CHALMERS
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Patent Valuation in the Automotive Industry

Creation of Patent Valuation Model

Master's Thesis in the Master's Programme
Entrepreneurship and Business Design

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Abstract

The automotive industry is currently in a state of transition (Corwin et al. 2012). New customer purchasing behaviors, the growing importance of emerging markets and diminishing profit margins are causing automotive OEMs to rethink their business strategies and what business they are ultimately in (Porter & Hemmelmann 2014). As vehicles become increasingly complex in terms of technological content, new technology specialists from outside of the industry are beginning to enter the market for vehicle technologies, causing the fight for automotive technology development to intensify (Foy 2013). The automotive industry has experienced more growth in patent applications than any other industry over the last few years (Thomson Reuters 2015). Despite growing competition in the industry and the increase in patenting activity, there is a lack of tools that facilitate patent related decisions for automotive actors. In most managerial decision situations, valuation models are used to enable option comparison, in patent related decisions however, this is not the case (Murphy et al. 2012). In order to enable vehicle manufacturers to make well-informed patent related decisions, the purpose of this thesis has been to develop a model for patent valuation to be used by OEMs in the automotive industry.

The purpose of the thesis has been fulfilled by combining research in the area of patent valuation with an in-depth analysis of competition and patent related value creation in the automotive industry. In order to develop a useable framework for patent valuation, identified patent benefits were quantified in order to generate a monetary patent value. A constructive approach has been used, and the thesis has been conducted in close collaboration with an established industry actor. In order to further investigate how patents create value in the industry, the constructive approach was complemented by four case studies.

In this thesis, five secondary patents functions; blockade, attack, commercialize, bargaining chip and reputation; have been identified in the automotive industry. Given the use of patents in the industry, seven possible patent benefits have been found to be relevant. By dividing the industry into five key technological fields; Propulsion, Handling, Safety & Security, Entertainment and Navigation; differences in the competitive environments of different technological markets have been identified. These differences in competition is causing patents to be used differently depending on technological market, hence creating different patent benefits and patent related value streams. In order to value patent in accordance with these findings a two-step income-based valuation model has been developed.

The main challenge in applying the valuation model was in collecting the necessary data to enable accurate calculations to be made. Due to the complexity of products in the market it was difficult to determine how much a given value stream ultimately stemmed from a specific patent or patent portfolio. This has led to the insight that patent valuation is significantly easier in relation to aftermarket products, as these are often more limited in terms of technological complexity.

Acknowledgement

This master thesis is a result of collaboration with an industry practitioner from the automotive industry. First of all, we would like to thank the many employees within the corporation who have supported us throughout this thesis process and have taken their time to contribute to the thesis. We would also like to thank all of you who have contributed with inputs to the small case studies which we have compiled. Even though the interviews as such have not been used as the primary sources behind the case studies and analysis, your comments and thoughts have been valuable inputfor us in deciding which cases to deep dive into.

In addition, we would like to send a special thanks to our supervisors at the Company. Thank you for believing in us and supporting us when issues and questions appeared along the way. It has been a challenging, interesting and greatly enjoyable spring for both of us and we once again thank you for giving us the opportunity to work together with you.

Last, but not least, we would like to thank our Chalmers supervisor Bowman Heiden. Special thanks to you for helping us to sort through the research area, identify an academically relevant problem area and creating an appropriate research design. In this thesis we have tried to approach a specific problem from broadly and you helped us take a step back and consider the whole picture before digging into the details – thank you.

May 2015

Caroline Egeland Therese Matshede

Table of Contents

Definitions

Automotive Industry	Industry consisting of commercial vehicle manufacturers and car manufacturers
Commercial Vehicles	Any type of motor vehicle used for transporting goods or paying passengers, including, but not limited to buses, trucks, boats and construction equipment
Automobile Industry	Industry consisting of car manufacturers
Original Equipment Manufacturer (OEM)	Manufacturer of the end product sold on the market. The final product can consist of parts and subsystems produced both internally and by external suppliers and are often sold to the customers by reseller. In this report the OEM is said to be active within the automotive industry.
Non Practicing Entity (NPE)	Industry actor who holds a patent for a product or process without intentions of using it
Intangible Asset	Asset that lacks physical substance
Intellectual Assets	A codified description of specific knowledge of which a business or other actors can claim ownership
Intellectual Property (IP)	Creations of the mind, such as inventions, literary and artistic works, designs, and symbols, names and images used in commerce
Intellectual Property Right (IPR)	Legal right of ownership to intellectual property
Patent Right	Exclusive right to block other actors from using, selling, producing or importing a protected technology for a limited period of time (maximum 20 years) in a limited geographical area in exchange of publishing a detailed description about the technology.
Design Right	Protection of a three-dimensional design in a limited period of time in a limited geographical area
Patent Portfolio	A collection of patent rights protecting one invention, technology or product
Standard Essential Patent (SEP)	Patent right protecting an essential technological feature in a technical standard, decided by a standard organization
Economic Value	The present value of any future revenues an asset is expected to generate, less the present value of any future costs related to it
Value (verb)	Estimate the monetary worth of an object
Decision Process	Thought process of selecting a logical choice from available options
Unique Selling Proposition (USP)	Unique benefit that sets a product apart from competing products

1. Introduction

"One cannot make a well informed decision without valuation." *(Murphy et al. 2012, p. 3)*

This thesis will be about the process of valuing patent rights and how this type of valuation can be used in the business setting of an Original Equipment Manufacturer (OEM) in the automotive industry. In this chapter the background and problems related to patent valuation will be described, and the purpose and research questions of the thesis will be presented. Finally, delimitations that have been made in the thesis process will be discussed and the reader will be presented with a thesis outline to serve as a reading guide.

1.1 Background

The automotive industry is experiencing tremendous change in terms of technology development and as no one knows where the development will end, innovation has become a critical factor to staying competitive and surviving in the market for motor vehicles (Corwin et al. 2012)(Stevens 2014). In 1911, Henry Ford won a patent dispute against the first automotive cartel and started building the automotive industry in the US (Foy 2013). Now, one hundred years later, the entire industry is facing a period of new innovations, as green-engines, self-driving cars and interactive vehicles are entering the market (ibid). The first car was considered a great innovation within mechanical engineering and historically the development of superior mechanical functionality has been the focus of industry actors (CAR 2014). Today the car has become a highly complex system of technologies and mechanical innovations are no longer the drivers of development in the industry. The focus of innovation in the automotive industry has changed and now spans over scientific disciplines such as chemistry, material science and consumer electronics (Corwin et al. 2012). Research and development (R&D) efforts have not only become broader, but also shifted to increasingly focus on clean technologies and ecological and efficient manufacturing (Marsch 2013). The high rate of innovation growth in the automotive industry is causing some to suggest that the car might be the most technologically advanced product a person will ever buy (Lampinen 2015).

The growing rate of innovation within the automotive industry can also be seen in patent application statistics. According to Thomson Reuters (2015) the automotive industry is experiencing more growth in patent applications than any other industry. In overall patent filings the industry ranks third, behind Computing & Peripherals and Telecommunications (ibid). Their report also shows that actors who are traditionally not viewed as automotive companies are among the most active patentees in some automotive related technologies. Many of these new actors are highly specialized within narrow technical fields and have caused the automotive industry to decentralize in regards to technological development (Corwin et al. 2012). Innovation in the automotive industry has traditionally been centered around OEMs and major suppliers, and as a result of the decentralization of technology development, the competitive environment in the industry has changed (ibid). Traditional automotive actors are forced to adapt to the new market situation and decisions in regards to R&D and the protection of research results are becoming increasingly important. New actors from outside the automotive industry are in some cases more aggressive in their use of intellectual property protection, such as patent rights, compared to traditional automotive players (Foy 2013). Competition from these actors may affect the overall competitive culture in the automotive industry and how intellectual property rights (IPR) are managed among industry actors (Marsch 2013) (Foy 2013).

Two or three decades ago, IPRs such as patents were less critical to a firms´ success than they are today (Murphy et al. 2012). While it may have been acceptable for companies to have a carefree approach to patent valuation in the past, it is no longer a viable strategy (ibid). By managing their intellectual property rights companies can reduce their costs and increase the value of their patent portfolios hence giving them a stronger market position (Hunter 2005). Patent valuation methods can be a starting point towards better decision making and sustainable business management (ibid). In order to be competitive, companies are increasingly developing tools to extract maximum value from their intellectual property rights (Pitkethly 1997). The traditional valuation tools are perceived as complex and uncertain, and companies often do not consider the information they generate to be worth the effort they require (Murphy et al. 2012). As a result, valuation tools are not as commonly used within the patent context as in other business settings and decision within this context are more readily based on insufficient analysis (ibid).

1.2 Purpose

The increasing importance and decentralization of innovation within the automotive industry has led to a growing focus on protecting research results and new inventions. Since competition in the industry is tough and resources are scarce, patents need to be used as efficiently as possible to create revenue streams and control for the patent holder. In order to make well-informed decisions in relation to patents and patent portfolios, patents need to be assessed and valued. Existing patent valuation models are perceived as too complex and uncertain to motivate the effort required to generate a result. As a result, valuation is not as readily used as a tool for patent related decisions as in other decision situations.

The purpose of this master thesis is to develop a framework for patent valuation that can be used to facilitate decision making for OEMs in the automotive industry.

1.3 Research Questions

To be able to fulfill the purpose of the thesis, the benefits that OEMs in the automotive industry experience as a result of patent protection need to be identified. Patents can strengthen the competitive position for an OEM and in order to find out how, the competitive environment within the automotive industry has to be investigated. The results from the investigation will be used as an important input to the framework development process. In order to get an increased understanding of the industry, different technology fields, their competitive environment and their patent landscapes need to be outlined. Therefore, the first research question is:

1. What technological fields exist within the automotive industry and what characterizes competition within the industry at large and in each individual technology field?

In order to create a well-adapted valuation model, the specific industry characteristics need to be taken into account (European Commission 2013). A second step is therefore to get an increased understanding for how patent rights enable increased revenue streams in the industry. The second research question is:

2. What are the benefits of patent protection for OEMs in the automotive industry?

As a third step, the most suitable process for patent valuation has to be investigated. Valuation tools are commonly used within other business settings and by investigating existing models, a suitable valuation model that can be used as a foundation for the valuation framework development can be identified (Murphy et al. 2012).

3. What types of valuation tools currently exist and how can these be adapted to best meet the needs of OEMs in the automotive industry?

1.4 Delimitations

The framework developed in this thesis will be adapted to function as a foundation for patent related making for OEMs in the automotive industry. It will be designed to be applicable for patents that have successfully been granted and have passed the date for geographical expansion. Thus, the framework is not created to work as a foundation for decisions regarding whether or not to file a patent application or what geographical regions the protection should be expanded to. The framework will be limited to the valuation of the patent right and will not be designed to be used to determine the value of whole inventions.

The developed framework will measure the value of a patent right. The value is defined as future economic benefit stemming from the patent right. This definition means that only future instrumental value, i.e. the economic benefit of the patent, will be measured (Murphy et al. 2012). Value that has been generated historically and the intrinsic value[1] of the patent will not be taken into consideration when developing the framework. This means that contexts in which patent can be considered to create intrinsic value, for example to attract research collaborators or establish supplier partnerships, will be outside the scope of this master thesis. Despite this delimitation, it is important to keep in mind when applying the framework, that patents may have benefits other than instrumental value.

1.5 Thesis Outline and Reading Guide

The thesis is divided into seven chapters with additional sections for references and appendices. An outline of the report including a brief description of the content of the different chapters is given below. To allow readers to easily maneuver to relevant parts of the thesis, a reading guide aimed at different types of readers is also presented.

1.5.1 Outline

In Chapter 1, *Introduction*, the background to the thesis and the problem situation are explained. This is followed by a description of the thesis' purpose, research questions and the delimitations of the study.

In Chapter 2*, Methodology,* the data needed to answer the research question is listed and the chosen research design is described. In the end of the chapter, the method used to gather the data is presented as well as an account for how validity and reliability of the study has been achieved.

[1] Intrinsic value: Non-economic rewards such as reputation, prestige or a feeling of accomplish something (Murphy et al. 2012)

Chapter 3, *Theoretical Framework,* contains the theoretical frameworks on which the study is built. The frameworks included in this chapter are: Concepts of Value, Industrial Value Creation, Patents as means to Appropriate Value and Measuring Value Stemming from Patents.

In Chapter 4, *The Automotive Industry – A Literature Review*, the automotive industry, including current market structure, future trends, main actors and patenting activity, is described.

In Chapter 5, *Case Studies*, four different cases in which patents are used to create value are described. The different cases are concerned with a patented invention in automotive technologies, the battery industry, the automotive aftermarket and a discussion of infotainment systems.

Chapter 6, *Analysis*, contains a discussion around the automotive industry, analysis of the benefits patents create in each of the case studies, how different patent strategies are used within the different technology fields, how a model can be built to measure the value created by patents and how that model has been revised after testing it on real patents.

In Chapter 7, *Conclusion*, the findings of the analysis are summarized and suggestions for further research are made.

1.5.2 Reading Guide

For readers from the automotive industry, especially persons in management positions at OEMs, focus when reading the thesis is recommended to be on the first, fourth, sixth and seventh chapters. Together they describe the reason behind the thesis and the chosen research questions as well as industry trends that have been identified through the thesis process. Finally, chapters six and seven contain an analysis in regards to the research questions and conclusion of the thesis.

For readers from the academia, the entire thesis is recommended to be read, but extra focus is recommended to be on chapters one, two, three and seven. These chapters will enable the reader to get a clear understanding of the background to the thesis, the chosen research questions, the methodology used and the theoretical frameworks on which the thesis is built. In addition to this, chapter seven presents new insights which have emerged as a result of the thesis process.

For master students, using the thesis as inspiration for their own future thesis work, focus is recommended to be on chapter one, two and seven. Chapter one and two will give master students an indication of what should be included in a thesis, how a problem can be described and delimited and how the methodology used to solve a problem can be presented. Chapter seven can serve as an example of how to present conclusions and summarize a thesis as well as a source of inspiration and ideas for future thesis work.

2. Methodology

In this chapter the data required to answer the research questions will be discussed and the chosen research design will be presented. In the end of the chapter, the chosen data collection process will be discussed as well as considerations that have been made in order to ensure the reliability and validity of the thesis.

2.1 Required Data

In Figure 1 the data required to answer each of the research questions is presented. The data includes input from both primary and secondary sources. The first research question is concerned with the automotive industry. In order to answer this question, theories regarding value creation and market competition were deemed necessary. In addition, background information about technology fields within the automotive industry and how value creation and competition within the industry is structured was also required. The second research question is centered on how patents can be used to create value. To enable answering this question, theories regarding possible functions of patents and potential benefits of patent protection were required. In order to understand how these theoretical functions and benefits manifest themselves within the automotive industry, several case examples were also deemed necessary. To answer the third and last research question information regarding existing valuation models was required as well as knowledge about what characterizes the automotive industry in terms of competition and patent use. In order to ensure the usefulness of the developed valuation model, insights into how the characteristics of the industry influence the valuation process were also necessary.

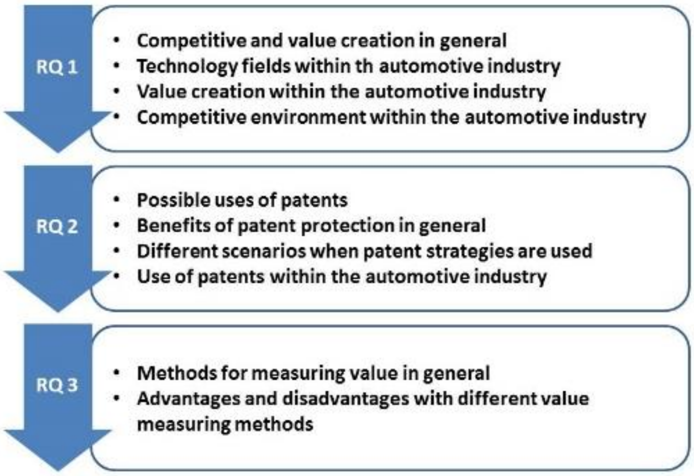

Figure 1 Data required for answering the research questions (RQ)

2.2 Research Design

Patents are a part of a structure constructed by society as a means to incentivize innovation (Petrusson 2004). Outside of this socially constructed structure patents do not exist and cannot be valued. According to Searle (1996), this characteristic of patents makes them ontologically subjective, which subsequently also makes patent valuation and patent value ontologically subjective. The value of a patent depends on context and strategic setting in which the patent is used, aspects that are difficult to quantify and measure objectively. From an epistemological perspective, the value of individual patents can therefore be considered subjective. The goal of this master thesis is to develop a framework that takes the subjective attributes of a patent into consideration and provides the user with a monetary value measure. Hence, the aim is to quantify epistemologically subjective patent characteristics and transform patent value into an epistemologically objective attribute, as is illustrated in Figure 2. The master thesis as a whole can therefore be placed on the intersection of epistemologically subjective and epistemologically objective.

Due to the epistemologically subjective nature of patents, a qualitative research method was chosen. A quantitative research method could have been used, by for example quantifying the use of different valuation models and identifying trends using a market survey. However, since the goal is to develop a framework that out performs existing models in terms of industry requirements and expectations, qualitative inputs were considered crucial to the framework development process. A qualitative research method was considered more dynamic than a quantitative method and therefore more suitable for the thesis.

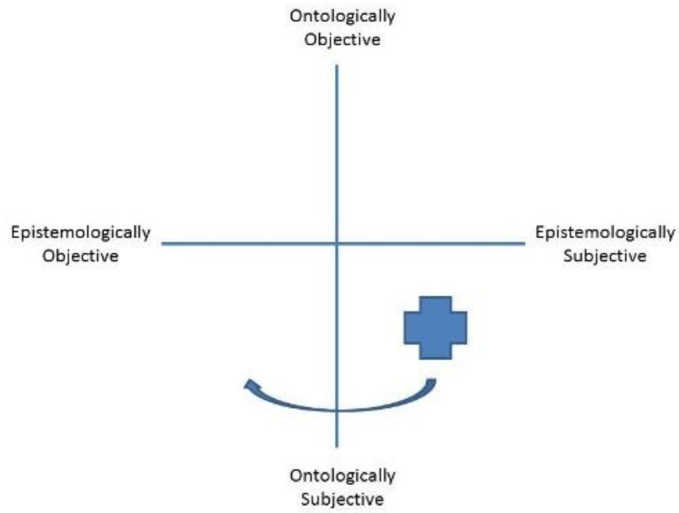

Figure 2 Aiming for transforming patent value into an epistemologically objective attribute, based on Searle (1996)

In order to collect all required data, a constructive approach combined with interviews and small case studies was used. The constructive approach is a problem solving research method, in which a literature review is used to construct a customized model specifically designed to solve an identified problem (Kasanen et al. 1993). Opponents of the constructive approach claim that it is not scientific enough, however according to Kasanen et al. (1993) the open and developing nature of science means that there is no strict definition of what constitutes scientific. In this specific case the use of a constructive approach was appropriate since the thesis was focused on a real-world problem of patent valuation and the development of a customized framework to solve the valuation problem was the foremost sought after output (ibid).

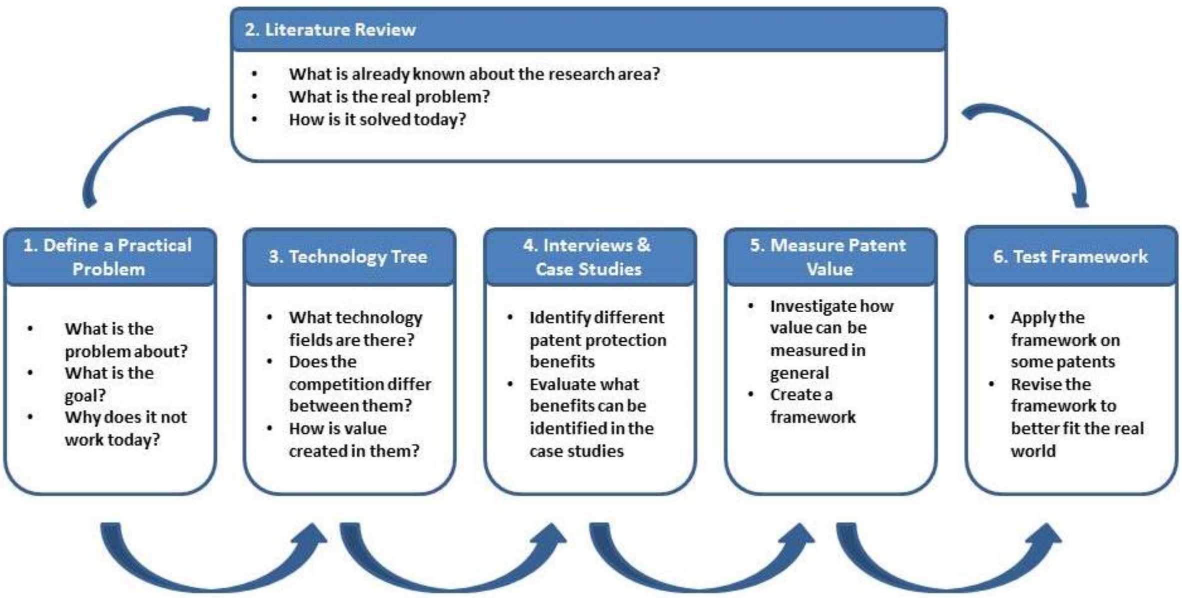

Figure 3 Illustration of the chosen Research Design for the thesis, based on Kasanen et al. (1993)

Figure 3 illustrates an outline of the research design, combining a constructive approach with interviews and several case studies. The chosen design closely resembled the steps of a constructive approach as presented by Kasanen et al. (1993). After having identified the problem of lack of suitable valuation tools, a theoretical framework for the thesis was created. The aim of the theoretical framework was to find out what was already known about patent valuation, but also to identify what characterizes value creation and competition in the automotive industry and to define potential benefits of patent protection. Parallel to developing a theoretical framework for the thesis, a technology tree for the automotive industry was created in order to facilitate a brake-down of relevant technologies in the automotive industry. In order to develop a framework that sufficiently incorporated the conditions and characteristics of the automotive industry, while measuring the benefits of patent protection, the theoretical framework was complemented by a literature review of the automotive industry and four small case studies. The cases were identified through the industry literature review as well as through interviews with employees at an industry practitioner, henceforth referred to as "the Company". Considering the findings of the cases, the theoretical framework and the characteristics of the industry identified in the literature review, a model for patent valuation was created. According to Lukka, a constructive approach generally produces results that are useful to industry practitioners as the gap between research and industry is usually narrow. This generally benefits the study since it incentivizes the collaboration partner to supply researchers with high quality data (ibid), which in turn enables a more thorough analysis. To ensure the usefulness of the model developed it was tested on several patents in close collaboration with the Company. All patents were owned by the Company.

Whether a study should be considered inductive or deductive can sometimes be difficult to determine, as the majority of research studies will include elements of both (Bryman & Bell 2011). According to Bryman & Bell (2011) the deductive or inductive nature of a study should be thought of as a tendency rather than a clear distinction. Although this master thesis drew significant input from existing theory, the method involved making relevant observations and contributing to new theory rather than testing a predetermined hypothesis. The research method as described earlier had inductive tendencies rather than deductive and the thesis overall should therefore be considered an inductive study.

2.3 Data Collection

To be able to answer the three research questions mainly secondary data was used. Primary data from the interviews was used to validate the secondary data and as input when searching for interesting areas to use as case studies.

2.3.1 Theoretical Framework and Literature Review

The theoretical framework was created as a foundation for the thesis, as illustrated in Figure 3. The four main concepts that were investigated in the theoretical framework were:

1. Concepts of value
2. Industrial value creation
3. Patents as a means to appropriate value
4. Measuring value stemming from patents

When searching for theory about these subjects, google scholar was used to identify cited and reliable authors. As a second step, the names of the authors were used as search terms when searching for articles and books at libraries and Chalmers' library databases. When theories were described similarly in new and old articles, the date of first publication was deemed non-crucial to the quality of the source and hence the thesis.

When conducting the Literature review, the data was mainly collected from management consulting reports and articles published by research institutes. The goal of the literature review was to identify current trends and changes in the automotive industry. In order to do so, current and updated information was needed. Due to the high speed of change within the automotive industry, many consulting houses and research institutes have shown interest in the industry. This interest made a vast array of recent industry reports concerning a variety of different industry topics available for the benefit of this thesis.

To ensure reliable sources of data, triangulation was used (Bryman 2004). The same information was sought from different sources and databases, and the findings were compared with each other. To the highest possible extent, the primary source of data was sought in order to mitigate the risk of faulty interpretations. In general the number of citation of articles was used as a qualitative measure, as high quality sources were assumed to have high citations relative to other publications in the field. For newly published reports this type of analysis was not possible since they had had less time in which to be cited. In these cases the authors' previous publications and citations thereof where used as a quality measure.

2.3.2 Interviews

Several interviews were held with employees at the Company. The aim of the interviews was to verify findings from the literature review, but also to get input when searching for interesting case examples. The interviewees had different background and worked for different departments within the Company, see Figure 4. The divergence of the interviewee's area of expertise aimed to give a comprehensive overview of how patents are used in the product development within different technological fields and how they contribute to marketing and pricing of products. In addition to these primary interviews, an in-depth interview was held with a sales person from the industry actor providing the brake system, as a part of the *Braking System* case study. To ensure quality of interview results, several people were asked the same questions as this allowed for a comparison to be made between the given answers. By asking more than one interviewee the same question, the risk of catching only one person´s opinion rather than industry characteristics was mitigated.

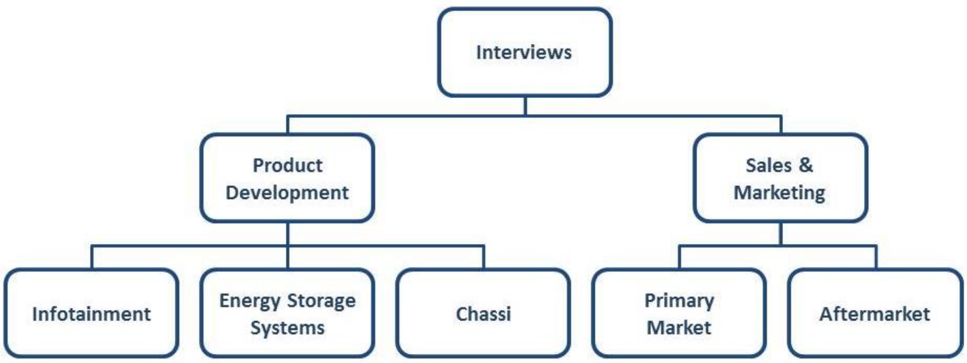

Figure 4 Interviews were held at five different departments at the Company in order to collect necessary data

Even though the interviews were not used to answer specific research questions, they contributed to a broad understanding of relevant issues in the automotive industry and allowed for validation of the data collected in the literature review. In order to gain insight into as many perspectives as possible the interviews were semi-structured and the interviewees were asked to formulate their own answers. A less structured interview process is emphasized when conducting qualitative research, in comparison to quantitative research where a structured process will maximize reliability and validity (Bryman & Bell 2011). During each interview, there was a great interest in understanding the point of view of the interviewee. When using a too structured interview template there is a risk of losing understanding of the interviewee's personal insights (ibid). Unstructured interviews tend to be similar to conversation and follow no guided structure. To avoid missing any information needed, a semi-structured approach was chosen and an interview guide was used during the interviews (ibid). The interview guides for each interview can be found in Appendix I.

