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MASTER'S THESIS

REAL-TIME SIMULATION'S APPLICATIONS IN THE VALUE CHAIN AND ITS EFFECT ON THE BUSINESS MODEL CANVAS

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ABSTRACT

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Real-time simulation is a new technology that has not yet been fully employed in business. Companies are starting to adopt it, the benefit of it is not clear for managers. This study is aiming to capture and analyse the benefits of real-time simulation and its ability to serve the needs of companies, through analysing its contribution to each of the value chain activities, and the resulted changes in the business model. In order to find solutions for this phenomenon, the research questions were formulated as follows, the main question: 1. How is the real-time simulation adding value to different activities in the company? And two sub questions: 1.a How could the real-time simulation be used for different activities in the value chain? 1.b What type of effect does these activities have over the different building blocks of the business model?

The theoretical part resulted in a series of potential findings, as an outcome of the analysis of previous studies. The results showed five main applications of the real-time simulation in the value chain, in research and development, marketing, predicting the faults, training, and logistics. A detailed assumption of the effect on the business model was also provided.

The primary data was collected from five major manufacturing companies, who used this technology in different levels and fields. A qualitative research analysis was conducted, through semi-structured individual interviews with six correspondents. The analysis resulted in multiple findings, it showed that the use in research and development reduced the cost and the resources needed of the company, and the use in marketing improved the relationship with customers. The use for training had an effect over the value proposition and key activities, among other results.

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Walking with god's guidance makes every path of success accessible.

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Lappeenranta

Table of content

Tables and figures

Introduction

In today's rapidly changing market, industries are becoming not only interconnected but also interdependent on each other. The digitization and globalization of our century are increasing the pressure on companies to stay competitive and stay in the market. Companies have to keep up with the latest technologies and business trends to stay on top of the game. Adopting technology is not enough, companies are also pressured to understand its complexity. While digitization caused a rapid development and complexity in electronics, challenging the upper and middle management to understand the new and emerging needs of the business and adjust to it by innovating and updating their business model, in order to make sure that it is capable of taking full benefit out of it, and the value also reaches the customers.

1.1 Background

The three previous industrial revolutions were triggered by the innovation of technologies, the introduction of water steam-powered mechanical manufacturing at the end of the 18th century, the division of labour in the beginning of the 20th century, and the appearance of programmable logic controllers for automation purposes during the production process in the 1970s (Brettel et al., 2014). This research will examine real-time simulation as a result of the fourth industrial wave of revolution that has been triggered by the internet, which allows interaction between humans and machines in a cyber-physical world through a large network. In addition to technological innovations, the companies had to undergo a huge shift in its organizational structure to cope with the complexity in the market (Brettel et al., 2014). Scholars have also recognized the shift from mass production, to mass customization, to a personalization of the product and co-design with customers (Kabasakal et al., 2017). All that would have an effect over the value proposition and the business model.

This digitization era is giving birth to so many new technologies. These technologies are playing an important role in generating a huge sum of data, together with the data gathered previously from traditional methods if used efficiently, it would create yet another form of smart management. However, benefitting from this vast amount of data is also challenging, creating another dilemma for managers waiting to be solved. Thus, some companies have realized this phenomenon and built their whole business model in the form of services to help advice different companies and leverage their strategies concerning different elements of the business model.

In an excursion visit organised by Lappeenranta University of Technology to a Company Z which is a data driven, it helps other companies innovate their marketing strategy, for the purpose of this study it will be referred to as company Z. Company Z believed in a future based on algorithms for the companies. Companies believe that there would be a shift from depending on delivery channels in the 1990s to intelligence and technology-based business environment (Dirican, 2015). Customers were more interested in getting a brand experience through the brand itself and the media, as for the 2000s digital experiences were more common and expected due to the easy access to the digital devices and the breakthrough of mobile phones. Nowadays -due to the massive existence of data and algorithms built through the heavy use of technologies- the experience of intelligence is replacing the digital experience for the companies, as Company Z believe that in the future all successful companies will be built on algorithms. This would help the managers and directors to make decisions and save the problems depending on more accurate results, led by numbers rather than instinct, and it will be supported by stronger proves.

