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Deconstructing the Value of IoT

Towards a value-centric and managerial framework for categorizing use-cases

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

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Cover:
An image illustrating the range of use of IoT Technology. Source: (Hinson, 2018)

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Abstract

The Internet of Things (IoT) is connecting and digitalizing the physical world, requiring the convergence of multiple technologies. However, the field is very broad, crossing 10ths of different industry verticals and there is a lack of an aggregated approach explaining the value of IoT, which is increasing the uncertainty and limiting the understanding of IoT needed for the technology convergence to be realized. Hence, this study aimed to investigate a starting point for an income-based IoT valuation method that could improve on this situation. Through a qualitative cross-sectional study, the value creation and capturing of six different IoT applications was investigated with data from both literature and interviews. The analysis of the results showed that the factor with the most impact on what source of value was the implementor's role, either integrator or provider, with a focus on value-activities and products/services respectively. Based on this, the authors propose a value-centric framework with four collectively exhaustive categories: process efficiency, resource utilization, legacy product/service innovation and new product/service innovation; creating a foundation for evaluation of IoT use-cases for which no comparable valuations are available. The framework could hence help managers to overcome initial uncertainty and decrease efforts needed for assessing the value of an IoT use-case. In light of the conclusions, the study suggests further research into IoT value for consumers and quantitative case studies in IoT with income-based methods.

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Deconstructing that which is abstract and subjective is a tedious task, and it wouldn't have been possible without the support from our academic supervisors, Bowman Heiden and Karla Soler Riba. Your feedback and extensive experience of detangling the intangible, objectify the subjective and concretize what others might consider to be abstract helped us to structure our insights, observations and conclusions into something that certainly could look beyond the initial hype of IoT, and hopefully, accelerate future efforts in income-based technology valuation!

Kista, May 16th, 2019

Johan Andersson & Erik Lenning

Abbreviations

3GPP	Third Generation Partnership Project
B2B	Business to Business
B2C	Business to Consumer
BATNA	Best Alternative To Negotiated Agreement
CLM	Connected Lawn Mower
EDI	Electronic Data Interchange Applications
ICT	Information and Communication Technologies
IIoT	Industrial Internet of Things
IoT	Internet of Things
IS	Information System
IVC	Intellectual Value Chain
M2M	Machine to Machine Communication
MRPII	Material Requirements Planning
nRPM	Non-Remote Patient Monitoring
OMS	Operation Management Systems
QoC	Quality of Care
RPM	Remote Patient Monitoring
RPS	Resource Planning Systems
SP	Service Providers
URLLC	Ultra-Reliable and Low-Latency Communication

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1 Introduction

This first chapter of the report intends to outline the prerequisites of the study to contextualize the research subject, illustrate the shortcomings of existing research and highlight the intended focus.

1.1 Background

The fourth industrial revolution, powered by information and communication technology (ICT), pave the way for new opportunities for firms to create value for its customers (Amit & Zott, 2001). As the number of connected units increases with 20% CAGR yearly, Cisco (2016) predict the number to reach 500 Billion units by 2030. These connected units, powered by the internet and, equipped with technology to communicate, sense and interact with their internal states and the external environment, is what is defined as the Internet of Things (IoT) (Gartner, 2019). The IoT digitalize the physical world, and by doing so, realizing the major economic impact of the fourth industrial revolution. McKinsey (2015) expects IoT to drive a market worth $18 Trillion Dollar annually by 2025. Simultaneously, IoT will drive impact an even broader impact on society, saving lives through better care and safer work, and increase the sustainability of production through higher productivity (McKinsey, 2015).

Digitalizing the physical world requires the convergence of multiple technology platforms, which also require actors to collaborate across industries. As new IoT technologies are being developed, diffused into the market by providers and put into use by integrators, new use-cases of IoT emerge. Several types of IoT use-cases are already adopted by actors in different industries (McKinsey, 2015), and several new opportunities get unlocked with the increasing development of sensors, batteries and automation tools (Porter & Heppelmann, 2014) and network performance (Ericsson, 2018).

With IoT bringing such a radical change with obvious and enormous implications, it is easy to jump to the conclusion that *everything will instantly change for businesses*. Porter and Heppelmann (2014; 2015) argue that it is a dangerous oversimplification. Since IoT bridges, the old and physical into the new and virtual, elements of both worlds need to come together.

The value from IoT does not get created and captured on its own. IoT unlocks new business model opportunities for firms to create and capture value from IoT Technology (Ehret & Wirtz, 2017). For implementors and technology owners this means an urgent need to look beyond the initial hype and develop their understanding of how the IoT will affect their competitive environment and their value-creating activities (Porter & Heppelmann, 2014; 2015). This understanding from all involved actors of IoT is instrumental to incentivize further technology development and collaboration towards realizing the economic impact that would give everyone involved a fair return on their investments.

1.2 Prior Research

Even though the technology field is relatively new, given its societal and economic impact, plenty has been written on the topic of IoT already. In order to give some further contextual preferences, the major research areas surrounding the thesis subject of this report have been preliminarily researched to position this study in uncontested subject space. As a starting point, it is worth exploring IoT Technology and its intended use. Furthermore, it useful to explore the existing thinking around the valuation of technology and how it could be priced in a licencing context.

1.2.1 Use-Cases of IoT

Despite the growing popularity of the IoT, few studies have focused on the categorization of the IoT use-cases (Lee & Lee, 2015). Porter and Heppelmann (2014) attempt to categorize IoT Products following a cumulative logic of increasing technical capability, from Monitoring and Control to Optimization and Autonomy which has the most sophisticated technical function. Focusing on the technical capabilities however, miss the involvement of customer need that encourages the use of the technology which is an important aspect of IoT Use-cases. According to Lee and Lee (2015), understanding customer need is a prerequisite to understanding successful value creation and capturing. Likeminded, Chui et al., (2010) present a framework based on the opportunities IoT provide to enterprises, see Figure 1. The model clusters use-cases in broader applications areas, dispersed over two broad categories; Information & Analysis, and Automation & Control. Each application area integrates all contexts where IoT technology could be deployed in and the purpose for which to do so into segments with a similar type of technologies and functions. In Telia and Northstream's (2018) *Connected Things* report, the focus on business needs are further emphasized with interesting results. However, it lacks clarity in the defenition of the different needs making it difficult to use as a basis for evluating IoT use-cases, and the research methodology is unknown making it hard to assess the quality of the findings. Still It did inspire the thinking and methodology in this study with the emphasiz on business needs and value, moving away from technological properties.

Information & Analysis			Automation & Control		
Tracking Behavior	Enhanced Situational Awareness	Sensor Driven Decision Analytics	Process Optimization	Optimized Resource Consumption	Complex Autonomous Systems
Monitoring the behaviour of objects, individuals and data trough space and time.	*Achieving Real Time Awareness of Physical Environments.*	*Assisting Human Decisionmaking thorugh deep Analysis and Data Visualization.*	*Automated Control of Self-Contained Systems.*	Control and Consumption of Optimized Resource Use Across Networks.	Automated Control in Open Environments with Great Uncertainty.

Figure 1: A segmentation of IoT Use-Cases in six categories based on the opportunities they provide to enterprises. Source: (Chui, et al., 2010)

1.2.2 Value Creation and the Internet

Business research on how information technologies create value have existed for many years. Already in 1985, Michael Porter wrote about *How Information Gives You Competitive Advantage*. By using the same theories on competitive advantage, the value chain and the five forces that he is synonymous with today, he concluded that the information revolution affected competition in three main ways: the industry structure, new ways to outperform competitors, and spawning whole new businesses (Porter & Millar, 1985).

More recently, in the early 2000s when companies just started to take advantage of the internet, Amit & Zott (2001) explored how the value was being created by those firms. They found that it *goes beyond the value that can be realized through the configuration of the value chain*, critiquing Porter's thinking, but also going as far as saying that *no single entrepreneurship or strategic management theory can fully explain the value creation potential of e-businesses* (Amit & Zott, 2001, p. 494). As a solution, they combined several of the theories and constructed a model of the sources of value creation consisting of efficiency, complementarities, lock-in and novelty. Amit & Zott also proposed the business model as the unit of analysis for understanding how e-businesses create value, this study will draw on this thinking.

Following in the footsteps of previous authors, Björkdahl (2009) also had the business model in focus. Arguing that the economic dimension of multi-technology products had been ignored he investigated the link between technologies and their economic effect. The observations showed that *the main challenge was not to make the offering work from a technological point of view, but to find an appropriate business model in order to profit from the cross-fertilization* (Björkdahl, 2009, p. 1475), coming to the conclusion that *to unlock the value inherent in a new technology* the firm need to change business model putting additional emphasis on using the business model concept when analysing what value new technology brings.

In *Unlocking the Value of Machines* Ehret & Wirtz (2017) continued this thinking of the need to change the business model of a firm to create and capture value from multi-technological products like the Industrial Internet of Things (IIoT). They proposed three new categories of business models on the basis of non-ownership contracts as a solution for IIoT implementors: servitization, data-driven business models and customization (Ehret & Wirtz, 2017).

Summarizing the above, previous researchers have established a connection between the business model and value creation when using the internet in your business. A broad set of theories have been used to explain the observations shown, implying the need to look across large parts of the innovation and business research spectrum for an explanation. However, none of the authors has taken an aggregated approach to value creation in the IoT spectrum and explored the connection between value creation, capturing and applications, industries and value chain roles. Björkdahl (2009) and Ehret & Wirtz (2017) looked at manufacturing companies, Amit & Zott (2001) at firms using the internet while Porter & Millar (1985) analyzed the impact of IT without the opportunities of the internet.

1.2.3 Royalties and License Pricing with Income-Based methods

In the telecommunications industry, technology licensing is an established method to monetize technologies beyond implementing the technology into products yourself (Heiden & Andreasson, 2016). This practice is based on the patent system used by many countries where one can register an exclusive right to a specific technology. However, if another actor trespass and use the technology anyhow, this grants the owner right to compensation. Article 284 of the U.S. Patent Act state:

> *Upon finding for the claimant the court shall award the claimant damages adequate to compensate for the infringement but in no event less than a reasonable royalty for the use made of the invention by the infringer...*

This reasonable royalty also becomes the alternative cost to infringement, effectively putting a price on the access to the technology. The courts have used several methods to determine a reasonable royalty however, the most common way in the U.S. is the Hypothetical Negotiation method according to Fish & Richardson (2019) outlined by the fifteen Georgia-Pacific factors (Georgia-Pacific Corp. v. United States Plywood Corp., 1970). The factors relate to several properties of a licensing deal, such as term, scope and exclusivity of licensed technologies. How one more practically should calculate the royalty is however not described by the Georgia-Pacific factors.

First, for the actual calculation of the royalty, the courts generally use either market or income-based methods to determine the price of the technology (Heiden, 2018). Comparable licenses give a direct indication of the price while the while profit or revenue would conventionally give the value of a product, which then needs to be apportioned between the technologies it comprises. The latter method has been cherized by e.g. Park and Park (2004) for being the most accurate, but critized by e.g. Chiesa et al. (2007) for lacking nuance in the quantiative assessment. All the mentioned authors highlight the challenges of implementing income-based methods due to its complexity, and advocates for research on guidelines and frameworks that would increase the managerability.

Second, there is also a need to determine the share between the technologies in the product, to apportion the royalty base. However, when *"The combined use of two or more assets is worth more than their individual use, no unique way exists to apportion the overall value among the assets"* (Bailey, et al., 2011, p. 257). This makes apportionment in ICT a difficult task.

Lastly, a price (royalty rate) would be set out which considers e.g. options of using alternative technologies and other Georgia-Pacific factors. Reference royalty rates for industry and rule of thumb have also been proposed here. But it needs to consider that no actor would make a deal that is worse than their best alternative, BATNA (Fisher & Ury, 1991).

Summarizing the above, applying an income-based logic can be distilled into a list consisting of three steps or questions needed to be answered when determining the price of technology, of which the first question is the primary focus of this study:

1. What is the total added value of the technology?
2. How should this new value be apportioned between the functional elements?
3. What is the appropriate price for each element?

1.3 Problem Definition

The previous section painted a scarce and scattered research landscape concerning IoT Value. There seems to be some research existing on the use of IoT technology, the industry implications, how the internet creates value for enterprises and how that could be captured through the business model, but these subjects have all been treated in isolation and not specifically to IoT. There is also no aggregated approach at explaining a value-centric view of the IoT use-case landscape that could catalyze the understanding and adoption of solutions for implementors.

For technology owners, the lack of clear implementation research inhibits the use of valuation methods that would contribute to a fairer value distribution and thus overcoming the uncertainty to collaborate and develop the technology. Plenty has been written on valuation methods and pricing approaches, but the actual implementation of them is far from clear in the existing literature, and several authors, including Chiesa et al. (2007) and Park & Park (2004) advocate for more research into applications of the theory in order to increase manageability for technology owners.

1.4 Purpose

With the given challenges of today and the shortcomings of the state-of-the-art research, the purpose of the study is to propose a starting point to an income-based valuation method applicable to all IoT technologies by enhancing the understanding around the value of IoT for businesses, finding the value drivers of IoT. Additionally, the study aims at increasing the implementation ability and decreasing managerial burden when evaluating IoT business cases through distilling the insights into a framework. This could in the long term increase the accuracy of valuations and hence the accuracy of value capturing by technology owners. Ultimately, the study hopes to produce a result that could remove some of the uncertainty around IoT investments, thus stimulating further development, adoption and collaboration.

1.5 Research Questions

To fulfil its stipulated purpose, and advance the body of knowledge within the field, the study investigates the following research question:

Main Research Question:
How can income-based methods be used when evaluating an IoT technology-license price?

Supporting the main research question two additional sub-questions are posed in order to investigate how value is being created and captured when implementing IoT, and how these values can be used to segment IoT use-cases. The answers to the sub-questions constitute the basis in combination with previous research for answering the main research question.

Research Question 1:
How is value being created and captured by IoT use-cases?

This research question will help in understanding how an IoT use-case affects a business, what are the benefits to implementors? These values would give insight into the factors that build the valuation model. The answer is then used as a foundation for answering the next research question.

Research Question 2:
How can IoT use-cases be segmented based on value creation and capture?

This question investigates how different IoT use-case related factors related to value creation and capturing. Additionally, it serves as a basis for creating a framework of IoT value as described in the purpose.

1.6 Delimitations

Even if the study positions itself within the field of technology licenses and pricing, it does not aim to give guidance on how to solve all questions that are posed when determining a license price. As stated previously, this is a multi-step process with different questions to be addressed at each stage. This study only aims at solving the problem of finding the value drivers of the technology, and then put this into the context of technology licensing. Hence, the study reviews what methods are proposed by industry and academia to e.g. appropriate value but do not propose changes or solutions the state of the art outside of technology valuation. It does neither give insight into or relate to other issues that may impact a technology license pricing, e.g. cross-licensing, bargaining position, previous agreements, and technology-related factors such as standardization and patent protection. Consequently, when mentioning technology, the study generally describes all technologies that can achieve a certain function or subfunction, e.g. sensors, connectivity, actuators etc.

Moreover, when discussing value, the study has primarily concerned IoT effects that drive profits in monetary terms for firms. Hence, the study does concern itself with value not captured by the firm such as consumer surplus, societal and environmental value.

Finally, the field of IoT is, even if it has achieved some maturity, still emerging. Especially some industries and for applications that require *Ultra-Reliable and Low-Latency Communication* as such performance does not yet have widespread availability on the market.[1] Hence, this study is based on the current knowledge base in the field and may have limited *Dependability* i.e. longitudinal validity.

1.7 Thesis Outline

The first chapter serves as an introduction to the study, including previous research relating leading up to the issue at hand, the problem definition, the purpose of the study, the research questioned set up to solve the said purpose and a set of delimitations that together provide the scope with the study.

The second chapter outlines the foundation of the study consisting of theories and concepts used in the research. This includes an introduction to IoT but also Market Economics, Competitive Advantage, the Industry, and the Business Model. This framework of theory will provide a platform when collecting and analysing data.

The third chapter describes the methods of research. This comprises the research strategy, epistemological considerations, overarching research design, data sources, a more detailed description of the data collection and analysis and lastly the impact of the method on the research quality is being assessed.

The fourth chapter utilizes the previously outlined framework in the theory section and explores IoT value creation in line with the method proposed in the third chapter. This is carried out by six studies of IoT application across four different industries presenting the within case analysis of value creation.

The fifth chapter then compares the different value creation described in the fifth chapter across three dimensions: application, industry and role, giving the answer to research question 1. Based on this, the perspective is changed to a value-centric view, providing an answer research question 2.

The sixth chapter draws conclusions from the analysis of chapter six and revisits the main research question. By using the answers to the subsequent research questions, the study proposes a foundational framework behind an income-based model for valuing technology, which for example could be used in licensing.

The seventh and final chapter then discusses the practical and theoretical implication of the study, the limitations to the same conclusions and proposes suitable areas of further research.

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[1] These are fields of technologies in the 5th generation cellular communication standard. (3GPP, 2017)

2 Theory

This chapter covers the relevant theories and literature for this study with the aim of creating a source of value framework for IoT. The theory will begin with with a technology-centric view of IoT to act as a platform for further understanding around the usage and implicated business opportunities for technology, and to begin explaining the roles in the IoT value chain. Then, the theory moves into an economic definition of value to set the basis for further discussion around IoT value creation and capturing. From there, the chapter will explore sources of competitive advantage and strategies of how to realize them. Closing remarks will be made with attention to details around sources of value in the industry, followed by a discussion on the business model with attention to the IoT context.

2.1 The Technology Elements in IoT

In order to compose a use-case of IoT, several technology elements need to co-operate create, transport, refine and act on data in order to create value. To enhance the understanding of the usage scope for IoT technology, and to refine the understanding of the business-related aspects of IoT, the technology elements of IoT is an important starting point. The architecture of the Internet of Things include some essential layers which in a generic case could be described as; Smart objects Layer, which include actuators and sensors; Network layer, which include wireless and wired technologies; Management Service Layers, or Big Data, which include Cloud, fog computing and data analytics; and IoT Application Layer; which include context-specific software responsible for effective utilization of the data collected. (Lee & Lee, 2015; Ehret & Wirtz, 2017; Hussain, 2017).