2.3.3 Cases

The choice of relevant case studies was based on findings made both when collecting secondary data and when conducting the interviews at the Company. Each case study was designed as a deep dive into a limited area of interest and when describing all but one of the chosen cases, secondary data was used. The information was sought from industry magazines, consultancy reports and websites of industry actors. As an exception, the data for the braking system case was collected through semi-structured interviews with sales personnel at the company providing the braking system. This difference in data collection method is due to lack of public information about the benefits of the braking system patent. Since all information in this case was collected from one source, there is an imminent risk of bias and no general conclusions can be drawn based on the case study alone.

2.3.4 Research Validation and Verification

"Without rigor, research is worthless, becomes fiction, and loses its utility" (Morse et al. 2002, p. 14). Even though it is easier to validate and verify quantitative research, by using statistical measurements, hard numbers and p values, it is still important to prove rigorousness of qualitative research (ibid). According to Guba & Lincoln (1989) verification and validation are best suited for use in quantitative research. In qualitative research, they instead propose using trustworthiness as a synonymous concept (ibid). The trustworthiness of research can be ensured by having substantial engagement, carefully observing the problem, conducting member checks[2], collecting data over time and assuring that interpretations and outcomes are determined by persons apart from the valuator (Guba & Lincoln 1989). By applying these tools in the thesis process, it was ensured that the identified problem was correctly understood and clearly defined (ibid). The tools were used continuously throughout the thesis process to assure that no threats to the reliability and validity of the thesis were missed or identified too late in the process (Morse et al. 2002). By using an iterative work process rather than linear one, the data was systematically checked, the focus was maintained, and the fit of data, interpretations and the developed valuation model were confirmed continuously (ibid).

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[2]Member checks: "The process of testing hypothesis, data, preliminary categories, and interpretations with members of the stake holding groups from whom the original constructions were collected." (Guba & Lincoln 1989, p. 238)

To ensure that the developed model was applicable and useful for an OEM, it was tested on four patents, chosen by the Company. The Company that was chosen as a collaborative partner in the thesis process was selected based on their global presence in the industry, their substantial patent portfolio within several technological fields and their broad product offering within several industry segments. After applying the framework on the chosen patents, the framework was evaluated and revised to better fit its purpose.

3. Theoretical Framework

In this chapter the theoretical framework, which this study is based upon, will be described. The theories that are included are the concept of economic value, value creation in the industrial and knowledge based economy, patents as means for appropriate value and valuation models.

3.1 The Concept of Economic Value

According to Oxford Dictionary of Business and Management (2009) economic value is more specifically "the present value of expected future cash flows" or "the present value of any future revenues it (an asset) is expected to generate, less the present value of any future costs related to it". To value an object can be defined as estimating its monetary worth (Oxford Dictionaries 2015). While these definitions are relatively computative, the concept of economic value is one that has gradually evolved through the different stages of economic theory (Boisot 1998). In early economic theory, value was believed to reside in nature itself or in the transformation of nature by man (i.e. in land and labor) (ibid). As a result of economic revolution in the 1870's, this view was slightly changed. In classical economic theory value is instead believed to reside only in humans' transformative actions upon nature, making labor by humans or animals the sole source of all economic value (ibid).

In neoclassical economic theory, the concept of economic value was transformed and value was no longer considered to reside solely in the factors of production (Boisot 1998). According to Boisot (1998) the neoclassical theory of value is well suited as a foundation when considering the value of knowledge assets. In this economic theory, value is a matter of utility and scarcity (ibid). Utility is a measure of what an individual, person or firm, gets out of consuming an economic good. Due to its focus on individual perspectives, utility can be considered subjective as the same good can provoke different experiences in different people. The scarcity of a good is based on its supply and demand and is greatly affected by trends in production as well as consumption.

3.2 The Transition from the Industrial based Economy to the Knowledge based Economy

In today's increasingly globalized market it is no longer enough to deliver superior products and services, companies also need to understand the market need and innovate in order to be successful and survive in the long-run (Kalb 2013). According to Murphy et al. (2012) the driving force behind sustainable growth in today's economy is the creation and commercialization of new technologies. He claims that the only way for a company to reach economic success is to create a continuous stream of inventions and to convert ideas into products and services (ibid). As a result of these theories, knowledge has become a key asset and can be considered crucial to the survival of companies competing within most global industries. This development has resulted in a growing focus on knowledge creation within companies and has led to the transition from the previous industrial-based economy to a knowledge-based economy. In this emerging *knowledge economy*, knowledge is central to value creation and can therefore be considered the most important asset within companies today (Petrusson 2004) (Drucker 1993).

In the industrial based economy, physical products are produced and transferred on the market (Heiden 2014). As the economy changes, knowledge and capabilities have become necessary in order to produce these physical products, even in previously industrial industries. In some industries, knowledge itself has become the main asset, and by controlling this asset, third parties can be blocked from entering the market and even producing physical products (Drucker 1993) (Heiden 2014). An illustration of the transition, from industrial economy to knowledge economy, can be seen in Figure 5.

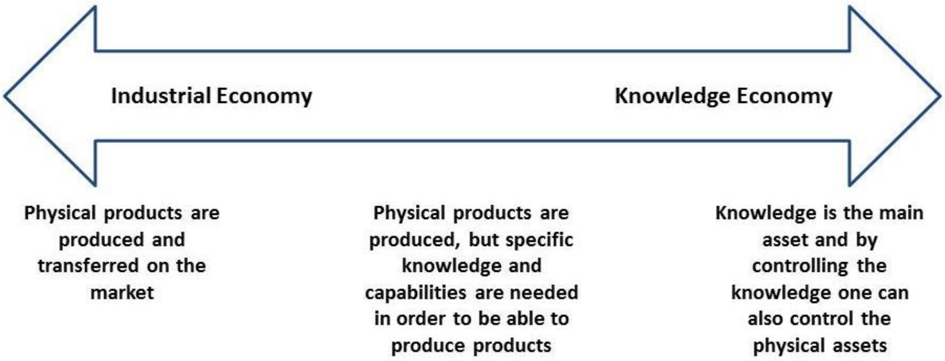

Figure 5 Illustration of the transition from the industrial economy and the knowledge economy, based on Heiden (2014)

3.2.1 Generic Strategies for the Creation of Competitive Advantage

There are two generic strategies by which competitive advantages can be created, either by reducing the total unit cost of a product or by increasing the customer value, i.e. by differentiating the product offering (Porter 1996)(Grant 2008). These two strategies are fundamentally different in how they influence the creation of an overall business strategy. Porter (1996) claims that a company has to choose between the two in order to be successful and profitable, according to Stabell & Flejstad (1998) however, technology development can sometimes enable both process improvements and product adaptation to customer demands simultaneously. Development within technology can therefore potentially lead to both reduced cost and increase customer value at the same time (ibid). Table 1 illustrates the key strategic elements, resources and organizational capabilities required to be successful with the two strategies.

For manufacturing companies, managing activities requires complex and differentiated combinations of resources and capabilities (Grant 2008). The differences in resource endowments within an industry have a high impact on what type of competition is most likely to occur. In industries where all firms possess similar resources and capabilities, competition by imitation is likely since most actors will look to fulfill the customer need in a similar manner (ibid). In industries with greater differentiation between the actors' resources and capabilities, indirect competition by substitutes is more likely to occur (ibid). In these industries, the differences between the actors will lead them to meet customer needs in different ways using the resources and capabilities at their disposal. How companies compete differs in the industrial based and the knowledge based economy. In the following sections, competition from both perspectives will be investigated.

Table 1 The two generic strategies for how to create a competitive advantage, including the key elements of each strategy and the resources and organizational element necessary for success (Grant 2008, p. 219)

Generic Strategy	Key Strategic Elements	Required Resources and Organizational Capabilities
Cost Leadership	Scale-efficient plants Design for manufacture Control over overheads and R&D Process innovation Outsourcing Avoidance of marginal customer accounts	Access to capital Process engineering skills Frequent reports Tight cost control Specialization of jobs and functions Incentives linked to quantitative targets
Differentiation	Brand advertising Product design Service offerings Quality New product development	Marketing abilities Product engineering skills Cross-functional coordination Creativity Research capability Incentives linked to qualitative performance targets

3.2.2 Competition and Value Creation within the Industrial Economy

It is generally accepted that the primary function of an industrial company is "to make use of productive resources for the purpose of supplying goods and services to the economy" (Penrose 2009, p. 64). Few markets function under the prerequisites of perfect competition[3], and when more than one actor is looking to supply similar goods and services it generally leads to competition between these actors. In a competitive market with several actors, a firm which earns higher profits than the rest can be said to possess a competitive advantage over its rivals (Grant 2008). Competitive advantages can be gained in a number of different ways, for example by investing in a specific market segment, specific superior technology, customer loyalty or executive perks (ibid).

Over time, competition within industries eliminates differences among competing firms (Grant 2008). Competitive advantages are hence a disequilibrium phenomenon that is a consequence of change within an industry and will subside over time (ibid). The prospect of gaining a competitive

[3] Perfect competition can only exist where perfect information is available, no entry- or exit barriers exist, no product differentiation is possible and there are many buyers and sellers (Grant 2008). In a market with perfect competition, the price is the same as the marginal cost and no profits can be made (Eklund 2010).

advantage in manufacturing industries depends on the magnitude of the change within the industry and the extent to which competing firms' differ in terms of resources and capabilities (ibid). In industries which are rapidly changing or where the actors have access to significantly different resources or capabilities, more competitive advantages will arise among competing firms (Grant 2008). In markets where the dominant competitive logic is subject to significant change it is especially important for competing actors to understand the customer need in order to adapt and stay alive (Prahalad & Hamel 1994). There are two main generic strategies for the creation of competitive advantages, which can be used to either strengthen internal operations or external market position. The nature of these strategies and their use internally and externally will be discussed below, followed by a description of how competitive advantages can be made sustainable.

A competitive advantage can stem either from internal factors, such as the capability to be creative and innovative, or from external factors, such as changes in customer demand, prices of raw materials or technological advances (Grant 2008). Innovation and the creation of new knowledge and ideas can come in many different forms, for example as new products or processes or as new approaches to doing business. Due to its many possible variations, innovation within a given market can influence competition and competitive advantages both internally and externally. Below the internal and external factors will be described further.

Internal Competition in the Industrial Economy

The internal factors influencing the creation of competitive advantages differ significantly between the industrial economy and the knowledge economy. In the industrial economy, internal factors influencing the creation of competitive advantages stem from a firm's primary and supporting activities (Porter 1996). According to Porter's *Value Chain*, the primary activities of a firm operating in an industry where the value creation logic is based on the transformation of input into products are inbound logistics, operations, outbound logistics, marketing and services (Porter 1996). The supporting activities are the infrastructure of the firm, the human resource management, the technology development and the procurement (ibid). Considering the generic strategies for the creation of competitive advantages, a competitive advantage can thus be gained by either performing these activities at a lower cost or in a way which increases the customers´ perceived value (ibid). In manufacturing companies, scale and capacity utilization are the main cost drivers (Stabell & Fjelstad 1998). This means that cost leadership can be gained by for example superior production management or designing products with more scalability than competitors. The customer's perceived value of a product can be improved by for example superior post-sale services or effective marketing campaigns.

External Competition in the Industrial Economy

External factors influencing the creation of competitive advantages stem from five forces, as can be seen in Figure 6 (Porter 1996). The sum of these forces defines the profit potential of an industry. The weaker the forces are the greater is the potential profit (ibid). In an industry with very strong forces, the prospect for long term profitability is lower. However, the higher the speed of structural changes in the industry, the more limited is the use of the five forces framework (Grant 2008). The advantages stemming from the external changes highly depend on the company´s ability to respond to the changes and speed with which this is done (ibid). As a consequence, external factors of change affect different companies in different ways. As markets become more turbulent and more difficult to forecast, flexibility, i.e. speed of response to changes, has become important as a source of competitive advantage (ibid). For firms to be responsive they need resources, in form of information, and capabilities, in form of flexibility. Direct relationships with suppliers, customers and competitors enable firms to scan the environment, gather information and quickly identify new trends. To be a flexible organization short cycle time is a requirement (ibid).

Figure 6 Porter´s five forces, illustrating the External Competition Advantages, based on Porter (1996)

3.2.3 Competition and Value Creation within the Knowledge Economy

In the knowledge economy a firm's ability to create a competitive advantage will stem from their internal ability to manage several key challenges as presented in the Intellectual Value Star Model in Figure 7 (Petrusson 2004). The first challenge is to manage human resources and company culture to promote an understanding and participation in the knowledge economy. The second is to create internal structures that foster and incentivize innovation. The third challenge is to create an environment in which value visions are captured and utilized for value creation. The forth challenge is to manage knowledge internally to ensure the claiming of intellectual property. The fifth challenge is to shape the market as to ensure that value propositions result in positive experiences and hence customer value. By managing these challenges in a superior way the value extracted from a firm can be maximized hence creating a competitive advantage in the knowledge economy.

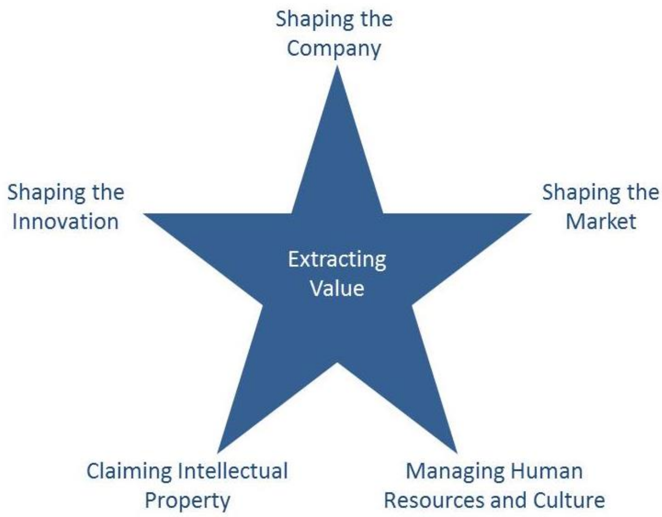

Figure 7 The Intellectual Value Star Model (Petrusson 2004, p. 249)

The external competitive environment in the knowledge economy can be analyzed by using a technology market break-down (Heiden 2014). By dividing the product into different technologies, often illustrated in a so called technology tree, sub-technologies and the access to those technologies can be investigated (ibid). Based on this break down, decision on whether technology should be developed in-house or acquired from suppliers can be made and an outline of a company's competitive market position can be made (ibid).

Measuring Value in the Knowledge Economy

While pre-classical and classical economic theory is often sufficient in expressing the value of physical goods, these theories are lacking when it comes to valuing knowledge assets (Boisot 1998). Physical assets can be considered inherently scarce, knowledge assets on the other hand are inherently non-rival and can be reproduced without virtually any cost (Child & Ihrig 2013). Due to these differences, knowledge assets and physical assets cannot be valued using the same logic and procedures. According to Boisot (1998) neoclassical theory offers a more suitable logic for the valuation of knowledge as this economic theory considers the scarcity of an asset in the valuation process. Knowledge, when not protected by intellectual property rights, can be shared publicly making it openly and freely available (ibid). According to neoclassical theory, this knowledge does not have an economic value due to its lack of scarcity (Child & Ihrig 2013). Claimed knowledge on the other hand, can be considered to have both utility and scarcity, hence giving it an economic value. Due to the dynamic nature of knowledge, both of these valuation approaches are necessary in the valuation process (ibid).

According to Biosot (1998) the value of knowledge assets can be determined by considering three key dimensions; codification, abstraction and diffusion. In his model, the scarcity of a knowledge asset is a function of its diffusion within the target population. The diffusion, in turn, is dependent on the asset's level of codification and abstraction. Highly abstract information that is difficult to articulate does not easily diffuse while knowledge that can easily be structured into a few simple symbols can be spread globally with very little effort (ibid). Boisot (1998) divides the utility of an asset into two dimensions, its usefulness within a given application and the number of possible applications. In order to value an asset using this model, the asset should be considered to have some relevance within at least one application. The asset's utility is then partly decided by how standardized and easily understandable it can be made, in other words its degree of codification. More abstract knowledge assets can more easily be generalized across a number of applications. This means that the asset becomes useful for a larger population, giving it a higher level of utility. As both utility and scarcity depend on the same three variables, they can both be expressed in Boisot's (1998) information space. As can be seen in Figure 8, the most valuable knowledge assets are those that are undiffused, highly abstract and codified.

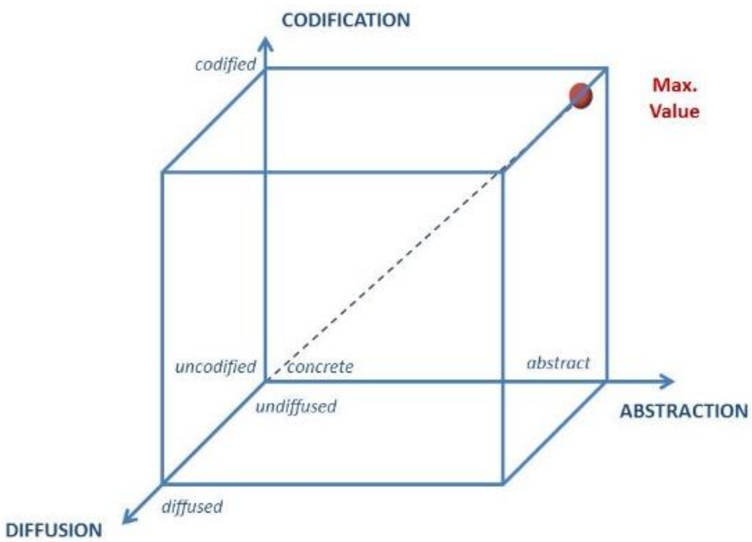

Figure 8 The information space in which the value of a knowledge asset can be determined by considering three dimensions, codification, abstraction and diffusion (Boisot 1998, chapter 4.5)

Value Creation in the Knowledge Economy

As a result of the transition to the knowledge economy, companies are faced with the challenge of managing knowledge and other intellectual asset to ensure maximum value creation. Knowledge is inherently elusive and difficult to control which makes managing its use within the value creation process a time consuming challenge (Drucker 1993). The intellectual property system allows companies to structurally package and legally claim ownership of knowledge assets and is therefore a crucial structure to value creation. The growing importance of knowledge can be seen in an increased share of intangible assets in companies over the last thirty years (Ocean Tomo 2010). During these years the share of knowledge and other intangible assets are estimated to have increased with over 300%, now making up 80% of the average company's total value (ibid).

In the industrial economy value is created by producing and transacting raw materials and products through a material value chain, as can be seen in Figure 9 (Petrusson & Heiden 2008). In this traditional view of value creation the number of possible business models is limited and competitive advantages are difficult to obtain (ibid). The transition to a knowledge economy calls for an updated view on the value chain logic, Petrusson & Heiden (2008) therefore introduce the concept of an intellectual value chain to function as a complement to the existing framework. The intellectual value chain can be seen in Figure 10. In the intellectual value chain, value is created by managing intellectual assets, property and capital into four main market offerings: a physical product, a virtual product, a license offering and or a service (ibid). This new value chain logic allows for a wide range of different business models to be used which in turn influences the competitive environment creating a more dynamic market. In the intellectual value chain competitive advantages are determined by which actor is best able to identify and act on opportunities and threats within the market rather than from cost benefits and product differentiation as in the traditional framework (ibid).

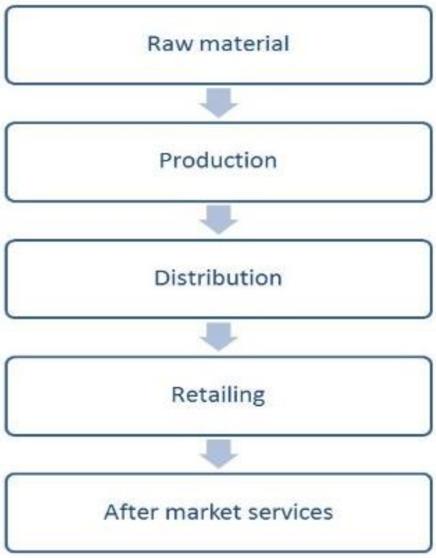

Figure 9 The industrial value chain (Petrusson & Heiden 2008, p. 281)

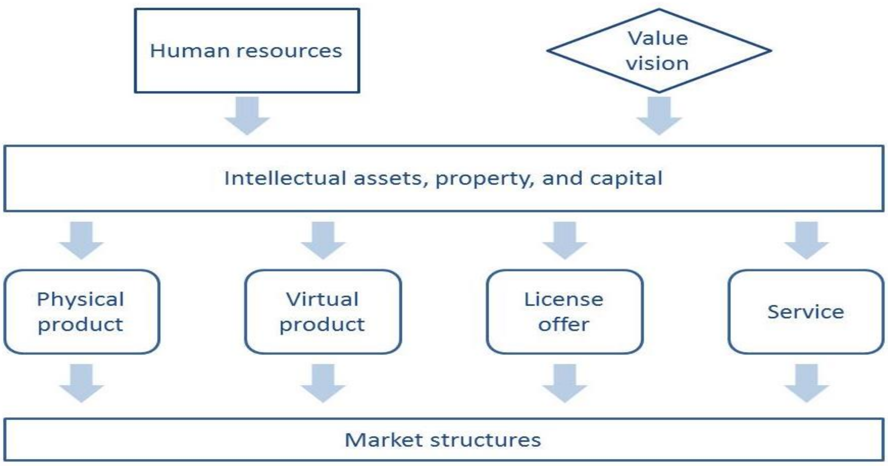

Figure 10 The intellectual value chain (Petrusson & Heiden 2008, p. 282)

3.2.4 Sustainable Competitive Advantage

While patents can be used to prevent new actors from entering a market it is not the only, nor the most crucial barrier to market access (Levin et al. 1987). Other aspects that can enable barriers are lead time, secrecy, learning advantages and sales and services efforts (ibid). The so called VRIN paradigm claims that products and services should be Valuable, Rare, In-imitable and Non-substitutable in order to create a sustainable competitive advantage (Grube 2009). According to Grant (2008) these four attributes can increase a firm's ability to stay competitive over time and appropriate the returns of competitive advantages.

Lead time is the main force of first-mover-advantages and is sought by the innovator also in the absence of other protection such as patents or other intellectual property rights (McEvily & Chakravarthy 2002) (Levin et al. 1987). A reason for this might be that the first actor is not only favored by the ability to set monopolistic prices, but also by the opportunity to establish entry barriers for competitors, in the form of for example a powerful brand and strong customer relationships (Grube 2009). Advantages like these have the possibility to sustain even after imitators have entered the market (Mansfield et al. 1981). The leading position can however only be upheld if the company continues to successfully launch new products and services. The benefits of a leading position are even higher when learning effects and scale economies occur (Levin et al. 1987).

3.3 Patents as a Means to Appropriate Value

The value of an asset refers to the benefits that come from it (Murphy et al. 2012). A patent is a negative right, i.e. the owner gets the right to block other actors from making, using, or selling an invention but does not necessarily get the right to use the invention himself (Grube 2009). In exchange for this time limited[4] negative right, the inventor has to disclose detailed information about the invention and share this knowledge with society (Grube 2009). Patent rights can generate economic income either by exclusive or cooperative exploitation (Grube 2009). When using the patent right exclusively the patent owner will keep all incomes himself but will also have to manage potential risks alone. In the case of cooperative exploitation, both income and risks are shared between patent holder and external partners (ibid).

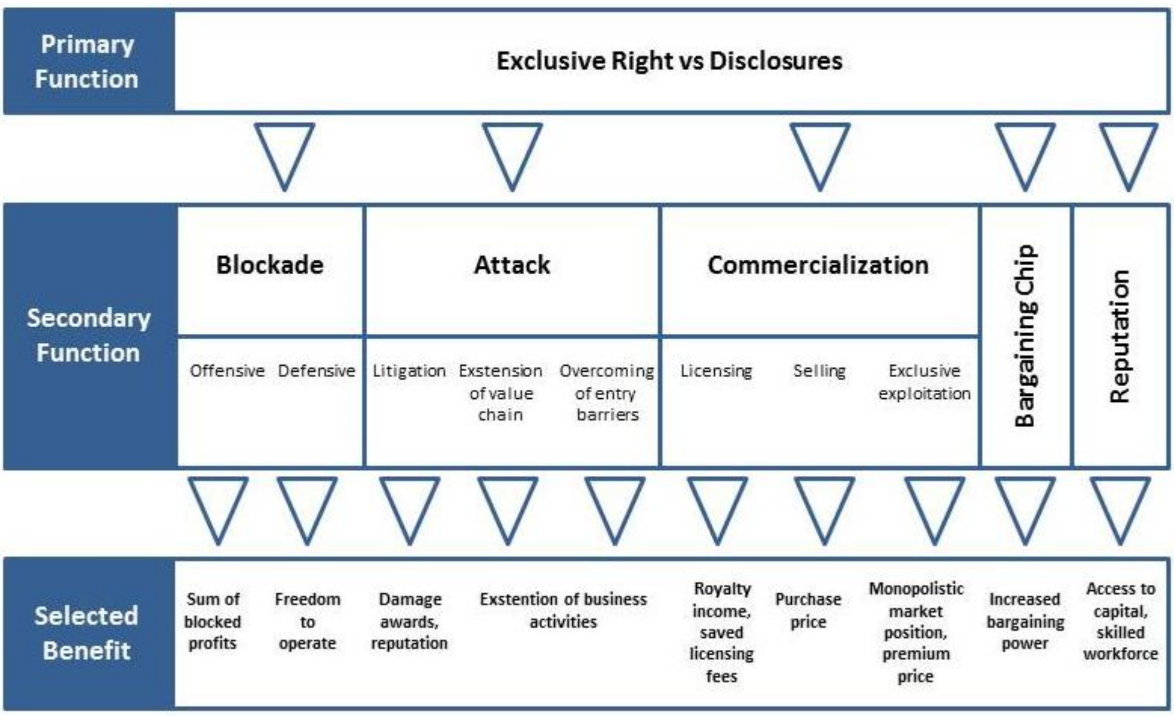

Figure 11 Patent functions and benefits of patent protection, based on Grube (2009)

The primary function of a patent system, to give inventors the right to block others in exchange for disclosing technical information about their invention, is accompanied by alternative uses of patent rights that aim to create additional value for the patent holder. Grube (2009) has divided the function of a patent right into five secondary functions and has identified different economic benefits in relation to each function, see Figure 11.

3.3.4 Value Creating Patent Strategies

In the following section the five different secondary patent functions as described by Grube (2009) are presented as well as the potential benefits stemming from each function.

Blockade

To exclude a third party from a technology segment for a period of time is at the core of patent protection (Grube 2009). Patent rights do not always succeed in blocking a third party from entering a market completely, instead they can either delay a third party's entrance or make it costly for the third party to invent around the patent (Vaver 2006). The ability to obtain a temporary monopoly of a technical market is what makes patents particularly valuable for many companies (Grube 2009). Depending on the purpose of the blockade there are two different types of blocking. Offensive blocking means that a company creates patent fences and thicket to block third parties from entering a market and is particularly useful for discrete technologies such as chemicals and pharmaceuticals (Reitzig 2004). In these cases, the patentee files for patents which are not intended for own use, simply to block competitors from a specific market. The value of the patent right is then driven by limiting the competitor ability to realized potential profits within a given technology (ibid). Defensive blocking on the other hand is about patenting to block competitors from one's own technology fields, thus securing access and freedom to operate within that field. In addition, defensive patents may also support the enforcement of one´s own technology standards (Blind and Thumm 2004).