This adoption of new technologies and basing decisions upon real-time data has effects on the business model of the company. Production is the most common application among scholars when thinking about digitization and new technologies, as it helps in saving costs and finding the most efficient way to achieve the desired outcome (Mooney et al. 2001 & Dirican, 2015). The effect on costs will result on changes in the business model, including the cost block. The same goes for the application of real-time simulation in marketing, it would increase the engagement, affecting the sales and resulting in multiple consequences on the business model. Thus, deeper analysis of the results of the real-time simulation application and its effect over the business model needs to be conducted.

In summary, companies are struggling nowadays to stay competitive in the market, under the shadow of globalization, and the difficulty to meet customers' changing needs and expectations, many challenges and trends have made an appearance in the industry, companies in order to keep up with the trends and overcome those challenges, they have to be innovative and adapt to the new emerging technologies that benefit its operations, understand it, develop it, and upgrade the business model with the new technological employment. Many technologies have made an appearance in the past decade, creating what researchers call industry 4.0, the latter includes many technological innovations, and the simulation is one of them. Researchers were able to prove the benefits of using simulation throughout the production process. However, no research was found that has displayed the case of upgrading the business model under the effect of simulation or display how the value of using technology has been affecting different players in the value chain. Thus, comes the need to further understanding of the real-time simulation.

1.2 The Concepts and Questions

This study is tackling three different concepts for the purpose of answering, starting from the real-time simulation as a new technology used in business. In the literature part, the study is aiming to comprehend this technology in a simple/non-technical manner. This discussion would help in understanding real-time simulation and its use for the business.

The second concept is the value chain. In this concept, the study is not targeting the whole industry value chain, as it varies from one industry to another and it includes multiple businesses. This study is targeting the internal value chain of the company, which involves different actions inside the company that creates the value delivered for the customers, this would help to indicate the possible usage for real-time simulation for each action.

The third concept of this study is the business model, in this study we will focus on the business model canvas, as the most commonly used model. This model was chosen for its effectiveness in answering the research questions and other reason which will be mentioned in detail in the theoretical part. The aim of this study is to find out how the uses of real-time simulation are affecting each block of the business model canvas.

The literature part of this study aims to tackle each one of these three concepts, starting by an introduction of the real-time simulation technology and what have the previous scholars mentioned about it. Then the value chain concept is going to be discussed, a number of value chain models has been discovered so far, therefore one is going to be chosen for this study. Accordingly, we are going to explore the uses of real-time simulation in each of the value chain parts. As for the third part of the following literature, the business model concept will be explained, we will come across the business model canvas and discuss it thoroughly, the purpose of that is to find out what are the effects of the application of real-time simulation over the business model canvas.

In order to reach the purpose of this study, a few questions need to be answered in this regard. Questions are as follows:

1. How is the real-time simulation adding value to different activities in the company?

In order to answer this question, we must understand

1.a How could the real-time simulation be used for different activities in the value chain?

1.b What type of effect does these activities have over the different building blocks of the business model?

The empirical part of this thesis concentrates more on the primary data collected for the purpose of this study. This is a qualitative study, therefore the data has been collected through semi-structured, in-depth interviews with the corresponded people of each company. Five companies will be included in this study, the reason for choosing this method of collecting data will be explained in the methodology chapter of this study. The analysis of primary data would help in achieving this study's goal and answering the research questions.

Theoretical Background

2.1 Real-time Simulation

Many manufacturing companies are using nowadays digitization in order to improve the production process. This chapter will introduce real-time simulation as one of the methods in industry 4.0 for its multiple potential uses throughout the value chain. For the purpose of finding out how this technology is viewed? how it could benefit the business? And what are its applications so far?

This chapter will start by introducing the background that helped in preparing the way for this technology to appear, the simulation and how it is different from real-time simulation, then the chapter will discuss the challenges that helped in nourishing and developing it to become the way it is today. Then, this chapter is going to review some applications of the real-time simulation nowadays, to get an idea of how this technology is able to help managers and companies, and the way this technology is beneficial in the perspective of the previous literature.

2.1.1 The revolution of Industry 4.0 and Simulation Systems

Rubmann et al. (2015) described industry 4.0 as the fourth wave of technological advancement or the fourth industrial revolutions as Almada-Lobo (2015) called it. The latter explained that this evolution is giving solutions for connected yet decentralized production and supply chain processes. This chapter will use the word technology frequently, which is scientific knowledge used in practical ways in industry, for example in designing new machines to make use of the most modern technologies, as Oxford dictionary defines it.