According to Hussain (2017), selecting of smart objects to accurately portray and control an environment is the number one challenge of a successful IoT use-case, and also put create the framework of performance requirements on the other involved technologies. Smart Objects have process power and are interconnected, which means that they can communicate and perform tasks towards a mutual goal. Sensors can identify, log and transmit the state of things and contexts. Sensors include motions sensors, RFID, accelerometers, pressure sensors, light sensors etc. Actuators drive movement and change in the system. As the name suggests, they actuate on the commands that are derived from the collective data in the system. Actuators could denote a robot or other types of machine equipment. (Ehret & Wirtz, 2017; Hussain, 2017)

To manage the massive amounts of data that transmits to and from smart objects, data fusion, data abstraction and data summarization is required, actions which are commonly denoted *Big Data Management.* Cloud Computing and Fog Computing exist to bridge the four challenging dimensions of Big Data, namely volume, velocity and variety, veracity (Zaki, et al., 2015). Cloud computing offers to access the stored data from anywhere, anytime, and afterwards expanding the services independent of end-user hardware. Cloud computing presents numerous benefits compared to conventual computing in terms of cost, scalability, performance and maintenance, which means that it can deal with volume velocity and variety. Fog Computing exists to support the data gathering process from a massive amount of geographically widely distributed smart objects. Fog is an intermediate layer that increases reliability and reduces latency. (Hussain, 2017; IBM, 2017)

The IoT Application layer is extremely broad and growing. Examples include fleet management systems, remote asset management, supply chain, parcel tracking, surveillance etc. (Chui, et al., 2010;

Lee & Lee, 2015). The Application layer is what outlines the use of the collected data from previous layers, and process and present in various ways to make it actionable. According to Rowley (2007), the usefulness of data is varying with the analytical complexity of the processing. A useful hierarchy of the analytical complexity and its impact on the usefulness of the data is done by Nokia (2016) that outlines a scale from Sensing to Control, where the lowest level of usefulness is to simply provide the data, and the higher levels relate to descriptive, predictive and prescriptive analysis. Descriptive analytics is able to collect and aggregate knowledge, while predictive analytics are able to foresee some element of the future. At the highest level, prescriptive analytics allows for suggestions or recommendations on actions related to the foreseen future (Nokia, 2016). Having gone through this extensive refinement, the data is considerably more useful, and thus more worth (Rowley, 2007).

The network layer includes the technology that produces connectivity thereby shipping the data through from the smart objects layer. As is the nature of communication technology, interoperability is a crucial factor, which is one of the reasons why technology standards have been formed, governed by organisations like the 3rd Generation Partnership Project (3GPP) to direct the development. Wired technologies particularly include ethernet, which has protocols that some are specific to the context such as the *Industrial* Ethernet. Industrial Ethernet is an umbrella term for protocols such as Ether-CAT, PROFINET, Ethernet/IP and Sercos. These protocols effectively exist to support multiple connections, low latency networks (Lin & Pearson, 2018). Recently, Time Sensitive Networking has been rising in popularity for deterministic allocation nature which enables a guaranteed maximum latency, thus the enablement of using the same network for multiple use-cases from monitoring to automation (Lin & Pearson, 2018; Alpha, 2019).

A cornerstone for a wide range of IoT use-cases is wireless connectivity, providing the flexibility which enables scale and usefulness of a connected system of things (Ernst & Young, 2016; Alpha, 2019). Examples of wireless protocols are wide and very disperse depending on the performance requirement of the intended use.[2] Two important differentiating factors are the transmission range and the use of licensed or unlicensed radio spectrum (Alpha, 2019). Transmission could range between 5 centimetres and 10 kilometres, some solutions only work at short range such as Bluetooth and Zigbee, and some work on all ranges, such as the 4G, 5G, Sigfox and LoRaWan (Linklabs, 2016). Furthermore, some frequencies on the radio spectrum have regulated the use and could, therefore, be licensed. The intention is to obtain exclusivity and therefore ensure speed and reliability of the connection (Liberg, et al., 2018). Solutions operating in the licensed spectrum include the cellular connectivity standards such as ass 4G and 5G, while e.g. Sigfox and LoRaWan operate on unlicensed spectrum.

2.2 Strategy and Competitive Advantage as a Source of Value

To begin understanding the relationship between value creating and capturing in the value chain, it is useful to look at the nature of the theoretical economic incentives behind these two terms. In the traditional neo-classical surplus thinking coined by Alfred Marshall in the mid-19th century, value is

[2] According to Linklabs (2016), there are more than 20 wireless network protocols that are used in the IoT with different purposes, strength and weaknesses.

seen as the monetary gain, by either a consumer or supplier, that is higher than the costs associated with said gain (Boulding, 1945). In theory, a transaction can only occur whenever consumer and producer surplus, is zero or greater. Those are the only conditions where rational parties have an incentive to trade, and anything else would not happen since it would be irrational. However, it might still be rational in discrete situations or in the short term due to long term strategic implications of such transactions (Besanko, et al., 2013).

Expanding the definition of value beyond the neoclassical context, Grant (2015) argues that value and performance are created and sustained through a strategy. The goal of a strategy is to achieve a competitive advantage (Grant, 2015; Rumelt, 1999). Competitive Advantage is widely discussed in the strategic management literature and has come to be almost synonymous with strategy. Thus, the nature of competitive advantage makes it useful to categorize value creation and capturing, which is how it is used in this study. A commonly used definition is the one coined by Barney, stating that: "..a firm is said to have a competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors" (Barney, 1991). Continuing, "a firm is said to have a sustained competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors, and when these other firms are unable to duplicate the benefits of this strategy". Hence, competitive advantage have a tight connection to value creation, making it fit to use when analysing what's the value drivers of implementing IoT.

Crucial elements of a successful strategy include; clear and consistent long-term goals, a profound understanding of the competitive environment; and objective appraisal of resources (Grant, 2015). A long term thinking allows you to critically assess risks and make successful investments when you know a return could come in the future, a thinking Grant have in common with one of the first famous strategists, Sun Tzu, that in his book, The Art of War, wrote "Sometimes you can afford to lose a small battle if it means you will win the war". While detailing the relationship between the strategy and the business model, Teece argues that the short perspective should be outlined by the business model, which is why it is crucial to conduct strategic analysis in line with your long term strategy in order to protect and sustain your competitive advantage in the long run (Teece, 2010).

Porter is more elaborate on Grant's reasoning around understanding the competitive environment, arguing that the strategy should detail how one aim to manipulate the competitive environment of an industry in order to increase your own attractiveness to the market (Porter, 1985). Porter also identifies five competitive forces that determine the ability of corporations to earn rates of return on investments. These five forces are *rivalry among the existing competitors*, the *threat of substitutes* and the *entry of new competitors*, the *bargaining power of buyers*, and the *bargaining power of suppliers*. Imposed by this framework, Porter continues to group strategies by their intended competitive advantage (Porter, 1985). Strategies could be divided into two generic categories, cost strategies and differentiation strategies. Making the two generic strategies more explicit and uniting them with Grant's environment and resources argument, one can also describe them as *operational efficiency* and *positioning*. The former relates to the value activities of the firm, i.e. firm structure and performance, while the latter relates to the strategic fit between the firm's value proposition and the nature of demand in the market (Porter & Heppelmann, 2014). Additionally, Porter (1985) introduces a cross-sectional dimension to strategic advantage, namely the "competitive scope". The scope is the breadth of company activities, and depending on the scope, differentiation and cost strategies might have a different effect in creating competitive advantage.

2.2.1 Differentiation Advantage

In essence, an differentiation strategy is about improving the quality of a product or service, making it stand out from the competition. A differentiation strategy is appropriate when the target customers have specific needs, the market is competitive and saturated, and the firm has unique resources (e.g. brands, patents or other intellectual properties) and capabilities (e.g. technical, marketing expertise or innovative processes) (Pisano & Teece, 2007; Teece, 1986; Porter, 1985). Penrose (1959) argues for a "resource-based view", that a unique combination of capabilities and resources in itself is a source of value. Exploiting resources that are unique to the firm means that other firms would have to use other type resources in another combination of the same goal. Hence, a firm's potential to create and sustain a competitive advantage is increasing with the uniqueness of their combination of resources and capabilities (Barney, 1991). The recent year's paradigm shift into the knowledge economy has broadened the view of what constitutes a firm's competitive advantage. Grant (1996) argue for that knowledge, trough the creation of intellectual assets, add to a firm's sustainable competitive advantage. Intellectual assets such as brands, know-how, and product and process technologies are the driver of profit, revenue and ultimately a firm's valuation (Lev, 2016). The brand is intellectual elements of perception, image and reputation that adds to an offering on top of its technological features and performance. This added value allows a product or firm to stand out from the competition, capturing superior value from the market (Davis, 2009). The nature of branding is different depending on the relationship between company and recipient. According to Honarmandi et al. (2019), business to business (b2b) branding is based on logical reasoning and a focus on risk aversion, while business to consumer (b2c) branding is based on emotions and focused on matching the archetype of the consumer.

Differentiation in the knowledge economy is also largely achieved through innovation (Teece, 2010; Teece, 1986). This theory is detailed by Schumpeter (1934), introducing the *Creative Destruction* phenomenon. Sources of value derived from innovation, Schumpeter argues, could be the introduction of new goods or production processes, entering new markets and combining resources in a new way. Additionally, the rates of return of investment associated with investments in innovations have consequently been denoted *Schumpeterian rents* to describe the value that can be captured by early adopters of technology (Schumpeter, 1934). This value is closely related to a common source of value for innovators, first movers' advantages. Such advantages include; lock-in effect on customers, raising switching costs to the competition (Amit & Zott, 2001); and technology leadership, being able to quickly catch the next wave of innovation (Schilling, 2016; Teece, 2010).

Innovation could have a varying degree of novelty, but also a varying degree of impact the market and the value created. There are also strategic differences between the two major types of innovation, radical and incremental (Mebert & Lowe, 2017). Returning to the theories of Schumpeter (1934), he described radical innovation as the key to economic development through a process of creative destruction, a revolutionary change, a breakthrough in a product, process or organization. In other words, this type of innovation has a high degree of novelty, a result of a non-obvious path, and breaks with previous structures, procedures, activities and products in a firm (Souto, 2015; Schumpeter, 1934; Teece, 2010) to create new uncontested market space (Mebert & Lowe, 2017). With great risk, significant opportunity follows, and radical innovation renders greater profitability, revenue growth. It also tends not to do a trade-off between value and cost, it raises buyer value by creating elements in the industry never previously offered while reducing costs of unnecessary factors that industry competes on (Mebert & Lowe, 2017). In contrast, incremental innovation is an innovation with a low degree of novelty, that comes at a lower cost and risk than radical innovation does. It has significantly less potential for positive impact on the firm's performance. Thus, it does not break with previous structures but alters them slightly adding new features to an old product or service (Teece, 2010; Tushman & Anderson, 1986).

2.2.2 Cost Advantage

In comparison to differentiation, cost advantages is not about the quality of the product, but the price of it. To achieve a cost advantage, a firm have to accomplish, according to Porter, having the lowest price to value ratio (Porter, 1985). Most of the literature on ICT-enabled cost advantages to focus on transaction costs (Amit & Zott, 2001; Ehret & Wirtz, 2017). Traditional transaction cost economics is concerned with how to minimize the cost of transacting goods and services between buyers and the firm. The logic behind the theory is that a firm only creates value from completed transactions, therefore the firm will maximize profits if actions leading up to a completed transaction are made using minimal resources (Williamson, 1979). Clarifying these potential efficiency streams, Grant (2015) introduces seven sources of cost advantages; Economies of Scale, Economies of Learning; Production techniques, product design, input costs, capacity utilization and residual efficiency.

The theories of *economies of scale* were first implied by Adam Smith who stated that division of labour and specialization are the two major factors that influence the productivity of production. Economics of scale occurs when the average cost of production is lowered by an increased output of goods or services. Central to the notion is the decrease in the unit cost of inputs. Input costs of e.g. raw materials could be lowered by bulk buying. Specialized costs i.e. investments of e.g. R&D, skilled labour, machines or equipment could be spread out on more units. Organizational inputs could be centralized such as e.g. sales, marketing or account to reduce per unit cost.

Henderson (2001) describes how Alfred Marshall in the 19th century discusses that there are internal and external dimensions of economies of scale, internal stemming from productivity increase within the corporation in the manner that was explained in the previous section. External, Marshall refers to changes in the context that the firm operates in, i.e. industrial ecosystem and geographical location. These changes in turn externally impact the costs of inputs, e.g. by tax cuts on certain materials or productivity increase by a supplier that would enable a lower input cost thus achieving economies of scale for another actor in the ecosystem. (Henderson, 2001)

Economies of learning do not depend on producing more quantity (scale) or a wider portfolio (scope), but from becoming a true specialist in a certain field, perfecting a process and consequently increasing efficiency over time. This notion implies that the time spent per unit of production is decreasing over time exponentially. The function can be portrayed as the learning curve on a time versus cumulative number of product basis, and an organizational overview on a direct unit cost versus cumulative number of production basis, which is then referred to as an *experience curve* (Henderson, 2001; Grant, 2015)

Process Technology and Process Design could be the source of significant cost economies. With the presence of lead time dynamics, it is however often only utilized on a system-wide scale (Grant, 2015). Toyotas system of lean production incorporates process efficiency work practices to reduce waste including just-in-time scheduling, pull-manufacturing, job flexibility, and supplier partnerships (Liker, 2004). *Designing products* for the ease of production instead of simply for the functionality and esthetics—can offer substantial cost savings, especially when linked to the introduction of new process technology (Grant, 2015).

In the short and medium term when capacity is fixed, variations in output cause *Capacity Utilization* to rise and fall. Underutilization equals lower output which means that the fixed costs of resources get spread out on fewer products, causing the marginal cost to rise. Pushing output beyond full capacity can also render costs in overtime payments, higher maintenance costs and shorter asset lifetime, and decreased quality (Grant, 2015).

Not all firms pay the same price for identical inputs. *Prices of input*, wages in particular, wary with location (Grant, 2015). Impact on input costs due to wages, particularly of very low skilled and highly expertise work, could be downsized with automation (Hawkins, 2013). Bargaining power in relation to the firm's suppliers might also help to mitigate the high cost of e.g. raw materials. Sources of bargaining power often relate to how interchangeable and critical the supplier and the supplied good is to production (Porter, 1980).

Finally, Grant discusses the excess costs that are done once the other factors are dealt with. *Residual efficiency* refers to organizational slack that occurs, often due to some kind of legacy, either an ageing workforce, legacy hierarchies or other organizational systems, or even a destructive corporate culture that creates unnecessary bureaucracy (Grant, 2015).

2.2.3 Focus

A competitive scope is a powerful tool for creating competitive advantage. A broad scope can render synergies and a narrow focus can add a competitive edge when catering to a small unique set of customers (Porter, 1985). A broad scope can resemble the theories of an *economy of scope* stating that the average total cost of a company's production decreases when there is an increasing variety of goods produced. The economy of scope gives a cost advantage to a company when it produces a complementary range of products while focusing on its core competencies (Panzar & Willig, 1981). The term is somewhat contradictive to that of Smith who advocates specialization to achieve scale, but the differentiating factor is the idea of synergies. Synergies could be achieved by e.g. sharing of resources two produce two similar products so that the product split the cost which would make it cheaper than producing the products separately. Synergies could come to be either to directly decrease costs as the example above showed, but synergies could also be revenue combining market channels enable greater revenue by combining business rather than separate. Other synergies could also be related to brand value, as in the situation of co-branding where both brands get a boost from the association between them (Schilling, 2016; Chartier, 2018). With the increasing digitalization, capturing synergies has become increasingly potent due to the integration of ICT into organizations and products, essentially to lower the cost of communication (Porter & Heppelmann, 2014; Williamson, 1979).

Synergies play a significant role in the technological innovation context. Schilling (2016) argues that when *network externalities* are present, one cannot only consider the value of the new product/service compared to the old. Network externalities exist when compatibility or interoperability between products is important. When there is a growing value of a single product with a growing total number of the same product, *installed base,* and when the product is dependent on complementary products, *complementarities* (Schilling, 2016). In markets with network externalities one need to add the individual value of the product with the value of the installed base and complementary goods available, a new differentiated product is only more valuable if it can achieve a higher combined value. The importance of complementarities is confirmed by other authors on value creation which also states that complementarities can be an equally important source of value creation as the core product (Amit & Zott, 2001) and means to value appropriation (Teece, 1986).

By selecting a narrow scope, or what Porter called *"Focus",* on the other hand, a company may be able to tailor the value chain to a particular target segment to achieve lower cost or differentiation. The competitive advantage of a narrow scope stems from customizing the value chain to better serve particular product varieties, buyers, or geographic regions. If the target segment has unusual needs, broad-scope competitors will not serve it as well (Porter, 1980; Porter & Heppelmann, 2014). Focus strategies are also becoming increasingly accessible as disruptive technologies are making customization of products and services increasingly cheaper (Porter & Heppelmann, 2014).

2.3 Sources of Value in the Industry

The industry which a company is a part of is made up of several other companies that perform different activities that create and refine products and services. Porter call this the *value system* but in line with other authors we will refer to this as the *value chain* (Petrusson & Heiden, 2008), and value is created and captured differently depending on the position in the value chain (Petrusson & Heiden, 2008; Osterwalder & Pigneur, 2010), which is why it the dynamics of the industry is important to understand in this, a study on IoT value. The other companies in the value chain provide inputs to the firm and use the firm's products and services to create value with their own value activities (Porter, 1980). What these inputs and outputs are is dependent on the vertical integration of the firm, i.e. how much the firm is performing by, optimizing and coordinating the connections, using the value others have created in an effective way, is another source of competitive advantage (Porter & Millar, 1985).

All in all, the industry bears a lot of similarities with the firm, it's made up of companies that each perform a set of activities which individually and all together create value. The positioning of the firm in the value chain and its vertical and horizontal integration affects the value creation of the firm.

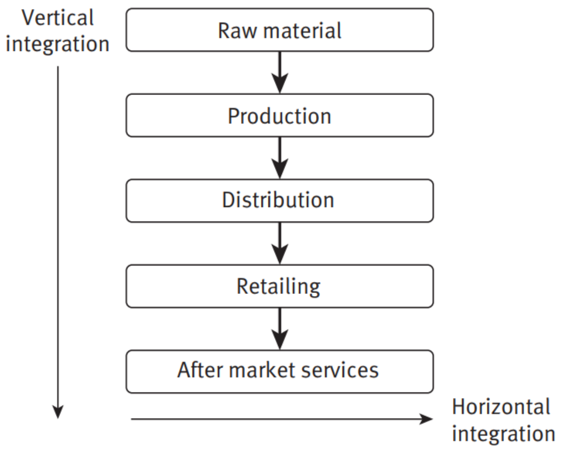

Figure 2: The Material Value Chain (Petrusson & Heiden, 2008)

Just like most technology progress was on the physical component of things during most of the industrial history; the physical component of the product was also the primary value unit transferred between sellers and buyers. With the increased importance of the information component, this can with the help of ICT becomes the primary value of a product. (Drucker, 1994)

This means that the value chain as previously described needs to be altered turned into what Petrusson and Heiden (Petrusson & Heiden, 2008) call the Intellectual Value Chain (IVC) seen in Figure 7 below. This model put emphasis on the information component but also that there are multiple ways to create products in which the physical component not necessarily is present. (Petrusson & Heiden, 2008)

Following on this, that one can easily exchange products and services that have a limited physical component, this allows for new industry constellations. A firm can now specialize further, focusing only on a specific part of the value chain like R&D or Distribution enabling competitive advantage through a new competitive scope, narrowing or widening e.g. it's vertical or horizontal integration (Drucker, 1994). The firm can also specialize even further, e.g. to only develop a small part of the technology needed for a product or service to function, collaborating with others. This is what Chesbrough calls Open Innovation (Chesbrough, 2003).

The increased importance of information, the lowered transaction costs and the enablement of non-physical products have created a need to alter the view of the industry. With the intellectual value chain, one can give such a perspective. Porter and Heppelmann (Porter & Heppelmann, 2014) add that the effect of the intellectual value chain is also that the boundaries of an industry become significantly broader, and with that, a significantly larger amount of actors have to consider each other's incentives in order to co-exist. Additionally, the increased possibility of specialization for the companies of the industry changes the industry composition and dynamic (Porter & Heppelmann, 2014).