In both offensive and defensive blocking, the value of a patent is driven by two parameters. Firstly, the strength of the patent in an infringement case, and secondly the probability that the patent holder will detect if a third party is infringing on their intellectual property right (Grube 2009). In addition to these parameters, the value of the patent right is also dependent on the number and availability of substitute technologies (ibid). Substitute technologies should offer the same utility to the customer but do not need to have the same technical function as the patented technology. In technology segments where many substitutes exist, the values of patents are generally lower.

Several patents, with overlapping patent scopes, can be called a patent portfolio (Grube 2009). Often, the value of such a portfolio exceeds the sum of the individual patent values since any challenge of the validity of one patent can be compensated by neighboring patent rights (ibid). Creating a portfolio of patents will also make it more difficult for competitors to invent around, hence enforcing the patents' blocking abilities (Murphy et al. 2012).

Patent protection is not actively enforced by the patent system as such (Lanjouw 1998). In order to block a third party a patent holder must therefore actively identify and prove infringement in a court of law before any protection in its legal terms can be upheld (ibid).

Attack

If a patent owner detects an infringement by a third party, they have three strategies to choose from (Crampes & Langinier 2002). The patent owner can strive for a settlement with the infringer, sue and start a legal proceeding or decide not to do anything. If the patent owner accepts the infringement and decide not to take action against it, the value of the patent right will decrease to zero (Grube 2009)(Lanjouw 1998). To be able to attack an infringer, there are four conditions that need to be fulfilled, these can be seen in Figure 12.

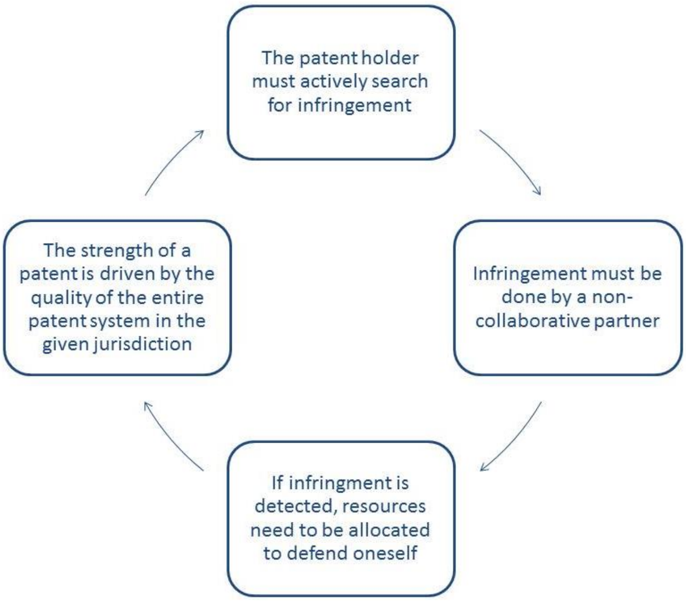

Figure 12 Conditions which need to be fulfilled to be able to attack an infringer, based on Grube (2009)

The economic benefit of an infringement action stems from the potential damage awards (Grube 2009). The indemnification can be based on either the patent holder´s loss, i.e. what the patent holder would have earned if licensing fees had been paid by the infringer, or on the undeserved profit made by the infringer (European Commission 2013). In latter, the undeserved profit should be estimated as both profits stemming from sales of the infringing technology, but also for convoyed sales which would not have occurred without the infringement (ibid). If the patent owner cannot prove infringement or if the patent system in the given jurisdiction fails, the value of the patent will ultimately diminish (Grube 2009).

Commercialization

A patent can be commercialized in three main ways, through transfer to a third party, through licensing or through exclusive exploitation. If the patent is commercialized through transfer, the value of the patent right will be equal to its market value (Grube 2009). In the case of licensing of a patented technology, the patent value will consist of the royalties generated through the licensing agreement (Grube 2009)(Murphy 2012). If a patent is commercialized through exclusive exploitation, its value can stem from two main effects, increased volumes or higher profit margins (Grube 2009). If the patent right protects the product per see, the patent owner will have the opportunity to either increase the price of the product or increase production volume, since no other actor can offer the same product (ibid). In this case, the value of the patent right stems from the higher profit that the patent owner stands to make (Grube 2009). If the patent right instead protects the production method and that method enables production of a technology at a lower cost, the value will instead stem from lower production cost, i.e. higher profit margin (Grube 2009).

Bargaining Chip

Beyond the fact that patents can create value by exclusive exploitation, they can also serve as a means to support and maintain freedom to operate (Grube 2009). In industries with complex technologies, such as for example electronics, companies create patent portfolios to increase their negotiation position in the patent litigation game. In these cases, patent rights are used as bargaining chip or currency in complex negotiations between key industry actors (Grube 2009). Since complex products contain many different patentable inventions, it is not uncommon that several actors have patents covering different parts of the same product (ibid). In these cases, patent owners often assume that they may infringe on someone else´s patent and at the same time that someone else may infringe on theirs (ibid). This can lead to situations where a patent holder does not sue an infringer because they want to avoid being countersued (Grindley & Teece 1997).

As a result of intellectual property becoming more and more important, cross-licensing has become an additional dimension of competition (Grindley & Teece 1997). Technology is no longer only considered the primary source of future revenue, but also a currency or a bargaining chip to be used in negotiations (ibid). If a company lacks the ability to offer an IP portfolio equivalent to the other in negotiations, this often leads to expensive licensing fees. With an equivalent portfolio however, the company has a valuable bargaining chip and the licensing fees can be reduced by signing cross-licensing deals (ibid).

Reputation & Image

Companies holding an extensive patent portfolio can create and maintain the reputation and image of being a technology leader among the general public and on the capital market (Grube 2009). The number of patents can also work as an indicator of quality of research and reward for the R&D personnel. Thus, an extensive patent portfolio can facilitate access to equity or debt capital for financing investments and growth (ibid). In addition, having an image of a high quality research actor can also attract new research collaboration partners and personnel (Petrusson 2004). There can also be risks in relation to having a large patent portfolio as it does not in itself necessarily create beneficial reputation and image. Simply filing as many patents as possible can come across as unsophisticated and will in some cases have the opposite effect to the one described above (ibid).

3.3.5 Technical Standards and Patent Pools

Patents and standardization processes are important to technical innovation (Blind & Thumm 2004). Since the end of the 20th century both global patent filings and the number of standards released by standardization organization have increased massively (ibid). Companies in the leading edge of new technological development often have such a strong market position that they do not need the support of standards to successfully commercialize their products (ibid). However, some theories suggest that the stronger the protection of technological know-how, the more likely it is that a company joins a formal standardization process. This in order to leverage the value of the developed portfolio since only a broad diffusion of technology triggered by standards and technical regulations can create economic growth (ibid).

When deciding on a technology standard, an agreement is not always reached and there are many examples from history where standards for technologies compete as a result of dissension among standard setting organizations (Shapiro & Varian 1999). Modems, video games and VCRs are just some examples of technologies in which more than one standard has existed. The fight between two incompatible technology standards, battling to become a de facto standard, is called a *standards war* (ibid). An example of a company that has successfully established a de facto standard is Microsoft with its Windows operating system (Shapiro & Varian 1999). Standards wars are above all likely to occur in network markets due to their powerful positive feedback (ibid). According to Blind & Thumm (2004) a strong patent portfolio is the most powerful weapon within a standards war. Shapiro &

Varian (1999) even claim that the chance of survival of actors involved in standards wars is often determined by the outcome of the conflict. Seven key assets will influence a company's ability to establish a standard and to successfully wage a standards war, these are described in Table 2.

Table 2 Seven key assets that will help companies successfully establish a standard and win a standards war, based on Shapiro & Varian (1999)

1	**Control over a user base**
	By having control over a large group of loyal or locked-in users, a company can block other standards and force a standards war
2	**Intellectual property rights**
	Companies with intellectual property right such as patents or copyrights are able to control valuable technology and have a stronger position in setting standards
3	**Ability to innovate**
	Other than current technologies and IPRs, a company's ability to innovate can strengthen their position in a standards war
4	**First-mover advantages**
	By being further along the learning curve than competing actors, a company's competitive position in standards setting is strengthened
5	**Manufacturing abilities**
	Cost advantages, stemming from economies of scale or manufacturing competence, can help companies survive standards wars
6	**Strength in complements**
	Producing a product that is an important complement for the market in which the standards war is raging, can be a strongly motivating factor for a company since acceptance of the new standard will stimulate sales of the complementing product
7	**Brand name and reputation**
	Brand name and reputation can be important factors in any large market, but are especially significant in markets with large network effects. In order to win a standards war it is not enough to have the best product, the customer also has to believe you will win.

3.4 Valuations Models

When making a decision a choice has to be made between the available options. In order to do so the value of the different options for the company in a given situation have to be evaluated. For competing, revenue driven companies, the best option is often the one that generates the highest value for the decision maker (Murphy et al. 2012). To determine the potential value of the options before making a decision, information about the different scenarios is collected and compared. The goal of a valuation analysis is to help the decision maker identify the best alternative among different and uncertain options (ibid). Valuation analysis is particularly beneficial for patent related decisions (Murphy et al. 2012). By quantifying aspects of the different options and hence determining their value, the alternatives can be compared to each other without making a direct comparison between individual options (ibid). When it comes to patents, direct comparisons should be avoided since it can be very challenging to compare many, complex alternatives with different arrays of judgments and uncertainties (ibid). In the following chapter different decision situations in which patent valuation can be beneficial will be presented. This will be followed by a description of the patent valuation process and different methods that can be used for patent valuation.

3.4.4 Decision Situation in which Patent Valuation can be Beneficial

Patents are means to protect new and unique inventions, which have a big enough inventive step from all previous inventions (Murphy et al. 2012). The fact that all patents are different means that it is difficult to measure the value of patents in a uniformed, definite, line by line and totally consistent calculation (ibid). The context in which the valuation is made should determine what type of method is most appropriate to use in the specific situation (ibid). Table 3 illustrates examples of decision situations in which patent valuation can be beneficial.

Table 3 Examples of decision situations when patent valuation may be beneficial, based on Murphy et al. (2012)

	Decision Situation
1	Decision concerning IP maintenance and commercialization
2	Identification and prioritization among internal assets and R&D projects, including analysis of the potential of early R&D projects
3	In bargaining situation, since by knowing and communicating the value of the patents involved, the bargaining position can be increased
4	Decisions in regards to potential merger, acquisitions or spin-offs
5	Increase communication and transparency between businesses
6	In shareholder related decisions patent information is very important since this information ultimately influences the value of the whole company
7	Enterprise related causes including company law
8	Situations involving finance and accounting

Despite the benefits of valuation in the decision making process, companies have to consider how much time and effort should be invested in the valuation analysis (ibid). Murphy et al. (2012) claim that the importance of the decision being made should influence the valuation process and have identified three different decision making strategies. The amount of time and effort invested in the valuation analysis should reflect the importance of the decision itself (ibid). The three different decision strategies, Maximizing Strategy, Optimizing Strategy and Satisfying Strategy, are illustrated in Figure 13.

If the decision is very important and the difficulty of collecting information is low, the maximizing strategy is best suited for the decision making process (Murphy et al. 2012). Using this strategy, the decision maker does not have to consider the cost of obtaining information and should aim to perform an extensive analysis before making a decision (ibid). The maximizing strategy is most suitable in situations where one is facing major infringement-litigations or is about to acquire or sell

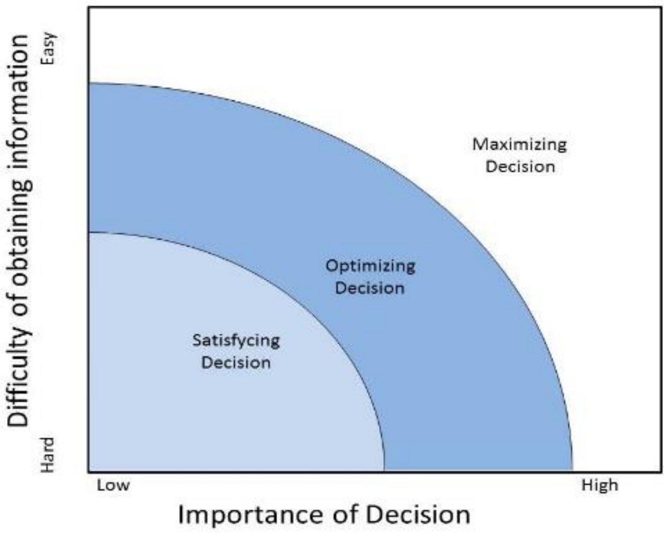

Figure 13 Depending on difficulty to obtain information and the importance of the decision, different decision strategies are recommended to use (Murphy et al. 2012, p. 54)

a patent-based startup company or spin-off (ibid). In both of these cases the information needed for the valuation should be relatively easy to obtain and the outcome will affect the company to a large extent. Decisions that need to be maximized only make up a minority of patent related decisions in companies (ibid).

When using an optimizing strategy, the decision maker still searches for the best suitable option, but with limitations in how much time and effort can be invested in the analysis (Murphy et al. 2012). This means that the decision maker will have to rely on a limited amount of information when making the decision and will have to have a cost-benefit perspective in mind when conducting the analysis. In most important patent related decision situations, the optimizing strategy will be the best suited alternative. This strategy is for example sufficient when valuing alternatives for funding, major licensing deals or patent portfolio acquisitions (ibid).

The last strategy, the satisfying strategy, should preferably be used when the importance of the decision and the cost of obtaining the necessary information does not justify using an optimization strategy (Murphy et al. 2012). By definition, the decision maker is not searching for the best alternative, but rather an alternative that meets one´s predefined needs (ibid). The majority of patent related decisions are best suited for a satisfying strategy, which means that a decision process can be significantly improved by conducting a simple valuation analysis. One example of a situation when the satisfying strategy can be used is when deciding whether to continue paying maintenance fees or not. In this case, the patent valuation analysis can show whether the patent generates more value than the cost of its maintenance fees (ibid).

3.4.5 The Patent Valuation Process

The patent valuation process can be divided into four different steps (Grube 2009):

1. Identify the reason for doing a patent valuation
2. Collect all necessary data
3. Decide upon which model to use
4. Analyze the result

A comprehensive patent valuation requires a link between the legal aspects, the economic benefits and costs of the patent (Grube 2009). The valuation should also include the disadvantages resulting from disclosing information about the invention. In order to perform a good patent valuation, the valuator needs to make reasonable and defined assumptions, have access to comprehensive databases, and make correct calculations (Grube 2009). The result will be highly dependent on the assumptions that have been made (ibid).

All valuations are in some sense subjective (Grube 2009) (Murphy et al. 2012). This means that the outcome of a valuation will depend on who is conducting it and the context in which the valuation is conducted. Market transactions rely upon the buyer valuing an asset higher than the seller hence enabling both parties to be satisfied with the transaction (Murphy et al. 2012). The subjectivity of valuations is therefore ultimately what makes market transaction work (ibid). When conducting a patent valuation, many firms use either a patent attorney or a business person to conduct the valuation (Murphy et al. 2012). Both of these choices of valuators constitute a risk. While a patent attorney is likely to over-estimate the legal aspects of the patent, a business person may over emphasis the strategic importance of the patented technology (ibid). To avoid valuation bias, it is therefore important to us a method where both legal and business persons can contribute and combine the knowledge and valuation insights (ibid).

Any valuation analysis needs to exhibit a certain degree of flexibility to fully reflect the underlying valuation model and the aim of the valuation (Grube 2009). For an analysis to be reliable, a third party should be able to replicate the valuation process. In order for the analysis to also fulfill the criteria set for credibility, the model has to have a theoretical foundation, built upon a standardized method. In addition to these criteria, the model has to be consistent, cost effective and usable (ibid).

3.4.6 Pre-Valuation Model

To value all patents in a portfolio can be both time consuming and costly, however the portfolio as a whole still has to be managed in order maximize value creation (Murphy et al. 2012). By conducting a preliminary analysis of the patent portfolio as a whole, managers can prioritize between patents and determine which patents to analyze further (ibid). This preliminary analysis can help managers to identify:

1. Valuable inventions that lack sufficient legal protection
2. Patents where the strategic importance are in balance with the legal protection
3. Inventions which are not strategically important enough to motivate the cost for their legal protection, in terms of time and expenditure (ibid).

To enable a brief analysis of a large number of patents Murphy et al. (2012) suggest using a so called Preliminary Patent Valuation (PPV). This model should not be used to establish monetary values of individual patent rights, but rather to, in an efficient way, prioritize among patents in a given portfolio. In this model the preliminary value of patents is based on two main parameters – legal and strategic. The legal parameter is determined by considering the legal strength and breadth of the patent claims, how courts in general interpret patent claims in the given industry and the legal practices in jurisdiction where the patent is valid (ibid). The strategic value of the patent is determined by analyzing sub-parameters such as the future market for the patented technology, competition in the market, and access to alternative technologies (ibid). As the PPV model does not give a value in monetary terms, the analysis should be seen as useful input to for example due diligence or benchmarking analyzes (European Commission 2013).

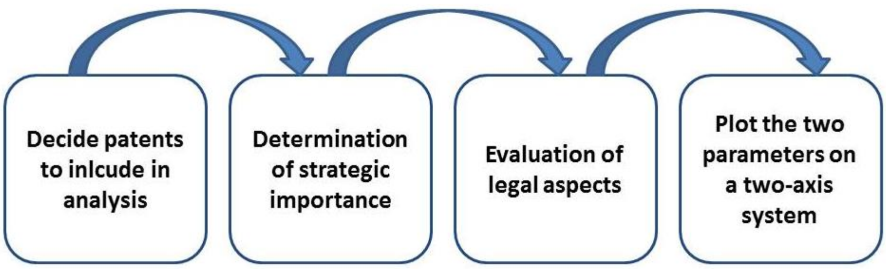

Figure 14 The process of conducting a PPV illustrated in four steps, based on Murphy et al. (2012)

The process of conducting a PPV consists of four steps as are illustrated in Figure 14. In step two and three, value drivers need to be defined beforehand and a uniform scale for how to determine their value needs to be set. When evaluating the strategic importance of a patent in step two, it is important to consider all strategies within the firm and the importance of the patent in pursuing these strategies. This step may also involve the consideration of potential future strategies for a business and therefore the identification of patents that may increase in importance in the future.

3.4.4 Direct Valuation

Direct valuation models include models in which direct calculations of financial value are made (Grube 2009). These different models can be divided into three sub categories – cost based, market based and income based (Grube 2009) (European Commission 2013). Pitkethly (1997) and Murphy et al. (2012) have added a fourth category which is option based valuation, in which the notion of future option and choice is included.

According to Grube (2009), a valuation based on expected economic benefit is most appropriate when valuing a patent. A patent is valid for a maximum number of years. This means that the basic economic principle of sunk cost can be applied on past expenses and the focus of the calculation can be on potential future profits (ibid). All valuation models can be adapted and are more or less suited for different circumstances. The main methods primarily vary in terms of their time perspective, the cost based method is based on historical data, the market based method is based on current data and the income and option based methods are based on predictions of the future, see Figure 15.

Figure 15 Illustration of the time perspectives in Cost based, Market Based and Income Based valuation methods (Murphy et al. 2012)

In addition to the time perspective, there are seven features which are dealt with differently in the four methods (Pitkethly 1997). Some methods are easier to use but are not as accurate, while others are very detailed but require more time and effort (Pitkethly 1997)(Murphy 2012). Figure 16 illustrates the complexity level of each of the methods and how the seven different features are used in each one. In the following section, the four different valuation methods will be described and compared to each other.

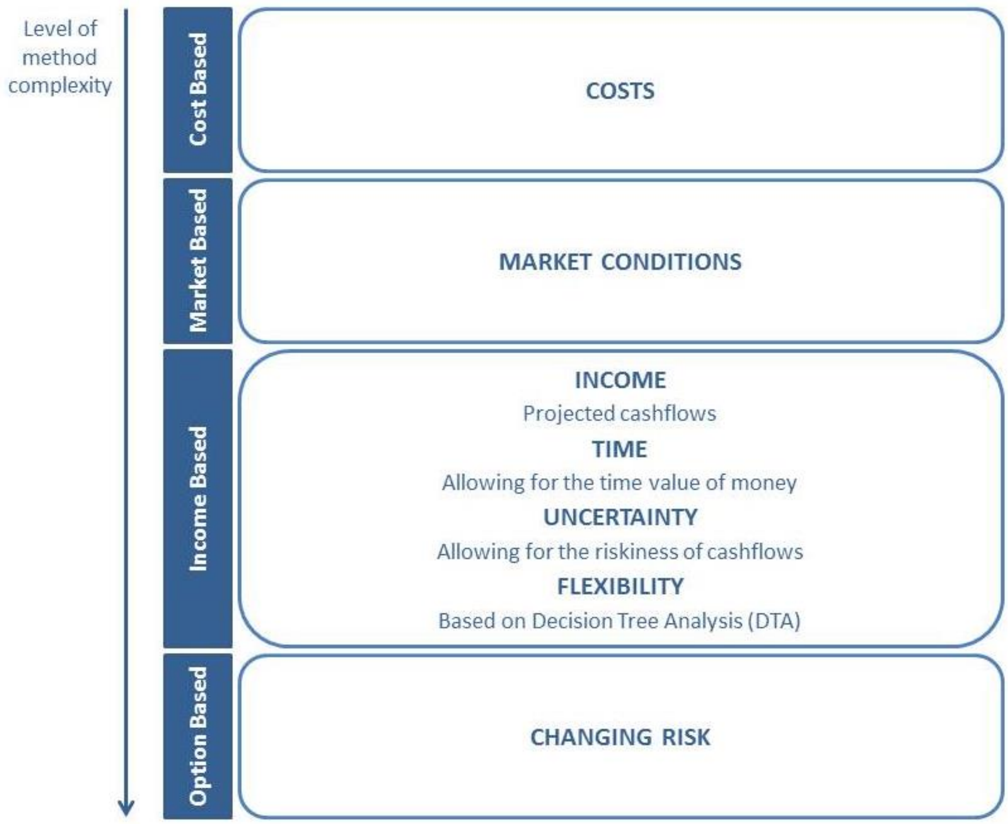

Figure 16 Different patent valuation methods, what features are included in each and how difficult each model is to use, based on Pitkethly (1997)

Cost Base Method

In the cost based method the value of the patent is determined by its historical costs (Pitkethly 1997). These costs can stem from the investments made when developing the patent or the cost of using an alternative technology instead of the patented one (Murphy et al. 2012). These two different approaches are called the reproduction approach and the replacement approach (ibid). The aim of the cost approach is to define an upper limit, for how much someone would pay for the protection that the patent gives before opting for another technology option (Grube 2009).

The two main costs that should be included in a cost based patent valuation are R&D costs and legal expenditures (Grube 2009). If the technology is bought instead of developed in-house, the acquisition costs should be included in the model. Legal costs consist of for example patent application fees, renewal fees, and, in case of legal disputes, court costs (ibid). The cost based method does not take any future benefits, which might stem from the patent, into consideration. This means that the model is only of help for historical cost based accounting, or where taxation methods are used (Pitkethly 1997). The method is of little help in determining the future value of intellectual assets (ibid).

Market Based Method

In market based methods the asset is valued by comparing it to similar asset which have been transferred on the market already (Pitkethly 1997). The model is based on the principles of equilibrium, competition, and substitution where an "equilibrium prices of substitute goods in a competitive market provide an indication for the value of the valuation object" (Grube 2009, p. 124). This means that, for the model to be applicable, a similar recently transferred asset needs to be known as well as the details of its transfer. The same logic can be applied when setting reasonable royalty rates in licensing agreements (Grube 2009).

There are several reasons why it is difficult to use the market based method for the valuation of patents. The inherent uniqueness of a patent makes it difficult to find a similar asset with which to compare (European Commission 2013). The fact that patent transfers are usually confidential also makes getting information about comparable patents difficult to obtain (Grube 2009). There is currently no efficient and active market where patent rights are frequently transferred between independent parties (ibid). Since the basic principles for a market based method are not fulfilled in the patent market, the limited information available about patenting deals, litigations and patent auctions have excessively high influence on the result of this valuation (ibid). This makes the market based method highly unreliable when it comes to patent valuation.

Income Based Method

In the income method, any future incomes stemming from the patent right are projected. The net present value of the income stream, minus taxes, equals the value of the patent (Grube 2009). The method is based on the principle that a patent-generated income stream can be separated from the rest of the value streams of a company (Grube 2009). If the object for valuation is a patent portfolio, i.e. several patents, the valuation model has to reflect the differences in expected lifetime of the patent rights.

There are several different ways in which the income based method can be constructed and different features that can be included in the valuation. The simplest version is to only predict the future incomes, summarize them and compare them to the costs. More detailed and accurate methods also include features like time and risk. When it comes to time, the future value of money is lower than that of the present. This means that future income should be discounted to present time (Murphy et al. 2012). Incomes stemming from a patent can be periodical, and if so, periods are recommended to be one year (Murphy et al. 2012). The risk a patent holder faces is driven by technological, legal, and economic aspects (Grube 2009). The risk rate can be either constant or vary over time, however varying risks are seldom used in patent valuation as a small change of the risk rate will have low impact on the results (Neil 1988). Since there is a lot of uncertainty in regards to the future application of patents there are always uncertainties involved when predicting their future value. Pitkethly (1997) recommends not to use income based methods without taking time and risk into consideration since they strongly impact the result.

One advantage of using the income based method when valuing patents compared to when valuing physical assets is that a patent right has a limited lifespan (Grube 2009). This means that when using the income based method for patent valuation a calculation of terminal value is not required (Damodaran 2002). The result of the valuation will therefore not depend on the assumptions made when determining the terminal value (ibid). One key assumption that is necessary when using an income based method for this type of valuation is a prediction of how long the patent right will be used to generate income (Grube 2009).

When using an income based method the difficulty lies in predicting future incomes generated as a result of the patent protection. Murphy et al. (2012) distinguish between two types of incomes, direct incomes and indirect incomes. Direct incomes are relatively easy to identify, isolate and quantify. Examples of direct incomes are licensing fees, extra profits based on exclusivity, cost-savings in production or damages fees from infringing companies (Murphy et al. 2012)(Grube 2009). The indirect incomes are more difficult to identify, isolate and quantify. These can stem from for example market dominance or reduced licensing fees (ibid). When determining these incomes, a comparison with a hypothetical company without the patent right could be necessary (Grube 2009). The difficulties of carry out such a comparison limit the use of such an approach (ibid). Regardless of whether direct or indirect incomes are being calculated, only a limited share of sales volumes and cash flows can be credited to the patent and used to calculate the patent value (Grube 2009). When determining what this reasonable share should be, the following should be considered:

1. The impact of the technological product features on product sales
2. If an individual patent is valued, no other technological assets that drives the commercial success should be included
3. The valuation must reflect the legal quality of the patent right
4. Only the geographical area covered with the patent should be included

Option Pricing Method and Decision Tree Analysis

Option-valuation and decision tree analysis (DTA) are additional methods for valuing patent rights (Grube 2009). In these more advanced methods, potential future strategic choices in regards to the patent are taken into consideration in the valuation process. Example of future options are whether or not to pay the maintenance fees, if a lawsuit should be brought against an infringing competitor or whether to license out a patent or not. The future decisions related to a patent can be illustrated using a decision tree which is why decision tree analysis can be a valuable input to the option pricing method (Murphy et al. 2012).

