	2011					0			0					0			0
	2012					0	Guilford Mills	Specialty fabrics	1					0			0
	2013					0			0					0			0
	2014					0			0					0			0
	2015	Arada Systems	V2X Communications	SW+ELE	Connectivity & Big Data	2	Eagle Ottawa	Leather for seatings	1					0			0
		Autonet Mobile	Intellectual property and technology of communication software and devices for automotive applications	SW+ELE	Connectivity & Big Data												
	2016					0			0					0	Tempronics	Thermoeletric set heating and cooling	1
Total #		2					2								1		
All		28					28			42					18		

APPENDIX B: OEM ANALYSIS TABLES

	Year	New technology acquisitions	Description	Technology		New technology partnerships	Description	Technology	
	2011				0	Microsoft	Telematics/Cloud platform	Connectivity & big data	6
						Ford	Hybrid technologies	EV	
						Salesforce.com	Services	After market services	
						Intel	IVI systems	Infotainment	
						UIEvolution	Platform for connected applications	After market services/infotainment	
	2012				0	Samsung	Phone connectivity	Connectivity & big data	1
	2013				0				0
	2014				0	TomTom	Navigation solution	ADAS & autonomous driving	3
						IBM	An app framework for cars	After market services	
						SAP & Verifone	Services	After market services	
Toyota	2015	Preferred networks	AI	ADAS & autonomous driving	1	MIT & Stanford	AI R&D	ADAS & autonomous driving	2
						Ford	Smartphone, infotainment	Connectivity & big data, after market services	
	2016				0	University of Michigan	AI research, autonomous	ADAS & autonomous driving	6
						University of California	Autonomous cars	ADAS & autonomous driving	
						Uber	Ride-hailing / in-car apps	After market services	
						Microsoft	Data management	Connectivity & big data	
						KDDI	Global communications platform to support connected cars	Connectivity & big data	
						Getaround	Car-sharing	After market services	
						Japan Federation of Hire-Taxi Associations	ADAS / autonomous driving	ADAS & autonomous driving	
	#	1				18			
	2011				0	Siemens	Electric cars development	EV	1
	2012				0				0
	2013				0	Apple	Smartphone integration	Connectivity & big data	3
						Google	App development	After market services	
						Inrix	Traffic data	Connectivity & big data	
	2014	Blackberry	Infotainment R&D center	Infotainment	1	TomTom	Highly automated driving systems, digital map	ADAS & autonomous driving	2
						SAP	Connected car ecosystem, services	Connectivity & big data / After market services	
	2015	HERE	Digital map	ADAS & autonomous driving	1				4
						Huawei	Smartphone connectivity	Connectivity & big data	
Volkswagen						QNX	Infotainment systems	Infotainment	
						Cubic	M2M technology	Connectivity & big data	
						Samsung	Smartphone connectivity, apps	Connectivity & big data	
	2016				0	Gett	Ride-sharing, autonomous vehicles	After market services / ADAS & autonomous driving	7
						Baidu, Alibaba and Tencent	Smartphone apps, services and maps	After market services	
						LG	Connected car platform	Connectivity & big data	
						Texas Instruments	Infotainment platform	Infotainment	
						Pivotal	Services	After market services	
						Samsung & SAP	Connected car services	After market services	
						University of California	Autonomous vehicles	ADAS & autonomous driving	
	#	2				17			