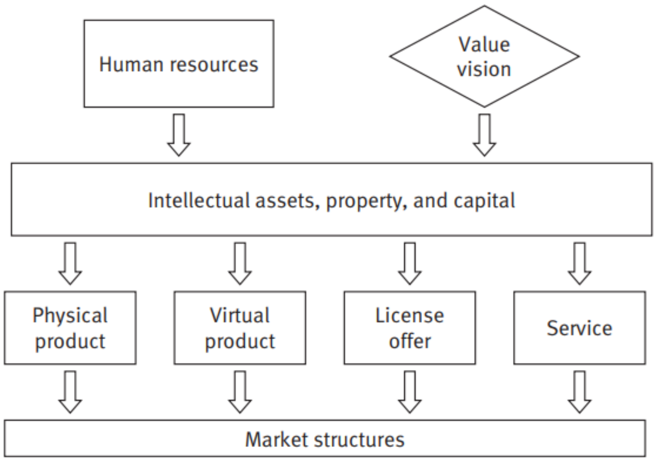

Figure 3: The Intellectual Value Chain. Source: (Petrusson & Heiden, 2008)

A crucial element of an intellectual value chain are license based transactions (Heiden & Andreasson, 2016). According to the same authors, two factors choose an appropriate licensee, patent exposure and ruling industry norms. Patent exposure refers to when a company is using a technology which is potentially covered by a patent, and since the study doesn't go into detail about what technology is used, merely general high-level function, this factor cannot be used to scope down the research. Additionally, due to its emerging nature, there are no established licensing norms in the IoT Industry just yet, however, because the telecommunication industry has both a central role in IoT (McKinsey Digital, 2016) and established licensing norms, there is a strong case to be made that the ruling licensing norms in Telecom will diffuse into IoT as well. Heiden and Andreasson (2016) explain that, in telecom licensing, the convention is to license on the end product level in the value chain. The reason is, that the value gained on the end-product level, is the best representation of the cumulative value of the technology.

Transferring the same approach is however not trivial, both due to the emerging state of the industry where no ecosystem has yet crystallized, and that a major part of IoT use-cases take place in industry settings and not in products sold but to use in internal value activities (Foresight, 2013). Moreover, there are also actors that create IoT products, similarly to handsets in the telecom industry, but which customers are other businesses. With this in mind, this study has implemented a terminology to describe these different roles: *IoT Providers* and *IoT Integrators*, this is visualized in **Error! Reference source not found.**. An IoT application carried out by a certain role in the value chain is what is defined as a use-case. The providers have similarities with the telecom OEMs while integrators can either use providers full solutions or combine IoT-elements themselves to create IoT units. An example of the latter is Ericsson's factory in Nanjing which attached connected sensors to their tools and in that way got benefits from IoT without selling the same units (Ericsson, 2018). Note that the same utility could be created by purchasing *smart tools* from the beginning.

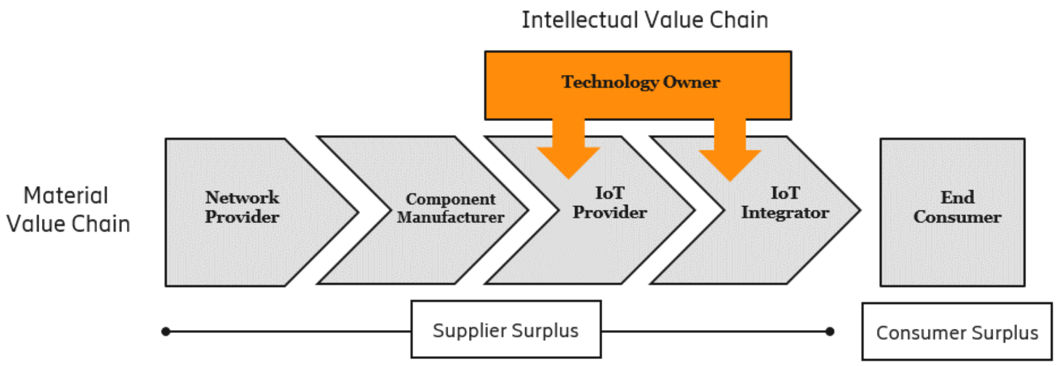

Figure 4: A schematic value chain and associated license logic adapted from Heiden and Andreasson (2016).

2.4 Creating Value through the Business Model

With the purpose of translating strategy into implementation, the blueprint on how to achieve a strategic position and operational effectiveness, these are references to the business model of the firm (Ehret & Wirtz, 2017; Andersson & Mattsson, 2015). The business models outline the mechanism from which the firm creates and captures value (Björkdahl, 2009; Osterwalder, et al., 2005; Amit & Zott, 2001). Coupling business models with strategy is necessary to sustain and protect your competitive advantage (Teece, 2010), which is why it is so critical to understand for each examined use-case in this study. The following section on business model representations is a good way of making sure that each element of the business model is examined properly.

The business model is a conceptualization and simplification of the concepts and relationships that describe what value is provided to the customer and how this is done. In short: How a company creates value. (Osterwalder, et al., 2005; Teece, 2010). Osterwalder et al. (2005) compared what previous authors on the subject had mentioned as critical parts of the business model and synthesized these into nine building blocks. These are categorized into four pillars: *Product*, outlining the value proposition; *Customer Interface*, including target customer segments and the channels and relationship the company should have with them; Infrastructure Management; highlighting the resources, activities and partners that a company needs to deliver said value proposition to said customers; and finally, *Financial Aspects*, that outlines the cost structure needed to realize and maintain the business model and the revenue streams which the business model seeks to capitalize on the value proposition (Osterwalder, et al., 2005).

2.4.1 Business Model Representations

A business model is not a financial or mathematical model, but something more tacit and conceptual which makes it sometimes hard to discuss (Teece, 2010). Building on their previous work, Osterwalder and Pigneur (2010) simplified the business model building blocks into the *Business Model Canvas* with the goal of making a generic discussion platform that could apply to all companies. It has become arguably one of the most popular representations of a business model, with more than five million users globally (Strategyzer, 2019). So much so, that e.g. Ching and Fauvel (2013) argues that it has transcended into the very definition of a business model. The categories with descriptions are as follows, with a visual representation in Figure 8 below (Osterwalder & Pigneur, 2010):

Customer segments – who is the value created for and who are the most important customers.

Value proposition – which offering creates value for a specific segment, what needs and problems are being solved and satisfied

Channels – the modes of communication and value delivery to the customer segments

Customer relationship – types of relationships established to maintain customers

Revenue streams – the way in which the value proposition is capitalized on

Key resources – the essential assets that enable the business model

Key activities – the most important actions needed for a successful operation

Key partnerships – the strategic alliances with partners and suppliers

Cost structure – the fundamental cost structure to realize and maintain the business model

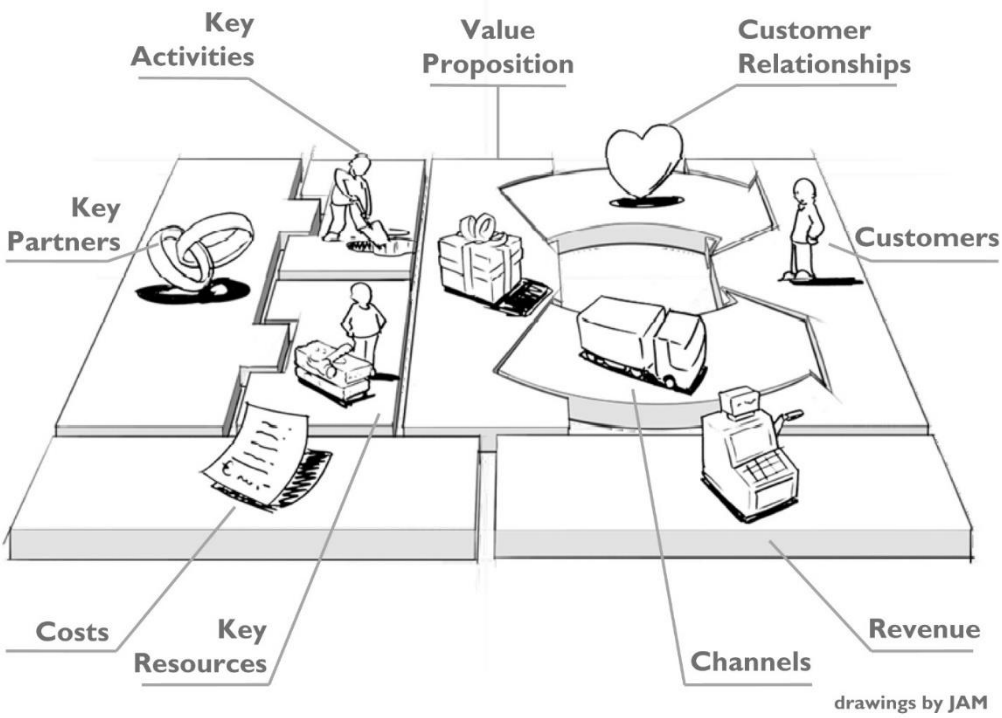

Figure 5: The picture shows a visual representation of the business model canvas. Source: (Instructables, 2019)

With its widespread use, there is also a broad body of criticism in the literature. In the aggregational study of the subject, Ching and Fauvel (2013) highlight the simplicity in use and the application spectrum as the model's core strength. The negative aspects are, however, that the lack of building block revolving around competitive advantage and positioning in a value chain was missing in the model (Ching & Fauvel, 2013). In this study, the business model canvas has been used because it resembles a structured definition of a business model. This is why, to strengthen the analysis with strategic implications of said business model, the theory section includes, first, a section on value chains, and second, a discussion of competitive advantage and strategy.

2.4.2 Business Models enabled by IoT

In relation to general business models which may be applicable in any situation, there are also business models that are extra relevant to investigate in the case of IoT commercialization or even enabled by IoT technology. These are of extra interest when stuyding value creation by IoT.

With the introduction of IoT, it becomes easier to change from selling products to service-based models, *Product-as-a-Service* and *Servitization* business models. Such models can increase revenue and create more predictable and stable cash flow as well as make it easier to perform maintenance and lock in customers (Foresight, 2013). Even if there is an increased interest for product-as-a-service now, they have however been around for a long time, one example is when Xerox started to lease out their printers and charging a small amount per copy a customer printed (Chesbrough & Rosenbloom, 2002). Ehret & Wirtz (2017) denote these types of services as non-ownership contracts and attribute their success to the fact that servitization let companies specialize further by moving the asset ownership risk from the user to the producer. This is in line with the discussion on Rolls-Royce's *power-by-the-hour* and that airlines don't want to make an initial investment in motors and then additionally for repairs and maintenance, that Porter and Heppelmann (2014) have.

Another business model that IoT enables is the possibility to aggregate product data and take advantage of the new insights that can be made when combining large datasets across e.g. an organization, *data-driven business models*. These business models may make local information, the form says the factory floor, available worldwide for others that can use that data in their activities. But the opposite is also possible, making worldwide data easily available to the internal processes (Ehret & Wirtz, 2017). This enables new products/services that are based on facilitating this link between different data repositories and insights based on aggregated data (McKinsey Digital, 2016). A well-mentioned example is TRUMPF's AXOOM platform that helps manufacturers to analyse their data (McKinsey Digital, 2016) another one is GE providing e.g. weather data to power plants for them to optimize generation (Ehret & Wirtz, 2017). According to Zaki et al. (2015), it is crucial for data-driven business models to consider the quality of the data according to availability, accessibility and integrity. These factors entail the size of available data sets, and the segmenting, categorization and other measures needed to access them. Finally, the usage of data could also be inhibited by integrity issues connected to information that could be considered private or personal (Zaki, et al., 2015).

Lastly, IoT is seen to drive business models based on *customization* and *personalization*, companies can more easily and to a lower cost provide a larger amount of variations to their products and consequently create more value for their customers (Foresight, 2013). One example of this discussed by Ehret & Wirtz (2017) is that as equipment can easily be controlled it can produce single or low amount batches of products. The control can also be on the opposite side, with products changing their functionality and/or aesthetics depending on who or where they are being used. Similarly, a seller can manufacture a large set of general-purpose products and then electronically determine their functionality and performance, like John Deere, is using the same engines in multiple tractors but artificially control the power (Porter & Heppelmann, 2014).

3 Method

This chapter outlines how the study has been carried out with the purpose of describing the different methodological considerations made and the appropriateness of these to fulfil the goal of the study. First, the abductive research strategy is laid out, followed by the considerations on epistemology and ontology describing the qualitative approach to the subject. Then, the choice of a comparative research design is put forward, unfolding the research process approach to data gathering. Finally, the strengths and weaknesses of the research quality of the chosen strategy and design are assessed and discussed.

3.1 Research Strategy

The research questions are formed as questions of *how*, suggesting an exploratory research strategy (Bryman & Bell, 2011). However, as previously mentioned there is not enough empirics or observations connected specifically to the case of IoT value creation, so there seems to be a need for the study to alter between theory and empirics. Hence, in line with the flexibility needed, the logic of this study should be abductive as shown in Figure 2. The nature of the abductive study could be characterized by two phases. The aim of the study was to gather insights on the use-case level which constitutes the second and final phase. Thus, the findings started on the broader *Application* level, constituting the first phase.

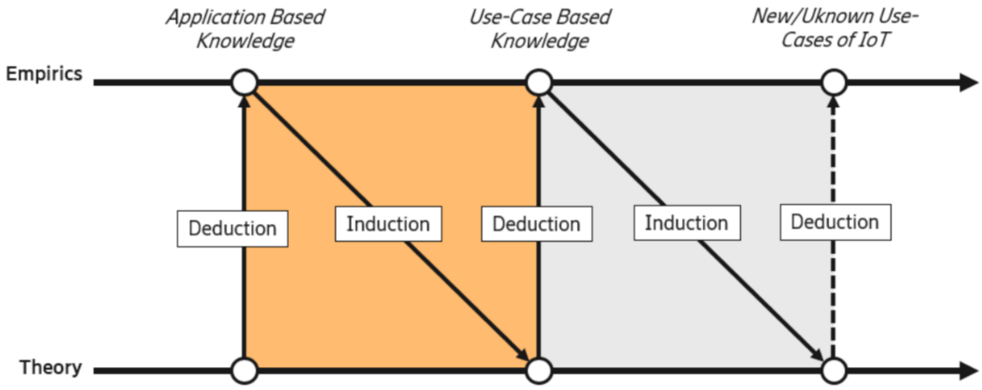

Figure 6: A schematic view of the abductive approach of the study. It was conducted in two phases, the first one focused on the broader Application Level, and the second on the more specific Use-Case Level as the study progressed, and the findings became more refined.

Ontology is the theory of how social facts exist (Searle, 1995). With Searle's reasoning, one should consider the lion share of the studied phenomena, such as technology and business, to be ontologically subjective. Thus, the ontological nature of this study will take a constructionist position (Bryman & Bell, 2011). Epistemology concerns the theory of knowledge, justification and rationality of belief (Searle, 1995). As technology is a subset of knowledge is subjective in terms of utility to the one in possession of it. Consequently, there is an interpretation of how to determine the value of a technology, it's dependent on the use and has no intrinsic value (Foray, 2004). In essence, this is why it exists several different valuation methods with different approaches to determining value. Hence, the core of this study is epistemologically subjective. However, the study also includes several concepts with clear objectivity, when asking experts on what IoT is, there is a broad consensus on several elements and what their function is. Moreover, concepts on value creation and capturing such as the business model and competitive advantage have widespread diffusion in industry and academia. Hence, there are also clearly epistemologically objective concepts in the study. In summary, the concepts of the study are more objective while their relations are more subjective with an epistemologically lens, the difference between both is merely a matter of degree (Searle, 1995). Consequently, this implies a need for taking an interpretive approach to the research.

Reflecting on the above, the value could have both quantified and qualitative nature, the value may have a distinct quantifiable nature such as in monetary terms. However, it has also been established that an interpretive approach is needed. Thus, when gathering data on value creation by IoT, the study applies a qualitative research strategy.

3.2 Research Design

Looking at the applicable ways of designing the research, there are several popular designs such as case studies and cross-sectional design. The strength of a case study is the in-depth understanding of a phenomenon in a particular context, which would reflect the study aim of understanding how to successfully implement income-based valuations methods in IoT. The weakness of such an approach, however, would be the challenge of generalizing the results to contexts outside of the case. Since the purpose of the study was to develop a generalized framework applicable to multiple applications of IoT, the singular applications approach would be limiting. With this in mind, a comparative approach was more fitting, where multiple smaller studies were examined to understand the relationship between the different values created by IoT.

3.2.1 Research Process

With the purpose of understanding the value created by the use-cases of IoT and how it could be measured, a selection of use-cases has been carefully outlined and investigated. Since the object of study are sources of value by IoT, and the way which an actor is able to capture that value is through a change in business model (Björkdahl, 2009; Ehret & Wirtz, 2017; Amit & Zott, 2001; Magretta, 2002), the application study has in line with previous research (Björkdahl, 2009; Ehret & Wirtz, 2017) focused on the business model changes, the benefits that follows, and how the benefits could be measured.[3]

Mapping the value created by IoT through the business model, the role in the value chain plays a distinct difference as Ostenwalder et al. (2005) points to, and there should be no reason why this would act differently in a multi-technology ICT product like the ones featured in the IoT Value Chain (Björkdahl, 2009). Following this rationale, the time limit of the study and fulfilling the study context of licensing, the study have chosen to focus on the IoT Integrator and the IoT Provider as described in Section 2.3.

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[3] There is no agreed upon definition of a business model change (Björkdahl, 2009), so a definition has been developed for the purpose of this story. The Business Model Canvas by Ostenwalder and Pigneur (2010) has been applied to represent business model dimensions. The change to a dimension is then defined as any change made to the components, or the relationship in between them within each dimension.

Continuing with the description of how the application studies were chosen as part of the comparative design, a framework for analysing the entire scope of IoT needs to be manageable to serve the purpose of the study. Manageability is determined by being granular enough to gain insight on how use-cases differ from each other, however, the granularity also needs to be at a level of abstraction where every segment of the framework could be examined with an application study within the time limits study. The application studies have been selected to span the entire spectrum of IoT Applications as shown in Table 1. The applications studies consist of the application of technology, and the context around it, i.e. the industry, to give the full perspective of IoT value creation.

Table 1: This is showing the studies of the application that were conducted in the study, shown here in an application versus industry matrix. The goal of the study was to encompass all types of IoT, thus, one application of each type was selected for deeper in

Top Industries (Based on Revenue Potential)	Information & Analysis			Automation & Control		
	Tracking Behavior	Enhanced Situational Awareness	Sensor Driven Decision Analytics	Process Optimization	Optimized Resource Consumption	Complex Autonomous Systems
Manufacturing			Condition Based Maintenance	Remote Operations		
Energy & Utilites	Smart Meter				Smart Grid	
Healthcare		Remote Patient Monitoring				
Home Automation						Connected Lawnmowers

Almost all industries have applications spawning the entire spectrum (Ericsson, 2018) but in order to be able to compare different industries, a plurality of applications in different industries were picked for this study. Manufacturing, Energy and Utilities, and Healthcare where picked for market size relevance[4]. To encompass the final category in the automation and control spectrum, there was no application in the above-mentioned industries that had come far enough to have enough amounts of data. In order to accomplish the task of encompassing the entire IoT spectrum, an application from the home automation industry was selected with documented implementation and benefits. The following sections will detail the studies of the application by industry, beginning with an industry description and continuing with a more thorough study of the applications and the benefits created in each.