The option pricing method originated from financial theory in which an option can be defined as a right, not an obligation, to buy or sell an asset at a specified time, at a price which is subject to a random variable (Pitkethly 1997). This method of valuation makes it possible to analyze different scenarios, in which different cash flows, risks and developments occur over time. In order to make the model manageable, the number of different options included needs to be limited (Murphy et al. 2012). An advantage of using an option pricing method is that it takes the uncertainty of the future into consideration and allows for managerial flexibility in a way that conventional valuation models do not (Pitkethly 1997).

Summary Direct Valuation Models

Advantages and disadvantages with the direct valuation models are shown in Table 4.

Table 4 Summary of direct valuation models including the strengths and weaknesses of each model

Type of Model	Strength	Weaknesses
Cost Based	+ Reliable in cases where an alternative technology has recently been acquired + Improved available data if historical costs are recorded + Easy to perform + Appropriate when the aim is to estimate historical patent value	– Focus on the past – No future benefits are included – No risk is included – No correlation between cost, price and value – Subjective nature of replacement cost – Less applicable when valuing a third parties´ patent
Market Based	+ Increased objectivity if comparable transactions or patent exist + Easy calculation + Market replacement cost	– General absence of an active market where patent rights are frequency transferred – Limited assessment of future benefits and risks – Difficult to find comparable transaction, if patents are sold in combination with other assets
Income Based	+ Includes future economic benefits and transparent assessment of risk + No issues with terminal value + Includes value drivers + Well known and accepted among various disciplines	– Requires a lot of input data – Result will depend on the quality of inputs – Subjective assessment of the future is required – May lead to overestimating patent value
Option Based	+ Allows analysis of different scenarios + Mimics the actual decision making process + Most rigorous valuation tool	– Option value decreases with patent age – May be too complex – Risk of influence sensitive variables

3.4.5 Indirect Valuation

The indirect patent valuation models take advantage of the fact that all patent documents are public and fully available (Grube 2009). The basic idea behind the research of indirect valuation is based on the concept of positive trade-offs and assumes that when renewing a patent, the patent holder has estimated the patent value as being higher than the renewal fee and vice versa (ibid). Based on data extracted from patent documents, fundamental value drivers have been identified which can be used to approximate the patent value (ibid). The potential incomes stemming from the patent combined with the strength of the legal protection are the main drivers behind patent value (ibid).

The value drivers can include aspects such as intellectual property protection, technology development level, market for product utilization, financial factors, and management competences of the organization owning the patent (European Commission 2013). A combination of these drivers, weighted to compensate for their relative importance, can be used to determine the value of a patent (ibid). A lot of research has been conducted to identify connections between the bibliographic information, the risk that a patent will be attacked and the economic value of a patent right (Grube 2009).

As mentioned before, a patent holder might benefit from holding a large patent portfolio, by for example getting an increased bargaining power. In these cases, it is not unusual that the patent portfolio's value exceeds the sum of the individual patents. This can leads to renewal of weak patents, despite their low individual value, and may be a source of error when analyzing the connections between bibliographic information and individual patent value (Grube 2009). Indirect valuation can be beneficial to use when differentiating between valuable patents and less valuable patents (ibid).

4. The Automotive Industry – A Literature Review

In this chapter the characteristics of the automotive industry will be explored. The current market structure as well as major trends in terms of technology, competition and patenting will be discussed. Finally the use of patents among actors in the industry will be described as well as how this is changing as a result of industry trends.

4.1 An Automotive Industry Overview

The automotive industry is a global industry in which a few major actors have historically dominated most geographical regions (Hashmi et al. 2010). In 2004, the thirteen largest market actors produced and sold more than 95% of all vehicles world-wide (ibid). Figure 17 illustrates the profits of the top 10 automobile manufacturers in 2014 and shows that while the market is dominated by actors from established vehicle manufacturing regions such as Europe, North America and Japan, actors from emerging markets are beginning to make their way into the top performing segment.

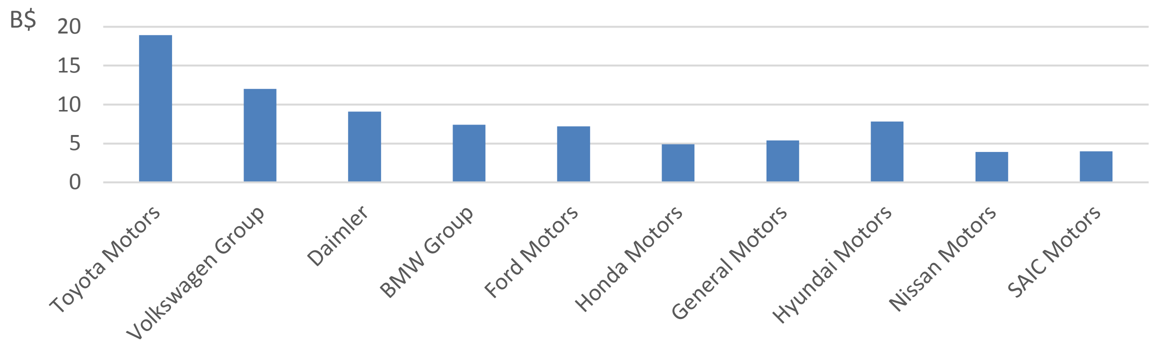

Figure 17 The top 10 automobile manufacturing companies in 2014, estimated based on market value, sales and profit (MBA Skool 2015)

The development and manufacturing of a vehicle is a highly research intense activity (Hashmi et al. 2010). A car consists of more than 20,000 parts, all of which are essential to the production and completion of the product (Mojonnier 2011). Current technological shifts within the automotive industry are putting increasing pressure on automotive players to innovate and keep up with technological developments and trends (CAR 2014). As can be seen in Figure 18 the automotive industry ranks third in terms of research and development spending among all industries (Jaruzelski et al. 2014). According to Wagner et al. (2013) many actors from the automotive industry are among the most innovative of all companies globally.

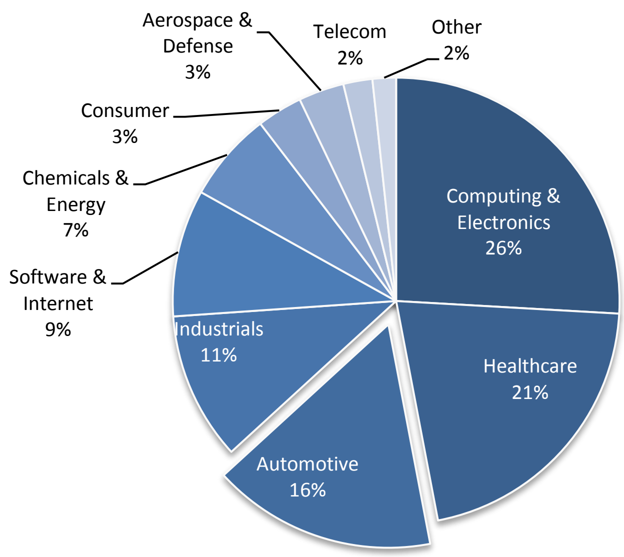

Figure 18 R&D spending per industry (Jaruzelski et al. 2014, p. 6)

The automotive supply chain typically has between three and five levels. While vehicle manufacturers generally produce some key parts in-house, most components and systems are delivered by a number of different tier suppliers, see Figure 19 (Mojonnier 2011). In the past, industry actors were focused on keeping their main operations in their home regions, while exporting finished products to relevant markets. Growing competition and an increased focus on customer needs however, has caused many actors to increasingly move a wide range of value-adding activities abroad (Schmid et al. 2008). In order to stay competitive, many vehicle manufacturers have also increasingly chosen to work together with competitors and suppliers (ibid). The consolidation trend can also be seen among industry suppliers, who are increasingly interested in mergers and acquisitions as industry manufacturers look to decrease their supplier base (Strategy& 2015).

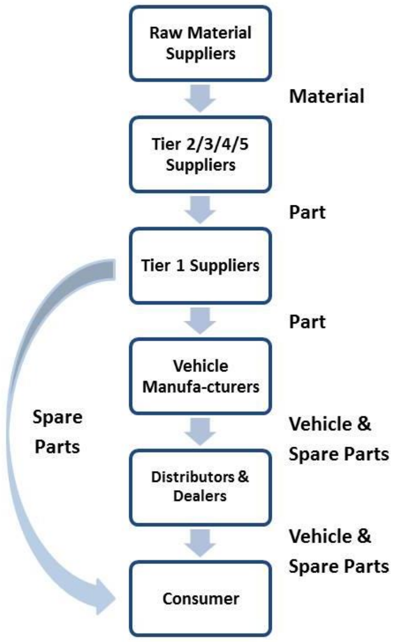

Figure 19 The automotive supply chain (Mojonnier 2011)

4.2 Major Trends in the Automotive Industry

The automotive industry is currently experiencing a technological shift (CAR 2103). From historically having been focused on mechanical innovation, IT focused development is becoming increasingly important to the functionality of today's vehicles (CAR 2013). Cars and commercial vehicles are rapidly becoming more complex in terms of technological input and today software based systems are involved even in previously mechanical functions such as gear transmissions and steering (Porter & Hemmelmann 2014). According to Auto Alliance (2014), this development will make the car of the future the most technologically sophisticated product owned by consumers. Since the economic crisis of 2008, the automotive industry has recovered and is beginning to show growth in profitability (McKinsey & Company 2013). In this new growth phase, five major trends have been observed, a change in customer groups, emergence of new markets, developments in powertrain technologies, growing use of connectivity and a focus on autonomous driving (Semcon 2013). How these trends manifest themselves within the passenger and commercial vehicle industries will be discussed below.

4.2.1 A Change in Customer Profile and Behavior

According to Semcon (2013) the average car buyer is changing in term of profile and purchasing behavior. Due to changes in society overall, first time buyers are older than in the past and people are able to continue driving into old age (ibid). This means that the average car buyer is gradually becoming older (ibid). In addition to being older, today's car buyers increasingly want to influence the features and functionality of their vehicle (McKinsey & Company 2013). The increasing demand for design influence is causing car manufacturers to decrease their model assortment and instead increase the derivatives offered to customers (ibid).

Another customer trend relates to purchasing behavior. Buyers within the automotive industry are increasingly looking to purchase a transportation service as opposed to a physical good and vehicles are no longer considered lifestyle symbols (Semcon 2013). This means that alternative ownership structures such as car-sharing and leasing agreements are becoming increasingly popular, forcing automotive manufacturers to adjust their product and service offering as well as product development processes (McKinsey & Company 2013) (Semcon 2013). In the truck industry leasing and financing solutions have reached a higher penetration rate than in the car industry as can be seen in Figure 20. Actors from both segments however, have increasingly developed financing offerings in order to compete with banks and insurance companies (KPMG 2011). In response to the emerging interest in car-sharing, several traditional automakers have developed their own market offerings in order to retain first-hand customer interaction and influence (Porter & Hemmelmann 2014).

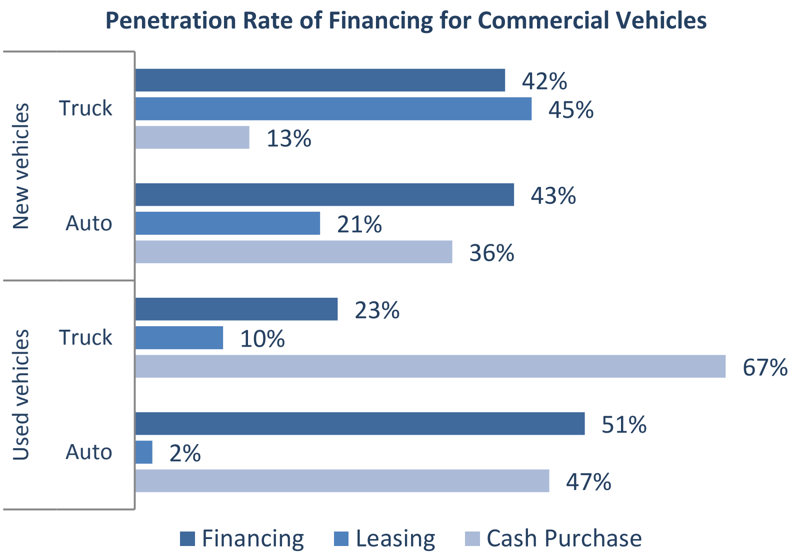

Figure 20 Penetration rates of financing for commercial vehicles

4.2.2 New Markets are Taking Over

While Europe has historically been the most important manufacturing region in the automotive industry, the industry is currently experiencing a geographical shift (Semcon 2013). Emerging markets are becoming increasingly important and China has recently emerged as the world's largest commercial vehicles market, surpassing the US with a 30% share of the global market in 2010 (see Figure 21) (KPMG 2011).

In the truck industry, China, India and Russia have been identified as key emerging markets and actors, primarily from China, are steadily out-competing established truck manufacturers in terms of market dominance (KPMG 2011). The growing importance of emerging markets is a challenge for established European and North American truck makers both in terms of production planning and product offering (ibid). There is a substantial difference in the product demand between emerging and established markets, and the production of established automotive actors is not sufficiently aligned with future demand (McKinsey & Company 2013).

In emerging markets the market share of low-cost trucks is significantly higher than premium alternatives, whereas premium brands still dominate the established markets (KPMG 2011). This difference in customer demand makes it difficult for large western automotive actors to establish themselves in emerging markets and calls for alternative approaches to market entry (ibid).

According to KPMG (2011), Full Line Manufacturers[5] (FLM) have the best chance of successfully taking a share of emerging markets due to synergies between segments and multi-brand strategies.

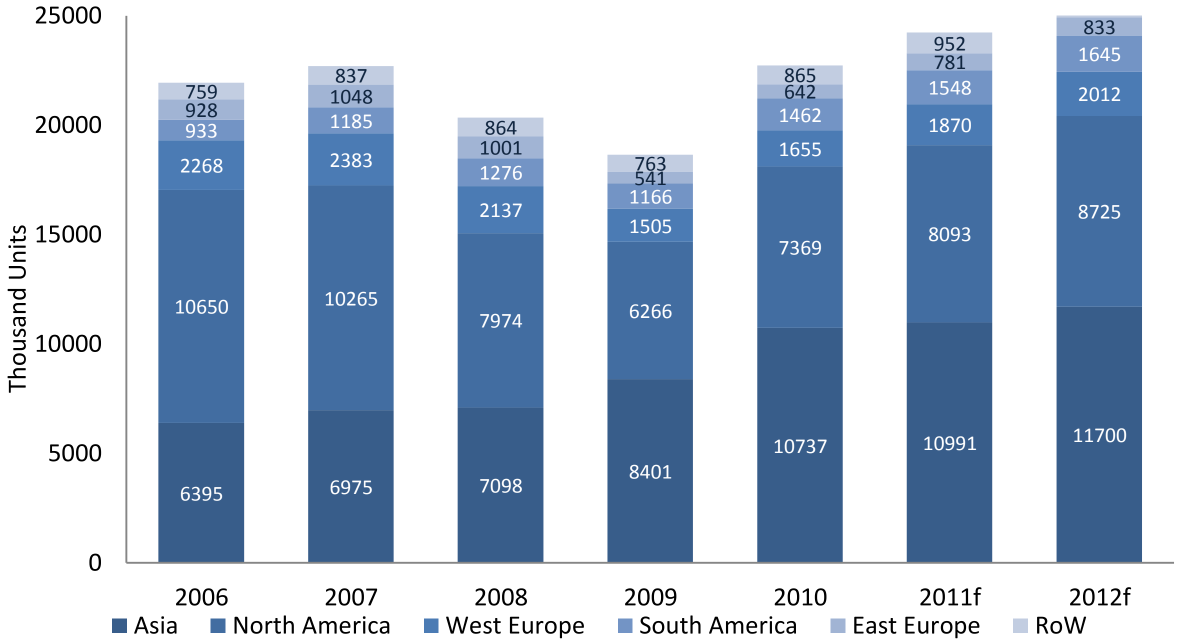

Figure 21 Global development of commercial vehicles market across all market segments (i.e. light commercial vehicles up to 6 tons + heavy commercial vehicles over 6 tons) (KPMG 2011, p.5)

In order to stay competitive both in terms of capacity distribution and customer segment demand, consolidation has become increasingly common in the automotive industry. Considering the truck industry, the European and North American markets are highly consolidated and increasing consolidation is unlikely, however in emerging markets there is still room for consolidation growth (KPMG 2011). Having been less effected by the recent recession, actors from emerging markets will now be looking to reach scale as fast as possible (Ernst & Young 2013). This will be done through acquisitions in their home markets and internationally and will further drive global OEM consolidation (ibid).

4.2.3 Advances in Powertrain Technologies

Despite the widely accepted fact that fossil fuels will sooner or later run out, as many as 98% of cars today still use fossil fuels (Semcon 2013). In a quest to minimize their dependency on fossil fuels, actors within the automotive industry are struggling to define how the vehicles of the future will be propelled. This trend is driving developments within several alternative powertrain technologies as well as reduced fuel consumption. In the market for passenger cars, electrification is a growing trend and electric vehicles (EV) and hybrid vehicles are becoming increasingly popular (ibid).

In the truck segment alternative propulsion technologies have not yet been as widely adopted and customers within the commercial vehicle segment are showing a lower willingness to pay for eco-

[5] Full Line Manufacturers: A truck manufacturer who produces and sells commercial vehicles in the light commercial vehicle segment as well as the heavy commercial vehicle segment (KPMG 2013)

innovation than in the passenger car segment (KPMG 2011). The offerings that do exist are mainly within micro-hybrid technologies, encompassing automatic start-stop systems and brake energy recovery that can significantly influence fuel consumption in frequent start-and-go traffic (ibid). Trucks using mild-hybrid systems, in which diesel engines operate alone or with the support of an electric engine, are also available in the market, however these more heavily hybridized engines are uncommon in commercial vehicles (ibid).

While alternative fuel technologies are less prominent in the truck segment, developments in emissions and fuel consumption are key research areas (KPMG 2013). Governmental regulations, such as emission standards, are pushing the technological development within this field and are becoming increasingly important to industry actors' ability to compete (KPMG 2011). Within the truck industry Total Cost of Ownership (TCO) is seen as a key input to purchasing decisions (KPMG 2011). In mature markets TCO is mainly made up of fuel costs, and fuel consumption is therefore crucial to customers purchasing decision (ibid). In emerging markets however, fuel is relatively cheap and repairs are less frequently performed by authorized repair shops. In these markets the TCO is mainly made up of the purchasing price and fuel consumption is less influential in buying decisions (ibid).

4.2.4 Connectivity

Semcon (2013) have identified the use of systems and platforms for connectivity as a trend within the automotive industry. The trend includes connectivity between the car and handheld devices, such as smartphones, as well as communication between vehicles, also known as Vehicle-to-Vehicle (V2V) communication (ibid). According to McKinsey & Company (2013) the consumers of the future are looking for more connectivity and ease of use in their vehicles. Smartphone communication allows drivers to use phone features in their car but also to control their vehicle remotely through their phone. Volvo on Call is an example of a smartphone app that allows the user to remotely activate functions in their car and monitor fuel levels (Volvo Cars 2015). Vehicle-to-infrastructure (V2I) communication is another trend within connectivity and allows vehicles to communicate with the infrastructural system (Narla 2013). This includes communication with traffic lights, roadside devices and the roadway itself (ibid). Collectively referred to as V2X technologies, V2V and V2I, can have several safety benefits (ibid). Narla (2013) describes how these systems allow the car to process information about position, speed and location and detect hazards with a 360 degree view of its surrounding. They can subsequently calculate risks and possible threats and issue warnings and notices to the driver (ibid).

In the market for commercial vehicles, the connectivity trend is primarily focused on Fleet Management Solutions (FMS) and telematics services (KPMG 2011). V2X communication allows for large vehicle fleets to be managed for optimal logistic and economic efficiency (ibid). The technological advances in the fields of IT and communication enable transportation companies to get real time updates of information and adapt their actions accordingly (ibid). Fleet Management Solutions have primarily been implemented in established markets as shortcomings in infrastructure and network coverage limit the scalability in emerging markets (ibid).

The framework on which today's V2X technologies are built is made up of IT and telecommunication standards and protocols as well as new standards that are being developed (Narla 2013). Some standards, such as for safety messaging, have already been established in a cooperation between

European and American industry, governments and standards communities (ibid). According to Ernst & Young (2013) industry actors are more likely to collaborate in the future as new standards are drafted for emerging vehicle technologies.

4.2.5 Autonomous Driving

Given the developments in vehicle communication technologies, a completely self-driving car is not far in the future (Semcon 2013). By processing data from techniques such as radar, GPS and computer vision, cars will soon be able to monitor their surrounding and maneuver themselves without interference from the driver (Narla 2013). Many major automakers have already developed prototypes of driverless cars and according to Semcon (2013) these will be seen on US and European roads in ten to twenty years. The main obstacle to autonomous vehicles is that despite having many benefits in terms of safety and convenience, they are in fact illegal on most public roads (Narla 2013). While driverless cars face challenges in terms of legislature as well as customer acceptance, semi-autonomous vehicles including the underlying technologies can be found in vehicles already on the roads today (Semcon 2013).

Over the last few years, the US National Highway Traffic Safety Association (NHTSA) has been investigating the safety benefits of various crash avoidance technologies in light vehicles as well as heavy-duty trucks and busses (Foley 2014). The research has been focused on several different autonomous driving technologies, such as lane departure prevention, crash imminent braking (CIB) and dynamic brake support (DBS) (ibid). The use of V2X technologies in improving the effectiveness of these support systems has also been investigated with the goal of determining the feasibility of mandating these technologies in future vehicles. During the end of 2014, the agency issued an Advanced Notice of Proposed Rule Making (ANPRM) as a means to gather public input to the departments work towards a future requirement of V2V technologies in vehicles (NHTSA 2014). Should they find it cost-justified, one or more autonomous driving technologies may be mandated in vehicles in the future (ibid).

4.3 Changes in Industry Structure

The trends in the automotive industry as well as the growing complexity of products has disrupted the value chain and forced actors to rethink not only their internal processes but what business they are ultimately in (Porter & Hemmelmann 2014). Below the impact of the current trend in the industry on the overall industry structure will be discussed.

4.3.1 New Technology Specialists

As new technologies are introduced into the automotive industry and vehicles become increasingly smart, new actors with specialized competences are entering the market (Corwin et al. 2012). The use of information and communication technologies in the vehicle industry is attracting new actors from the digital arena to the automotive market and is causing competition to intensify (McKinsey & Company 2013). Traditional automotive actors often lack the specialized capabilities needed to develop certain technologies (Porter & Hemmelmann 2014). This means that in order to deliver the functionality demanded by customers, OEMs will need to collaborate with specialized actors from outside of the automotive industry (Strategy& 2014). While the industry has historically been characterized by a few OEMs and large suppliers dominating the market the increasing need to specialization among suppliers has led to more suppliers and growing suppliers networks (Corwin et al. 2012).

As the components delivered by suppliers become more complicated the suppliers ultimately deliver more value to the end product (McKinsey & Company 2013)(Porter & Hemmelmann 2014). This causes a change in the power dynamic between OEM and supplier (Porter & Hemmelmann 2014). In the case of high-tech components, suppliers will have high bargaining power as their delivery will be essential to the value of the end product. In the case of physical components however, the bargaining power of traditional automotive suppliers will fall as their products will become commoditized and eventually replaced by software (ibid). The emergence of the connected vehicle is forcing automotive actors in to supplier relationships in which they are no longer dominant (Porter & Hemmelmann 2014). Through the Open Automotive Alliance, GM, Honda, Audi and Hyundai joined forces in utilizing Google's Android operating system in their vehicles (ibid). Working with supplier such as Google, OEMs traditional bargaining power is greatly diminished (ibid).

4.3.2 Diminishing Profit Margins in the Industry

The price of trucks has remained relatively stable for a lengthy period of time while the technological complexity of the vehicle has increased, this has led to a reduced price-cost gap (McKinsey & Company 2013). In terms of managing internal processes and ensuring economies of scale, truck manufacturers have a lot to learn from car manufacturers (KPMG 2011). In the car industry, growing competition and demand for variations has since long forced manufacturers to use modular platforms, a trend which is expected to continue throughout the automotive industry (KPMG 2011)(Strategy& 2014).

The diminishing profit margin on vehicles is putting increasing pressure on automotive actors to be competitive in terms of aftermarket sales. The after-sales market has high earning potential, especially in the commercial vehicle industry where efficient spare part supply is of great importance to customer satisfaction (KPMG 2011). In this market, customer loyalty and hence a competitive advantage can be obtained by minimizing vehicle downtime (ibid).

4.3.3 Collaborations in the Automotive Industry

Within the automotive industry, collaborations are becoming more and more common (Ernst & Young 2013)(Strategy& 2014). According to Ernst & Young (2013) collaborations are being setup between OEMs with other actors in the industry but also with technology companies and telecoms which are not traditionally active in the automotive market. In the truck industry, the increasing consolidation is reflected in numerous collaboration agreements being made (KPMG 2011). While these agreements range from niched technical agreements to high scale integration, they are often a first step towards a full scale merger (ibid). The complexity of the vehicle and market is causing OEMs and suppliers to look to collaborations as a means to establish standards for emerging technologies, especially for in-vehicle connectivity and battery charging technologies for electric vehicles (Ernst & Young 2013)(CAR 2014).

The customers growing demand for derivatives is also strongly influencing automakers attitude towards collaborations, as flexibility in production can be reached through platform sharing (McKinsey & Company 2013)(Ernst & Young 2013). Platform sharing can decrease R&D costs, reduce risks and shorten time to market hence creating a competitive advantage (Ernst & Young 2013). According to McKinsey & Company (2013) OEMs should consider how they can collaborate with each other to a greater extent in order to enhance the use of platforms across geographical regions and customer segments.

4.4 Patents in the Automotive Industry

The number of patents filed in the automotive industry has consistently grown over the past five years (Thomson Reuters 2015). In this section, the industry trends in terms of patenting and patent litigations will be outlined.

4.4.1 Patenting Trends in the Automotive Industry

In the automotive industry, patent filings have steadily increased over the last few years as can be seen in Figure 22 (Thomson Reuters 2015). While the automotive industry has historically been dominated by a limited number of companies, advances in vehicle technologies has exposed the industry to competition from outside actors (Foy 2013). According to Foy (2013), the threat of new technology developers within the industry may be driving an increase in patenting among vehicle manufacturers, particularly in areas such as electric vehicle systems, hybrid propulsion technologies, vehicle safety and telematics. A recent study of automotive patenting trends has shown that compared to the industry at large, OEMs have managed to increase their percentage of patent filings in the last few years and that traditional automotive actors, such as Toyota, GM, Honda and Ford, are now among the top automotive patent filers in the US (DeSantis et al. 2015). However, over 75% of patents in automotive related technologies are still filed by non-OEMs indicating that industry innovation is far from isolated to vehicle manufacturers (ibid).