This technological wave has risen nine foundational technology advances. With this technology transformation, sensors, machines, workpieces, and IT systems will be connected along the value chain beyond a single enterprise (Rubmann et al., 2015), they explained that these systems are able to interact with one another, allowing it to analyze in order to predict failure, configure themselves and adapt to changes. This way the processes over the value chain would be fast, flexible and efficient, allowing the companies to reduce costs and improve productivity (Lee et al., 2014). The latter also has a vision of establishing factories that are self-aware, self-predicting, self-comparing, self- reconfiguring and self-maintaining, all that due to the need to evolve in order to meet the increasing expectations of the customers, in terms of innovation, quality, variety and the speed of delivery.

Previous scholars saw a huge potential in these new technological advancements, not only in benefitting one area or for R&D functions, but affecting the whole value chain. For that reason, they created the term of a new industrial revolution “Industry 4.0”, and began to predict how these technologies would affect companies, starting from the manufacturing process. Rubmann et al., (2015) went further in their paper to explain each pillar of the technological advancement and their potential benefits for the manufacturers and the suppliers of production equipment. They believed that these pillars will transform the production to make it fully integrated, automated, and optimized, leading to great efficiency in the process and changing the relationship between the producer, supplier, and customers alike. The nine pillars of industry 4.0 consist of 1. Big data and analytics 2. Autonomous robots 3. Simulation 4. Horizontal and vertical system integration 5. The industrial internet of things 6. Cybersecurity 7. The cloud system 8. Additive manufacturing 9. Augmented reality (Rubmann et al., 2015). Thus, the simulation is comprehended as one of the many other high techs in industry 4.0, with high potentials in benefitting the companies and finding more advanced ways to benefit from the resources that already exist.

2.1.2 The simulation system

After understanding the background, what influenced the appearance of real-time simulation. It would be necessary to understand how this technology work and its components for it to understand its uses.

CIMdata (2018) have mentioned some of the virtual engineering practices in business, including Systems modeling and simulation (SMS), they explained it as the tool to conceptualize, design, analyze, verify and validate an organized set of components, subsystems, systems, and processes. As for the definition of simulation in the American Heritage Dictionary, it is seen as an imitation or representation of a potential situation or experimental testing. The simulation was also described by Rubmann et al. (2015) as a tool to leverage real-time data to mirror the physical world in a virtual reality model, which includes machines, products, and people.

All these definitions imply that the simulation provides an alternative or an imitation of the reality which grants its users the possibility to understand the results of certain theories or alternatives without causing any consequences in real life. This allows changing the simulation machine settings to optimize and test the product in the virtual world before providing the virtual changeover, which leads to a decrease in the machine setup times and increase the quality.

2.1.3 The simulation abilities in tasks

The improved techniques of simulation throughout the product development process and project planning were explained by researchers Cho and Eppinger (2001), projects need proper planning of tasks, resources, and time. The same could apply for planning a production process, where certain tasks need to be achieved in an optimal time, using the least amount of resources. Cho and Eppinger (2001) discussed that the ability for simulation to analyze related and frequentative processes involving multiple repetitive tasks would enable it to predict the cost, as well as the duration of a certain project or task, allocate the resources across tasks, and model uncertainty in estimated task durations using certain methods. They also added some tasks by the model that they have developed, including the ability to transfer information patterns across tasks, which helps in predicting the dynamic workflow of the tasks. They have also added the uncertainty of a task duration addressing three different durations presented by the model (pessimistic, most likely, and optimistic) that way the simulation would arrive at a more realistic assumption of the duration of a task, the model also solves resource conflicts, assuming that each task requires a certain amount of resources constantly over a period of time, there might happen that two or more tasks are competing for these resources, in this case, the simulation model prioritizes the tasks by certain rules (Cho and Eppinger, 2001). After understanding some of the numerous abilities of the simulation model, it becomes easier to see the importance of simulation assistance during different actions of the value chain.

2.1.4 Real-time simulation's abilities

After understanding the simulation systems, it is important to note if the real-time simulation works in the same manner, as well as understanding the different attributes and abilities that the real-time simulation can provide. The expression of real-time simulation is mentioned a lot in the paper. Thus, for the purpose of making the reading more comprehended, from this point forward the researcher will refer to the real-time simulation by RTS.