3.2.2 Research Method

In contrast to previous sections, this one is not about how the study is designed, but how the actual data collection technique. Initially, interviews were held with technology experts at a telecommunication corporation. The aim of these interviews was to gain further understanding of IoT technology in general and cellular technology particularly. Moreover, the interviews with business and IP professionals were similarly used to give introduction and further insights into valuation principles and technology licensing. The interviews were important steps in order to understand a corporation's business aim, how to create wealth and how the license discussion could help drive that.

[4] The market potential for ICT players in IoT by 2026 concludes that the share of revenue is as follows, *Manufacturing (18%)*, *Energy and Utilities (16%), and Healthcare (12%) making it the three biggest market segments* (Ericsson, 2018) .

Table 2: A list of conducted interviews and discussed topics. The name the company have been anonymized a replaced with a pseudonym. The name of the interviewee is represented by their role in their respective company.

Interviewee/Role	Company	Main Topic(s)	Secondary Topic(s)	Time
Commercialization Manager	Alpha	MF, PO, SDDA	VC, BM, PM	90 min
Engagement Manager	Alpha	EU, TB, ORC	VC, BM, SM, SG	90 min
PhD Healthcare Technologies	Beta	HC	VC, BM, RPM	60 min
Business Developer	Gamma	PO	VC, BM, FM, RO	60 min
Pre-Sales	Alpha	MF, PO, SDDA	VC, BM, RO, PM	90 min
Researcher IoT	Alpha	IoT	V, L	60 min
Senior Researcher IoT	Alpha	IoT	V	45 min
Pricing Director	Alpha	TL, TP	V, L	90 min
Business Developer	Delta	EU, TBA		60 min
CEO	Epsilon	ESA	VC, BM,	60 min
Innovation Manager	Alpha	CAS		60 min

During the main study, data was gathered with two main techniques: documentation and interviews. All of the following methods were present in the data collection across all application studies. Data was primarily gathered through: internal documentation (principles, routines, sales materials etc.), public case studies (business cases, and court cases), public company information (annual reports, marketing material etc.) and academic research (e.g. studies on the societal impact of a certain IoT application). As the study concerns IoT applications, the major part of the data is gathered from the firms that implement these applications and gain benefits.

This was nuanced by interviews with primary sources: industry actors that have experience with the implementation and the IoT business case or secondary sources; and IoT pre-sales, engagement managers and similar that have a deep understanding of the implementors business and situation as well as being experts in what the technology can provide. Due to the interpretive nature of the subjects of the interviews, the lack of existing observations and the knowledge asymmetry between the interviewer and interviewee, the nature of the interview was semi-structured to allow for some flexibility while still providing an area of focus. Information on what interviews have been held and their topic can be studied in Table 2**Error! Reference source not found.** and Table 3**Error! Reference source not found.**.

Table 3: Explanation of abbreviations used in Table 2.

	Primary Topics		Secondary Topics	
Industries	**MF**	Manufacturing	**VC**	Value Chain
	EU	Energy and Utilities	**BM**	Business Model
	HC	Healthcare	**CBM**	Condition Based Maintenance
Use-Cases	**TB**	Tracking Behavior	**RO**	Remote Operations
	ESA	Enhanced Situational Awareness	**SM**	Smart Meters
	SDDA	Sensor Driven Decision Analytics	**SG**	Smart Grids
	PO	Process Optimization	**RPM**	Remote Patient Monitoring
	ORC	Optimize Resource Consumption	**V**	Valuation
	CAS	Complex Autonomous Systems	**L**	Licensing
	TL	Technology Licensing		
	TP	License Pricing		

3.3 Research Quality Assessment

Lincoln & Gruba (1986) stresses the need for assessment of the validation of the data gathering. According to Bryman & Bell (2011), the data can be assessed upon four quality criteria's; credibility, transferability, dependability and confirmability. Additionally, Bryman & Bell (2011) included replicability and reliability into the dependability criterion, for the purpose of this study, replicability will be considered and discussed separately.

As mentioned, due to the setting in which the authors are conducting an internship parallel to the study, they are able to provide multiple and contextual examples and perspectives, however the reason for the study is that there are no current applications or adopted valuation principles for this specific case, which also is yet to have happened, and that could impact credibility. Also, the theoretical framework assumed to be accurate and appropriate for its purpose, is also difficult to validate and might impact the credibility of the data gathering as well as overall findings of the report.

One of the main objectives of the study is that the results should be applicable to multiple applications of IoT. Although the study is influenced by the setting in which it is conducted, the focus is on IoT technology as a whole and not specifically the contributions of any actor. This makes it likely that the study will be applicable to a large scope of settings in relation to IoT, i.e. it is a strong case for transferability.

The study concerns to some degree cases taking place in the future which means that some of the elements of the study will be hypothetical, e.g. projections around the value created in a particular application. The predictions of the future become more and more accurate the closer the future is; thus, dependability of the study can be said to vary depending on the element of study. The challenge for this study was, therefore, to establish a sufficient lowest level of certainty to observations on projections. To overcome this challenge, the study used cross-referenced observations with multiple sources and validated the findings using experts with different points of view.

As most of the data is collected in the public domain, this strengthens the replicability. However, the study is also based on a number of interviews, where there is a problem of fully capturing and storing the data from each interaction, this has a negative impact on the replicability of the study.

Finally, while there are numerous upsides to being situated at a telecommunications firm, a relevant setting for the applications of IoT technology since this enables access to expertise and data, there is obviously a risk of lacking objectivity, thus impacting conformability. The study has mitigated this by using external sources such as industry and IP experts to validate the findings as well as critically reviewed obtained data from the organization.

4 IoT Application Studies

In this chapter, we utilize the Business Model Canvas and the IoT Value chain model developed in the previous section to explore the spectrum of value creation by IoT using six application studies spread across four industries. To give sufficient context to each application, the industry will be elaborated at first, outlining the value chain and relevant trends. Each section will then dive into the value creation in each associated use-case, studied from the perspective of business model change in accordance with previous research.

4.1 Manufacturing

According to the UK Standard Industrial Classification of Economic Activities, the current definition of manufacturing is the following (Sir Mike Gregory, 2016):

"The physical and/or chemical transformation of materials, substances or components into new products. The material, substances or components are raw materials which are products of agriculture, forestry, fishing or mining as well as products and semi-finished products of other manufacturing activities."

This highlights a narrow approach to manufacturing focused on physical productions, and some recent trends view manufacturing as a broader range of activities in the value chain including e.g. R&D, design and distribution of service (Hawkins, 2013).

Here we aim to introduce two applications situated in the Manufacturing industry. First, the industry is elaborated upon, giving insight into what activities and hence roles different actors may take in the industry and drivers of change. Second, the Condition Based Maintenance application is defined, and the value creation described. Third and finally, the Remote Operation application and its value creation are elaborated on.

4.1.1 The Value Chain

This section aims at showing a schematic view of the IoT Value chain in Manufacturing. The different roles in the said ecosystem will then be outlines with the aim of defining the actors which will later be mapped in relation to value creation. While the different roles in the ecosystem might be distinctive, the industry has various degrees of consolidation and vertical integration depending on which vertical in manufacturing that is in focus. Using a framework by Foresight (Foresight, 2013), a mapping of the essential components of the Manufacturing value chain could be mapped out. Influenced by Ehret and Wirtz (2017) highlighting on actors that are involved in the IoT value creation.

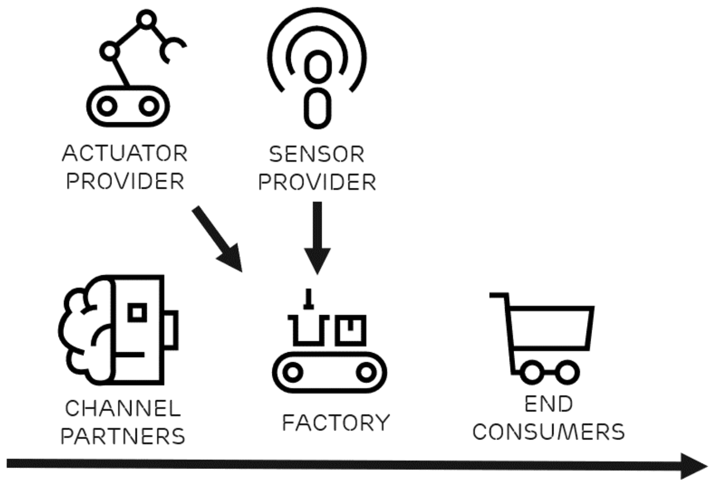

Figure 7 shows a schematic view of the manufacturing value chain. The roles have been trimmed down to fit the perspective of the Smart Factory and the relevance to the applications presented Source: (Ehret & Wirtz, 2017; Foresight, 2013).

4.1.1.1 Actuator Provider

An actuator denotes all types of components the automated system that drives movement and change. Contextually speaking for manufacturing, this means robots, lubing systems, laser-cutting objects etc. that translates machine to machine (M2M) communication into action. That is, actuators translate commanding signals into physical effects and change in manufacturing systems, such as moving robots, heating systems, or laser-cutting objects. The IoT builds on Internet-connected actuators, which enable often centralized operators to remote control the manufacturing process, and to conduct remote repair and maintenance activities. Examples of actuator providers include robotics manufacturers like ABB, Fanuc and Yaskawa. (Robotics and Automation News, 2018)

4.1.1.2 Sensor Provider

Smart objects create data about the status of manufacturing equipment and its context and work therefore as an information interface between physical devices and the internet. In Ericsson's Smart Panda Factory, ADI supplied motion sensors (Ericsson, 2018). Other notable sensor producers for Manufacturing include Bosch, Infineon, Broadcom, Texas Instruments and NXP. (MarketsandMarkets, 2017)

4.1.1.3 Customer

End customer in this regard is, in fact, the owner and operator of the factory who reaps the benefits of the IoT capabilities, improving factory performance in various ways.

4.1.1.4 Channel Partners

It is very common for factories to use 3rd party information system (IS), providers. In a study conducted by Rasmus and McKinney (2015), it was shown that a higher percentage of outsourcing to system providers resulted in higher productivity, margins and revenues. Broadly speaking, Banker et al. (2006) divide manufacturing information systems into three main categories, Operation Management Systems (OMS) and Electronic Data Interchange Applications (EDI), Resource Planning Systems (RPS).

EDI are those systems that improve the accuracy and timeliness of information exchange. These systems are in place to support joint decisions and development of products with external stakeholders. It means that applications include customer/supplier involvement in forecasting and management processes such as e.g. vendor managed inventory, condition-based maintenance etc. In the space of computerized maintenance management systems, you can find IFS, Emaint and Dude Solutions (Reuters, 2017).

OMS are those systems that control and monitor internal plant processes and workflows. OMS applications encompass manufacturing execution systems, connecting actuators, and product data management which applies analytical tools to sensor-derived data. These types of applications could also commonly be denoted a *digital twin* or *virtual factory* applications and include holistic actors such as Siemens (Camstar), GE and ABB. More niched actors in this category focus on e.g. automation such as Emerson, Rockwell and Honeywell (ABB also resides in this category with parts of its product portfolio). (Marketwatch, 2019; O'Brien, et al., 2017)

RPS enable integration and alignment between production and other functional areas. They provide the capabilities necessary to collaborate intra- and inter- sectionally across the firm(s). RPS encompass three classes of applications: ERP systems, which manage customer, product, planning, and financial data; advanced planning and scheduling systems, which provide decision support tools for supply chain management; and material requirements planning (MRPII) systems, which support production planning, and order processing. With the knowledge economy and the transition into viewing knowledge as a strategic resource e.g. (Drucker, 1994; Grant, 1996), RPS has also come to span knowledge management systems. This category is populated by actors such as SAP, Oracle, Microsoft globally and especially Visma in the Nordics. (Pang, 2017)

4.1.1.5 IoT Provider and IoT Integrator

Looking at the use-cases, it is also important to define the role perspective of value creation. As of today, it is the factory that collectively invests in the different components to produce an IoT solution. In this regard, the factory owner and operator could be seen as the integrator of the IoT. There are several contenders for the IoT Provider Role, and practically all actors back-end have some interface towards the IoT Integrator due to the complexity of the solutions (Alpha, 2019). Some argue that the future customer interface would be split between IoT Service Providers, operators and Networks providers as Cellular IoT gets more adoption in the market (Ericsson, 2018; Alpha, 2019). Operators like Tele2 have full-scale offerings towards manufacturers (Tele2 IoT, 2019), and Network Providers like Ericsson provide platforms to connect factories (Ericsson, 2018). However, the current fact of the matter is that a major share of the current IIoT use-cases is utilizing wired connectivity, which is usually provided by the actuator provider (Alpha, 2019). Providers, such as e.g. Honeywell, Siemens, ABB and Fiiix also offer software analytics to process data and carry out the use-case purpose (ABB, 2018; Honeywell, 2018)[5]. With the current state of the IIoT in mind, the actuator provider will, therefore, be considered as the IoT Provider.

[5] Fiix provide sensor and associated software for condition-based maintenance. ABB offers automated robotics, software for remote monitoring and operations, and industrial Ethernet networks (ABB, 2018). Honeywell and Siemens have an extremely wide portfolio in application software, production and assembly hardware, OT and industry ethernet connection.

4.1.2 Industry Trends

This section elaborates on the current trends in the industry to provide the reader with additional context and insight into the dynamics of the industry as well as value creation.

In a report to the Government Office of Science UK, Foresight (2013) suggests that the new era of manufacturing will be marked by highly agile, networked enterprises that use information and analytics equally skilful as they employ talent and machinery to deliver products and services to diverse global markets. A major part of the trends within manufacturing reverts to IoT with the connectivity being in the centre of growth drivers (Reuters, 2017). A study made by RT Insights (2018) projects that 64% of factories globally will be fully connected in 2022, compared to 43% today. Conversely, the use of manual processes in crucial manufacturing steps is expected to drop dramatically, from 62% today, to only 20% in the same time period.

Discussing the trend from a macro to a micro perspective, with major trends encompassing several sub-parts, one could start in the Industry 4.0. Focusing in on production use-cases, a sub-part of Industry 4.0 is Smart Factories that encompassed the two different use-cases Condition Based Maintenance and Remote Operations.

Categories	Market Size, 2018 USD Billions	Market Size, 2023 USD Billions	CAGR (2018 – 2023)
Industry 4.0	64	330	37%
Smart Factories	157	244	10%
Condition Based Maintenance	10 – 25	45	35%
Remote Operations	10 - 15	30	5% - 15%

Figure 8: A summary of the market sizes and CAGR of the two major trends in manufacturing and the use-cases associated.

The paradigm shift characterized by that virtual and physical system of manufacturing cooperate on a global level, enabling the total customization of products and services – is what the German trade and invest association (GTAI) coined in 2011, and what is now commonly denoted the fourth industrial revolution, or *Industry 4.0* (Schwab, 2016; Germany Trade and Invest, 2019). Contextually speaking, while the previous time period was focused on the optimization of individual machines and processes, industry 4.0 integrates clusters of machines and entire ecosystems of actors through end-to-end digitalization (PwC, 2018).

GTAI further adds that Industry 4.0 represents "the technological evolution from embedded systems to cyber-physical systems," an approach that "connects embedded production technologies and smart production processes." In other words, Industry 4.0 is a state in which manufacturing systems and the objects they create are not simply connected, drawing physical information into the digital realm, but also communicate, analyze, and use that information to drive further intelligent action back in the physical world to execute a physical-to-digital-to-physical transition.

The smart factory is a seamless flow of information across entire ecosystems unlock the full potential of other technology trends, robotics, augmented reality, 3D printing etc. to mention a few (PwC, 2018). Taking a more focused approach to industry 4.0, in a study to define the term *the Smart Factory,* Bilberg et al. (2014) articulate it as follows:

"A Smart Factory is a manufacturing solution that provides such flexible and adaptive production processes that will solve problems arising on a production facility with dynamic and rapidly changing boundary conditions in a world of increasing complexity. This special solution could, on the one hand, be related to automation, understood as a combination of software, hardware and/or mechanics, which should lead to optimization of manufacturing resulting in a reduction of unnecessary labour and waste of resource. On the other hand, it could be seen in a perspective of collaboration between different industrial and nonindustrial partners, where the smartness comes from forming a dynamic organization."

Putting the definition into context, it is the introductions of cyber-physical systems (CPS) in production that gives rise to the smart factory concept. Through CPS, the merging of virtual and physical worlds becomes possible through real-time quality, time, resource and cost advantages in comparison to classic production systems. (Germany Trade and Invest, 2019; Ericsson, 2018)

4.1.3 Condition Based Maintenance

Conditions Based Maintenance is the process of using sensor data and analytics to understand the optimal conditions under which to perform maintenance of an actuator, such as a machine, a tool, or an engine. These conditions balance the quality of output with potential downtime and asset life expectancy to optimize total productivity of said actuator, often from an entire system perspective. Thus, Condition Based Maintenance could be seen as *Decision Driven Analytics* in the application spectrum.

4.1.3.1 Condition Based Maintenance Integrator Value Creation

Condition-based maintenance (predictive maintenance) could be modelled as *productive maintenance*. **Error! Reference source not found.** below shows the relationship between the production process and the changes in profits. What can be shown using this model is that an increasingly productive maintenance process directly impacts the production process efficiency and effectiveness which in turn has an impact on firm profits.

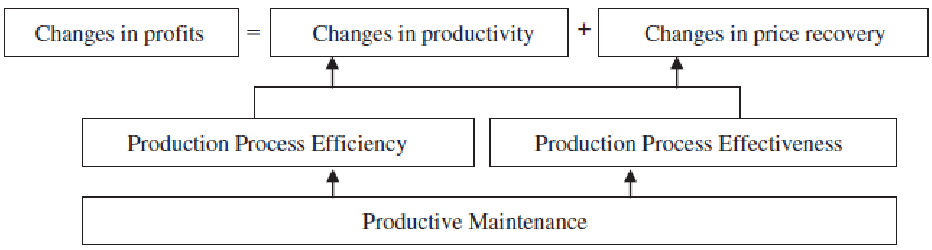

Figure 9: A schematic relationship between changes in profit and changes in maintenance productivity. Source: (Bilberg, et al., 2014)

Examining and evaluating material from academic case studies, industry reports, marketing materials, websites, annual reports, and interviews, the study found beneficial business model changes in three dimensions; Value Proposition, Key Resources and Key Activities.

4.1.3.1.1 Value proposition

With an optimized maintenance routine, production machines will have an average increase in performance. Several sources, including Billberg et al. (2014) suggests *product price could be increased* due to increased quality of the product and the company goodwill from higher customer satisfaction.