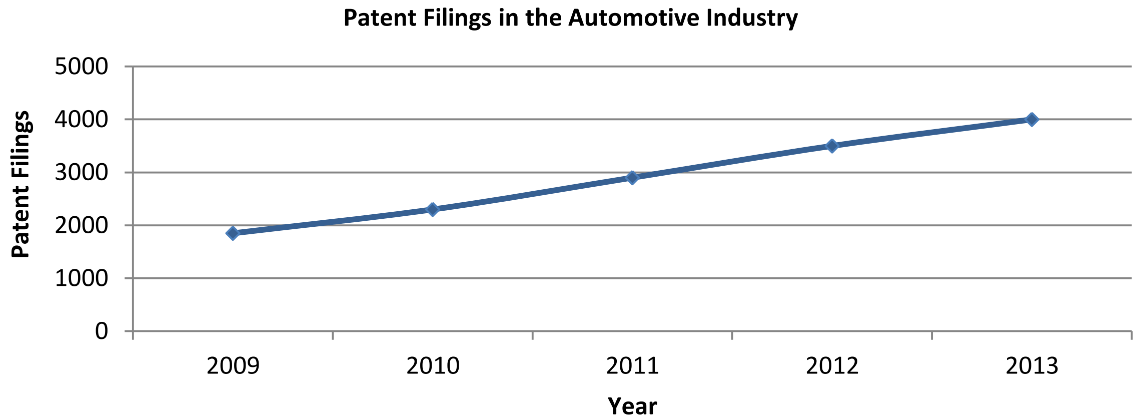

Figure 22 The number of overall patent filings in the automotive industry (Thomson Reuters 2015, p.4).

In order to identify patenting trends in the automotive sector, Thomson Reuters (2015) have divided the industry into five high-level categories as can be seen in Table 5. Among these categories, propulsion technologies have experienced the highest growth rate in recent years and in 2013 made up about 45% of all automotive inventions (ibid). According to Thomson Reuters (2015), the top ten patent assignees in the automotive industry consists of six vehicle manufacturers, three automotive suppliers and one electronics company, illustrated in Figure 23. While these companies dominate many of the technology fields within the industry, they collectively represent only 20% of patent filings (ibid).

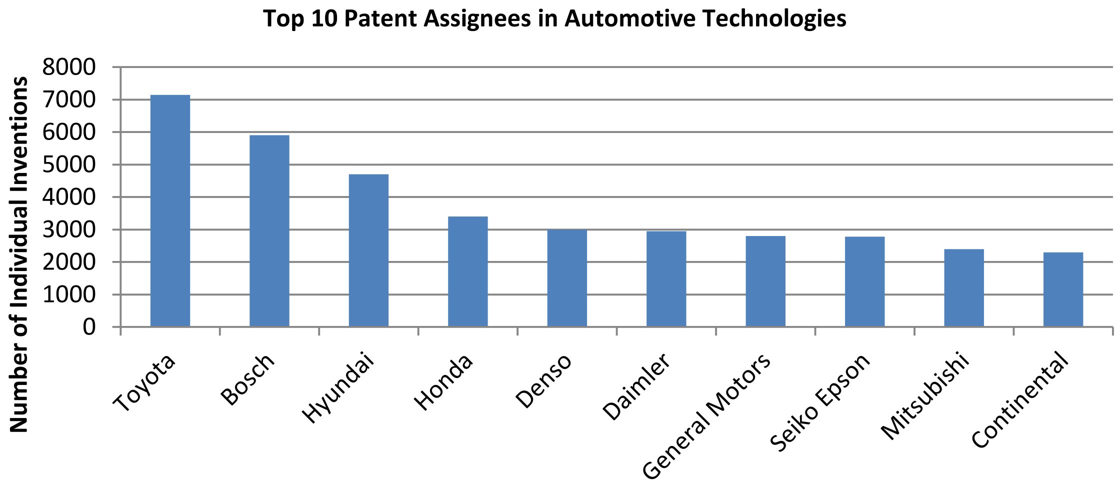

Figure 23 The top automotive patent assignees (2009-2013), based on number of individual inventions (Thomson Reuters 2015, p. 5)

Within each of the patent categories, the top patent assignees as well as "hot topics", in which patenting activity has been especially intense, have been identified (ibid). An overview of the categories and their definitions can be found in Table 5. In the following section, the patenting trends within each category will be discussed, detailed graphs illustrating the patenting activity and main actors within each category can be found in Appendix II.

Table 5 Five high-level categories of technologies within the automotive industry (Thomson Reuters 2015, p.4 & 10)

Category	Definition	Example Technologies	Hot Topic
Propulsion	Systems and components of automobiles responsible for generating motion, or movement of the vehicle	Engine design, Transmissions, Alternate Power Systems, Powertrains	Fuel Economy
Navigation	Systems and components dedicated to determining where the vehicle is located and how it interacts with other vehicles	GPS, Dedicated Short Range Communication	Telematics
Handling	The aspects of automobiles responsible for determining direction and velocity of the vehicle	Braking Systems, Steering Systems, Suspension Systems	Autonomous Driving
Safety & Security	Systems and components for protecting the vehicle and its inhabitants	Safety Systems, Seats, Seatbelts, Airbags, Security Systems	Driver Assistance
Entertainment	Systems and components for occupying passengers and for allowing them to interact with internet based systems	Smartphone Integration, Heads Up Displays (HUD), In-Car Communication	Heads-up Displays

Propulsion

In the propulsion category, the actors within the top 10 list can also be found among the top 10 assignees overall (Thomson Reuters 2015). Two actors among the top 10 propulsion assignees, patent significantly more compared to the other actors (see Figures in Appendix II). According to Foy (2013) alternative engine technologies is a key patenting area within the automotive industry, making up a fifth of all automotive related patents in 2012. The hot topic identified by Thomson Reuters (2015) however is fuel economy, or in other words described as "the maximization of the distance travelled on a unit a fuel" (Thomson Reuters 2015, p. 10). They state that while alternative powertrain technologies get a lot of attention when it comes to propulsion technologies, fuel economy is an area of intense interest for many industry actors (ibid). According to Thomson Reuters (2015) external factors, such as governmental mandates and regulations, provide growing motivation for developments within this field.

Navigation

The list of top 10 navigation assignees is characterized by a mix of traditional automotive actors and large international electronic companies (Thomson Reuters 2015). One electronic company, Seiko Epson, stands out as dominating within the field in terms of patenting activity (see Figures in Appendix II). Within the navigation category's hot topic, telematics, the mix of actors in among the top ten patent assignees follow a similar trend, however two new entrants, in the form of Electronics and Telecommunications Research Institute and Universal Parcels Service (UPS) can be found within this field of technological development (ibid).

Handling

Similarly to the Navigation category, the list of top 10 Handling assignees is dominated by one actor while the rest of the actors perform on a similar level. The hot topic that Thomson Reuters (2015) have identified within Handling is Autonomous Driving. A lot of innovation is taking place within this field and while Google get the majority of the attention, the top three patent assignees, Toyota, GM and Hyundai, are traditional automotive companies (ibid).

Safety & Security

Considering the top 10 assignees in Safety & Security, actors such as Autoliv Development, Tokal Rika and Takata, do not appear anywhere else in the patenting trend analysis (Thomson Reuters 2015). Within the hot topic of Driver Assistance, Bosch has until recently been a clear leader in terms of innovation but was surpassed by GM in 2013 (ibid). In this category, both Bosch and Autoliv can be considered large automotive industry suppliers and their patenting activity in this technology field indicates that the category is dominated by traditional automotive actors.

Entertainment

Unlike the Navigation category, which includes several electronics companies among the top innovators, the Entertainment category is, with a few exceptions, dominated by traditional automotive actors (Thomson Reuters 2015). The hot topic within Entertainment is Heads-up-Displays (HUDs), systems for displaying smartphone data on the windshield of a car to allow the driver to keep their eyes focused on the road while operating the handheld device (ibid). Compared to the other four hot topics discussed above, HUDs is the most rapidly growing in terms of patenting activity (ibid). The topic is dominated by non-automotive actors and the top 10 list includes companies not previously seen in any of the topic lists, Universal Display and Johnson Controls (ibid).

4.4.2 Patent Litigation in the Automotive Industry

As the number of patents granted continues to increase in the US, so does the number of patent cases (PWC 2013). According to PWC (2013), patent cases within the Automotive and Transportation sector made up 5% of all cases between 1995 and 2012, making it the eighth most litigation intense industry. As shown in Figure 24, patent infringement lawsuits have increased significantly in the automotive industry since 2008 (DeSantis et al. 2015). The study by DeSantis et al. (2015) shows that the number of OEMs and automotive suppliers named as alleged patent infringers grew from 51 in 2008 to 205 in 2013, an increase by more than 300%. While factors such as an increased number of patents in force and changes in patent litigation rules may have some influence on the number of patent infringement cases, the increasingly complex nature of today's vehicles is creating more opportunities for patent owners to claim infringement of their patent (ibid). Today's cars include technologies such as entertainment, networking systems and telematics that were not originally designed for automotive applications and as patent claims within these fields increasingly apply to the automotive industry the number of potential infringement lawsuits increase.

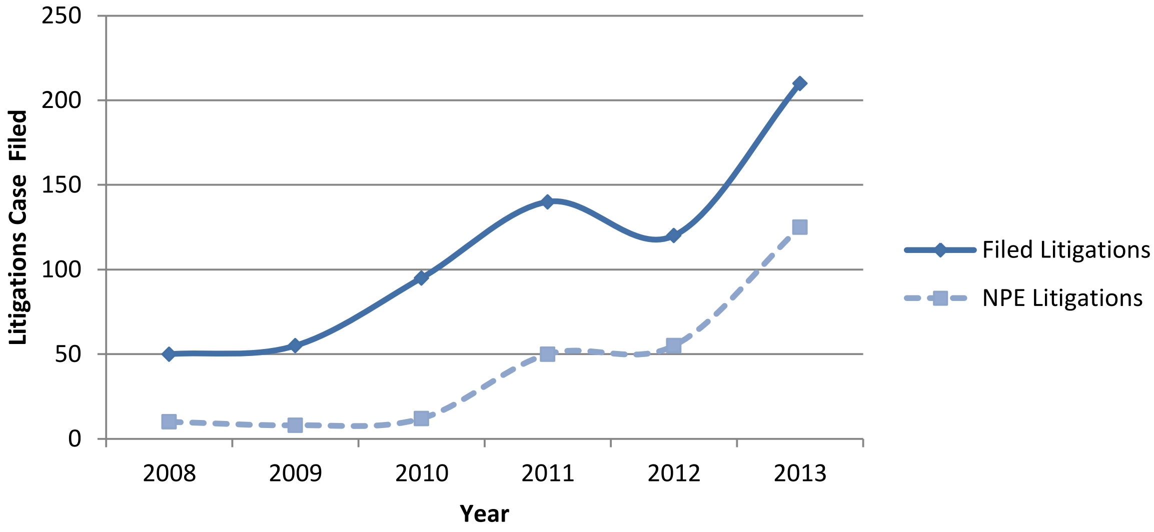

Figure 24 Patent litigations within the automotive industry in the US 2008-2013 (DeSantis et al. 2015, p. 2)

Considering the patent infringement cases in recent years, major actors within the automotive industry have more often been the targets of lawsuits than the initiators (DeSantis et al. 2015). A study shows that only 10% of patent infringement cases in the automotive industry between 2008 and 2013 were initiated by OEMs or automotive suppliers. A majority of patent litigations within the industry are instead brought by so called Non Practicing Entities (NPEs), and trend which expected to increase in the coming years (Foley 2014) (DeSantis et al. 2015). NPE is a collective term for actors who do not themselves make use of their patented technology, and therefore includes everything from so called patent trolls[6] to university based research institutes. While these actors may have very different objectives for building their patent portfolio, they have in common that their only means of

[6] "A company or person that acquires a lot of patents without the desire to actually develop the products. Instead of making money from the product, the company or individual launches a large amount of patent infringement lawsuits. The sole purpose of a patent troll is to identify infringers and sue them" (Business Dictionary 2015).

profiting from their patents is by enforcing them in some way. Many NPEs have a large amount of IT related patents as these were acquired cheaply shortly after the burst of the IT bubble in 2000 (DeSantis et al. 2015). According to Foley (2014) the increasing number of lawsuits involving NPEs in the automotive industry can be partly explained by the increasing use of software in today’s vehicle and high frequency of NPE suits involving patents within software (ibid).

PWC (2013) claim that damages awarded to NPEs average more than double those given to practicing entities over the last ten years. The relationship between median damages awarded to NPEs and practicing entities varies greatly between industries (ibid). In the automotive industry, the median damages awarded to NPEs are more than four times that awarded to practicing entities (ibid). However, PWC’s (2013) report also shows that the success rate of patent holders is twice as high among practicing entities compared to NPEs.

5. Case Studies

In this chapter four in depth case studies will be presented. The four cases are a patented braking system, a description of the battery industry, a description of the automotive industry aftermarket and a review of how infotainment has been introduced into the automotive industry. The aim of the case studies is to be able to identify and analyze different patent protection benefits used in the automotive industry.

5.1 Case 1: Braking System

In the beginning of the 1990's a new and innovative braking system was invented by an established OEM. The invention was patented and launched on the market a few years later. As described in the methodology chapter, the following case study is based on interviews conducted with people in the sales department of the OEM.

5.1.1 The Invention

The aim with a braking system is to decrease the speed of the vehicle or prevent it from starting to move. According to Swedish law, all vehicles need to have two independent brakes, one parking brake and one service brake. The braking system works on the principle of friction in both cars and trucks, but car brakes are hydraulic systems, relying on fluid, and truck brakes depend on compressed air. All friction-based braking systems are susceptible for brake fade when used extensively over a longer period of time. A brake fade can be devastating in some situations, and to prevent that it occurs in heavy vehicles, a supplementary, non-friction based, system can be used to augment some of the functions of the primary braking system. This supplementary device is called a retarder.

The aim of the new service brake system was to achieve an exhaust valve mechanism, which was able to be used together with a cam shaft. By doing so, a vehicle with compression brakes could be designed without a retarder, as the patented technology enables the same or similar functionality. Other OEMs had to install a retarder as a complement to the primary brakes, which was both heavy and about three times as expensive, to reach the same performance.

In terms of key customer utilities, the new braking system gave better braking effect, superior vehicle control, noise reduction and a lower total vehicle weight. In addition the new system was unaffected by altitude and therefore offered superior performance when travelling in hilly regions. The system enabled the truck to manage heavier loads and keep a higher average speed in downhill slopes. By offering superior performance to alternative technologies the OEM was able to increase their share of the market. When sold for a price similar to competing systems, the new braking system also enabled increased profit margins as it was less expensive to produce than alternative technologies, since no retarder was needed.

5.1.2 Patent Protection

In 1994, the brake system was patented. The original patent was complemented with other related patents resulting in a patent portfolio. The technology was continuously developed and improvements for the system were patented, enabling protection for an longer period of time. The patent enabled the OEM to have a near to monopolistic market position, increased profit margin and increased sales volumes. The first patent's claims were very narrow, but covered the critical attributes of the invention. One of the patent attorneys at the OEM described the patents as comparable with “patenting the needle of a sewing machine”. The narrow, but critical claims made it difficult for other actors to invent around the patent while still achieving a high level of utility.

5.2 Case 2: Battery Technologies

Over the past couple of decades, the outsourcing trend has led to an increase in the external value creation within the automotive industry. Today, only 30-35% of value is being created internally by the OEMs (Maurer et al. 2004). As suppliers deliver more value, they are becoming drivers of innovation within the industry and OEMs have to increasingly depend on them in their product development (ibid). In order to manage this newly developed dependency, new strategies for how to capture innovations from suppliers need to be developed (ibid). In Europe and the US, the innovation focus of suppliers over the past ten years can also be seen in patent filings statistics, where patents registered by suppliers have increased up to three times faster than automotive manufacturers (ibid). Especially in technical fields, such as electronics and mechatronics, suppliers are predicted to become the primary drivers of innovation in the future (ibid).

5.2.1 Battery Trends within the Automotive Industry

The demand for alternative, green, source of energy requires developments in terms of energy storage system (Scrosati et al. 2011). Many different types of batteries are employed in automotive applications, enabling decreased fuel consumption and reduced CO2 emissions (Eurobat et al. 2014). Due to increasing oil prices and an increased interest in decarburization of transport, Eurobat et al. (2014) claim that further technological and economic development of all battery technologies are likely. They also predict an increase in market penetration of Hybrid, Plug-in Hybrid, and Electric-Vehicles. Because of their high value of energy density, lithium ion batteries are currently the most promising candidate for these types of vehicle applications (ibid). The lithium ion battery is already powering e.g. cell phones and laptop computers (Scrosati et al. 2011).

While many agree that the number of electric vehicles will increase in the future, the predictions as to how big the increase will be vary greatly. IIT and Deutsche Bank predict 4-5 million electric vehicles will be sold globally in 2020 while AAB´s predict only half a million (Eurobat et al. 2014). Common among the predictions is a belief in an increased market penetration and that Plug-in Hybrid Electric-Vehicles and Electric-Vehicles will still only comprise a minor share of the total global vehicle market in 2020 (Eurobat et al. 2014). Between 2014 and 2019, the global automotive battery market is predicted to grow by $2.6 billion reaching a total of $7.7 billion, an annual growth of 8,4% (PR Newswire 2014).

5.2.2 Actors in the Automotive Battery Industry

les and lithium ion batteries.

Table 6 shows the top players within the global battery market (PR Newswire 2014). This includes all types of vehicles related batteries, for example batteries used to start combustion engines, batteries in hybrid vehicles and lithium ion batteries.

Table 6 Top Players within the Global Automotive Battery Market (PR Newswire 2014)

Company	Country
GS Yuasa Corp.	Japan
Johnson Controls, Inc.	US
Exide Technologies, Inc.	US
Robert Bosch GmbH	Germany
Saft SA	France

Due to high entry barriers the conventional view has been that it is in the nearest impossible for a newcomer to break into the automotive business (Anderman 2014). Tesla Motors has proven the opposite by becoming the second biggest electrical vehicle retailer in the US in 2013 (ibid). Tesla and Panasonic now jointly plan to build a new giant battery plant in the US (Tully 2014). The plant is planned to be fully operational by 2020 and will supply a range of industries with Tesla's battery technologies (Tully 2014). Another example of non-automotive companies entering the field of automotive batteries is consumer electronics companies, such as Samsung and Apple (Galbraith 2014).

Table 7 Prediction of the Top Players within the Lithium Ion Battery Market

Company	Predicted Market Share 2015
Automotive Energy Supply Corporation	26 %
LG Chem	18 %
Panasonic Sanyo	15 %
A123 Systems	14 %
Sb LiMotive	6 %

5.2.3 Patents in Battery Technologies

Since the beginning of 2000, patent filings in battery technologies for hybrid vehicles have experienced significant growth (Thomson Reuters 2012). The actors with the largest portfolios (Tier 1) are still responsible for most of the filings (ibid). This indicates that the industry is dominated by few players and that the entry barriers are high for small companies (ibid).

The top patent holder in electric vehicles, electric vehicle batteries and lithium ion batteries are listed in Figure 25 (Relecura 2014). The lithium ion battery market for hybrid vehicles is a young and dynamic field which is dominated by Asian-Pacific actors (Thomson Reuters 2012). As can be seen in Figure 25 the top actors within electric vehicles and electric vehicle batteries are a mix of automakers and battery manufacturers, however in lithium ion batteries Toyota is the only automaker among the top six patent holders (Relecura 2014).

Top 10 Electric-Vehicle Patent Holders	Top 10 Electric-Vehicle Battery Patent Holders	Top 10 Lithium Ion Battery Patent Holders
1. Toyota	1. Toyota	1. LG
2. Nissan	2. Honda	2. Bosch
3. Honda	3. Nissan	3. Toyota
4. General Motors	4. General Motors	4. Sony
5. Bosch	5. Bosch	5. Samsung
6. Panasonic	6. Hyuandai	6. Hitachi
7. Hitachi	7. Ford	7. Daimler
8. Hyuandai	8. Daimler	8. SB Limotive
9. Mitsubishi	9. Hitachi	9. SB Limotive
10. Daimler	10. Mitusbishi	10. Peugeot

Figure 25 Top Electric-Vehicle patent holders and Top Lithium Ion Battery Patent holders

Despite recent market success, Tesla cannot be found in the list of top patent holder within battery technologies. The main difference between Tesla's patents and those of the companies listed among the top patentees is that while they focus on the manufacturing of batteries, Tesla is concerned with systems that make the function of the batteries more efficient (Relecura 2014). Although Tesla is not among the top actors patent-wise, General Motors, Audi, Toyota, Ford, Samsung and Panasonic all cite Tesla´s patents, indicating that there is an overlap in their research (ibid). Tesla has been consistently filing within electrical vehicle technologies, however the number of patents filed per year is lower than that of the top patent holders. In June 2014, The CEO of Tesla, Elon Musk, wrote that "Tesla will not initiate patent lawsuits against anyone who, in good faith, wants to use our technology" (Musk 2014). This open source approach has been widely recognized in media and has resulted in other automotive actors such as BMW and Toyota, announcing their willingness to open up their battery technologies for use by other companies (Relecura 2014)(Winton 2014).

According to Rechtin (2014), Toyota is planning to abandon the lithium-ion battery field in favor of its effort in hydrogen fuel cell vehicles. Toyota leaving the lithium ion battery market would lead to none automaker among the top six lithium ion patent holder in the future. There is currently an ongoing discussion on whether lithium ion battery techniques will win over hydrogen fuel cells in the future (Spence 2013). While the outcome is difficult to predict, there are researchers claiming that the victor of this technology battle will determine what powers the vehicles for decades to come (ibid).

5.3 Case 3: The Automotive Aftermarket

Since the 1990's, companies in Western Europe, North America and Japan have gradually moved away from the traditional product development process and are instead focused on delivering customer value through service offerings (Cohen et al. 2006). In the transition from offering product to instead offering solutions, the aftermarkets for spare parts and services has emerged as an attractive source of additional profits and revenues (ibid). According to Hawker (2011), an increasing competition in the automotive primary market has also driven OEMs to look to the aftermarket for revenue streams. In the automotive industry, new car sales account for only 37% of the total revenue streams of a typical car lifetime[7] (Capgemini Consulting 2010). After-sales and services accounts for the remaining 63% of vehicle related revenue streams (ibid). In the aftermarket, margins are generally higher than on new car sales and a study has also shown that for some spare parts profit margins are as much as 76% higher than for finished product business (Hawker 2011)(Deloitte Consulting 2013). These factors are making the aftermarket increasingly important to vehicle manufacturers in terms of profitability.

5.3.1 The Structure of the Automotive Aftermarket

The automotive aftermarket can be defined as the market for all maintenance of a vehicle once it has been sold, until the end of its lifecycle (Capgemini Consulting 2010). This includes activities such as manufacturing, remanufacturing and distribution of vehicle parts; accident repairs; as well as standard servicing of vehicles (AASA 2012a). Due to the increasing complexity of vehicles and growing competition, the automotive aftermarket can be described as fragmented and complex (Book et al. 2012) (Capgemini Consulting 2010). Despite its complexity, the aftermarket can be divided into two distinct market channels; an “authorized channel” and an “independent channel” (Book et al. 2012). The authorized channel is made up of OEMs, their national organizations as well as a network of dealers and repair shops (ibid). The independent channel on the other hand consists of independent aftermarket service providers such as third party parts manufacturers, independent wholesalers and independent repair shops see Figure 26.

Compared to the primary market, which consist mainly of OEMs, the automotive aftermarket is made up by a wide array of different actors. Due to differences between the primary market and aftermarket, OEMs are faced with two distinctly different competitive situations; intersystem rivalry between different vehicle manufacturers in the primary market; and intrasystem rivalry between the authorized and independent channels as they compete for consumer sales (Hawker 2011). These competitive contexts are significantly different in nature and hence require different strategies for market success.

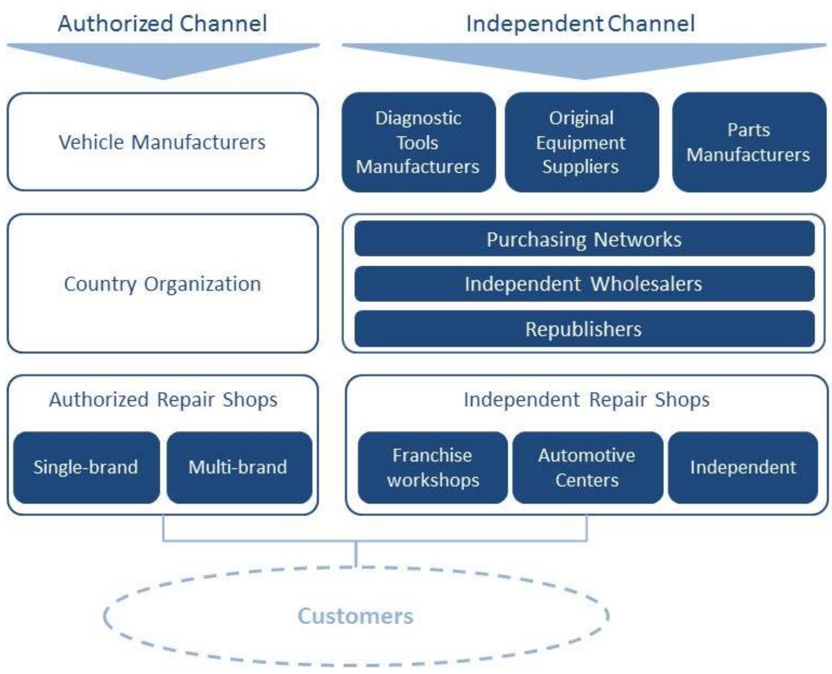

Figure 26 The structure of the automotive aftermarket, based on Book et al. 2012, p. 4

[7] Typical car lifetime of 13 years (Capgemini Consulting 2010)

5.3.2 Vehicle Age and Choice of Channel

Studies have shown that while customers generally have a high level of brand loyalty in the early life of a vehicle, this level declines as the vehicle ages (Book et al. 2012) (AASA 2012a). The reason for the initially high level of loyalty may stem from customers choosing a channel based on factors such as reliability, quality and warranty on the vehicle (ibid). While customers may perceive the authorized channels as more reliable in terms of quality, a recent study has shown that retail prices in the authorized channel are 26% higher than in the independent channel (Hawker 2011). As the vehicle ages, and possibly changes owners, price becomes a deciding factor in the choice of service provider, increasingly favoring independent repair shops (ibid).

5.3.3 Intellectual Property in the Automotive Aftermarket

Different types of intellectual property have historically been used to gain control over the automotive market (Hawker 2010). While patent rights and design rights are usually used to protect the design and function of different vehicle parts, trade secrets can be useful in keeping valuable know-how about internal processes and operations confidential (Ardiyok 2010). In the past, car manufacturers sought design protection for the car as a whole, preventing competitors from manufacturing an identical vehicle (Hawker 2010). According to Hawker (2010) automobile manufacturers are increasingly relying on design rights as a means to control the aftermarket for collision parts and are now using design rights to protect individual elements of the car. Design rights can only be used to legally protect visible parts of a vehicle and protects only the exact design stated in the right (ibid). When it comes to collision repairs, the customer demands identical replacement parts, this make design rights sufficient protection in this section of the aftermarket (ibid). In addition, consumers, who are the primary victims of automobile accidents, usually rely on insurance to cover some or all of the parts and repair service (Hawker 2011). This makes the aftermarket for collision parts relatively price insensitive as consumers do not pay for the replacement parts directly (ibid).