RTS is a computer model of a physical system. Bélanger et al. (2010) have defined it as simulation during discrete time when time only moves forward in steps of equal duration. So for example, if the task needs ten minutes of performance in real time it also needs ten minutes in a RTS system. Thus, the real-time simulators resemble their original machine and predict its actions in real-time. Mikkola et al. (2016) in their paper presented during the 4th joint international conference of multibody system dynamics, they have described multibody RTS as a prediction tool, in real time, for the dynamic behavior of complex machines, such as mobile machinery. They explained RTS's ability to do that by engaging the machine operator

actively with the dynamic performance of the machinery when RTS reports accurately the multi-physical behaviors of the mechanical components in action and also the contact behaviors in accordance with control algorithm instructions. In other words, when RTS is mimicking a certain machine, it can predict its behavior and showcase it as a software system in a physical machine. It can also simulate the physical laws and the environmental conditions that surround the simulated subject. Bélanger et al. (2010) explain that in order to solve mathematical functions and equations at a given time-step, each variable needs to be solved at the end of a time-step. Meaning that each task happens at the end of a certain time-step that matches its equivalent in real-time, with this mechanism of RTS, it serves its real purpose.

The methodologies used for RTS have included the use of hardware, such as digital signal processors, general-purpose processors and even also computational solutions employing field-programmable gate arrays, this simulator is proposed for electronic power systems, which is implemented in a computer with a multi-core processor coupled with data acquisition and signal conditioning boards (De Souza et al., 2014). In a simpler way, RTS is based on multibody system dynamics enable measurements that would be otherwise difficult for the purpose of controlling the product process electronics (Mikkola, 2017). This enables a controlled state for different mobile vehicles, by enhancing the automation and performance of the machine. Thus, the data acquisition is an essential mission for the RTS to be able to perform, as well as the issue of data generated as a result of running the RTS, which will be discussed later on in this chapter.

During RTS, the amount of real time required to compute the equations or the system's functions needs to be synchronized, shorter or faster than the simulation time-step, so the RTS performs with an acceptable resemblance to its physical counterpart in the same expected performance, if the equation or the state of the simulated system are solved accurately. For each time-step, the simulator takes certain actions that are the same for every time-step, those actions or tasks are as follows (Bélanger et al. 2010):

1) Reading inputs and generating outputs

2) Solving the model equations

3) Exchanging results with other simulation crossings

4) Waiting for the start of the next step

There are other variable time-steps solving techniques, but they are related to non-linear systems and solving high-frequency dynamics (Sanchez-Gasca et al., 1995). These techniques are different from RTS; hence they will not be part of this research.

As noticed from the previous steps, all the data that is gathered as an output could be exchanged and shared, this potential creates another form of communication between stakeholders, which could include current customers or potential ones, other dealers that are involved in the selling action such as sub retailers and wholesalers, partners and investors, or any other party that would make a use out of the gathered real-time data from the simulators. Traditionally, product and service development decisions are made, for the most part, by the few experts tasked with directly addressing the development issues and questions. In this approach, customer needs and wants are solicited via verbal or written interview. For a completely new product, this approach is challenging. It is difficult to describe a concept-level product to customers, and it is equally difficult for customers to fully understand the advantages or disadvantages of the resulting product. Furthermore, if the product contains a radical innovation, customers may not even be able to articulate what their specific needs related to the product would be like (Mohr et al., 2010).

Scholars have discussed how RTS technology was able to help in decreasing the cost and increasing the performance, as a result, the system's capacity to solve problems has increased. In addition to the reduction in its cost, it was made more available and accessible for a large number of users and with multiple application, especially after its evolution in becoming fully digitalized (Bélanger et al. 2010). After proving RTS's ability to boost performance and assist in planning and predicting, in addition to their increased availability, companies are more encouraged to start and adopt this technology. The need for RTS has emerged from the importance of properly understanding the needs and wants of the customers during the product design process (Mikkola, 2017). Thus, involving the customers in the product development process through a virtual prototyping experience through RTS tools. The appearance of these evolutionary abilities, alongside the reduction of costs, has influenced managers to consider maintaining the RTS system.

2.1.5 Challenges and trends influencing the need for real-time simulation

Real-time simulation is one of the technological innovations that has appeared as a result of recent trends and challenges that multiple companies were facing, as well as it has resulted in other challenges for the industries that this research needs to discuss. Investigating these trends would help in enlarging the conception of the fields where RTS could be used, which is the topic of the final paragraph of the first theoretical part in RTS.