4.1.3.1.2 Key Resources

If resources, i.e. the actuating machine will be used more through more productive maintenance the effect would be increased effectiveness on the actuators, thus yielding higher utilization (e.g. less unplanned stoppages, better product quality, less short stoppages, etc.). This will decrease the fixed manufacturing cost per unit and thus impact profit. Furthermore, because the maintenance is better tuned to the needs of the machines, they will on average have improved performance and endurance.

4.1.3.1.3 Key Activities

Somewhat implied, the maintenance process in itself will be improved in the sense that it will happen at the exact right time in relation to the machine flow and under the right conditions in relation to the resources as previously explained. Better maintenance activities would have an impact on *total manufacturing cost* due to the e.g. reduction in spare parts inventory, less buff and work-in-progress costs, fewer product liabilities claims, etc. (Ericsson, 2018; Bilberg, et al., 2014)

IoT Integrators are also not shy of telling the world that they are using IoT Solutions, and the intent seems to be two folded. One, there seems to be a need to communicate to customers, but also to owners, that they can be seen as "future-proofed" and "sustainable". An important part from a marketing perspective, specific to condition-based maintenance as a part of the IoT applications spectrum, is that better maintenance in part leads to fewer costs, fewer scarps and longer lifetime. These factors can shape a sustainability argument that can be used for marketing and branding purposes. (Briodagh, 2016; Foxconn, 2019; Alpha, 2019)

4.1.3.2 Condition Based Maintenance Provider Value Creation

This section concerns the value created by a provider of condition-based maintenance products and/or services. The study found beneficial business model changes in five dimensions; Customers, Value Proposition, Customer Relationships, Key Activities, and Revenue Streams.

4.1.3.2.1 Customers

While IoT Providers's customer segments for their actuators hasn't changed, a broader product portfolio and an increasing presence of communication standards, there is a possibility to extend the complementary product and service offerings beyond the regular customer base.

4.1.3.2.2 Value Proposition

With connectivity, IoT Providers will be able to differentiate its offering with an optimized routine for maintenance and an IoT branded solution. Knowing the conditions of each machine, maintenance time could be optimized based on output requirements, machine conditions and other time constraints. These additional services and brand associated advantages differentiate an actuator from a non – connected one, driving revenue through their main product sales, on-top-services and complementary products such as maintenance analytics. In some cases, the data can be agreed to be shared with the IoT Integrator, driving additional revenues as a complementary product.

4.1.3.2.3 Customer Relationships

A broader portfolio offering infused with service-based business models enables a more intimate and longer lasting relationship with customers. From the traditional customer-supplier relationship, the IoT enables a relationship model more resembling a partnership with bidirectional feedback loops and joint development efforts. These new intricacies of relationships require significant investments from both parties, with a long-term scope of return, meaning that service contracts lifetime is prolonged, which in turn creates lock-in effects.

4.1.3.2.4 Key Activities

As much as the brand advantages of enabling IoT is a part of the value proposition to its customers, IoT Providers are also happy to utilize their connection to IoT through statements as “Innovative” and “Thought Leading”. The intent is to impact the customers and owners, enhancing the goodwill of the company.

The servicing costs are often included in the price of the actuator, and with an optimized routine, the maintenance requirements are kept at the minimum which in turn decreases the cost of maintenance and service for the IoT Provider.

4.1.3.2.5 Revenue Streams

Connected actuators provide the opportunity for new service-based revenue models, so-called performance contracts. These models are, much in line with what Ehret and Wirtz (2017) see a non-asset driven opportunity, or what is also known as servitization (Foresight, 2013). Servitization enables companies to switch to a subscription-based payment structure with a single fee for the service of having their actuators up and running as much as possible. The result is a much more stable cash flow for the IoT Provider, as apart from the one-off significant income from the selling of actuators (Foresight, 2013; Siemens, 2018).

4.1.4 Remote Operations

Manufacturing is essentially a bundle of resources refined through a production process using energy, labour and machines to create a product and/or service. Remote operations of a manufacturing line are essentially a case of automation offsite, meaning a process is automated partially with an operator that can control an actuator remotely from an unlimited distance. In the application spectrum, detangling the operator from the actuator allow for the optimum usage of both the actuator assets and the human resources, thus enabling *process optimization*.

4.1.4.1 Remote Operations Integrator Value Creation

Bridging the limits of human operators is essentially the value that an integrator of remote operations could expect to gain. Examining and evaluating material from academic case studies, industry reports, marketing materials, websites, annual reports, and interviews, the study found beneficial business model changes in three dimensions; Value Proposition, Key Resources and Key Activities.

4.1.4.1.1 Value Proposition

Using more skilled labour that does not get exhausted as easily could improve quality. Primarily, this could lower scrap rates and lead times and increase fill rates and yield. A more optimized quality process could lead to a better quality product with fewer defects and recalls. Thus, this could lead to either a competitive edge for the client impacting revenue through price increase or volumes sold. (Deloitte, 2017; RoI International, 2019; Park & Lee, 2016; Lampela, 2015)

4.1.4.1.2 Key Resources

Automation through remote control enables to utilize your resource, employees as machines in a more productive manner because you can detach them from each other. This would translate into lower asset downtime, optimized capacity utility, and reduced changeover time. This will have a direct impact on production efficiency. Higher productivity on resources means less waste and investments in new equipment, which has a positive impact on the environmental footprint. Also, remote operating operations could enable automation of some processes that are fatiguing and distressing which could harm employees in the long term and reduce their employee satisfaction. Conversely, the operation remotely could isolate the most intriguing assignments which could enhance employee satisfaction. (Deloitte, 2017; Alpha, 2019)

4.1.4.1.3 Key Activities

With the enablement of working remote, relocation of staff would go down, decreasing the number of transported miles by the company which would have a positive impact on their environmental footprint. [6] This, in turn, could have a positive impact on the goodwill of the company, which could lead to a higher demand spawning a greater output and/or higher price. Remote operations would also keep employees out of potentially dangerous environments and/or human errors that could cause harm to employees. (Deloitte, 2017; Park & Lee, 2016; Lampela, 2015; Boer, 2019)

Autonomy at least in part, as is the case of remote operations, is a question of optimizing processes. Primarily, the main idea behind remote operations in the cost spectrum is to increase the efficiency of the labour force. This, in turn, would also lower the administrative costs of staffing as employees could seamlessly relocate. Secondarily, an optimized process could also render lower costs through more predictive inventory requirements and reduced process and operations variability. Tertiary, a better-quality product would also lead to lowered warranty and maintenance costs for the finished products. (Bartodziej, 2017; Deloitte, 2017)

4.1.4.2 Remote Operations Provider Value Creation

This section concerns the value created by a provider of Remote Operations products and/or services. The study found beneficial business model changes in four dimensions; Value Proposition, Customer Relationships, Key Activities, and Revenue Streams.

4.1.4.2.1 Value Proposition

By adding sensors, controlling capabilities software and connectivity to their actuators, IoT Providers could offer real-time operations of their machines to their customers. As suppose to a non-IoT enabled machine, a remotely operated machine could create several cost, safety and sustainability advantages that differentiate the machines and extend the product and service offering, ultimately driving revenue through complementary products and services. Similarly, to other IoT use-cases, a part of the value proposition is to offer an IoT brand component, and specifically for remote operations, a crucial component is the “automation” and “safety” components. An additional value stream can also be that the collected data from the sensors can be of value for the process owners, i.e. the factory owner and

[6] A situation where this problem becomes evident is when the labour is scarce and the manufacturing sites are located in remote areas such as in the Oil & Gas industry. (ABB, 2018)

operator. The process owner could use this data to monitor other equipment, and in some cases, optimize the process as a whole. The data could e.g. be used to produce exercise material for operators or be used to observe quality issued with the products. This could either drive revenue separately or as differentiating service in the existing offering. (GE Aviation, 2019; Honeywell, 2018; Gamma, 2019)

4.1.4.2.2 Customer Relationships

Since the IoT Provider moves from only providing actuators to now providing software that partially automates the use machine and directly controls the interface with the operators, the relationship becomes much more intricate with a more extensive knowledge sharing between parties. This level of intricacy typically requires longer setup periods and greater investments, but with an increasing return to the integrator, thus creating lock-in effects to the Provider. (GE Predix, 2018; Gamma, 2019)

4.1.4.2.3 Key Activities

The data gathered on the machine could help IoT Providers understand how their machines are being used, which, as mentioned, have a positive impact on their R&D to enable quicker and cheaper updates, the impact on the IoT Provider's operational model however, is that shorter development cycles with the continuous data flow enable a more flexible development of their products and services. (GE Predix, 2018; KoneCranes, 2018; ABB, 2018).

4.1.4.2.4 Revenue Streams

The revenue model for IoT Provider of Remote Operations capabilities will switch more and more into a service-based model with additional services complementary to their legacy product. A broader product portfolio diversifies and stabilizes their revenue streams, especially since service-based models are reoccurring constant revenues. (ABB, 2018; Gamma, 2019)

4.2 Energy and Utilities

Commonly, Energy and Utilities denote all activities involving refining and delivering energy, water and other basic utilities to the consumer (Investopedia, 2018; PwC, 2019). With this chapter, we aim to give an introduction to two applications situated in the energy and utility industry. First, the industry is elaborated upon, giving insight into what activities and hence roles different actors may take in the industry and drivers of change. Second, the Smart Meter use-case is defined, and the value creation described. Third and finally, the Smart Grid use-case is defined, and the value creation is described as well.

4.2.1 The Value Chain

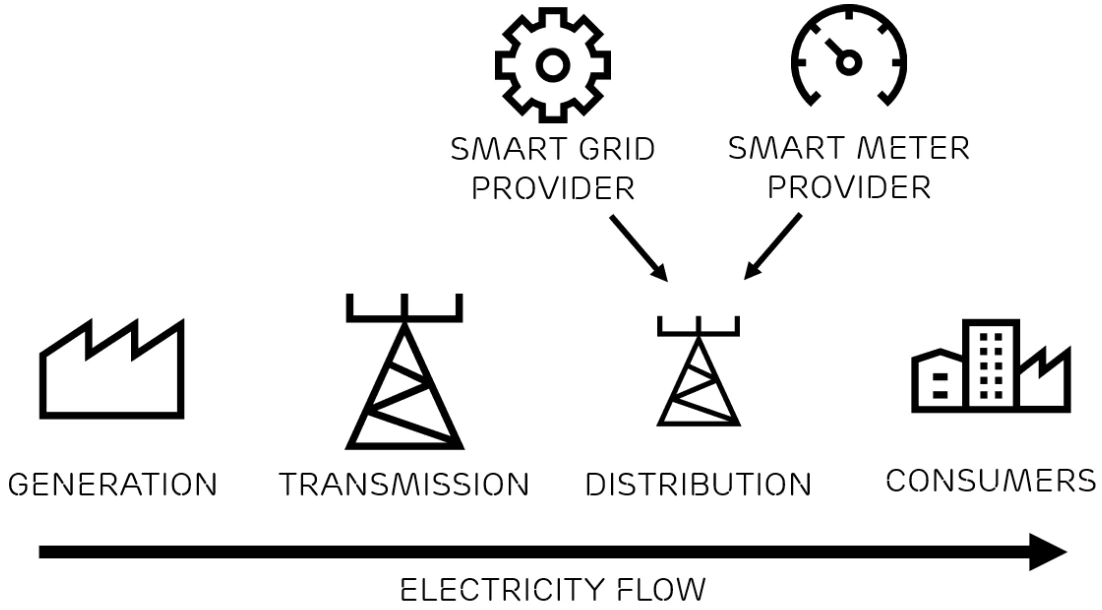

Figure 10 The energy industry consists of different roles regarding generation, transmission, distribution and consumption of electric energy. But also, the component suppliers that manufacture the equipment needed to perform these actions. Adoption of the Office of Gas and Electricity Markets (2016).

Understanding the industry starts with understanding the path of electricity which is visualized in **Error! Reference source not found.**. Starting upstream with the Generator role, these companies own and manage power plants that create electric energy, electricity. The main sources are Coal, Nature gas, Oil, Nuclear and Hydropower, but more small-scale resources like wind and solar power exist as well. The electricity is then transported to the consumers by the Transmission and Distribution companies that manage the network that connects the generators and the consumers, the power grid. Transmission is the high voltage long-range network that connects different regions while distribution is the low-medium voltage network the last kilometres between the transmission grid and the consumers. (Office of Gas and Electricity Markets, 2016)

Actors in this industry are often locally anchored with no global actors in that sense due to the natural monopoly characteristic of energy grids. Examples in the Nordic countries are E.ON. and Vattenfall which both own and manage both generation, transmission and distribution grids. However, these firms also need suppliers of equipment to perform their roles. In this case, we are specifically interested in the suppliers of Smart Meters and Smart Grid products. Major actors in these markets are Landis+Gyr and Itron; and ABB and Siemens respectively (Markets and Markets, 2018). Software offerings that is being offered and used by the previous mentioned actors are relatively young and have an emerging market structure where the traditional actors are being challenged by traditional large general management software systems firms like IBM and Oracle and new startups that specialize in energy and utility software but also telecom operators and consultancy firms have showed interest in taking a piece of the market (Markets and Markets, 2018; Alpha, 2019).

4.2.2 Industry trends

To give the reader more insight into the industry dynamics and context, this section elaborates on the current trends in the industry, this is dominated by environmental enlightenment and the dilemma of current business models for energy providers.

Recent years, the electricity consumption in rich countries, such as those in the European Union and North America, have flattened out and even decreased (World Bank, 2014). This has come to question the business models of the Electricity firms which essentially sells energy by the kilowatt-hour (Patterson, 2019). It is not intuitive for these companies that reducing energy consumption is good for the society which most others are convinced of. In addition, the introduction of renewable sources of energy creates a push for a more decentralized energy grid where there is not only the large coal and nuclear power plants, but also for example small scale solar and wind plants that generate energy (Patterson, 2018).

One source of this push is the governments in these countries and their regulative power. They want to lower energy consumption since that would lead to lower CO2 consumption, as the main base of the power generation is made up of fossil fuels like coal (International Energy Agency, 2017). This is the same reason why governments invest and promote renewable energy sources (European Commission, 2017). But governments also want other societal actors to contribute to this shift. There is a thought that by enabling private small scale actors to sell electricity back to the energy grid, they would invest in renewable energy sources and speed up the conversion of the energy mix to become less fossil fuel based (The International Renewable Energy Agency, 2013).

To enable this transformation of the energy industry, from centralized and fossil fuel-based the European Commission (EC) (2019) believes that digital technologies are a key enabling component and have hence set up a goal of that 80% of all electricity meters should be replaced by smart meters by 2020. Article 20 A of the European Commission's *DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity* (2017) states:

> *"The metering systems accurately measure actual electricity consumption and provide to final customers information on the actual time of use. That information shall be made easily available and visualized to final customers at no additional cost and at a near-real-time in order to support automated energy efficiency programs, demand response and other services"*

This is in line with the purpose that the Department for Business, Energy & Industrial Strategy (2016) of the UK have stated in their plan on smart meter roll out. One should note that there are several additional reasons, such as competition and consumer benefits, to deploy smart grid technology from a governmental perspective.

4.2.3 Smart Meter

A *Smart Meter*'s main part is the meter for electric energy consumption (one can use smart meters for e.g. gas and water, but this case study only discusses electric energy), which is then combined with additional smart functionality. This smart functionality can be seen to consist of two parts, processing and communications, that enable the collection and delivery of metering data to a grid operator (The

International Renewable Energy Agency, 2013). Thus, smart meters are seen as *tracking behaviour* in the application spectrum.

4.2.3.1 Smart Meter Integrator Value Creation

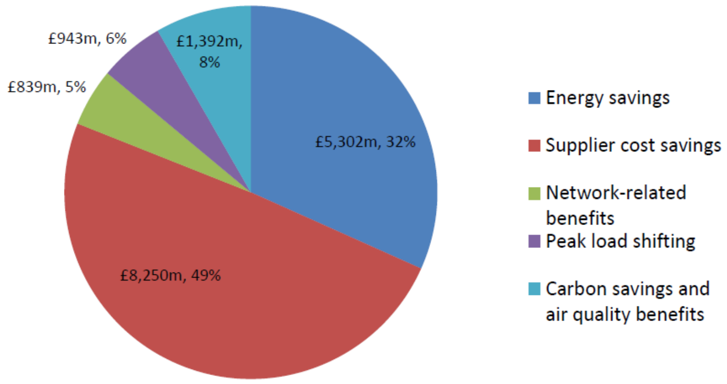

Figure 11: Smart Meter benefits in Great Britain, 2016 cost-benefit analysis. (Department for Business, Energy & Industrial Strategy, 2016)

According to Leysen (2018), the two most important benefits when installing smart meters are a reduction of so-called non-technical loss and metering expenses. The Department for Busines, Energy & Industrial Strategy (2016) calculated the two largest post of the present value benefits of smart meters to be Energy Savings and Supplier cost savings, see **Error! Reference source not found.Error! Reference source not found.**. In this figure, both non-technical loss and metering expenses are part of Supplier cost savings, while Energy savings are savings made by consumers. A typical supplier is the Distribution Network Operators who manage the Distribution grid which connects the consumers to the Transmission network.

Examining and evaluating material from academic case studies, industry reports, marketing materials, websites, annual reports, and interviews, the study found beneficial business model changes in three dimensions; Value Proposition, Key Resources, and Key Activities.

4.2.3.1.1 Value Proposition

As meter readings become faster and cheaper it makes for better billing and a faster and simpler process to change retailing company. This simplifies things for consumers which increase customer satisfaction and lower customer complaints. The retailing firm E.ON reported a 60 % drop in customer invoice complaints after installing smart meters in Sweden. This lowered the cost significantly for customer service such as call centres (Leysen, 2018; Department for Business, Energy & Industrial Strategy, 2016).

4.2.3.1.2 Key Resources

The distribution companies' main resource is their distribution grid, connecting the consumers with a reliable energy source. However, the grid is subject to several kinds of disturbances, among them technical and non-technical loss. It has been estimated that globally about 8 % of energy is lost due to non-technical issues (Christie, 2017), a Northeast Group study (2017) calculated the cost to $96 billion worldwide. Non-technical loss is when energy is lost due to unnatural reasons, things not caused by the grid itself. These can be faulty meters or theft of different kind (Navani, et al., 2012). Either actor bypassing or manipulating the meters, or even bribing the personnel making the readings. By installing meters that are connected and more or less continuously measure the energy consumption one can observe and avoid many of these losses, saving large amounts of energy and increasing the utilization of the grid (Leysen, 2018; Navani, et al., 2012; Department for Business, Energy & Industrial Strategy, 2016).

4.2.3.1.3 Key Activities

On the other hand, distribution companies also have to measure how much energy is delivered to consumers. Previous electricity meters measured energy consumption, but service personnel need to visit all metering sites to take notes on the consumption. This is required for every billing period when changing retailer and in some customer service cases (Leysen, 2018). When the readings of the meters can be done remotely, one can significantly decrease the labour cost in visiting sites and making manual readings (Department for Business, Energy & Industrial Strategy, 2016). The remote metering also eliminates most faulty readings increasing accuracy when billing consumers.

4.2.3.2 Smart Meter Provider Value Creation

Taking the perspective of the Meter Vendor, there are several ways Smart Meters create additional value. The study found beneficial business model changes in three dimensions; Value Proposition, Customer Relationships, Key Activities.