The differences in requirements for design rights and patents result in that a single invention cannot be protected by both (Hawker 2010). In the automotive aftermarket, inventions in relation to non-visible parts of the vehicle can therefore be patented. Recent developments within the legal arena now threaten to undermined hundreds of patents owned by vehicle manufacturers (Foot 2013). In recent cases of remanufacturing, a practice in the grey zone between repair and manufacture, courts in both the UK and Germany have ruled in favor of the alleged patent infringers (ibid). While this legal development is good news for independent aftermarket actors as well as price sensitive consumers, it will have negative effects on OEMs. In the US, the Automotive Parts Remanufacturing Association has filed a brief in the Supreme Court opposing the right of OEMs to impose restrictions on the use of patented products post-sale (Truckinginfo 2013). According to "exhaustion of rights", a person is free to use, resell or repair, a purchased item in any way they wish and should not be limited by patents. The aftermarket industry for rebuilding and remanufacturing automotive parts is built on the legal right to repair and would cease to exist should OEMs be allowed to impose post-sales restrictions (ibid). These legal developments are concerned with the replacement of parts that have a shorter lifespan than the vehicle as a whole and that are readily replaceable (Foot 2013). The changes mean that vehicle manufacturers will no longer be able to rely on patents protecting as part of their product to provide commercial protection for the product as a whole (ibid).

The increasing use of IT in today's vehicles is creating an access barrier for the independent channel (Hawker 2011). Servicing and maintenance of these new vehicles requires specific diagnostics tools and repair codes which are protected as the intellectual property of the car manufacturer (ibid). Traditionally, the independent channel has used tools from third parties that are compatible with a variety of vehicle makers and models, due to the current development this is no longer possible. According to EU law, car owners are free to choose any repair shop to perform repairs and services on their vehicle (MarLaw 2013). Vehicle manufactures are therefore obligated to provide independent service providers with the information necessary to enable servicing and repair (ibid). In many cases however, OEMs offer different diagnostic tools to the authorized and independent channels, making it impossible for independent service providers to compete on equal terms (Hawker 2011). In the cases where the same tools are offered to both channels, discussions are currently ongoing as to whether OEMs are overcharging the independent channel compared to their own dealerships (ibid). Even if the two channels were given the same price for access, the independent channel offers servicing of a wider variety of models than dealerships, and need access to a variety of tools giving them a significant competitive disadvantage over actors in the authorized channel.

Violation of intellectual property rights in the automotive aftermarket can take many different forms, for example counterfeiting, trademark infringement or non-compliant parts (AASA 2012b). According to the Federal Trade Commission and the World Customs Organization, counterfeiting is estimated to cost the global motor vehicle industry $12 billion per year (ibid). Counterfeiting economically harms actors within the automotive industry, however it also poses a serious safety risk as the parts may not meet safety standards and are often produced using inferior materials (ibid).

5.3.4 Vehicle Complexity and New Aftermarket Possibilities

As vehicles become increasingly complex products a market for new aftermarket service offerings is emerging (Cohen et al. 2006). According to McKinsey & Company (2013) delivering remote services such as smartphone capabilities, internet radio and entertainment services through the car, is a promising area in terms of differentiation and profits. However it is developments within technologies such as vehicle communications and telematics that will have the greatest effect on the aftermarket (AASA 2013). According to the AASA (2013), the growth in telematics could be one of the most disruptive trends within the automotive aftermarket in the upcoming decade. In the future, communication technologies will enable OEMs to offer services such as diagnosis and software updates remotely (Book et al. 2012). These developments will impact how drivers are informed about their vehicle's maintenance needs as well as how they choose their service provider. By communicating with the end consumer directly though their vehicle, vehicle manufacturers or authorized service providers will ultimately change the relationship structures in the aftermarket, potentially changing the industry as a whole (ibid).

5.3.5 Brand Reputation and Aftermarket Control

While the aftermarket offers the chance of additional revenue streams form OEMs, it is also crucial from a quality assurance perspective (Ardiyok 2010). As an OEM the reliability and functionality of every vehicle ultimately reflects upon the reputation of the company. By monopolizing parts of the aftermarket, OEMs are able to assure the quality of spare parts and secure influence over brand development (ibid). An example of brand deterioration in relation to spare parts can be taken out of newspaper headlines. In October 2011, Aftonbladet wrote about an accident where two trucks had collided resulting in emergency rescue and major traffic congestion (Aftonbladet 2011). The newspaper article included a picture of the collision site in which a crashed truck grill is displayed, the Scania logo clearly visible in the center of the picture, see Appendix III. The article does not mention the reason behind the accident, and it could potentially stem from for example poor servicing or low quality spare parts. While Scania cannot control the negative publicity in relation to the accident, it ultimately reflects upon their brand reputation.

5.4 Case 4: Infotainment Systems

Forty years ago, cars included virtually no electronic controls (CAR 2014). Today, almost 40% of the total vehicle cost is made up of electronics and software based technologies (ibid). The growing importance of software and electronics within the automotive industry has made software development and engineering the focus of many OEMs (ibid). Infotainment systems are an example of highly complex software based systems that can be found in today's vehicles. Below, the design of infotainment systems will be described followed by a discussion of the competitive environment in the consumer electronics industry, from which many of the system components originate.

5.4.1 Infotainment System Design

Developing systems for information, communication and entertainment are an important part of today's automotive industry (Robert Bosch 2015). According to Robert Bosch (2015), the only way to implement the large variety of software based systems is by using a high-performance driver interface, a so called infotainment system (ibid). While vehicle dashboards have until recently featured functions such as satellite radio, in-dash CD players and tiny navigation screens, they are increasingly becoming more complex and will soon be as versatile as a laptop computer (Stockton 2010). Developing these systems entails cost in terms of customized hardware, however the technology on which infotainment systems are based is already standard within the computer industry and will not involve substantial investments for automakers (ibid).

The current challenge among car manufacturers lies in determining how future infotainment systems will be designed (Mearian 2013). While the systems have traditionally been developed by third party suppliers, automakers are now working to standardize in-vehicle infotainment systems in a Linux-based platform (ibid). By using an open-source operating system, a reusable and upgradable platform can be created, ensuring a more smartphone-like customer experience and improved functionality (ibid). After its unveiling in 2014, Apple's CarPlay has recently begun to pick up steam and according to recent announcements, more than forty new vehicle models will be delivered with CarPlay-enabled dashboards by the end of 2015 (Goodwin 2015). The CarPlay is a software that, when installed in your car, allows your iPhone to connect to your infotainment system and enable functions such as audio, messaging, maps and other phone functions directly in your dashboard display (ibid). The other major mobile operating systems companies, Google and Microsoft, are also developing systems for vehicle integration, however neither have been able to deliver a complete system so far (Balestriere 2014).

5.4.2 The Consumer Electronics Industry

The category of "consumer electronics" includes product such as smartphones, computers, televisions and gaming consoles but also automotive technology and emerging product categories that have not yet reached the end consumer (Soo 2014). In recent years, two main trends have been observed in the consumer electronics market, convergence and connectivity (ibid). The functionality of several products are now being combined into once, hence products are *converging*, at the same time as customers are increasingly expecting their mobile phones and computers to be connected (ibid).

Actors in the consumer electronics market are experiencing tremendous pressure to create new and innovative products and bring these to the market (Soo 20014). The keen competition within the market means that any successful product quickly becomes the targets of copycats resulting in commodization and reduced prices (ibid). Alix Partners (2013) have identified two main tiers in the consumer electronics market, “The Top Two” (Samsung and Apple) and “The Rest”. Their analysis shows a “winner takes it all” mentality within the consumer electronics industry, in which “The Top Two” greatly outperform all competition in terms of revenue performance (ibid). While superior product innovation can explain the gap in performance, Apple and Samsung are unlikely to keep their leading position for long (ibid). Shortening technology lifecycles, eroding brand loyalty and a shrinking consumer attention span will most likely enable alert competitors to close the gap (ibid). In order to deal with the intense competition in the consumer electronics industry, strategic partnerships are beginning to form (Alix Partners 2013). Given the large number of companies active within the field and the emergence of actors from new key markets, financial restructuring and consolidations are also likely to increase in the coming years (ibid).

According to Statista (2014), technology companies dominate the list of most accused of patent infringement in 2013. Patent disputes between electronics companies are not uncommon and the recent “Smartphone War”, between Apple and Samsung, is just one of many examples of international patent infringement lawsuits (Chien 2009)(Gruman 2015). While NPEs file patent infringement suits against actors in all major patented industries, they have historically focused on computer related, high-tech inventions (Chien 2009). Due to the burst of the Internet bubble, many NPEs have sourced their IP from bankrupt computer companies (ibid). This means that software and electronics companies are a prime target for NPEs driven lawsuits. Computer related products tend to be protected by many patents, giving patent holder greater leverage against one another but also making them vulnerable to infringement cases by NPEs (ibid). Number of patent infringement suits filed in the US against US companies in 2013 can be seen in Figure 27.

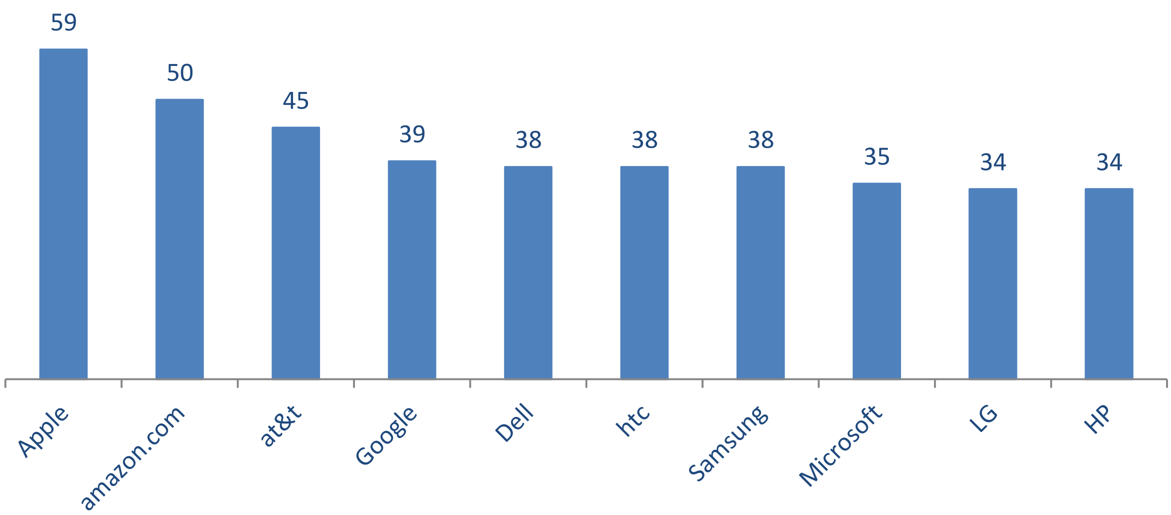

Figure 27 Number of patent infringement suits filed in the US against companies in 2013 (Statista 2014)

The telecommunication and electronics industries have since long relied on standards to ensure interoperability and connectivity of devices (Shapiro 2000). These industries rely on standards setting organization, such as the International Telecommunications Union (ITU) and the Institute of Electric and Electronic Engineers (IEEE), to decide standards according to which products should be designed (ibid). While standards in the automotive industry are concerned primarily with vehicle dimensions and emissions, standards in electronics are driven by compatibility. This means that for example all mobile phones should include the same 3G technology in order to be able to communicate with one another (Shapiro 2000). Patents protecting technology that is a part of a standard are referred to as Standard Essential Patents (SEPs). When producing products in which a standard is required, every manufacturer ultimately needs access to the patented technology. To ensure competition by fair means, patents included in a standard are often collected in a so called patent pool (Shapiro 2000). By becoming a member of a patent pool, companies will gain a license to SEPs for a relatively low royalty rate. Due to the frequent use of standards in consumer electronic goods licensing of technology in many different forms is a common practice within the industry.

Products in the automotive industry are transitioning into new technological fields (Thomson Reuters 2015). This transition can be seen in the growing functionality of today’s vehicles but also in patenting trends within the industry (ibid). As can be seen in Thomson Reuters (2015) report, consumer electronics companies are becoming increasingly active in automotive patenting. As new car sales continues to increase, the demand for factory installed electronics such as for example infotainment systems, are expected to increase (Soo 2014). However, the patenting trends indicate that consumer electronics companies are no longer simply delivering components and systems to the automotive industry. Rather, they are focusing immense effort on research and development in areas such as vehicle navigation, propulsion technologies and inter-vehicle communications (Thomson Reuters 2015). As the giants from consumer electronics work towards producing whole vehicles, competition within the automotive industry is threatened and will ultimately not go unchanged.

6. Analysis

In this chapter, the competition and value creation logics within the automotive industry will be described as well as different trends that have been identified within the industry's different technology fields. In the chapter's second part, the patent protection benefits in the industry will be analyzed based on the findings of the cases and the literature review. In the last part of the chapter, a valuation model will be presented based on the previous analysis as well as a description of the adaptations that have been made after testing the model.

6.1 Competition and Value Creation Logics in the Automotive Industry

In this section, the competitive environment in the automotive industry will be described and analyzed followed by an analysis of the competitive trends within each of the automotive technologies fields. The section will end with a brief discussion of how the automotive industry can be described within the context of a knowledge based economy and how this influences the internal management of an automotive OEM.

6.1.1 Competitive Environment – Porters Five Forces

In order to analyze the nature of competition within the automotive industry, Porter's (1996) five forces framework has been used. Porter's framework is primarily suitable for analysis of industrial industries. While the automotive industry exhibits signs of moving into the knowledge based economy in terms market offering, its structure is still fundamentally industrial, and the five forces framework can therefore offer valuable insights into the competitive environment of the industry. Below, the nature of the automotive industry within each of the five competitive forces will be described and discussed.

Threat of New Entrants

Competition within the automotive industry has traditionally occurred between a small number of large vehicle manufacturers (Corwin et al. 2012). As the industry is gradually transitioning into new technological areas and markets, new actors are increasingly entering the market (ibid). Actors from emerging markets are increasingly taking market shares from established actors and as customers in these new markets are gradually gaining more purchasing power, the geographical location of the main customer groups are also starting to shift (KPMG 2011) (Semcon 2013). In terms of technology development, traditional automotive industry actors are no longer alone among the most active patent assignees as actors from emerging markets and new technology fields are increasingly entering the market (Thomson Reuters 2015). Collectively these changes in the industry mean that the threat of new entrants as a competitive force has grown in recent years and will most likely continue to do so in the coming years.

Threat of Substitute Products or Services

In the automotive industry, products used to be fairly similar and competition can be said to have occurred by imitation goods. Due to technological advances and alternative technologies emerging, for example in the field of fuel technologies, competition in the industry is increasingly brought by substitute products and services. While the overall product offerings, for example cars, trucks and buses, have experienced relatively small changes in their overall appearance, the underlying technologies have changed immensely. Functionality previously controlled by mechanical technologies is now managed by complex software systems (Porter & Hemmelmann 2014). This development has created new opportunities for systems suppliers and vehicle manufacturers to solve similar problems using different solutions, enabling the threat of substitute technologies to increase.

Bargaining Power of Suppliers

Traditionally, suppliers within the automotive industry can be said to have had substantial bargaining power. They have historically not only delivered parts and components, but have contributed to developments in the industry through innovation and research activities (Corwin et al. 2012). Many suppliers are at the fore front of developments in key technological fields and outperform many vehicle manufacturers in term of patenting activity (Thomson Reuters 2015). Due to their large size and considerable influence, many of these suppliers dominate the automotive industry in terms of bargaining power (Sedgwick 2013).

The automotive supply chain consists of a large number of different tier suppliers, many of which are anticipated to deliver an increasing amount of the overall customer value in the future (Mojonnier 2011) (McKinsey & Company 2013). As new technologies are being integrated into the vehicles of today, new suppliers are beginning to enter the market (Corwin et al. 2012). Consumer electronics giants, such as Google and Apple, are among new market entrants and could, due to their size and dominant market position, greatly increase the bargaining power of suppliers in the automotive industry. How the overall bargaining power of suppliers will change in the automotive industry in the coming years is difficult to say. The power of suppliers will most likely vary depending on technology field and will be greatly influenced by vehicle manufacturers' ability to claim ownership of technology by means of patents and other IPRs.

Bargaining Power of Customers

Since the bargaining power of customers will have the same influence on all market actors and not effect patenting activities it is not the main concern of this thesis. What can be said is that as information becomes more readily available through a multitude of channels, customers within the automotive industry are gradually gaining more bargaining power. By being able to compare and contrast product offerings through online sales and marketing channels, customers are now able to make better informed decisions than they have historically been able to (McKinsey & Company 2013).

Internal Competition in the Industry

The previously rather predictable behavior of the automotive industry is now beginning to change. New leading market actors, new customer groups, new geographical locations and new technologies are all putting increasing pressure on market actors. As new technologies are becoming key competitive elements, vehicle manufacturers have to reconsider the focus of their research and development and decide what types of knowledge and know-how should be considered core-business. The structural changes in the industry and the increasing strength of the other four forces are causing the internal competition in the automotive industry to increase.

The Competitive Forces and Profit Potential in the Automotive Industry

According to Porter (1996), the sum of competitive forces within an industry defines its profit potential. He claims that the weaker the forces within an industry the greater the potential for profits (ibid). As shown in the analysis above, most forces within the automotive industry are expected to increase as a result of current market developments. This will, according to Porter's logic, make the automotive industry less attractive in terms of profits in the coming years. According to Grant (2008) however, the usefulness of a five forces analysis is limited in industries experiencing high speed structural changes, as the automotive industry can be described to be. This means that while the five forces framework can be a useful input to an analysis of the competitive environment in the automotive industry, other analysis should be considered in order to gain a true understanding of the current situation and be able to draw valid conclusions about development of the industry.

6.1.2 Trends within the Automotive Technology Fields

In order to analyze how value is created within different automotive technology areas, a technology tree of the technologies needed to develop a vehicle was created. The technology tree in Figure 28 is based on the technology breakdown presented by Thomson Reuters (2015) in their patenting trend analysis report. For definitions of the five main automotive technologies see Table 5.

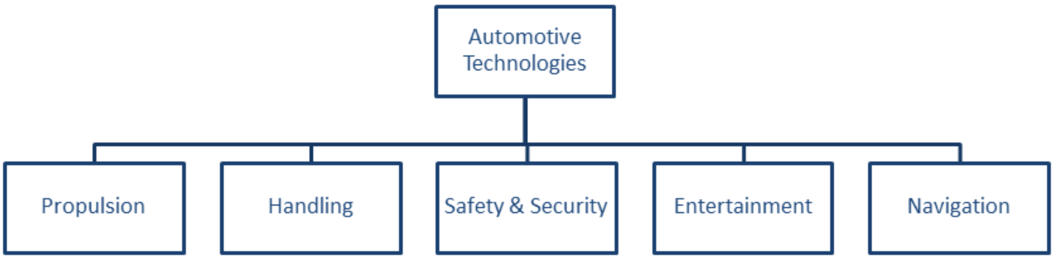

Figure 28 Technology tree based on Thomson Reuter's automotive technology division, based on Thomson Reuters (2015)

Each of the four case studies has focused on a unique technological area within the technology tree and collectively the studies cover all of the main automotive technologies. Figure 29 illustrates the focus of each case study in relation to the technology tree.

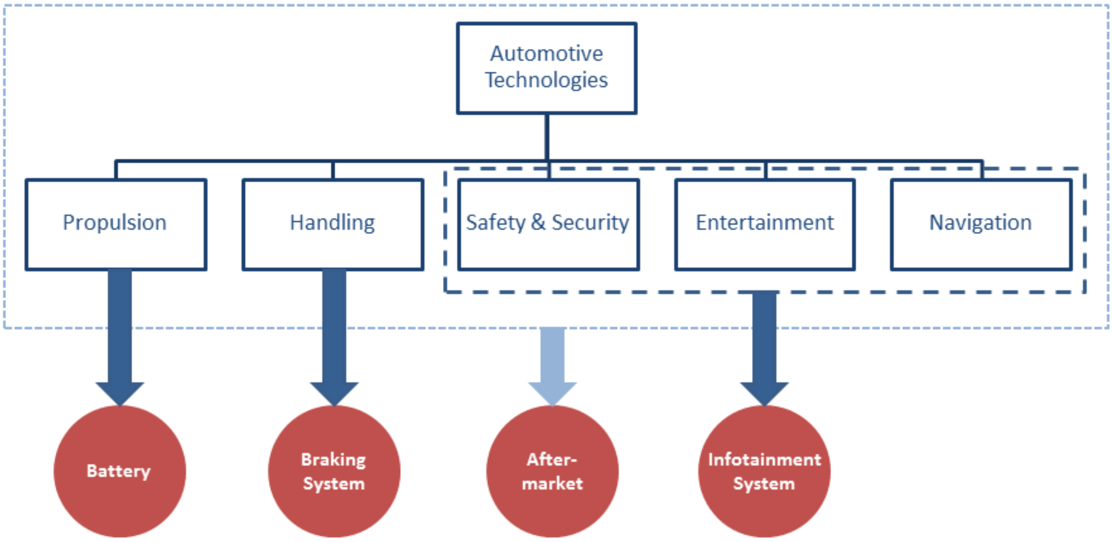

Figure 29 Each of the four case studies focus on different automotive technologies

Considering the findings of the four case studies and the automotive literature study, an analysis can be made of how patents are predominantly used to create value within each of the main technology areas. Below the use of patents in each technology tree branch will be discussed as well as the main challenges facing automotive OEMs within each branch.

Propulsion

Within the propulsion technology field competition is primarily occurring between automotive actors, such as vehicle manufacturers and different tier suppliers. As is custom within most traditional automotive technology fields, propulsion technologies are not shared between industry actors and patents are mainly used to block third parties while enhancing the commercialization of the patented technology. By patenting in this technology field actors offer products containing superior technology and hence get a competitive advantage in the commercialization process. Traditionally competition in this technology field has mainly been through imitation of incremental innovations. However, with the new green technologies, the competition logic has changed and new innovations are expected. Due to greater differentiation between the actors' resources and capabilities the competition is more likely to be dominated by indirect competition from substitute goods. This will likely change the overall competition logic in the industry. The high speed of structural change in the industry limits the usefulness of the five forces model in describing the competition and profitability of the industry (Grant 2008). This means that even though the sum of the forces is higher, profits can be generated due to indirect competition with substituting technologies.

What was evident in the automotive literature review and the case studies, was that many automotive actors have recently started to show an intense interest in battery technologies. From having been a commodity good within the industry, battery technologies are increasingly becoming USPs for many vehicle manufacturers. In the past batteries have often been supplied by designated battery suppliers, however many industry actors are aggressively patenting in this field in what can be taken as an attempt to bring crucial knowledge back in-house. This can be considered an expansion of business activities and therefore an attack on the battery suppliers' previously isolated market. The high saturation of patents in the field of battery technologies limits the extent to which the attack strategy will be possible. Most likely patents in this field will primarily be used as bargaining chips, enabling vehicles manufacturers to limit their dependency on suppliers' patents and protect them from getting locked in unwanted supplier relationships.

Within the field of alternative fuel technologies, such as electric and hybrid vehicles, car manufacturers have come significantly further than other automotive actors. While not all automobile technology is directly applicable to larger vehicles, large patent portfolios held by these actors may block commercial vehicle manufacturers from crucial functionality. The automotive industry has a tradition of not sharing technology between competitors and avoided licensing agreements. The need for technology patented by car manufacturers, will either lead to an increase of licensing deals within the industry or significant investments in propulsion technologies by commercial vehicle manufacturers in the coming years.

The governmental regulations, such as emission standards, are pushing the technological development within this field and are becoming increasingly important to industry actors' ability to compete (KPMG 2011). These regulations are however only governing the performance of the technology, i.e. emissions, and not what technologies that should be used. Nor are there strong demands for compatibility in between the different propulsion systems from the automotive manufacturers. Because of this, there are no clear indications that this field will follow the evolution of consumer electronics, where standards are dominating the industry. However, for refuel or charging the vehicle, there need to be standard ways, in order to facilitate for the driver. There might be more than one dominant technology on the market in the future, just like it today exist both diesel and petrol on the gas stations today. For the charging technology, there is likely to be a standard war, which will be beneficial and valuable to win.

Handling

In the past, patents within handling technologies have been focused on mechanical innovation. Just like for prolusion, the competition has mainly been by imitation, since the firms´ resources and capabilities have been similar to each other. Today, the systems in charge of the handling of a vehicle are increasingly relying on electronics and software technologies. The case study within handling related technologies implies that patents in this field are usually used to block others from specific functionality, hence giving patent holders a competitive advantage in the sales and marketing of a vehicle. The movement to electronics and software technologies has increased the differences between the involved actors when it comes to resources and capabilities, which made the competition more likely to become indirect and consist of substitutes (Grube 2009).

Thomson Reuters (2015) identify autonomous driving as a hot topic within handling and patenting trends indicate a growing interest by consumer electronics companies in automotive related technology development. Actors such as Google and Apple are both in the process of developing self-driving vehicles and are among the most active patent assignees in handling technologies. As the infotainment case study has shown, electronics and software companies are among the most aggressive when it comes to patent enforcement. The automotive industry has a tradition of using their patents passively and infringement lawsuits are rare. As consumer electronics companies begin to enter the industry there is a risk that the use of patents will change. If the change will lead to usage of SEP is however not for sure. Even though the competition changes and more and more companies develop self-driving cars, there is no indication that these systems need to be compatible with each other.

Infotainment – Security & Safety, Entertainment and Navigation

Infotainment systems consist mainly of software and electronics, technologies which have traditionally not been at the core of the automotive industry. The fact that software development and electronics have not been considered core business for most automotive companies means that vehicles manufacturers are generally not at the fore front of patenting in these areas. Any patents held by automotive companies within these technologies will therefore generally be used to gain freedom to operate and fend off potential infringement suits from other more prominent market actors. It also means that the actors in this industry are new competitors for the OEMs. Also here, the different in resources and capabilities among the active actors are implicating that the use of the five forces for analyzing the external competition is limited (Grant 2008).

Today’s vehicles contain an increasing amount of consumer electronics technologies which means that the threat of infringement suits being brought by both consumer electronics companies and NPEs constantly growing in the automotive industry. Given the relatively high risk that infotainment patents will be legally challenged in one way or another during their lifetime, the quality of these patents will be a crucial factor to their value. Should a patent be challenged and invalidated or a technology be found to infringe on another actor’s patent, this could seriously harm the competitive position of any market actor. Because of the indirect competition that permeates the industry, it cannot be ignored that it is likely that also OEMs will become the target for infringement suits in the future. The fact that consumer electronics companies, e.g. Apple and Samsung, are increasingly showing interest in technologies related to the steering and control of road vehicles is strengthening the statement even more (Goodwin 2015).

As mentioned in the infotainment case, standards are a wide spread phenomenon in the consumer electronics industry. As vehicles increasingly transition to become “smart” products, consumers expect them to not only connect to handheld devices but also to each other. This means that vehicle manufacturers will not only require access to these standards in their product development, they will also likely need to partake in the development of standards. A future use of standards in the automotive industry could potentially change the way in which IPR is used among industry actors. The industry’s traditional blocking strategy will no longer be viable, should technology be certain technology be standardized and therefore needed in all vehicles. This type of development will require automotive industry actors to improve their internal capabilities in terms of licensing agreements and contract management. This since a strong patent portfolio is the most powerful weapon within a standards war and the outcome of a war can determines the chance of survival for the OEM (Blind & Thumm 2004) (Shapiro & Varian 1999). By having patents within patent pools, the OEMs will not just become the vendor to the patent pool, but instead one of the creator and owner of ingredients in the patent pool.