Sustainability

Sustainability comes first to mind while discussing recent trends. It has been gaining growing recognition in the field of designing, engineering, and manufacturing (Muroyama et al. 2011). Therefore, comes the need for virtual environments that enhances sustainable innovations through multiple applications, one of such applications would be virtual testing, researchers have worked on simulation systems in order to test their ideas and explore the outcomes (Muroyama et al. 2011. Moon, 2016. Lakkala and Vehmas, 2011). Previous papers were addressing sustainability from different angles in economics, society, and environment (Moon, 2016. Shen et al. 2005). Therefore, it's not only the environmental consequences that simulation could help in discovering. That's why researchers were very dependent on simulating different scenarios on the changes that they would desire to make, in order to test their sustainable ideas and see their effects on the years to come (Moon, 2016. Lakkala and Vehmas, 2011). When Muroyama et al. (2011) expressed the need for simulation, their purpose was to investigate the causal effect of alternative manufacturing practices that have better sustainable results.

Researchers have been dependent on simulation in sustainability-related studies because of its complexity. Moon (2016) have summarised five challenges in his study about simulation modeling for sustainability 1. concept of sustainability is vast in scope temporally and geographically 2. study questions consider multiple interactions between economics, environmental, and social elements 3. interactions of different elements are often dynamic non-monotonic, and non--deterministic 4. the systems that are being studied often do not exist yet 5. there are different conditions and states, as well as different levels of granularity that cannot be handled at the same time.

These complexities could benefit from the simulation as it would be able to investigate the study questions that could be covering multiple regions and over a long period of time. In this case, the RTS's abilities could be limited due to that it simulates what happens in real-time, so if the study questions would cover hundreds of years, it could be a problem for RTS. One of the challenges explains that the systems do not exist and that's the reason for using RTS for different plans and scenarios before the actual execution. The latest challenge could benefit from RTS as it could be applied for different types and different conditions separately and explore the results.

RTS could play a role in supporting sustainable actions by researcher and developers inside the value chain of companies, meaning that RTS's benefit is not only limited to certain research areas, but it also involves companies that are interested in sustainable development. Thus, RTS plays a big role in changing the value chain process in order to become more

appealing in a sustainable way, this would impact the competitiveness and profitability of the company from different perspectives, resulting in transformations of the value proposition, and eventually the business model as will be discussed later on.

Complexity

This study has mentioned complexity in the previous point tackling sustainability subject. Complexity was mentioned in the context of researching and testing, indicating difficulty in the research questions and test subjects. However, the researcher brought up complexity again from a business point of view, showing its existence in products or ecosystems.

In CIMdata's new eBook about digital twins (2018) - in which they defined the digital twin as a digital innovation of a simulation twin that accompanies its real-world companion through its lifecycle, being changed in tandem with the physical version.- They explained that product complexity does not only come from the increased number of assemblies, but also because customers are expecting nowadays the use of electronics, software, and embedded systems. In addition to the fact that this technology needs to be connected with each other. Which makes it more challenging for business owners to keep control over the increasing complexity of the used technology.

As for the ecosystem complexity, this challenge has been shown through digitization covering the entire value chain. Digitization meaning "the process of changing data into a digital form that can be easily read and processed by a computer" from the Oxford dictionary. The ecosystem complexity challenges the companies in meeting their environmental responsibility on one side, and on the other, there is the social responsibility, as the companies manufacture products that are increasingly connected in order to meet the needs within the society (CIMdata, 2018).

This kind of complexity needs the help of technologies that can generate data that helps in finding the optimal usage of complex machines, that's where RTS takes on the role of reducing the complexity, helping in testing environmental and social solutions, as well as including other parties in the value chain in the decision-making process, by sharing the data and the results. This would help in fulfilling a transparent strategy, and sharing it with the society. However, this solution is connected with the companies' willingness to share data and privacy issue, which is the topic of the next challenge.

Customers demand choice and quality

Another trend is increasing the customization in the offerings, including products and services. The industries were facing a shift from mass production, to mass customization, to the personalization and co-design of products with customers (Kabasakal et al., 2017). Giving the customer the choice, as nowadays customers are demanding flexibility and are given a wide range of choices to choose from, if not a customized product or service (CIMdata, 2018). Companies are getting access to trendy and much better means, materials, and solutions, so customers are expecting reliable products with superior quality and has been tested well before being launched. There is a potential for RTS in increasing the engagement of the customers during the marketing and the production process and other actions of the value chain, these functions would be explored later on in this study.