4.2.3.2.1 Value proposition

First, there is the partially new market of smart meters compared to the older non-smart meters as they are more attractive to customers (see Section **Error! Reference source not found.Error! Reference source not found.**). These allow for the price premium over conventional meters and opportunity to take a larger market share if one can create a position with a stronger competitive advantage. Second, with meters are being monitored remotely one need to distribute this data to IT systems of the electricity distributors (Landis+Gyr, 2019). This is an attractive role for metering firms as they have designed and deployed the meters and can since relatively easy expand their service offering with complementarities that synergize with previous products.

4.2.3.2.2 Customer Relationships

When moving from a business model, focused sale of a product, to a business with continuous services, as discussed in Section **Error! Reference source not found.**, there is an impact on the relationship with the customers. Going from a relationship with short and little interaction with the buyer to a more long-term relationship, servitization, one can create a more stable revenue flow and increase customer lock-in for further revenue potential, see Section 2.4.2. However, full *Metering-as-a-Service* is not likely to occur on some markets due to industry-specific regulation of natural monopolies that encourage large investments since this is the basis for how much profit the distributors can make (Alpha, 2019).

4.2.3.2.3 Key Activities

An additional benefit occurs for meter companies which provide a service of deploying the meters when a distributor purchases a large number of meters. Included in this service is often to ensure that all meters work and measure correct data, with smart meters it becomes easier to make this troubleshooting and quality inspections. (Alpha, 2019)

4.2.4 Smart Grid

In general, a smart grid is understood as a collection of technologies that enable increased efficiency and flexibility of an electricity system's operation. When controllers and sensors in both power plant's, grid's and consumers' equipment are connected they can synergize and create large benefits for all actors in the industry. Consequently, both resources, collectors, controllers and assessors are part of the smart grid, see **Error! Reference source not found.**. (The International Renewable Energy Agency, 2013)

Figure 12 The energy resource generation, the data collection, the assessor and the controller communicate with each other and are the main functions constituting a Smart Grid (The International Renewable Energy Agency, 2013, p. 21)

In the application spectrum, the smart grid can be considered an *optimized resource consumption* since it concerns the optimum managing of a scarce resource (electricity).

4.2.4.1 Smart Grid Integrator Value Creation

The Smart Grid Integrator role is more difficult to define than for example the smart meter integrator. This is since the Smart Grid is about connecting and digitizing major parts of the energy system, from the generation to the consumption, and this way optimize the whole system (The International Renewable Energy Agency, 2013). However, Transmission and Distribution is the middlemen connecting the generation and consumption making this role a central piece in this value chain (The International Renewable Energy Agency, 2013; Delta, 2019), and can hence be seen as the main Smart Grid integrator. This is the definition being used in this study. Examining and evaluating material from academic case studies, industry reports, marketing materials, websites, annual reports, and interviews, the study found beneficial business model changes in three dimensions; Value Proposition, Key Resources and Key Activities.

4.2.4.1.1 Value Proposition

The smart grid also enables renewables integration with smart inverters, switches and meters. This creates an opportunity for distribution companies to allow consumers (mainly commercial and industrial) to sell energy back to the grid from local production (The International Renewable Energy

Agency, 2013). Other smart grid technologies like smart inverters can according to IRENA (2013) increase power quality, adding to the value proposition. One should note that since the distribution is a natural monopoly, there are limited possibilities to use the integration of renewables to gain customers as they cannot choose their distribution company (Alpha, 2019; Delta, 2019).

4.2.4.1.2 Key Resources

With a Smart Grid, an integrator can get higher utilization of current assets and hence increase the value of current resources (Landis+Gyr, 2019; Svenska Kraftnät, 2017). For example, Demand Response (controlling consumption of customers to fit with energy supply) can give the same effects as building and operating an additional energy plant for peak hours or an energy storage facility and helps avoid outages (The International Renewable Energy Agency, 2013). Additionally, with more data on demand and supply one can forecast future needs better and make better-informed investments into the grid (Department for Business, Energy & Industrial Strategy, 2016; Leysen, 2018). The enablement of small-scale renewable energy generation creates an additional supply of electricity to distributors which also increases the capacity of the energy grid (The International Renewable Energy Agency, 2013; Alpha, 2019).

4.2.4.1.3 Key Activities

Distribution automation help distribution companies to better manage their distribution grid yielding higher efficiency and lowering maintenance costs (The International Renewable Energy Agency, 2013; Department for Business, Energy & Industrial Strategy, 2016). Distribution automation also increases reliability by lowering frequency and time of outages (Navani, et al., 2012), as the distribution companies can identify problems and reroute the electricity to the consumers faster.

4.2.4.2 Smart Grid Provider Value Creation

In similarity to the integrator role for smart grids, the provider role is not obvious either. However, with the distribution companies as the main integrator, the study will concern the suppliers (not energy supply but equipment) to these companies as the smart grid providers, this includes, for example, switches, inverters and transformers. The study found beneficial business model changes in three dimensions; Value Proposition, Customer Relationships and Revenue Streams.

4.2.4.2.1 Value Proposition

Firms manufacturing and selling the conventional versions of switches, inverters and transformers and integrate connectivity into their products can take a price premium due to additional functionality of distribution automation and demand response. There is also an opportunity to increase market share, either if one can be faster and better in developing these new products or if one can create additional services such as management software complementing the core offering.

4.2.4.2.2 Channels and Customer Relationships

New software-based offerings also introduce a new opportunity in additional channels to customers which enables the providers to have a closer relationship with their customers. This may create increased switching costs and help drive future sales and aftersales opportunities.

4.2.4.2.3 Revenue Streams

In addition to providing the connected elements to a smart grid, firms have an opportunity to expand their offerings, creating complementary offerings, into the management software and algorithms that are needed to create the effects that the distribution companies want, see ABB and Siemens offerings (ABB, 2019; Siemens, 2019). This creates new revenue streams and maybe an introduction to more servitization and continuous subscription-based revenues originating from activities originally has been performed by distribution companies. However, in similarity with the case for Smart Meters, non-ownership business models where smart grid providers own and service equipment for distribution firms is not likely due to the regulatory environment that controls profits of those companies based on investments made into the network (Alpha, 2019).

4.3 Healthcare

According to the Oxford Dictionary (2019), the healthcare industry denotes activities connected to professional care for the sick and injured. It is typically, in part, included in the Public Sector, or the services provided by the government to the people within its jurisdiction (McGregor, 1982). Here we aim to give an introduction to one application situated in the Healthcare industry. First, the industry is elaborated upon, giving insight into what activities and hence roles different actors may take in the industry and drivers of change. Second, the Remote Patient Monitoring Application is defined, and the value creation described.

4.3.1 The Value Chain

With the obvious enormous scope and complexity of the entire healthcare industry, this report has only focused specifically on the industry connected to the use-case in question, remote patient

Figure 13: A schematic value chain of the healthcare industry with a specific focus on remote patient monitoring. Source: (Henderson, 2014)

monitoring (RPM). There is a particular set of s.c. Non-Patient Monitoring (nRPM) which is an umbrella term referring to monitoring or communication tools that are specifically targeted towards relatives, friends or family of the caretaker (Henderson, 2014). Henderson (2014) outline the value chain in four steps shown in **Error! Reference source not found.**, from RPM Manufacturers, to Caregivers, Consumers and eventually the Patients.

The manufacturing column represents a wide variety of smart objects providers (sensors and actuators) and software providers, most of them with global reach. Typically, these two come integrated into one solution sold to providers that distribute them to customers. Manufacturers include Intel, Bosch, Philips, Alcatel Lucent, GE Healthcare, Medulan, Polycom, Viterion and

Honeywell. There are also a specific set of providers that provide nRPM solutions such as LifeStation, GrandCare and HomeControls. (Henderson, 2014)

Within the Manufacturing column, there is extensive collaboration needed to deploy a full-scale solution. The main driver for this is that the smart objects are often medical devices which are then in need of integration to work together with an RPM software solution. (Morrissey, 2014)

Depending on whether it is RPM or nRPM, the value chain usually looks a little different. RPM work through an upstream caregiver that provides the solution to an operative caregiver, denoted consumer, who then deploy to the patients. As far as nRPM are concerned, these typically sell directly to patients through an installation provider. (Henderson, 2014; GrandCare, 2019; GEHealthcare, 2019)

4.3.2 Industry Trends

Providing additional context and insight into the dynamics of the industry, there is an overall digitalization trend in the healthcare industry, and one of the first applications where early cases of remote patient monitoring through e.g. telephone care in the beginning of the century (Morrissey, 2014). Technology implementations are mainly focused on gathering data, support decision making and automate some of the more trivial caring procedures (Newman, 2019; Beta, 2019). In the epicentre of this change, RPM is one of the areas that have reached farthest in the otherwise slow implementation process that characterize the healthcare industry (Morrissey, 2014; BBC Research, 2017). The market for RPM is emerging fast with the global market for health self-monitoring technologies is estimated to grow CAGR 28.3% from US$20.7bn in 2017 to reach US$71.9bn by 2022. (BBC Research, 2017)

4.3.3Remote Patient Monitoring

A Remote Patient Monitoring (RPM) use-case involves using a smart object to track and monitor the conditions of a patient outside the conventional clinical setting. Applicable cases of remote patient monitoring include dementia and falls, diabetes, infertility, and congestive heart failure. (Wikipedia, 2019)

Error! Reference source not found. below shows a schematic architecture of an RPM solution that includes measurement devices, i.e. sensors. Usually, the solution also includes some type of medical hub with additional means of communication between doctor and patient, such as a smartphone, computer and/or printer/fax machine. Through some healthcare service, the data can be processed with input from doctors and stored within the Electronic Healthcare Record (EHR). (Vavilis, et al., 2016)

Figure 14: A schematic architecture of a remote patient monitoring solution. Source: (Vavilis, et al., 2016)

There is a particular set of s.c. Non Patient Monitoring (nRPM) which is an umbrella term referring to monitoring or communication tools that are specifically targeted towards relatives, friends or family of the caretaker. (Henderson, 2014)

On the application spectrum, RPM has been picked to denote the *enhanced situational awareness*, due to its combination of real-time updating of multiple data sources. Even so, some RPM application could fit into a range of categories of the information and analysis scale. Some use-cases of RPM involves some additional actuating functions that allow for controlling and communicative functions. As an example of this, an Italian hospital implemented a selection of motion sensors that monitored physical exercise for dementia patients since exercise has a proven medical effect on the condition, and in the accompanying app, the patient could display their progress and communicate with the doctor through text or voice. (Beta, 2019)

Similarly, adding analytical capabilities that could help the caregiving personnel and caregiving institution to process the data in either a descriptive, predictive, or prescriptive manner could further enhance the effects of implementing said use-case. An example of this is remote treatment of chronical diseases, where a selection of sensors can monitor the state of a patient on several parameters and based on analysis on the aggregated dataset, can provide the caregiver with suggestions of when or what treatment is needed, and alert an ambulance in case of emergency (McKinsey, 2015).

4.3.3.1 Remote Patient Monitoring Integrator Value Creation

There are two important consumer groups in remote patient monitoring, the patients and the caregivers, i.e. the medical institution with personnel. This section concerns the value creation by those actors, denoted integrators by this study. Examining and evaluating material from academic case studies, industry reports, marketing materials, websites, annual reports, and interviews, the study found beneficial business model changes in four dimensions; Value Proposition, Customer Relationship, Key Resources and Key Activities.

4.3.3.1.1 Value Proposition

One of the main benefits to the patients is that remote monitoring allows them to live and be cared for in the comfort of their own home as suppose to the conventional clinical environment. This is a particularly evident benefit in the case of chronical diseases (Bayliss, et al., 2003). Another evident case with the same characteristics is when patients are on particularly complicated self-care processes, with a high risk of failure. The patient and supporting families and friends feel a safety which further increases the perceived quality of care (QoC) (Center for Technology and Aging, 2010). In a recent study on dementia patients in Italy, who were remotely monitored, the patients reported that they had no problems with being monitored, but rather felt an increased safety. They also perceived an increase in social interaction with the doctor through the messaging application built into the monitoring system which said to increase the trust in the healthcare institution (Beta, 2019). The satisfaction rates and decreased mortality rates vary between use-cases but there are several reported pilots with increases in both. (Armaignac, 2018)

4.3.3.1.2 Customer Relationship

The relationship with the doctor as opposed to the normal caring model changes as they go from intensely personal interaction and less frequent communication model to a model with continuous updates and more casual remote communication. Interestingly, as stated previously, this is something that can render increased notions of safety and perceived quality of care.

4.3.3.1.3 Key Resources

For the caregiver, early detection of the conditions of a patient could decrease the number of emergency department visits, hospitalization rates, hospital stays measured in (length of stay). (Center for Technology and Aging, 2010) One pilot study found had produced a decrease in emergency room visits, and a decrease in rehospitalizations (Coye, et al., 2009).

4.3.3.1.4 Key Activities

The central idea to RPM is to change the caring activities in multiple ways. An important change in RPM is also that the communication change and instead of face to face meetings, it is now done remote through telecommunications. Communicating with the patients allow for cheaper communication in general, which allows for more communication and education (Vavilis, et al., 2016). Sampling is also done remote and to larger degrees which means that the medical personnel can increase their efficiency on site, and also limit their visits to when it’s really needed by the patient. All in all, the cost of care delivery could go down. (Johnston, et al., 1997)

4.3.3.2 Remote Patient Monitoring Provider Value Creation

The following sections will outline the business model with which the manufacturers of the RPM solutions use, in this study called providers. RPM solutions could be said to be disruptive since they completely change the business model with which caregivers deliver to their caretakers, improve the quality of care and reduce the cost of care simultaneously (Coye, et al., 2009). The incorporated IoT Technology in part might not be new, but the bundled solution is, and with the radically new business model, it can in summary mandate it to be categorized as radical product/service innovation. The study found beneficial business model changes in six dimensions; Customers, Value Proposition, Customer Relationships, Key Resources, Key Activities, and Revenue Streams.

4.3.3.2.1 Customer Segment

Because of the nature of the industry context, there was previously no market for this type of solutions since and the caring activities were conducted, either in the hospital or not at all. This, in turn, has created a completely new segment of customer is created which could be catered with RPM solutions.

4.3.3.2.2 Value Proposition

An RPM value proposition is, as mentioned based on providing value for two major stakeholders, Care Givers that could have decreased their costs and Caretakers who will experience better care. This is in turn what drives revenue for providers of RPM solutions.

4.3.3.2.3 Customer Relationship

Manufacturers are typically providing the full solution to caregivers (providers) which in turn require very close relationships since there are several hurdles to overcome in order to validate the solution (see also **Error! Reference source not found.**).

4.3.3.2.4 Key Resources

The main resource is the software that collects analyzes the data. Smart objects such as sensors are typically bought off the shelve and integrated in-house, many solutions often rely on existing connectivity infrastructure, smart objects and sensors. These solution providers also usually collect data that could help them improve their software. Even so, due to the private nature of the data, this is usually in the ownership of the caring facility, thus providing no additional value stream to the provider.

4.3.3.2.5 Key Activities

Costs are primarily based on developing, maintaining and validating monitoring application software. Depending on the disease and the complexity of the solution, clinical trials might be obligatory, which has an operative cost and an investment cost.

Even though manufacturers sell their solutions to providers, it is important to them to raise brand awareness towards end consumers i.e. patients. Some players deploy the s.c. "Powered by.." or ".. technology inside" model whenever there is a direct consumer interface. Being seen as a pioneer in the field and a thought leader is important, particularly in an industry where much emphasis is put on an evidence-based approach.

4.3.3.2.6 Revenue Streams

Since this is an emerging market with very few solutions in the market, there is not yet a determined revenue model to be seen in the industry (Lehoux, et al., 2014; Morrissey, 2014). However, there are in general two broad streams that have been identified, larger care facilities buy in one-time investments, which also includes a payment for a pilot study, and smaller facilities such as care centres buy on a subscription basis. (Coye, et al., 2009; Madden, 2018)

4.4 Home Automation

According to Hill (2015), Home Automation, or Demotics, refers to applications of IoT that is automating tasks and objects in the home environment. If said automation requires internet connection, the application could be seen as a part of the application spectrum for IoT. Here we aim to introduce one application situated in the Home Automation industry. First, the industry is elaborated upon with a focus on Lawn Movers, giving insight into what activities and hence roles different actors may take in the industry and drivers of change. Second, the Connected Robotic Lawn Mover application is defined, and the value creation described.

4.4.1 Industry Trends

The drivers in lawnmowing are undoubtedly automation, here we elaborated on the industry trends to give an extra context of the dynamics. The autonomous features of lawnmowers are improving continuously with enhanced communication with the environment around it through sensors and connectivity (Allied Market Research, 2018). Today the Robotic Lawn Mower market has an estimated size of $500 million and is predicted to reach $1,250 million by 2025 with a CAGR of 13 % (Markets and Markets, 2019). As hinted, robotic lawn mowers have recently been improved further by adding connectivity. When the lawn mower can mow the lawn by itself, additional benefits arise from being able to communicate with it remotely.

4.4.2 The Value Chain

The Home Automation industry comprises consumer electronic products such as home appliances that are being used in residential homes by consumers. This being a very large industry with an enormous number of different products, this study focuses specifically on the industry related to the chosen use-case, robotic lawn mowers.

Figure 15 The Connected Lawn Mower Value Chain (Research and Markets, 2019)

According to Research and Markets (2019), the value chain consists of Component Suppliers, OEMs, Distribution channels such as retailers, dealers and direct to consumers online, and lastly customers being both consumers and professionals. Among the OEMs there are two leaders, Husqvarna Group and Robert Bosch, they are however likely to be challenged by new entrants from neighbouring markets such as legacy lawn mowers, robotic vacuum cleaners and electric power tools. The last part of the industry vertical is dominated by consumers, middle-class households now mainly in Europe and North America but there is an increasing demand in North East Asia due to economic growth there (Husqvarna Group, 2018; Markets and Markets, 2019). Some OEMs may also outsource the development and maintenance of software needed such as smartphone applications. In their annual report, Husqvarna (2018) states that the trend within the industry is the higher speed of technological development, the shift from combustion to electric engines and a change in consumer values and behaviour with new digital channels.

4.4.3 Connected Robotic Lawn Mowers

In the following section, a robotic lawn mower with connectivity functionality is in this study denoted as a Connected Lawn Mower (CLM). On the application spectrum, CLM has been picked to denote applications within *complex autonomous systems* since it includes elements of autonomy and connectivity.

4.4.3.1 Connected Robotic Lawn Mower Integrator Value Creation

The introduction of connectivity creates benefits compared to a non-connected one for users of robotic lawn mowers. However, these users are typically end-consumers and not a company and consequently don't have a business model. There is some business to business initiative from actors in the industry, however, it is in such an early stage that it has not been considered in this report. A list of consumer benefits has been collected anyhow as these are what the CLM Provider's business model is based on. The list is based on marketing communication/information towards consumers (Google Play, 2019; Bosch, 2018; Husqvarna Group, 2019). These are clustered according to what type of value they create. The study found four dimensions of value; User Friendliness, Maintenance, Quality and Security.