6.1.3 The Automotive Industry in the Context of a Knowledge Based Economy

As shown in the outline of the automotive industry in the automotive literature review, the industry value chain and structure very much follows traditional value chain logic. While the industry is experiencing change in terms of new actors, markets and technologies, the flow of value through the supply chain remains relatively unchanged and the sale of a vehicle to the end consumer is still controlled by the vehicle manufacturer.

When considering this final value transfer to the customer however, the case studies have shown that the object for transfer is no longer limited to a physical product. Value in the automotive industry is created in a number of different ways and closely resembles the logic of the intellectual value chain. While the transfer of a physical product is still the dominating business model, there is a growing use of other transferable assets. As an aftermarket for enhanced performance and functionality is gradually becoming feasible, there is a growing potential for virtual products. Interest from customers in for example car-sharing solutions as well as the aftermarket for maintenance and servicing is enabling vehicle manufacturers to offer services to the end use. In terms of licensing as a value offering, the automotive industry still seems relatively immature. Developments within several technological fields and the integration of complex systems into vehicles may require licensing deals to be made in the future. How these deals will be structured in terms of licensees and licensors still remains to be seen.

As all of the value offerings outlined in the intellectual value chain model can be found in the automotive industry, there are indicators that the industry is transitioning into the knowledge based economy. While this transition may vary in maturity between different technologies, it is important for automotive OEMs to consider how to manage their internal operations in order to stay competitive. The intellectual value star model should be considered as a guiding tool in this process and can be a help when building internal capabilities necessary to survive the transition period.

6.2 Patents as a Means to Appropriate Value in the Automotive Industry

According to Grube (2009), there are five main ways in which patents can be used to create value within a business setting. In relation to these, different patent protection benefits can be achieved. In the following section each of the five patent functions will be analyzed, with the aim of investigating whether they can be identified within any of the case studies. In the end of the section, a summary of which functions have been identified in each case will be presented.

6.2.1 Blockade

To exclude other actors from a technology segment for a period of time is the most essential benefit of patent protection (Grube 2009). Examples of both offensive and defensive blocking have been identified within the automotive industry. In the case studies, blockades have been identified both towards competitors, such as other OEMs, but also towards suppliers, IT-solution providers and producers of counterfeit parts. If no one is expected to be interested in copying a solution, for example because the solution is only applicable under very specific circumstances which only occur within one's own production, patent protection is unnecessary. Based on the findings in the literature review and case studies no clear conclusions can be made as to what extent automotive OEMs consider a technology's value to other actors when patenting.

The value of a blocking patent is dependent on both the strength of the patent and the chance to detect if a third party is infringing (Grube 2009). Having a legally strong patent portfolio is not enough for an OEM. If the patent holder cannot detect infringement or has no intent of suing a third party and the third party is aware of this standpoint, the patent ultimately becomes useless. The automotive industry has traditionally been centered around mechanical innovation, and while infringement of these types of patented technologies can be difficult to find, it can be identified through product analysis. The industry's recent focus on IT related R&D is proving to be a challenge as infringement of software patents is much more difficult to detect. This does not mean however, that one should not patent software when possible. There are numerous global giants in neighboring industries who have gained their market position solely based on software based products, the solution is therefore rather that OEMs learn how to detect infringements and manage the use of software patents.

Even though a patent may not fully succeed in blocking other OEMs, suppliers or other third parties from entering the automotive market, it may delay their entrance to the market or make it more costly, hence create value for the patent holder (Vaver 2006). By building patent portfolios that protect different aspects of a technology, the effect of the blockade can be increased for the OEM since the portfolio makes it more difficult for third parties to invent around and the value of the portfolio exceeds the sum of the individual patents (Grube 2009). The cost of inventing around is also dependent on what substitutes are available that enable the same customer utility (ibid). It is therefore not only the technical solution that should be kept in mind when evaluating the risk of third parties inventing around, but rather substituting technological solutions for reaching the same utility. In the case example with the brake system, the patents only protect the chosen solution and therefore do not prevent competitors from solving the issue with brake fade in another way. This means that third parties can hypothetically sell heavy load trucks with the same customer utility. In this specific case, the patent protection delayed the competitors´ from similar functionality for such a period, that the patent holder benefited from first mover advantages. In cases such as these it is not only the patents, but the learning experience, sales and service efforts that create entry barriers (Levin et al. 1987).

In non-traditional automotive technologies, such as for example electronics and IT, OEMs have historically outsourced much of the development and hence do not have the necessary competence in-house (Maurer et al. 2004). The suppliers who have historically been responsible for these developments have filed patents for many new technical functions and now own the innovations on which the OEMs rely for customer value. This has resulted in a situation where OEMs are blocked by their own suppliers and are locked into unwanted supplier relationships. When some of these technical features become Unique Selling Prepositions (USPs), OEMs are stopped from changing supplier or manufacturing products in-house. The patenting trends show that OEMs are increasingly patenting in fields previously dominated by suppliers, possibly to counteract the dependency on select supplier relationships (DeSantis et al. 2015). A clear example of a situation where this has happened is within the battery industry. Many OEMs have historically outsources the manufacturing of batteries, and are now, as Tesla has proven that batteries can be a USP, facing a huge challenge.

Since the aftermarket is growing and the profit margins are relatively high, an increased market share in the aftermarket can make a huge difference for overall results of an OEM. In the aftermarket patents and design rights are used to block other OEMs and suppliers from manufacturing spare parts that are compatible with one´s vehicles. Not only are other OEMs of interest when it comes to blocking third parties, but also producers of counterfeit parts. By blocking these actors, OMEs don't only get higher profit margins and a larger market share, but can also ensure the quality of spare parts and uphold brand image.

It is not always an advantage to block third parties from using your technology. In immature markets companies can be forced to collaborate and agree upon a technical standard before the technology can be commercialized in large volumes (Blind & Thumm 2004). The reason for this is that an infrastructure is needed and will not be implemented unless the volumes are high enough. An example where this is needed in the automotive industry is in alternative fuel technologies. Charging stations are required for electric vehicles to become widely adopted and only a limited number of parallel systems can survive. When too many different technical solutions are competing with each other, none of the solutions will reach large enough volumes. In situation like this, it can be a disadvantage to block third parties from producing a technology that is desired to become the new technical standard. Examples of leading developers who are seeking help by third parties to increase the total sales volumes are Tesla and BMW. These companies believe that they can't drive the development forward themselves and are therefore opening up for third parties to use their technologies free of charge. However, the fact that neither BMW nor Tesla have let go of their patents is an indication that they still believe that their patent protection will become valuable in the future (Relecura 2014) (Winton 2014). Letting third parties use one's patents for a period of time can be a viable strategy when setting a technical standard and can lead to future licensees.

6.2.2 Attack

As today's vehicles become increasingly complex, the automotive industry is gradually transitioning into the territory of other industries. New technologies, originally designed for use outside of the automotive industry, continue to be integrated into vehicles, making vehicle manufacturers and automotive suppliers increasingly vulnerable to the threat of outside actors. In order for OEMs to use their patent rights to attack third parties, both time and money must be invested in actively searching for infringers (Grube 2009). Historically, the use of patents to attack third parties has been an uncommon practice in the automotive industry. The industry is made up by a network of supplier relationships and should an infringement is detected the effect of a lawsuit on the network as a whole must be considered. This consideration has meant that many suspected infringement cases have been handled through closed interaction between the two parties, rather than in open court cases. The integration of new technologies into the automotive industry is now causing the industry network to grow. This could mean that the challenge of preserving relationships when attacking others will increase even more in the future.

In recent years, there has been a rapid increase in the number of patent litigations in the automotive industry. While the number of infringement lawsuits brought by OEMs and automotive suppliers has been consistently low, they are increasingly incriminated as alleged patent infringers. The growing number of patent litigations can be explained by an increasing interest, from NPEs and actors from outside of the industry, in bringing patent infringement lawsuits (DeSantis et al. 2015). By attacking industry actors who make use of patented technologies, NPEs can be awarded damages or force practicing entities into licensing agreements, hence creating revenue streams. The trend of using more software based technologies in today's vehicles is causing NPEs, who often have a large amount of IT related patents, to increasingly focus on the application of their patented technologies in the automotive industry, hence leading to an increase in patent litigations brought by these actors.

As the automotive industry transitions from being primarily concerned with mechanical innovation to increasingly focusing on other technologies such as chemistry, electronics, materials and software development, patent holders in other industries are beginning to show interest in vehicle development. This trend is evident not only in these actors involvement in automotive patenting, as shown in Thomson Reuters´ (2015) industry analysis, but also in industry patent disputes. In industries such as consumer electronics, patent enforcement through attacking is common, and it is consumer electronic companies who top the list of companies most sued over patent infringement (Statista 2014). Automotive patenting and development trends show that actors such as Google, Apple and Samsung are all developing technologies for automotive use. As actors from industries with more aggressive patent cultures begin to enter the automotive industry, they bring this more antagonistic approach to patent use with them. This is evident in a number of recent patent disputes in which consumer electronics companies point to OEMs as alleged patent infringers (DeSantis et al. 2015). While a growing number of infringement cases in the industry may be the result of today's vehicles increasingly using technologies protected by patent thickets, more aggressive patent holders may also contribute to this trend. As technological development in the automotive industry begins to overlap with other industrial fields, automotive actors will have to adapt to their new surroundings. In the future there is a risk that using patents to attack will not only become more common within the industry as a whole but will increasingly also be used by traditional automotive actors.

6.2.3 Commercialization

In the case studies and literature review, no trends of either transfer of patent rights or royalty-based licenses between OEMs have been identified. The study instead indicates that it is through exclusive exploitation and informal cross-licensing that patents owned by OEMs are commercialized and freedom to operate is created.

The use of patents to block third parties from entering the market can create a temporary monopoly in the market (Grube 2009). In that way, patent protection can be described as a tool for extending the market disequilibrium (ibid). When a temporary monopolistic position is achieved, as for example as in the braking system case study, OEMs can increase their market share and profit margins simultaneously. By patenting features that create USPs while creating a monopolistic position, customers are forced to buy form the specific OEM to get the utility they demand. In the braking system case specifically, the patent protection resulted in an increase in total sales for the OEM and enabled an increased profit margin through decreased cost of product. While Porter (1996) claims that differentiation and cost leadership cannot be achieved simultaneously, the braking system case is a clear example of how technology development can both increase customer utility and at the same time enable reduced costs.

In the developing countries, the purchasing price is the largest share in the Total Cost of Ownership and therefore important in the buying decision (KPMG 2011). In these markets it is therefore not possible to set a higher price on a vehicle with a patented technical function without losing sales, despite increasing customer utility. Increased profit in these markets can instead be achieved by increased market shares and decreased production costs (Grant 2008). Decreased production costs can partly be achieved by innovative production methods, but also by using new material or, as in the braking system case, by being able to remove an expensive part in the production (e.g. the retarder). In developed countries, and especially for premium brands, an increased vehicle price driven by improved utility is more likely to succeed since the purchase price is not the primary deciding factor in a purchase (KPMG 2011). In developed countries, the TCO is more dependent on fuel consumption and the purchasing price will not have as big effect on the buying decision (ibid). As a result of this, using patents that enable improved functionality and premium pricing is a much more valuable strategy in developed markets and especially for premium brands.

In the aftermarket, exclusive exploitation has a large effect on the overall performance of an OEM. Due to competition law, OEMs are not allowed to completely block independent actors in the aftermarket, however through patenting essential parts the market can be controlled to a higher degree. By patenting spare parts, the market share of OEMs can be increased. In some cases, where the patent blocks all other actors, the market share of OEMs can increase to levels of monopoly. Patenting spare parts also enables increased profit margins, especially since price is not always critical to the customers purchase decision. Especially for collision parts, where a third party, often an insurance company, is paying for the products, the price is likely to be higher for patented products (Hawker 2011).

The literature review has shown that early in the lifetime of a vehicle, the owner is more loyal to the brand and hence buy spare parts from the same provider even if there might be other alternative to choose from (Book et al. 2012) (AASA 2012a). Patents protecting spare parts that wear quickly can be difficult to enforce since repairs of these parts can be seen as re-manufacturing and hence not an infringement of the patent (Foot 2013). Later in the life of the vehicle, owners are generally less brand-loyal and more likely to buy spare parts from other providers. Patents protecting spare parts which are changed later in the life of the vehicle are easier to enforce, since the risk of being interpreted as re-manufacturing instead of infringement is lower. As a result of the change in customer loyalty and difficulty of enforcement, patent protection for spare parts used later in the product lifecycle can be considered more valuable. Other than physical parts, there is potential for new service offerings in the aftermarket. As a result of new technologies being implemented in vehicles, sales of updates for software and remote activation of enhanced performance, offer the possibility of creating new revenue streams in the automotive aftermarket.

In a technical advanced field such as the automotive industry, products sold to the customers contain many different technical functions and hence are protected by many different patents (Grant 2009). When there are different owners of these patents a cross-license structure can be very complex. To enable companies to still commercialize such products and solutions, standards and patent pools have been created in for example the ICT industry (Vaver 2006). Time will tell if this will be the case also for the automotive industry, but if it will, it will be ruling to have the most critical patents within the scope of the standard. To win potential future standard wars, OEMs need to control their customer base, protect their inventions, be able to innovate and come up with new solutions, manufacture and launch these solutions early in the product life time, produce complementing products, e.g. on the aftermarket, and finally work with the brand and image of the company (Vaver 2006). If succeeding and winning future standard wars, the patents will be even more valuable and generate direct incomes in form of royalties from other OEMs and third parties. This will result in a, for the OEMs, new approach of commercializing patents.

6.2.4 Bargaining Chip

Patent portfolios, whether actively enforced through attacking others or not, can in some industries be used as protection from lawsuits brought by other industry actors, and hence create a freedom to operate (Grube 2009). A suspected infringer might own a patent on which another actor is infringing. This catch-22 situation may put some actors off from bringing infringement cases against one another due to the risk of getting countersued (ibid). The ability to use patents as an insurance measure against lawsuits may incentivize some OEMs and automotive suppliers to increase their patenting activity. This behavior could potentially explain the increase in patent filings within some areas of the automotive industry. Thomson Reuters' (2015) patent trend analysis has for example identified Toyota as a leading patent assignee in most of the automotive technology fields. While Toyota may be an innovative company, it can be argued that their intense and perceivably unfocused patenting activity is primarily a way to create bargaining power and a dominant market position.

It is difficult to determine the financial value of this patenting behavior as the value of individual patents still depends mainly on their legal strength and strategic importance to their owner. While strategy of creating large patent portfolios aiming for creating freedom to operate may be useful in relation to other industry actors, the use of patents to gain bargaining power does not protect against lawsuits brought by NPEs. Practicing entities suspecting patent infringement by another party may benefit from avoiding the risks involved in a lawsuit. The same cannot be said for NPEs as they do not themselves practice technology and therefore do not risk being suspected of infringement. Despite the strategy's lack of effectiveness in fending off the threat of NPEs, it shows potential in terms of strengthening one's bargaining power in relation to other producers. As the automotive industry transitions into new technological areas, OEMs and automotive suppliers may benefit from developing strong patent portfolios as these may be used as bargaining chips in relation to other patent holders.

OEMs are currently facing the challenge of managing relationships with dominant industry suppliers. By letting suppliers own the patent protection of key technologies, OEMs lose control of innovation.

When not controlling a patent right, an OEM can be locked into a relationship with the supplier owning the patent and in worst cases forced into expensive agreements. In a later stage, when the supplier seeks protection of improvements made to a patented technology, the OEM becomes even more locked-in. As seen in the battery case, the owner of the patent right has the best bargaining position and can control the relationship to a larger extent. When supplier technologies become USPs, this creates additional challenges in terms of bargaining power. Should the OEM be in control of the technology, they can choose to exclude others from selling the invention. If however the supplier has the control, the invention can be spread to many OEMs ultimately removing the advantage of uniqueness. By owning the patents protecting supplier technologies, the bargaining power of OEM is increased in these relationships. This enables OEMs to change supplier if lower price or higher quality can be found somewhere else.

The increasing use of software in vehicles is enabling vehicle manufacturers to use different kinds of intellectual property as a bargaining chip in the automotive aftermarket for vehicle maintenance and servicing. When servicing today's more software intense vehicles, special diagnostic tools and access to software updates are required. While competition law prohibits vehicle manufacturers from denying actors in the independent channels access to these tools and software, patent and copyright protection enables them to strengthen their bargaining power in relation to these actors and thereby enables them to license these out for a higher price. As servicing and repairs is an inevitable part of a vehicles lifetime, patents enabling control over this aftermarket transaction are of substantial value and importance. By creating control of services and software diagnostic tools, OEMs ensure increase revenues from both virtual products, licensing fees and services, which are the three additional revenue streams to physical products in the intellectual value chain (Petrusson & Heiden 2008).

6.2.5 Reputation & Image

An extensive patent portfolio can create and maintain the reputation and image of being a technology leader for an OEM (Grube 2009). The portfolio can also work as an indicator for quality of research and reward for the R&D personnel. However, to maintain patents is expensive. Therefore it is important to cut unnecessary costs and let less valuable patent laps. As mentioned above, the literature review of patenting trends shows that Toyota tops most of the technical fields when it comes to patenting. This automatically gives them an image of being superior when it comes to R&D and innovation, however, the number of patents does not necessarily indicates anything about the quality of the performed research.

Pricing is closely connected to brand and image and by having a strong brand OEMs will have higher possibilities to increase prices and hence profit margins (Davcik & Sharma 2015). By patenting an USP, like in the braking system case, the OEM does not only have the chance to have a temporary monopoly but also to strengthen its brand by being the only OEM delivering a unique and valuable customer utility. The brand reputation can endure for a longer period of time than the actual patent protection (Darden University). Thus, even though other OEMs are able to invent around the patent protecting of the braking system, the customers still know which OEM launched it first giving the OEM the benefit of a first mover advantage. Another upcoming USP is the infotainment system. For car buyers, a report form Accenture (2011) showed that the features in the infotainment system were of great importance for the buying decision. For commercial vehicles it is not the driver who is the actual buyer and thus the infotainment is of less importance for the buyer decision. However, software based features that reduce fuel consumption, increase driver efficiency or reduce "notoperative" time are highly valuable and are affecting the buying decision to a large extent in developed countries (KPMG 2011).

In the aftermarket, patent can block counterfeit parts of low quality, and thus save OEMs from bad publicity. As in the case with the Scania truck in Aftonbladet (2011), nothing is stated about the reason for the accident. The only information published is that a Scania truck was involved in a crash, and drove into the vehicle in front (Aftonbladet 2011). The focus is thus on the OEM who manufactured the truck, not the supplier of the spare parts. Hypothetically, the accident could have happened due to low qualitative braking disc, provided by a third party, which made it impossible for the driver to stop in time. Some accidents might be avoided if low quality counterfeit parts were replaced by original spares, making the patents in the automotive aftermarket highly valuable to the image and reputation of vehicle manufacturers.

6.2.6 Summary Patent Value Drivers Identified in the Cases

In Table 8, the different patent protection benefits that have been identified in the cases are presented. The table illustrates which value benefits that are most commonly used within the automotive industry. Damages awards and transfers of patent rights have not been identified as benefits of patent right in any of the case examples or in the literature review.

Table 8 Overview of which patent protection benefits that have been identified in each of the case studies

	Brake System	Battery	Aftermarket	Infotainment
Blockade				
Sum of blocked profits	x	x	x	x
Freedom to operate		x	x	x
Attack				
Damage awards, reputation				
Extension of business activities		x	x	x
Commercialization				
Royalty income/Saved licensing fees		x		x
Purchase price				
Monopolistic market position, price premium	x	x	x	(x)
Bargaining chip				
Increased bargaining power		x	x	x
Reputation				
Access to capital, skilled workforce	x	x	x	

6.3 Measuring the Value of Patents in the Automotive Industry

Before measuring the value of a patent, the context in which a patent valuation should be made needs to be identified (Murphy et al. 2012). Aspects such as the importance of the decision demanding a valuation and the ease with which data can be collected need to be analyzed. Because of the differences in importance and effort needed, a two-step valuation process has been developed. Both steps will clearly define and link the legal and economic benefits of the patent. It is therefore important that the people conducting the analysis have knowledge of both the legal requirements and the strategic importance of the patented technology. Child & Ihrig (2013) claim that knowledge assets cannot be valued in the same way as physical goods since physical assets can be considered inherently scarce and knowledge assets are instead inherently non-rival. Boisot (1998) suggest valuing knowledge assets based on three main parameters, codification, abstraction, diffusion. Patents in general can be described as highly codified and widely diffused. In terms of abstraction patent rights can vary depending on the scope of the claims. The relatively high patent intensity in most automotive technology fields however, generally results in concrete and narrow patent claims. Due to the homogenous nature of patents according to Boisot's (1998) parameter, the use of his model for these knowledge assets will results in similar values for all patents in the automotive industry. Due to patent rights´ close resemblance to physical assets in their characteristics and behavior, it is therefore appropriate to value patent rights with similar methods as physical goods. The developed valuation model is limited to valuing the patent right itself, not the underlying knowledge. The model developed will be based on similar models valuing physical products.

For decision situations identified as needing a maximizing or optimizing strategy, the writers of the report encourage the valuator to start with step 1 and continue with step 2. If a comparison between certain patents is of interest rather than a value in absolute term, it is sufficient to only perform step 1. Also for decision where the outcome is of less importance or the data is difficult or expensive to collect, only step 1 is recommended. For satisfying decision strategies, a market based valuation is emphasized, meaning that when for example deciding on whether to maintain a patent of less importance, the decision can be compared with similar decision previously made.

Since any valuation analysis needs a certain degree of flexibility (Grube 2009), the model will be changeable depending on the setting in which it is used. Thus, the model will only be created as a foundation for the valuation. Depending on the circumstances, the valuator therefore only has to estimate and value the benefits applicable to the specific patent right. In order for the valuator to use the model and compare different patent rights, the same adaptions of the model need to be compiled in order for the valuation to be replicable and compared between different patent rights.

6.3.1 Patent Portfolio Overview –Step 1 in the Valuation Process

The first step in the patent valuation process aims to give a patent portfolio overview. The model is therefore named Patent Portfolio Overview (PPO) and is based on the PPV-model presented by Murphy et al. (2012). By conducting a brief analysis of the patent portfolio as a whole, managers of OEMs will be able to prioritize which patents are the most interesting and determine which patents to do a deeper analysis of (ibid). They can also see if patents are unnecessary given the low strategic importance of the invention or if strategic important inventions lack sufficient protection. The first step of the valuation can be done from two different perspectives. Either the valuator can choose a patent, evaluate its legal strength and lastly its strategic importance. Or, the valuator can choose a product, evaluate its strategic importance and as a last step evaluate the legal strength of its protection. Below the parameters affecting the legal strength and strategic importance of a patent will be described.

Legal Strength

The legal strength of the patent is dependent upon how broad the claims are, coverage of critical technical features and obstruction for third parties ability to invent around. By having a patent portfolio with complementing patent protection it will be even more difficult for third parties to invent around (Grube 2009). The legal strength of the patent is also influenced by the patent practice in relevant jurisdictions and historical patent rulings (Murphy et al. 2012).

For the evaluation of the legal strength seven different aspects of the patent protection have to be considered and graded on a scale from 0 to 5.

1. To what extent do the patent claims cover critical technological elements?
2. To what extent are there other close patents, building a patent portfolio?
3. How difficult would it be for competitors to invent around, reaching the same utility?
4. How easy can an infringement by a third party be detected?
5. To what extent is there close prior art?
6. To what extent is the patent granted in relevant geographical areas?
7. How reliable is the critical patent jurisdiction?

Strategic Importance

It is primarily the patent right, not the invention, that should be valued in the model, but since the value of the patent right is highly dependent on the strategic importance of the invention, the invention also needs to be evaluated. The strategic importance of products in the automotive industry is highly dependent on whether the product is sold on the primary market or in the aftermarket. In step 1 of the valuation model evaluation of the strategic importance will therefore differ depending on what type of product is being analyzed.

When performing the strategic evaluation, the value drivers identified in the cases and the literature review should be considered. In addition to the potential value drivers, the attractiveness for third parties to imitate have to be evaluated (Murphy et al. 2012). Since standard patent pools are not (yet) a common solution within the automotive industry, this aspect is not included in the model. If it will become more common in the future, this aspect could be added to ensure comprehensive valuation. For products sold on the aftermarket, the compatibility of the products with products sold in the primary market needs to be ensured and the patents protection against counterfeits needs to be evaluated.

For the evaluation of the strategic importance eight different aspects of the protection and the invention have to be graded on a scale from 0 to 5.

1. To what extent does the patent enable increased sales?
2. To what extent does the patent enable premium pricing?
3. To what extent does the patent enable cost leadership?
4. To what extent does the protected invention improve customer experience?
5. To what extent does the protected invention provide marketing advantages?
6. To what extent is the technical solution relevant for third parties?
7. To what extent does the patent help to create freedom to operate?
8. To what extent does the patent increase bargaining power?

Two additional aspects need to be considered for products sold on the aftermarket.

9. To what extent is the product compatible with products sold on the primary market?
10. To what extent does the patent increase the control on the aftermarket?

When all aspects have been graded, a result for step 1 can be displayed in a two axes diagram. Based on these results, the valuator can choose whether to continue with step 2 of the valuation model to receive a value in monetary terms or to make a decision based on the results of step 1. An illustration of what the result from the first step can look like can be seen in Figure 30.

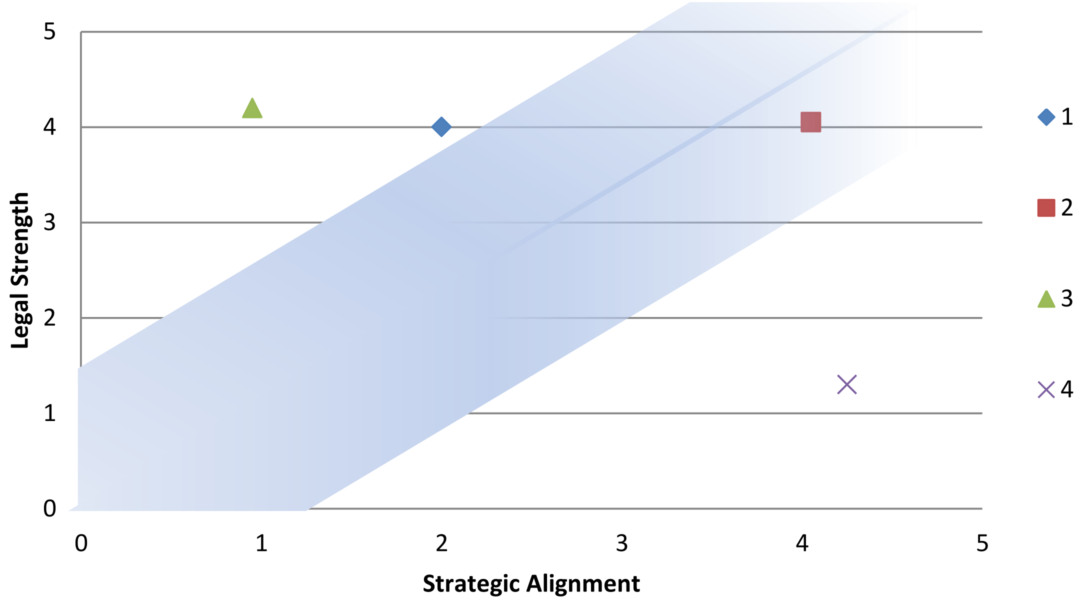

Figure 30 Illustration of the result generated by the first step in the valuation model, given that patent 1, 2, 3 and 4 has been evaluated

6.3.2 Patent Valuation in Monetary Terms – Step 2 in the Valuation Process

In this thesis, patent value is defined as the extra economic benefits, i.e. the extra profit, which is generated as a result of owning a patent. Grube (2009) emphasizes that patent valuation should be based on expected economic benefit, therefore step 2 of the valuation process will consist of a direct valuation. The cost based approach does not take any future economic benefits into consideration and is therefore not suitable for estimating future patent value (Murphy et al. 2012). The basic principles for using a market based method are not fulfilled in the automotive industry, making also this method inappropriate for valuation (ibid). When it comes to option based models, these are often perceived as highly complicated (ibid). To obtain a high level of model usefulness an option based method has therefore also been abandoned. Pitkethly (1997) claims that cost and market based methods of valuation may be relatively easy to use but may not provide results which are as accurate as the user may wish. He also claims that rigorous objective ways of calculating the value of a patent, for example option based model, still leave much to be desired in terms of usefulness. As a result of analyzing direct valuation models, an income based method has been chosen as the most appropriate method for patent valuation. To balance the risk of becoming too complex with the risk of not becoming accurate enough, the future costs, market conditions, incomes, time, and uncertainty will be included in the model while all other incomes based parameters will be ignored (ibid).