	Year	New technology acquisitions	Description	Technology		New technology partnerships	Description	Technology	
	2011				0				0
	2012	Tirazoo	Mobility services	After market services	1	Elektrobit	Software for ADAS	ADAS & autonomous driving	2
						Carpooling.com	ride-sharing	After market services	
	2013				0	Deutche Telekom	communications infrastructure, online services	Connectivity & big data	2
						Ford & Nissan	Fuel cell electric vehicle systems	EV	
Daimler	2014	Ridescout	ride-sharing	After market services	2				0
		MyTaxi	ride-booking	After market services					
	2015	HERE	Digital map	ADAS & autonomous driving	1	Qualcomm	Connected car technologies	Connectivity & big data	4
						Bosch	Intelligent parking, service	ADAS & autonomous driving	
						Wireless Car	Mobility services	After market services	
						Zonar	Connectivity, big data, autonomous trucks	Connectivity & big data, ADAS & autonomous driving	
	2016	Hailo	Ride-hailing	After market services	1	AT&T & Microsoft	OTA updates, connectivity	Connectivity & big data	2
						uSens	AR/VR technology	After market services	
	Total	5				10			
	2011				0	Hyundai	Vehicle connectivity	Connectivity & big data	5
						PSA	Hybrid systems	EV	
						Toyota	Battery technologies	EV	
						General Motors	Fuel Cell technology	EV	
						NVIDIA	Visual computing	Infotainment	
	2012				0	Nuance	Voice recognition	Infotainment	1
	2013				0	Now! Innovations	Smartphone app for parking reservation and navigation	After market services	2
						Continental	Highly automated driving system	ADAS & autonomous driving	
	2014				0	Mercedes-Benz	Wireless charging	EV	7
						Baidu	Autonomous car research	ADAS & autonomous driving	
						Inrix	Intermodal navigation	Connectivity & big data	
						Samsung	Remote control application	Connectivity & big data	
BMW						GoPro	Integration of video cameras with infotainment system	Connectivity & big data, infotainment	
						Allianz	Telematics insurance based on vehicle usage	After market services	
						SAP	Cloud based platform, navigation to parking spaces and location-based	After market services	
	2015	HERE	Digital map	ADAS & autonomous driving	1	Samsung	Develop brain for autonomous vehicles, voice regocnition, command	ADAS & autonomous driving	1
	2016				0	T-systems SA	Connected car platform	Connectivity & big data / After market services	5
						Microsoft	Open mobility cloud, platfor for intelligent services	Connectivity & big data	
						Mobileye & Intel	Autonomous car development for faster	ADAS & autonomous driving	
						Allianz & Toyota	Partner to licence technology from Nauto to understand driver behaviour nad develop autonomous vehicle	ADAS & autonomous driving	
						Ola	luxury mobility, ride-sharing	After market services	
	Total	1				21			

	Year	New technology acquisitions	Description	Technology		New technology partnerships	Description	Technology	
	2011					Toyota	Hybrid development	EV	1
	2012					Zipcar	Electric vehicles to car-	After marker services	2
						IBM & PG&E	Smart EV charging using cloud to provide intelligent interconnections, recommended charging schedules based on electricity prices	After sales services	
Honda	2013					General Motors	Fuel cell technologies	EV	1
	2014					Garmin	In-dash GPS for ADAS	ADAS & autonomous	1
	2015					General Motors	Self-driving car technologies	ADAS & autonomous	1
	2016					Visa	car-based commerce transactions, e.g. paying for gas without leaving the car	After marker services	3
						Softbank	Artificial intelligence for vehicles, vehicle-driver communication	ADAS & autonomous driving	
						Saitec	Battery development	EV	
	Total	0				9			
	All	9				75			

APPENDIX C: QUESTIONS OF INTERVIEWS

The interviews were carried out as face-to-face meetings with each interviewee, and an interview lasted approximately one hour. The companies participated were Elektrobit Automotive, Tuxera, Rightware, and The Qt Company. The experts from research sector were from VTT and University of Oulu. The questions are listed below.

Questions for company interviewees:

1. What is your offering and how it brings value to the customer?
    - Products/services
    - Competitive advantage
    - Customer base
    - Software and vehicle development have different cycles: a challenge or an asset?
2. How do you see the value chain and what part of it do you present?
3. How did you end up in the automotive industry?
4. How is your offering going to change in the future and why?
    - Added value
    - Business logic
    - Changes in the customer base
    - Increasing importance of software
5. What kind of changes do you see the technological development brings to competition?
6. Your most important partners in the product development and their role? Do you have other kinds of partners than firms?
7. What are the technology trends that affect the most your business and how you plan to benefit from them?
8. What are the advantages for Finland now and in the future in the automotive business? What needs to improve in order to succeed?

Questions for experts:

- Interviewee's background

1. How does the technological development affect the upstream chain?
    - Distribution of value
    - Changes in the value chain structure
2. What kind of challenges and possibilities new technologies bring to traditional players?
3. What kind of new entrants come along?
4. What kind of advantages and know-how does Finland have referring to the automotive industry?

5. What areas need improvement?

6. How does the technological development affect the downstream chain?
    - Changes in the value chain structure
    - New entrants
    - Challenges and possibilities for OEMs
    - Who is going to own the data?
7. Finland’s advantages and areas that need to improve?