4.4.3.1.1 User Friendliness

Users can remotely monitor and control the lawn mower with a smartphone, for example, turn it on and off, make it return home and see and change settings such as cutting height. One can also use voice assistants like Alexa enabling users to control the lawn mower via voice commands. With the app and voice assistants, one can also access statistics such as operation time, charging time etc.

4.4.3.1.2 Maintenance

With a connected lawn mower, users can update the lawn mower easily, essentially upgrading the functionality and quality leading to a prolonged lifetime of the lawn mower, decreasing the need to purchase a new one. Via smartphone apps, users can also troubleshoot and access remote customer services to help solve issues with the lawn mower. This can also make it easier to find the right accessories and replacement parts as one can be guided via the app on what parts that fit the machine.

4.4.3.1.3 Quality

By having autonomous scheduling connected to weather forecasts the lawn mower needs less cleaning and maintenance resulting in less work but also better grass cutting. This can also be combined with other home automation systems so one can avoid using the irrigation system and the lawn mower at the same time.

4.4.3.1.4 Security

The connection also increases the security of the lawn mower, users can track the lawn mower's position in real time and see where it is. Additional services to this are geofencing the operations of the CLM making it lock down when leaving the area, sending notifications to the owner, and needing authentication to start working again.

4.4.3.2 Connected Robotic Lawn Mower Provider Value Creation

The value proposition towards consumers has been gathered by examining the sales material published by a few OEMs on their websites. These have then been converted into insights in how they affect the business model of the OEM (Husqvarna Group, 2019; Bosch, 2018). The study found beneficial business model changes in four dimensions, Value Propositions, Channels and Customer Relationships, Key Activities and Revenue Streams.

4.4.3.2.1 Value Proposition

The connectivity gives the lawnmower an additional user interface via a smartphone app or voice assistant. Connectivity also enables security options like tracking and geofencing operations not available before. All of these enhances the product with increased functionality differentiating it from non-connected LMs, creating a stronger value proposition towards the consumers, driving revenue.

4.4.3.2.2 Channels and Customer Relationships

Integration with smartphone applications and voice assistants give an additional sales channel for accessories and spare parts when the system can suggest an order spare parts this adds extra revenue that would possibly go to non-authorized retailers, increasing product life, quality and safety of the product. It also is a way to build a stronger customer relationship, with potential to increase customer interactions/retention, adding complementary value through other services, brand awareness and lock in-effects.

4.4.3.2.3 Key Activities

With connectivity, the firm can push software updates and increase performance and utility of the lawn mower even after it has been shipped. Additionally, remote diagnostics may become available. These factors decrease the cost of having service operators or service centres and recall costs, compare with the automotive industry. Additionally, knowledge of how the lawn mowers are used increases R&D efficiency and effectiveness.

4.4.3.2.4 Revenue Streams

There is potential to innovate the business model of these firms, moving the ownership of the product from the user to the producer with a non-ownership business model. This is also referred to as selling “lawn care”-as-a-service and is possible due to the decreased transaction costs that can be enjoyed with IoT. Such servitization can increase revenue and create more predictable and stable cash flow as well as make it easier to perform maintenance and lock in customers.

5 Cross Application Analysis

This chapter outlines a cross-application analysis of the applications studies presented in the previous chapter. The analysis used the theories outlining value to deconstruct the sources of value in the application studies, answering the first and second research question. Hence, the first section will explore the difference in value across different application areas to answer the first research question. The second section will change perspectives, putting the sources of value in focus, and elaborate on the findings in relation to the second research question.

5.1 Sources of Value in IoT

In order to reach conclusions on the main research question, this chapter aims at answering the first subordinate research question of this study, namely:

How is value being created and captured by IoT use-cases?

Synthesizing the findings in the applications studies from the previous chapter, sources of value from each category in the competitive advantage spectrum emerge. As is portrayed Figure 18 the findings on the sources of value were distributed across multiple business model components (for additional details, please see **Error! Reference source not found.**). Considering Ostenwalder and Pigneur's (2010) grouping of business model components into four pillars, it seems as differentiation advantages were identified primarily in the *Product* pillar and *Customer Interface* pillar, while cost advantages were primarily found in the *Infrastructure Management* pillar. Considering their inherent properties, Ostenwalder and Pigneur's (2010) descriptions seems very similar to the theories of cost, e.g. (Williamson, 1979; Henderson, 2001; Grant, 2015), and differentiation (Teece, 2010; Mebert & Lowe, 2017; Amit & Zott, 2001). Considering that focus advantages have elements of differentiation and cost depending on the type of synergy that is aimed (Schilling, 2016; Porter & Millar, 1985) it is natural that business model changes associated with both differentiation and cost advantages are observed here.

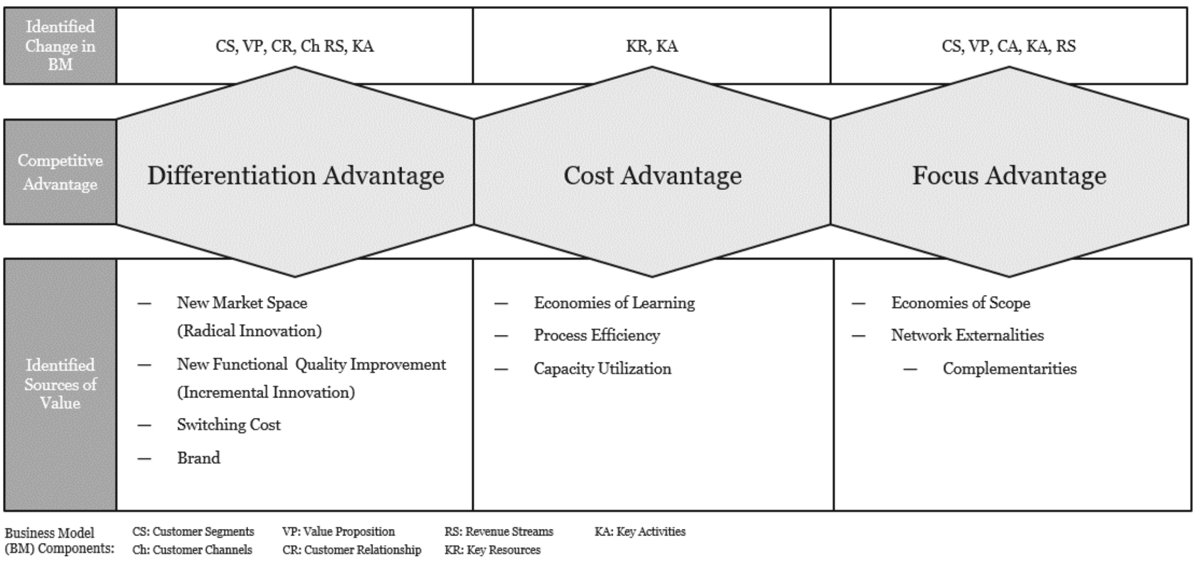

Figure 16 A synthesis of the findings of the Application Studies, showing the relationship between the Business Model Component and the Sources of Value that was identified in each category of competitive advantage.

The interconnection between the business model and the sources of value outlines the relationship between value creation and capturing in IoT. In order to fully outline *how* value connects to the nature of a use-case of IoT, the use-cases need further investigation. See how these concepts interconnect in Figure 19.

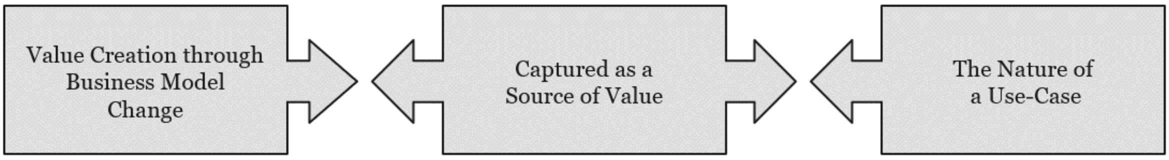

Figure 17 The connection between Business Model Change, Sources of Value and IoT use-cases.

The study has chosen the framework presented by Chui, et al. (2010) to segment use-cases into application areas, and the analysis starts with comparing application areas to each other, finding only minor differences. Secondly, a review of the use-cases across industries was made, showing major differences in adoption of IoT Business Models, seemingly stemming from different business norms and regulatory environments. Third and final, the different roles within use-cases are compared, where distinct differences in focus between differentiation and cost advantages as a source of value were discovered.

5.1.1 Source of Value by Application

The research explored six different application areas within two larger segments with the purpose of being mutually exhaustive. First, Information & Analysis with Tracking Behaviour, Enhanced Situational Awareness and Sensor Driven Decision Analytics. Second, Automation & Control with Process Optimization, Optimized Resource Consumption and Complex Autonomous Systems. Across the applications, major business model changes could be observed, but without any distinct differences between different applications. These findings imply that the IoT application fields does not impact the character of value creation or capturing.

All application areas showed significant business model changes that *differentiated* the products and services of the companies giving them a competitive advantage (Björkdahl, 2009). This change was seen in several ways, most pronounced in the value proposition, through additional functionality to existing offerings, and increased quality due to improved processes. Increased brand presence as a means for differentiation was present for the firms in all areas except Tracking Behaviour and Autonomous Complex Systems. Searching the definition of the application areas (Chui, et al., 2010), it does not explain the observation. Similarly, the use-case within Situational Awareness did not increase differentiation through new functionality to old products but through completely new market space, making it different in this aspect, showing a difference between radical and incremental innovation that is discussed by Schumpeter (1934). Also in this area, no increased switching costs were observed. This could be because of that there was no previous state from switching costs could be increased.

Similarly, all IoT applications had changes that gave a competitive advantage through *cost leadership*. Economies of Learning and Process Efficiency were benefits that IoT created in all application areas. Increased Capacity Utilization was however seen in all areas but Autonomous Complex Systems. However, Chui et al. (2010) to the contrary mentions that Complex Autonomous Systems increases the utilization of highway capacity by eliminating "phantom jams". Economies of Scale and Organizational Slack improvements were not observed in any of the application areas.

Ways to create competitive advantage through a *scope* strategy was observed in all application areas except Situational Awareness. In the other application areas, Economies of Scope and Complementarities was found giving scope benefits leading to a potential competitive advantage. The definition of the application areas gives no input on how scope relates to the applications (Chui, et al., 2010).

In addition to different ways to competitive advantage, *IoT enabled business models* was also observed across the application areas. Among them servitization was especially prominent, being mentioned in all application areas. Otherwise, it was found that both Sensor-driven Analytics and Process Optimization was impacted by Data-driven business models and Customization. The latter, customization was also present in Autonomous Complex Systems. The presence of servitization is according to Chui et al. (2010) expected in all IoT, why Customization and Data-driven business models are less prominent in some application areas are not explained. The difference might be explained by the maturity of the application area according to interviewees Epsilon (2019) and Alpha (2019) mentioning that at least in the monitoring category there was a hesitancy to monetize data at an early stage since you need considerable amounts and it needs to be managed and refined with a clear purpose to create value. These notions are similar to the challenges presented by (Zaki, et al., 2015), extensive big data management capability paired with clear monetization strategy is paramount to create value from data, and it requires an organizational maturity that the providers and integrators in this space might not yet possess.

5.1.2 Sources of Value by Industry

The application studies explored four different industries; Manufacturing, Energy and Utilities, Healthcare and Home Automation. Within industries, a varying degree of adoption to the IoT business trends could be identified which had an impact on value creation and capturing that could be identified. It seems that the adoption of IoT Business Models could be explained by the industry norms, primarily the regulatory space. Furthermore, differences in the disruptive impact of innovation were established across industries, which could be derived from industry maturity. These findings implied a distinct difference in value creation and capturing of innovation.

The Manufacturing Industry displayed the impact on several of the mentioned IoT business model trends, impacting the business models on both Provider and Integrator side. Both Integrators and Providers showed a beneficial business model change, particularly on resources and customer relationships that could be derived from implementing service-based business models. Similarly, both applications showed impact derived from being able to include data in the value proposition, in line with what Ehret and Wirtz (2017) discuss on the data-driven business model, although only on the provider side. Finally, some customization was identified impacting the Key Activities and Value Proposition, which is not surprising considering that e.g. Porter and Heppelmann (2014) mentions this as a trend is being driven adoption by companies in production. Considering the overall perspective in manufacturing, the results seem to be in line with theoretical propositions. Ehret and Wirtz (2017) mention that the manufacturing industry was the first to implement IoT applications due to an already established focus on measuring improvements. Furthermore, Foresight (2013) mentions that

Manufacturing is one of the fastest growing sections of IoT, and Ericsson (2018) highlights that Manufacturing is the IoT segment with the largest potential for ICT providers, implying that there is a well-established need that is vast and growing, implying that there is a further interest to explore new types of IoT enabled business models.

Looking to the Energy and Utilities industry, a few things stand out. First, there was a significantly lower adoption of IoT enabled business models identified. This does not appear to be in line with the logic of argument from in the previous section considering that the Energy and Utilities segment is large and growing fast according to Ericsson (2018). Some explanation could be found in the regulatory restrictions which to a large extent orchestrates the value capturing in the Energy and Utilities sector. According to e.g. McKinsey (2016), one of the main incentives to commercialize data is to make it available to other parties to analyse and provide insights for yourself, alternatively to benefit them in their business in some way. Because the energy consumption data, that characterizes the nature of the bulk of data in the industry, could be considered subjects to GDPR (Delta, 2019) and considered personal information, this put heavy restrictions on the possibilities to transact and share data (Alpha, 2019). This is also in line with the inhibitors to data-driven business models mentioned by (Zaki, et al., 2015). Additionally, the industry is also subject to a specific type of competition regulations due to that power distribution is a natural monopoly (Delta, 2019). Since servitization according to Ehret and Wirtz (2017), involves integrations across value chain roles trough non-asset ownership, and the regulations in for example Sweden are basing a revenue cap on among other things the asset base of the firm (Wallnerström, et al., 2017). This disincentivises the company to outsource ownership of assets to other actors (Alpha, 2019; Delta, 2019). A final reflection that can be derived from the industry-specific competition dynamic is the value sourced from Brands. Brands are a possibility to differentiate the product from the competition (Davis, 2009). Because of the partially regulated industry, companies basically have a monopoly and thus have limited need of differentiating themselves or their products from a non-existent competition, making branding a low reward investment and therefore not a priority to either request or offer.

Other industries seem to have similar issues to deploy data-driven business models, and from what the industry dynamics reveal, the problem might also be similar. If the energy consumption data could be considered personal data, it should be even more evident that data on health records are to an even more extent subject to GDPR (Beta, 2019). This could explain the lack of identified data-driven business models in Healthcare, an inhibitor that was also identified in the interview with Beta (2019). A unique factor to the healthcare industry was the presence of radical innovation, or new market space, as a source of value. Similarly, to how Mebert and Lowe (2017) discuss creating new market space, Remote Patient Monitoring (RPM) applications seems to show these characteristics by disrupting the entire caring model. With this in mind, and since the study couldn't conduct several application studies within healthcare, it is difficult to isolate whether this is an industry or application phenomenon. However, since Teece (2010), Souto (2015) among others identifies *radicality* as a significant delta between the distribution of value, and value activities, between the past and the present, it seems reasonable to consider this to be a firm phenomenon, and considering the broader value chain perspective, an industry phenomenon[7].

[7] This analysis was also expressed in the interview on Healthcare Technologies (Beta, 2019).

The Home Automation industry has an interesting difference from the others in the nature of it being largely business to consumer-oriented. This had a significant impact on the observations, firstly considering that the integrating role outlined the consumer benefits from deploying a connected lawnmower. This makes the roles and their relationship difficult to analyse from a business model perspective. The consumer involvement also might influence the ability to monetize data as the consumer integrity might act an inhibitor (Zaki, et al., 2015). The industry did, however, show some signs of implementing customization driven business models by customizing the value proposition through services in their app. This could in itself imply that there was at least some use of data on consumer behaviour and that the providing company could derive some value from data, even if it only could be monetized partly through another source. This notion could be reinforced by Porter and Heppelmann's (2014) argument that customization could only be enabled by some aggregation and usage of data.

5.1.3 Sources of Value by Roles in the Value Chain

The third and final analysis perspective concerns the impact that the role in the value chain could have on the sources of value, and some trends clearly emerged from the findings in each application study, where providers found their sources of value primarily in the differentiation space, while the integrator mainly sought their sources of value through cost leadership. Hence, the roles seem to be very different from each other in terms of value creation and capturing for IoT, implying that they outline the major difference from a value-centric perspective.

Beginning the discussion on the Provider side, the lion share of value could be derived from sources of innovation, by adding IoT functionality to their products to enhance the value proposition. Features were also implemented for a secondary reason for achieving a customer lock-in to their products and services. Given that these providers main object of business seems to be delivering IoT products to the market, it could explain why they primarily sought a differentiation advantage since it, according to Porter (1985) has the benefits of driving more revenue and profit through making products stand out from the competition. With similar reasoning, it is also not surprising to find lock-ins in the Provider's business models, since the benefit from these mechanisms is more frequently reoccurring revenues (Teece, 2010; Amit & Zott, 2001). Although the focus where on the differentiation side, most Providers sought cost advantages, with an emphasis on Economies of Learning and Process Efficiency. The two seems to be a source of value for key activities, particularly through a more efficient R&D process over time with access to data. This seems to be in line with how Henderson (2001) and Grant (2015) describe the main objective with economies of learning to over time become an expert on the value-creating activity and thus decrease the unit cost, in this case, R&D spend, over time.

A final characterizing attribute of the Providers in relation to the Integrators was an emphasis on Scope advantages as a source of value, and the study observed primarily economies of scope. Looking closer at Economies of Scope, Panzar and Wilig (1977) identify cost synergies, and e.g Schilling (2016) discuss revenue synergies from network externalities. The synergies observed in the application studies reveal a significant pattern, they seem to mainly be derived from complementarities. In this scenario, it seems as though the complementarities enabled primarily revenue synergies with existing products where a lot of the application value was captured by complementary products and services. In some cases, as e.g. that of Smart Meters, it could be identified a rise in the value of the IoT product due to the complementary services, much in line with what Schilling (2016) thinks about the nature and relationship between technological products and complementary products. Interestingly, there was no trend of cost synergies, even though Panzar and Wilig (1977) claim that cost synergies trough producing complementarities are one of the ways to further monetize on core capabilities. The reason why this is not emphasized by the Providers observed in this study could depend on their core capabilities and their relationship to the nature of the complementary product. Core capabilities were in essence production of machine equipment, and the nature of the complementary products where often software-based offerings, which makes it unlikely that there should have been any significant cost synergies that benefited the Providers, which could explain why it was not observed in any of the sources used for this study.