The model has been divided into four subcategories: cost, market conditions, incomes, and uncertainty. Additionally, the subcategories have been divided into different classes to simplify the estimations for the valuator. The classes included in the incomes stem from the patent protection benefits described by Grube (2009). In Figure 31, the subcategories and classes are illustrated and in the following sections a guide for how to estimate and quantify them will be given. The analysis is recommended to be performed by a group of employees, with different background and insights, as to maximize to level of accuracy of the results.

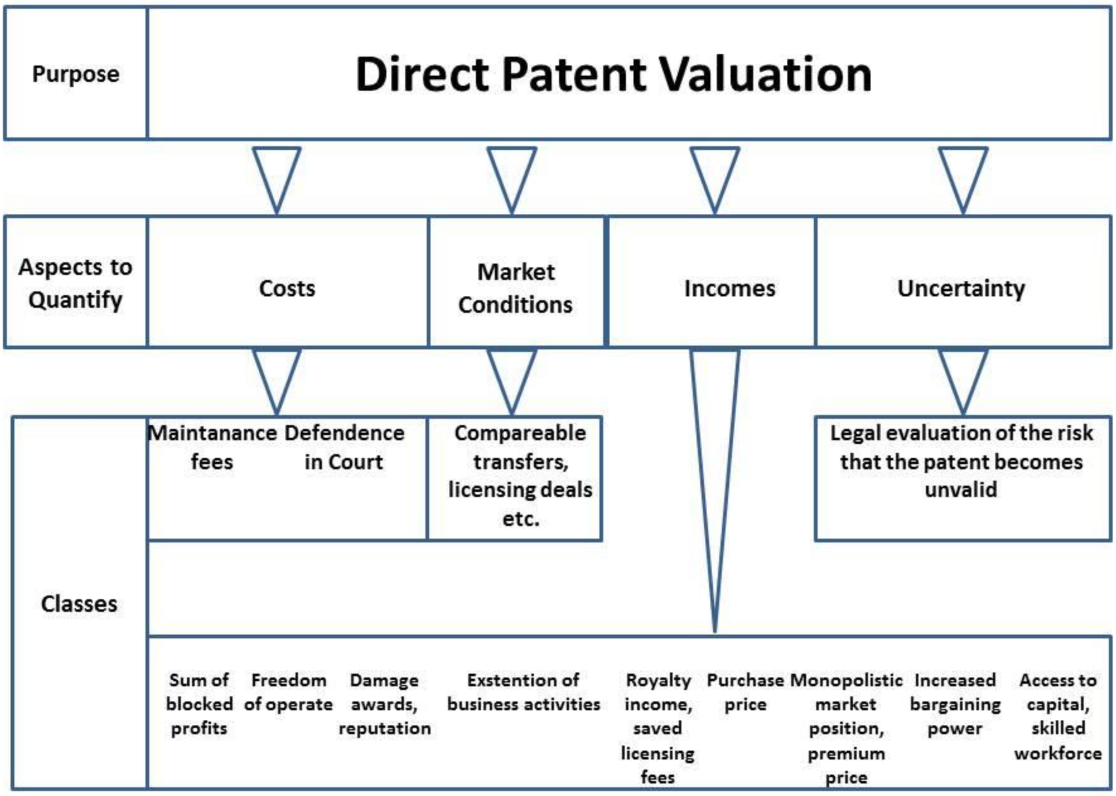

Figure 31 Illustration of step 2 in the valuation model

Quantification of Costs

The aim of the valuation is to analyze a granted patent that has passed the timeframe for geographical expansion. The fact that sensitive information has already been shown to the public is seen as a sunk cost and is hence not included as a cost or disadvantage in the model.

To enable quantifying the costs related to a certain patent, the following questions need to be addressed:

1. In what jurisdiction is the patent valid?
2. How much does it cost to maintain the patent in each jurisdiction?
3. When should the maintenance fees be paid?
4. How much will it cost to defend the patent in court, in the case of a lawsuit?

Evaluation of Market Conditions

The circumstances and market conditions that might influence the value of the patent, need to be evaluated. These can stem both from changed strategic importance of a patented technology or from a change in legal strength of the patent due to legal actions.

Questions to analyze are:

1. Are there any known comparable transfers on the market?

2. Are there any known licensing deals on the market?
3. What characters the patent environment in this technology field?

The aim with the evaluation is not to generate a specific number to the model, but rather to consider how the market condition will influence the incomes and uncertainties.

Quantification of Incomes

According to Grube (2009), there are nine main patent protection benefits. These should all be quantified in monetary terms when conducting the valuation. To be able to do so, following questions need to be addressed in regards to the patent:

1. How much will it cost a third party to invent around the patent to enable the same customer utility?
2. How much can be saved in terms of resources by avoiding inventing around other patents that this patent has given you freedom to use?
3. How much will the patent generate in damages fees?
4. How much profit does the patent enabled in terms of new business activities?
5.
    a. How much royalty does the patent generate?
    b. How big savings have been made in avoided or lowered licensing fees?
6. How much could the patent be sold for?
7.
    a. How much can the profit margin be increased?
    b. How much can the sales volume be increased (only incomes from the geographical markets where the patent is in force should be included)?
8. How much can be saved (in terms of margins) by having an increased bargaining power towards the suppliers?

Since the intrinsic value, for example access to capital and skilled workforce, is outside the scope of this thesis, this aspect will not be quantified in the valuation model. However it will still be part of the illustration in Figure 31, just to remind the valuators that it is an important aspect to have in mind. There are some shortcuts for quantifying the royalties in 5a (Grube 2009). The most accurate one is to collect data from existing agreements, comparable with the technology of interest, but this requires an in-depth investigation of license agreements and contracts. It is also possible to either use industry-standard royalty rates or a heuristic rule of 25 – 33% (Parr 2007). However, to ensure that the royalty rate is realistic, it should be compared to the profit margin. The royalty rate can never exceed the profit margin (Grube 2009). When addressing question 7b, it is important to estimate an appropriate share of the total sales volume that is due to the technological features (Grube 2009). In, a technically complex industry as the automotive industry, it is likely that several new inventions are combined in the same product. There are therefore potentially many patents to which the value can be credited, making a clear distinction between the sources of values critical to the valuation process.

Since the value of future money is lower than that of the present, each question will be quantified and allocated per year and future incomes will we discounted (Murphy et al. 2012). The timeframe for the valuation should be based on the remaining patent life time or the remaining product life time, whichever is shorter. Due to the fact that there is a clear maximum lifetime of a patent, there is no need to include a terminal value in the model, making the result less dependent on abstract estimations (Damodaran 2002).

Quantification of Uncertainty

Since the future application of a patent right is unsure, there are always uncertainties involved when predicting the future value of a patents. Because of this, Pitkethly (1997) recommends to include risk and uncertainty in the calculations. Based on recommendation from both Neil (1998) and Murphy et al. (2012), the risk in the developed model is constant.

The uncertainty connected to the value of patent rights depends on three main aspects (Grube 2009).

1. The attractiveness of the patented technology for competitors
2. Cost and difficulties for competitors to invent around
3. Ability for a patent holder to detect if an infringement has been done

When the three aspects have been graded it will result in an appropriate discount rate to use in step 2.

6.4 Adjustments after Having Tested the Model

As a step towards validating the valuation model it was tested on four patent rights. During this process, data collection was identified as the most difficult part of the process. To facilitate this part of the process, it is important to ask the correct questions to the right person in the right business unit. How to find the right constellation of employees to direct questions to is greatly dependent on the setup of the organization in which the patent is being valued. By formulating concrete and specific questions before searching for someone to address them to, the choice of appropriate sources of information can be facilitated.

The first step in the valuation model was, as expected, much easier to perform and find the required data for. The second step was more difficult and time consuming. One specific input that was difficult to estimate was to what extent the patent had resulted in increased sales volume. Since it is difficult to know how large the sales volume had been without a patent, a comparison was made with other products in the product range. The market share for a similar non-patented product was compared with the market share for the patented product. Depending on additional circumstances, a larger or smaller part of the difference in market share was estimated to stem from the patent right. The quality of the result of the model can never exceed the quality of the input data. If there is not enough time to collect the data necessary for step 2, it is recommended that only step 1 be conducted. If the data used in step 2 of the model is incorrect, the result of step 2 will not be accurate. In these cases the results of step 2 will not be reliable enough to make decision based on them and the use of this second step will not be motivated.

When testing the model, the complexity of the product including the patented technology was identified as another limiting factor to valuation. When valuing a patent that contributes values to a whole vehicle on the primary market, for example by protecting a technology that delivers a superior customer experience, it is difficult to know how much of increased profit margins or volumes that can be credited to the patent itself. When, on the other hand, valuing less complex products on the aftermarket it is easier to determine which value streams are influenced by the patent. In order to enable accurate valuation of patents on the primary market, the Company is therefore recommended to further investigate which patent benefits that are primarily driven by increased customer experience.

7. Conclusions

In this chapter, the thesis will be summarized and conclusions will be drawn. To facilitate for the reader, conclusions made in regards to each research question will be presented in separate sections. The chapter will end with suggestions for future research within the field of patent valuation models.

7.1 Competition Characteristics and Technological Fields in the Automotive Industry

The automotive industry consists of a complex value chain, comprising of many suppliers from different technological fields and neighboring industries. Along the value chain, many actors perform value adding activities on vehicle sub-systems, which are then put together by the OEM before being sold to the end customer. Traditionally, OEMs have focused on direct competition with other OEMs providing similar product and services, but as innovation within the industry becomes increasingly decentralized, in-direct competition and competition with non-OEMs has emerged as a relevant threat to market position. Substitute technologies from traditional automotive manufacturers, consumer electronics companies, software based actors and large automotive suppliers are competition for market share and patents are becoming increasingly important to the outcome of these conflicts.

The automotive industry is said to consist of five main technological fields: propulsion, handling, security & safety, navigation and entertainment. The leading innovators in terms of patent filings vary between the different technological fields, none of the fields however is dominated by only automotive actors. The differences in competition between the technology fields influence how patents and other IPRs are managed and thereby generate value.

The competition in the technology fields occurs in both the industrial and the knowledge based economy. In traditional automotive fields, such as propulsion and handling, patents protecting physical products are most common and the value creation logic still follows the industrial value chain. In these fields the automotive companies are still in top when it comes to innovation and relatively few patent disputes are brought to court.

For the technological fields closer to consumer electronics and software based technologies, security & safety, navigation and entertainment, the OEMs are increasingly competing in the knowledge economy with actors who are used to managing their IPRs in a more aggressive way. Within this category, more disputes are claimed. Patents in these technological fields are protecting physical as well as virtual products and value creation follows the logic of the intellectual value chain. Within this field, technical standards are seen as a big potential revenue stream for the OEMs. It is also within this field that NPEs are the most active. Due to the differences between the technological fields and the dynamic competitive climate, the strategy for valuing patent rights and other IPRs in the automotive industry should be adapted to the specific value creation context.

7.2 Benefits of Patent Protection for OEMs in the Automotive Industry

In the automotive industry, patents have traditionally been used to block third parties from using the protected technology. As the industry moves closer and closer to adjacent industries, additional benefits with patent protection have been identified. The five main patent functions, which all have been identified in the case study, are:

1. Block third parties

2. Attack infringers
3. Commercialize the own product
4. Increase ones bargaining power
5. Build a strong image and reputation

Resulting from these five functions, seven patent protection benefits have been identified in the cases:

1. Sum of blocked profit
2. Freedom to operate
3. Extension of business activities
4. Royalty incomes (saved licensing fees)
5. Monopolistic market position
6. Increased bargaining power
7. Access to capital and skilled workforce

In the theoretical framework, two additional patent protection benefits are stated, damages awards and purchase price, however these have not been identified in the case studies or the literature review. The reason why these were not identified in any of the cases is thought to be due to the fact that OEMs have not attacked infringer to the same extend as actors from other industries historically have. The same goes for patent transfers. Even though these are currently not as commonly used, it can still be good to know that they are valuable within other industries, since that behavior might influence how actors manage their IPRs also in the automotive industry.

7.3 Current Valuation Models and Adaptations of these to Better Fit the Needs of OEMs

A valuation analysis can be used in several different decision situations and therefore the valuation process needs to be adjustable to fit the specific situation. To be able to suite as many decision situations as possible, a two-step valuation model has been developed, allowing the valuator to only perform step 1 if desired. For more crucial decisions, the model generates a value in monetary terms as a result of the second step in the model.

The first step in the valuation model consists of evaluating the legal strength and the strategic importance of the patent and the patented invention. The results of the two parameters are plotted in a two-axis diagram. For those situations where the decision is important and it is relatively easy to gather necessary data, the second step of the valuation model is emphasized. The second step consists of a direct, income based valuation model, with costs, risks, incomes and time as parameters. The costs consists of maintenance fees and cost of defense in court, the incomes stems from the seven patent benefits and the uncertainty consists of the attractiveness of the patented technology for competitors, the cost and difficulties for competitors to invent around and the ability for a patent holder to detect if an infringement has been made. For the least satisfying decision strategies, where the data is difficult or expensive to collect, a market based approach to patent valuation was emphasized instead of the two-step model.

The main challenge in performing an accurate patent valuation lies in gathering the necessary data. This is especially difficult when it comes to patents protecting functionality of products on the primary market. Due to the high level of complexity of these products it is often difficult to determine how much of an increase in value streams ultimately stems from a specific patent or patent portfolio. Products in the automotive aftermarket have been identified as significantly less complex, hence making patents protecting aftermarket products easier to value.

7.4 Suggestions for Further Research

During the research period, a lot of interesting fields and problems have been identified for further research. In the list below, the most interesting research field will be presented in short.

7.4.1 New Patent Strategies for Actors in the Automotive Industry

The automotive industry is currently in a transition phase. Vehicles are becoming smarter, new actors are entering the market and the new functions do not only consist of mechanical solutions, but are moving more and more into software based technologies. An interesting field for further research is therefore to investigate how the new technologies and the new actors within the automotive industry will influence the way in which companies are managing their IPRs and creating value. In this type of analysis a comparison can be made to the developments within the telecommunication and information technology industry.

7.4.2 Adaptations of Valuation Model for use on Design Patent

The developed model is aimed to be used on patent rights, however much of OEMs' IPR value lies in design rights. Design rights follow a logic similar to patents, but are not as complex to enforce, since infringements can be seen with a naked eye. Due to the difference in detection of infringement and enforcement of design rights they have been excluded from the developed valuation framework. A suggestion for further research is to investigate the use of the patent valuation model to value design rights and the development of an adapted design right valuation model.

7.4.3 Adaptation of Valuation Model for use earlier in the Technology Lifetime

Lastly, the model developed should be used when the patent right is granted and the date has passed for geographical extension. However, it is likely that OEMs would like to predict the value of a patent right early in the technology's life. Therefore, the last suggestion for further research is to analyze how a valuation model can be developed for the valuation of potential patents and upcoming technologies. Thus the analysis can be used as foundation for the decision whether to file a patent application or not.

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Appendix I – Templates from Interviews

Sales & Marketing

Focus of interview:

To understand how patents can be used to influence profits, through premium pricing or marketing campaigns.

Interview questions Sales & Marketing:

- To what extent is premium pricing possible?
- In what segments is this used?
- How price sensitive are different markets? Market share of different price segment?
- How is premium pricing used in aftermarket sales? In different geographical markets? In different technological markets?
- How much does Total Cost of Ownership (TCO) influence pricing?
- How much does TCO influence customer purchasing decisions?

- How often is "patented technology" as a term used in marketing?
- How often are patented technologies described as a part of marketing?
- To what extent can other actors' marketing campaigns be used to find infringement?
- How local are marketing campaigns, geographically?
- Who is marketing targeted towards?

Research & Development

- 3 technology fields
    - Battery technologies – competitive research field
    - Chassis – traditional automotive field
    - Navigation or ITC – emerging field within the automotive industry, new competitors

Focus of interviews:

To understand how patents influence the R&D process.

Interview questions:

- How does the R&D process work in terms of patent landscape analysis?
- How often does a R&D person check for new patents?
- How often do patents create issues in the R&D process?
- When problems arise, how do they manifest themselves?
    - The patent blocks the wanted utility/function?
    - The R&D process takes longer because the patent has to be invented around?
    - The R&D process becomes more expensive as a result of the patent?
- Is there any specific technology (related to the interviewee's field) in which patents more readily create problems?
- Which actors are mainly involved in patent related R&D issues?
- How has patent environment within your research subject changed over the past five years?
- How have the actors involved in the R&D area changed over the past five years?

- How often is licensing of technology discussed as a viable option to developing?
- How influenced is your research field of the overall corporate R&D strategy?

Braking System – Case Study

Focus of interview:

Understand the benefits patent protection with the patent protection the specific braking system

Interview questions:

- How did you make profit on the braking system?
  - Increase sales volumes?
  - Lowered costs?
  - Premium pricing?
- How was the new advantages communicated to the customers and buyers?
  - That it was a patented invention?
  - Only the customer utilities?
- How did you ensure to achieve a (temporarily) monopolistic position on the market?
  - Look for infringers?
  - Attack infringers?
  - Communicate that the patent was granted?
  - Send letter of intend to sue?
- How was your market position affected by the patent?
  - Monopolistic market position?
  - Fewer competitors?
  - Not affected at all?
- Has the position been affected by the fact that the patent has lapsed?
  - New entrants
  - More competitors
  - More imitators
  - Competitors has launched identical products

Appendix II – Thomson Reuters' Automotive Patenting Trends

Propulsion

FIGURE 4: TOP 10 PROPULSION ASSIGNEES

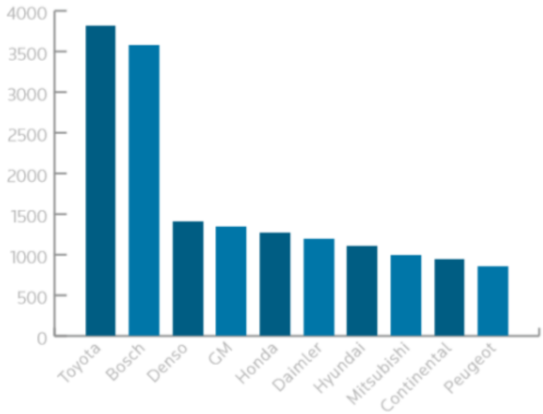
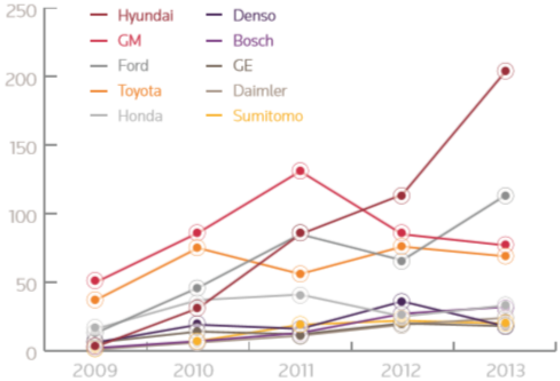


FIGURE 13: TOP 10 AUTOMOTIVE INNOVATORS FOCUSED ON FUEL ECONOMY



Navigation

FIGURE 5: TOP 10 NAVIGATION ASSIGNEES

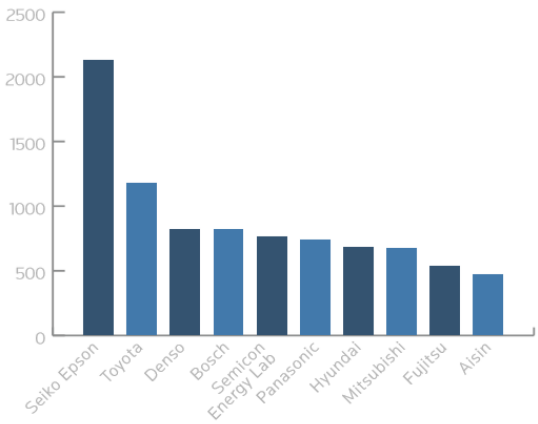
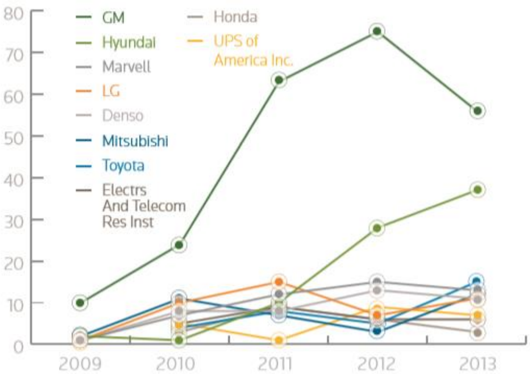


FIGURE 14: 10 AUTOMOTIVE INNOVATORS FOCUSED ON TELEMATICS



Handling

FIGURE 6: TOP 10 HANDLING ASSIGNEES

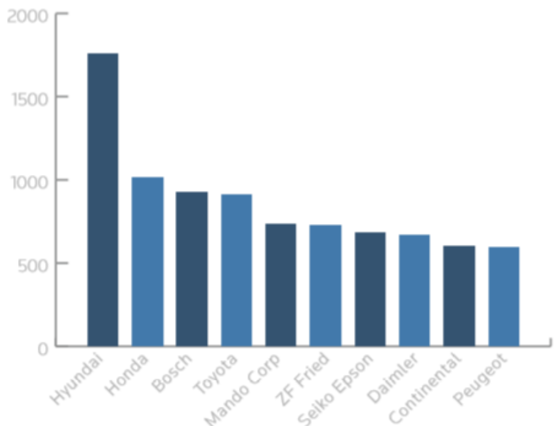
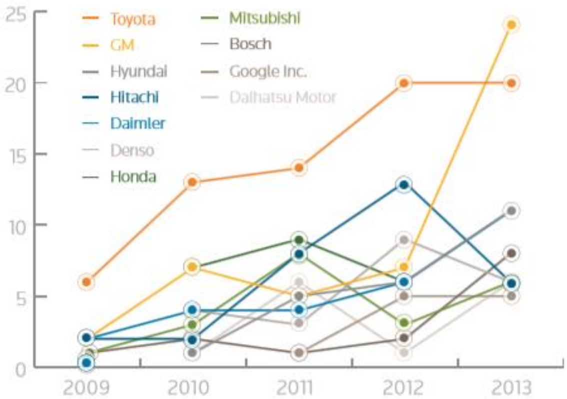


FIGURE 15: TOP 10 AUTOMOTIVE INNOVATORS FOCUSED ON AUTONOMOUS DRIVING, PLUS GOOGLE



Safety & Security

FIGURE 7: TOP 10 SAFETY & SECURITY ASSIGNEES

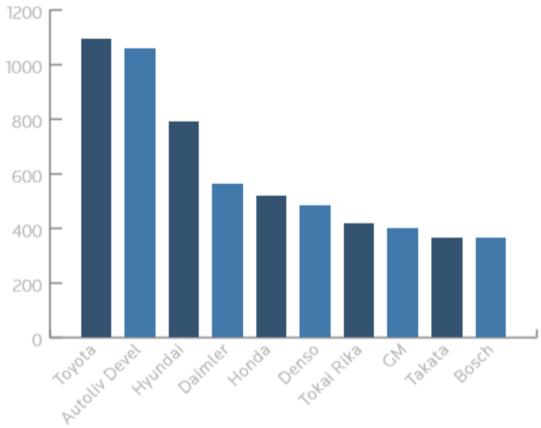
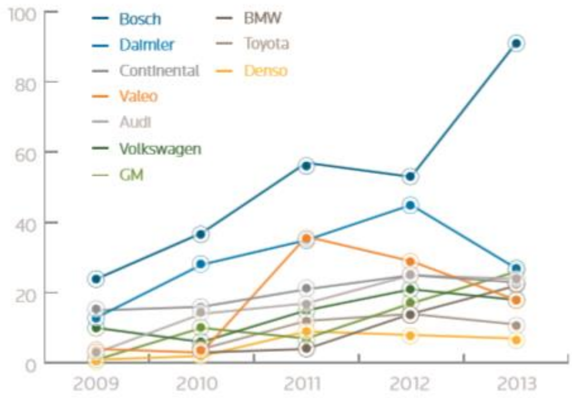


FIGURE 16: TOP 10 AUTOMOTIVE INNOVATORS FOCUSED ON DRIVER ASSISTANCE



Entertainment

FIGURE 8: TOP 10 ENTERTAINMENT COMPANIES

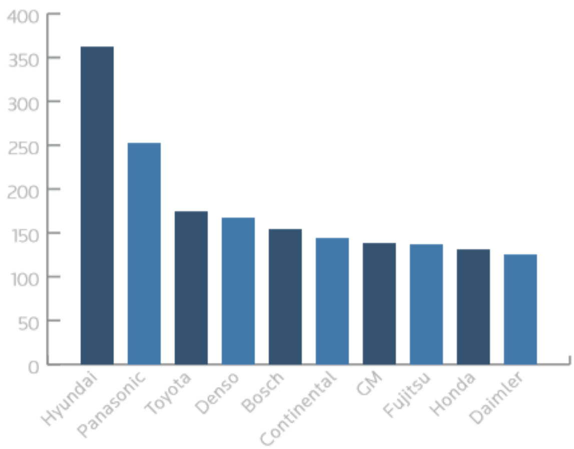
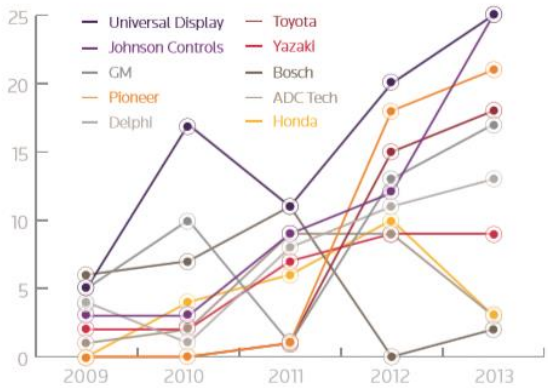


FIGURE 17: TOP 10 AUTOMOTIVE INNOVATORS FOCUSED ON HUDS



Appendix III – Picture from Article in Aftonbladet

Aftonbladet (2011)