Switching perspectives, looking at the Integrator role, there seems to be a distinct cost advantage focus in their strategies, ranging all categories but particularly in capacity utilization and economies of learning. Following the same argumentation as for the Provider Role, the lion share of the Integrator's value activities is directed towards the refinement of resources and production, which means that the IoT has an internal efficiency goal. This seems to be in line with what Williamson (1979) and Amit and Zott (2001) define as a transaction cost, eliminating all the communication efficiencies to make the value to cost ratio as high as possible in a transaction. Interestingly however which such a clear focus on cost strategy, there was also clear trends in the findings on the differentiating side, and the driving factors were an enhanced value proposition trough being able to get better quality on the products and services they serve to their respective customers, and to be able to strengthen their brand through a taking on the *thought leading* role. Some additional advantages outside its main focus seem to be present for both Providers and Integrators, but a stronger emphasis on branding is definitely standing out for the Integrator role. The explanation to this could lie in the nature and purpose of branding for each role. From the definition of each role, a distinction between the nature of relationships for Providers and Integrators could be made, where Providers have mainly b2b relationships, and Integrators, being further down the value chain closer to costumes, having relationships characterized by both b2b and b2c. Honarmandi et al. (2019) describe b2c branding as being more focused on emotions. B2b branding, however, is mainly focused on logic and reasoning, with emotions only coming into play when there is a risk or fear of making poor decisions. As Integrators are influenced by both types of branding strategies, it could explain the larger focus on branding provoking emotions such as "Thought Leader" or "Safe and Sustainable". With this reasoning for Providers, IoT does not provide any additional benefit outside of the logical reasoning in the business case of their products, which could help explain the lack of particular emphasis on brand values connected to IoT in their branding.

5.2 Value Clustering in IoT

Changing perspective from how different IoT use-cases creates value to what types of value are being created by different use-cases, this section aims to answer the second subordinate research question:

How can IoT use-cases be segmented based on value creation and capture?

Drawing on the previous analysis based on the use-case observations and theories used, the authors want to put the sources of value in focus. Proposing relationships and constructing the foundation of a conceptual framework of value-based clustering of IoT use-cases. The findings of the previous analysis section are elaborated upon in relation to the third research question, formulating the foundation of a value-based clustering.

The cross-analysis in the previous section showed several things regarding the characteristics of value creation. First, across the industries where IoT gave incremental innovation, there were minor differences in value creation. In the healthcare industry, however, where IoT was part of radical innovation, different value creation was observed. Second, across the application areas, no major differences were observed, implying the application area has low relevance for value creation. Third, across the two Roles, major differences in value creation were found. Integrators showed a focus on Cost Advantages while providers showed a focus on Differentiation and Scope. Consequently, a value-based clustering of IoT use-cases is proposed to begin in the different roles or implementors, integrators and providers, since these were shown to have the most impact on the characteristics of value creation.

Integrators had primarily cost advantages in Economies of Learning, Process Efficiency and Capacity Utilization but also differentiation advantages in processes leading to increased Product Quality and Brand improvements. When looking further into Economies of Learning and Process efficiency, the theoretical definition of the both also seems to overlap and their impact in the IoT spectrum are both stemming from the business model change of key activities. Hence, one might consider these two value creation aspects to be similar or equal when they follow from an IoT implementation.

Providers, on the other hand, had foremost differentiation advantages in New Functionality, Brand, Raised Switching Costs and processes leading to increased Product Quality, but also scope advantages in Economies of Scope and Complementarities and some cost advantages in Process Efficiency. As previously discussed (see Section 5.1.3 above) the economies of scope that have been observed stem from complementarities enabling economies of scope to be disregarded for the more precise description of complementarities. However, in the Healthcare Industry, there was a major difference as New Market Space was seen instead of New Functionality to Existing Products and Increased Switching Costs. These are signs of Radical Innovation instead of the Incremental Innovation found for the other providers. Consequently, one should take these innovation differences into consideration when segmenting IoT use-cases.

6 Conclusion

This chapter aims at concluding on the findings by the study, effectively answering the main research question and relating this answer to the study's purpose. Moreover, the findings are put into the context of technology license pricing and the implications of IoT-enabled business models on pricing is described.

6.1 A Deconstructed Value-Centric View of IoT

The object of this study was ultimately to answer the main research question, namely:

How can income-based valuation methods be used to model the added value of IoT?

To begin answering the main research question, it's useful to recap the findings in the previous sections on the subordinate research questions. The findings showed that the implementors of IoT could create and capture monetary value through several differentiation and cost advantages. Additionally, the different use-cases could be clustered based on the implementors role, integrator or provider, and the industry's innovation characteristics, incremental and radical.

Starting with the advantages generating Cost Leadership: Process Efficiency and Capacity Utilization, one can from the definition of these two concepts derive in which way they reduce costs. Process Efficiency reduces the time spent per unit of production lowering the operating costs and Capacity Utilization enables the firm to distribute the fixed costs of investing in resources over more units of production decreasing the marginal cost.

Continuing with the Differentiation Advantages observed: New Functionality, New Market Space, Brand, Increased Quality and Increased Switching Cost, but also the Scope Advantages in Complementarities, it has been established that all these drive revenues. Hence, increases in price and quantity of the product/service due to the implementation of IoT are the basis for evaluation. However, one also need to consider the new revenue from complementary offerings that stem from the implementation of IoT.

Combining and synthesizing these findings, one can answer the main research question. At this point, it's important to note that the purpose of this study was to increase implementation ability and manageability of income-based pricing models. Thus, the modelling of IoT value has been captured in an IoT Value Framework which is segmenting the use-cases of IoT in four distinct categories: Resource Utilization; Process Efficiency; Legacy Product & Service Innovation; and New Product & Service Innovation, see Figure 18 below. In accordance with good framework practice (Burton, 2003), the value framework is further elaborated, defined and exemplified in the following sections.

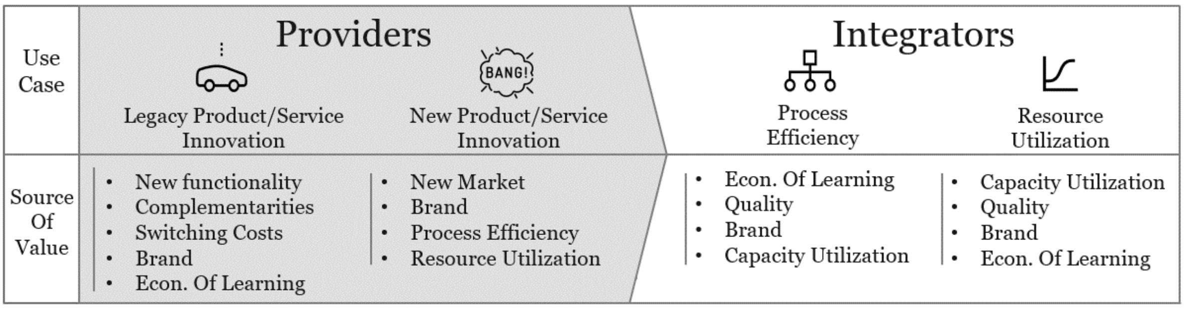

Figure 18 The figure outlines the researchers proposed a framework for clustering IoT use-cases based on the sources of value attributed to IoT. Additionally, the framework is put into a value chain perspective to illustrate the relationship between the roles. Economies of Learning are used to denote both process efficiency and economies of learning in this picture to not confuse the Use-Case Title with the Source of Value.

To define the use-cases where integrators primarily derive cost-cutting value from sources of capacity utilization, the category Resource Utilization is formed. Exchanging *Capacity* for *Resource* highlights the connection between the source of value and business model change further clarifies the nature of the use-case. Building on the use-cases in this study, a firm integrating an IoT solution for condition-based maintenance will mainly gain a higher uptime on its machines, achieving higher utilization on assets which will, given the output requirements, render the firm a cost advantage.

To denote the use-cases where integrators primarily derive cost-cutting value from sources of process efficiency and economies of learning, the category Process Efficiency is formed. As mentioned, the IoT context interlinked the two mentioned sources of cost advantages, and Process Efficiency speaks more to the context and nature of the use-case. A useful example in the category would be an integrator of a Smart Metering solutions would immediately cut the process of reading meter values into a fragment of its conventional time spend, effectively achieving a more time efficient process that could render the integrating firm a cost advantage over its competition.

To denote the use-cases where providers deliver an incrementally improved offering to the market, thus achieving differentiating innovation and scope advantages, the Legacy Product & Service Innovation category is formed. The relationship between incremental and radical innovation is complex to visualize given that it is context dependent. Thus, the main outstanding factor is that incremental innovation builds on something that was already there, which is why the term *Legacy* was chosen. The study also recognizes that innovation can come to happen in many places, not exclusive to the differentiation advantage spectrum, which is why the name should clarify that the innovation denoted in this context is a provided product and/or service. An example of a Legacy and Product Innovation from a provider is the Connected Robotic Lawnmower as it took the concept of a robotic lawnmower and connected to the internet in order to add complementary services to its offering which could also lock-in its customers, effectively achieving a differentiating advantage.

To denote the use-cases where providers disrupt the marketplace with an offering that solves a need so radically different than all others that they can achieve both cost advantages and an overwhelming differentiation advantage, the New Product & Service Innovation category is formed. Building on the reasoning in the previous category. Building on the argument from the previous section, radicality is hard to characterize, measure and visualize in comparison to its humble incremental brother. With this in mind and the name change made to the incremental category, a definition that differentiates the term from the old legacy-products is simply *New*. An example is provided of a remote patient monitoring solution, where the impact is so vast that a cost advantage in the form of process efficiency and capacity utilization can be achieved, accompanied by a differentiation advantage stemming from a completely new market.

Coming back to the purpose, *to propose an alternative income-based valuation method*, this framework now has done so by setting up this value-centric framework that serves as a guide to quickly and easily determine what figures is needed to evaluate a use-case. This effectively minimizes the managerial effort of setting up a valuation model based on the value the technology creates. The benefit with such models in general, and this, in particular, is that it enables a valuation of use-cases which nobody has evaluated before, which is a major problem for technology owners and implementors of IoT. Hence, due to the qualities of the framework, it becomes easier to overcome the initial uncertainty when assessing an IoT use-case. The use of the framework could consequently speed up the implementation and diffusion of IoT in industry and society, creating more value for everyone involved.

6.2 Implementing the Model in License Pricing of IoT

Apart from achieving further implementation ability and manageability of income-based valuation models, the purpose of the study further entertains the notion of giving better insights into pricing of IoT Licenses with the goal of improving the accuracy of value capturing by technology owners. Revisiting income-based models by e.g. Chiesa et al. (2007), Park and Park (2004) and Alpha (2019), it was outlined that there are three main questions one need to answer to achieve a reasonable income-based license price:

1. What is the total added value of IoT?
2. How should this new value be apportioned between the functional IoT elements?
3. What is the appropriate price for each element?

In the previous section, the study introduced a framework that decreases the managerial burden of answering the first question by providing a guide on how to evaluate an IoT use-case. What's left is to apportion this value creation between the different IoT elements and lastly, to determine the price of said value creation. To put this notion into a context, an example of a technology owner could be useful. Given the setting which this thesis is written in, the example will be a technology owner of cellular communication technologies, considering licensing its technology to an implementor, i.e. a licensee.

To complete Step 1 of the income-based pricing process, the technology owner needs to determine the ecosystem role of the licensee and the main purpose of the use, in order to determine the nature of the use-case. Once found, the technology owner can evaluate the value of the benefits derived from the sources of value to conclude on a likely value of a Royalty Base and suitable pricing mechanisms.

To complete Step 2, the IoT elements need to be evaluated. If connectivity is modelled as enabling access to data, the relative contribution of connectivity would vary with the complexity of analytics involved in the use-case. A solution would be established type rates for groups of use-cases in the descriptive, predictive and prescriptive spectrum respectively.

To complete Step 3, the technology license package needs to be evaluated. Since this example is based on a cellular connectivity provider, the IP should be evaluated in relation to the 3GPP standards, and possible competing technologies for the same use-case. A technology owner should consider the user need, how well that corresponds to the technical performance of its own technology and the competition.

Another implication for technology owners and implementors are that one company may implement several IoT applications. This is, for example, apparent when an implementor has integrated either horizontally across or vertically along with industries and hence relate to many businesses where IoT is applicable. In each of these use-cases, different sources of value may be present and additionally, the quantitative monetary value of said use-cases is most likely different. Hence, the licensing agreements between the technology owner and implementor may need to take these different value contributions into the account. This would make the licensing more complicated but may also satisfy the actors better.

6.3 Pricing Implications of Business Model Trends in IoT

The study has also found two trends that increase the difficulty of completing all the steps in the income-based method. First, there is an increasing part of the value created from IoT that stems from complementarities and monetization of data (data-driven business models). IoT is essential to creating the value proposition of these products and services, but are not necessarily packaged with the IoT offering, making it difficult to identify an appropriate value from these. The consequence is a discrepancy when determining the total added value of IoT.

Second, there is an increase in servitization and non-ownership business models that leads to a value appropriation from an IoT device which is distributed over time. In other words, IoT providers are not selling devices but charge their customers by how much they use the device. In a non-ownership business model a provider that design and produce an IoT device may not transact the product to customers, but let them pay for the use of the said product, see the Xerox and Rolls-Royce examples in Section 2.4.2. However, in conventional licensing, the price has been based on devices sold, which is in line with previous industry norms. This will become increasingly difficult, due to the servitization trend, creating a need to find ways that move away from unit-based pricing to use-based logic. Otherwise, technology owners will have limited success in appropriating the value of technologies via licensing.

7 Discussion

This chapter intends to discuss the practical and theoretical implications of and limitations in the conclusions made in the previous chapter. Based on the findings in the study, a few additional areas are suggested as suitable for future research.

7.1 Practical and Theoretical Implications

This study has made advances into a field scarcely researched by academia but highly sought for in the industry due to its massive economic impact. First, by investigating a set of IoT application areas that collectively exhaust the IoT-field a general view of the value creation for IoT has been established. This mapping of value creation produced a useful overview of how IoT typically change a firms business model. Secondly, the study established that the characteristics of value creation mainly relates to the role of the implementing firm (if it's an IoT provider or integrator) and if IoT had a radical or incremental impact on the industry, stressing that what application is implemented did not give insights into what IoT benefits are experienced. Third, using a value-centric approach, the study proposed an IoT use-case segmentation framework. This tool can help both technology implementors and owners to understand what type of value that the technology can create and hence provide a shortcut or guide when constructing a business case. This lowers the hurdles to approaching IoT, understanding the benefits and hence speeding up the diffusion of the technology in the industry. Fourth, the framework may also be suitable for technology owners that seek to license their technology to implementors of IoT. Most importantly as this builds a bases for an income-based that isn't dependent on comparables, it helps in overcoming the diversity and vastness of the IoT field for firms that want to assess the technology value of IoT.

For academia, this study gave a collectively exhaustive view of value creation in the IoT field, something that was missing in previous research which was focused on specific segments of the field. Additionally, this was achieved by the use of conventional business-research theory such as competitive advantage and the business model. Hence, the study has with high generalizability and basis in widely recognizable theory brought some order into a field otherwise plagued with buzzwords and hype, establishing a base for further researchers investigating IoT, value creation and evaluation.

7.2 Limitations of research

The study has identified some limitations that should be accounted for. As a starting point, the study could only concern itself with the current snapshot of IoT, which is problematic due to the emerging nature of the technology field and application range. While the range of value creation could be considered exhaustive in the present, it might change over time which will, in turn, would impact the findings. Therefore, a suggestion would be to continuously evaluate the range of value creation, particularly when more Critical IoT applications has reached enough market adoption, the URLLC part of 5G is to be released the summer of 2019, which probably will speed up the adoption. The study chose a method that could encompass a broad scope of applications, but with the broad scope, there is a risk that details and depth in some use-cases could be limited. It is therefore suggested to conduct a mixture of qualitative and quantitative case-studies, preferably within each category of the value-centric framework, particularly to explore value capturing mechanisms in better detail. Similarly, the strategic difference of radical and incremental innovation and its impact on value capturing and sources of value should be further investigated considering that the study only investigated one distinctly radical innovation.

The framework was also not verified by the study, which is to be an important first step for future implementing technology owners. Furthermore, the framework was adapted to fit a technology owner accustomed to telecom licencing norms, which was appropriate considering that the study was made in collaboration with Ericsson. This could, however, have an impact, particularly on the manageability of the presented framework. With this in mind, it is suggested that other technology owners that consider themselves to have licensing practices vastly different from Ericsson to critically asses the applicability of the framework before implementing it into its organisation.

7.3 Further Research

As the study has discussed, there is further research needed on the implementation of value-based pricing strategies in IoT. There is an interest, particularly from the industry, to determine the share of value between different technology elements. It is particularly interesting in within the connectivity layer of IoT considering the heavy focus on standards, where further research could focus on the appropriation between actors within the standard and between the different standards. The study also made some progress on the licensing norms in IoT, but with the emerging nature of the field, the interplay between several industries, their bargaining power and impact on licensing norms need further investigation to determine strategic implications for technology owners and technology implementors.

Looking beyond the licensing context, the value of IoT is still vastly unexplored in research, seemingly in two major dimensions. First, this study did primarily concern itself with a context appropriate for licensing, meaning businesses with either an integrating or providing nature, but there is a nature to the consumer surplus that the study did not explore. Similarly, the study mainly concerned itself with the value that could be captured in monetary gain. Further research could, therefore, be made into other softer sources of value in IoT and its long-term strategic implications for society. Second, the relationship between the actors in the IoT value chain is not set and the trends in the regulatory space around data, data monetization and data protection along with trends in business models all impact how value is being created and captured. Especially the emerging move from transactional product offerings to continuous service offerings have implications for licensing who still deploy a logic designed for the former. This is a field where there is both business and judicial uncertainty in potential solutions and hence further research is needed.

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9 Appendix – Use Case Mapping

Strategy	Sensor-driven Ana		Process Optimiz.		Tracking Beh.		Opt. Resource		Situational Awar.		CAS	
Use-Case example:	CBM		RO		SM		SG		RPM		CLM	
Integrator or Provider:	I	P	I	P	I	P	I	P	I	P	I	P
Differentiation												
• New operational processes improving quality	VP, KA		VP, KA		VP		VP, KA		VP, CR/CH			
• Combining resources in a new way												
• Raised Switching costs		CR		CR		CR		CR				CR, RS
• Radical Innovation: New market space										VP, CS		
• Incremental Innovation: New functions to old products		VP		VP		VP		VP				VP, CR, KA
• Brand	KA	VP, CR, KA	KR, KA	VP			VP?		VP, CR/CH	KA		
Cost Leadership												
• Economies of scale												
• Economies of learning	KA, KR		KA	KA	KA	KA	KR?, KA		KA	KA		KA
• Process efficiency	KA		KA	KA	KA	KA	KR?, KA		KA	KA		KA
• Capacity Utilization	KR		KR		KR		KR, KA		KR	KR		
Scope												
• Economy of scope (Synergies)		CS, VP		VP, RS		VP, KA		RS				CR
• Underserved market segments												
• Installed base												
• Complementarities		CS, VP		VP, RS		VP		RS				VP, KA
Non-conventional BMs												
• Servitization		CR, KA, RS		VP, CR, RS		CR		RS		RS		RS
• Data driven business models		VP		VP								
• Customization and personalization		KA, VP		KA?								VP
	Manufacturing				Energy and Utilities				HC		HA	

Customer segments	= CS	Partnerships	=	KP
Value Proposition	= VP	Cost Structure	=	Co
Channels	= Ch	Condition Based Maintenance	=	CBM
Customer Relationship	= CR	Remote Operations	=	RO
Revenue Streams	= RS	Smart Metering	=	SM
Resources	= KR	Smart Grid	=	SG
Activities	= KA	Remote Patient Monitoring	=	RPM
		Connected Lawn Mowers	=	CLM