Digitization

Another trend that has surrounded recent technologies is, of course, the digitization, where the companies do not only focus on bringing improved and well-tested products to the market, but they also need to do that quickly with a fast response to the market changes, in order to stay competitive in their field. To be able to do so CIMdata (2018) explains that all stages of the engineering process virtual capabilities need to be applied, from inception through product development to manufacturing to service. This requires data and process management, visualization, collaboration, and predictive capabilities. When the company achieves digitization that does not mean that it has everything in digital form, but it means that it is capable of capturing data, analyzing it, and using it for decision making. This has been discussed earlier in the data and information technology section.

After discussing those challenges, the researcher has listed some potentials for overcoming some of these threats. Summarized in 1. helping in testing ideas concerning sustainable development and experimenting its results before doing the actual execution 2. optimizing the use of complex systems 3. meeting customers expectations and including them in multiple processes of the value chain 4. helping in making data sharing possible and including multiple parties in the decision making 5. offering solutions of using the gathered data. On the other hand, RTS might effect in complexing the current technologies if not applied properly, and it also might generate more data that would need proper use. For that reason, we are going to explore applications of RTS in business that has already been mentioned in the previous literature and explore some potentials for RTS.

2.1.6 Applications of real-time simulators in business

The applications of RTS has not got its spotlight in previous literature. However, some scholars have mentioned the applications of simulation as a model and a system. Those two concepts -of simulation and RTS- are really close and similar as explained earlier in this study. Thus, this paragraph will include the application of simulation and discuss the possibility of applying it in RTS.

Moon (2015) Has mentioned five typical uses of simulation are (i) to develop a better understanding and gain insights of a system, (ii) to compare various plans and scenarios before implementation, (iii) to predict behaviors of a system, (iv) to aid decision making processes, (v) to develop new tools for investigation, and (vi) for training. As far as the researcher's understanding of the RTS, these applications also applies to it as there is no indication that real-time data wouldn't help in achieving them.

The previous scholars have mentioned RTS being applied, in order to help in so many fields including traffic, movies, gamification and HVAC (heating, ventilation and air-conditioning) systems (Pell et al., 2016; Jaiswal et al., 2018; Trcka and Hensen, 2010) Nowadays companies are gaining awareness in the advantages of using simulation to help improving their business, for that reason we are seeing more companies such as Siemens and another German machine-tool vendor developing a simulation machine that uses data from the real physical machine (Rubmann et al., 2015). According to them, this procedure has allowed the operators to test and optimize the machine settings for the next product in line in the virtual world before doing the actual makeover in real-life, thereby lowered the setup time for the real machining process by as much as 80 percent and increasing the production quality.

Previous literature mentioned that simulation modeling has been used previously to conduct studies in certain fields, in order to test some ideas and solutions. Those fields were agriculture, construction, ecosystems, energy, human health, information systems, manufacturing, mining (Moon, 2015). Certain subjects were studied in these fields using simulation modeling to search and investigate those subjects, which are social behavior, supply chain, sustainable development, tourism, transportation, urban and community planning, waste recycling, water resources (Moon, 2015). This shows that numerous researchers were interested in simulation as a tool to study their ideas, and they have implemented it in multiple fields.

RTS techniques are being used to develop advanced operator training simulators, as it could perform instead of the real machines, giving the trainees different kind of experiences in cases that could happen in real life, for example by changing the surrounding environment, where the trainee experience how the machine feels and how he/she should react in such situations.

As well as simulating accidents or injuries, that will teach the trainee the prevention of these errors or the best way to deal with them. In addition to the fact that the real machine is still in full capacity and it does not take out of the revenue-generating work (Mikkola et al., 2016). The following project plan by Mikkola (2017) stated that most of the real-time multibody simulation related articles are focusing on the computational aspects of the subject, while only a little attention is aimed towards the problem-solving aspect. For example, some researchers have also discussed the use of simulation in order to induct real-time tests, such as De Souza et al. (2014) explain that these tests are for the development of new embedded algorithms and control techniques for dynamic systems, for example, motors, industrial processes, automobiles, and aircrafts. However, Trcka and Hensen (2010) mentioned how RTS could be applied in a way that makes the production process more flexible, as they were able to prove that real-time simulation tools can be used during building operation to predict and monitor the performance and/or to detect and identify abnormalities in the system behavior.

Professor Mikkola (2017) also believes that detailed physics-based real-time models can be used in ways that have not been previously attainable in product development. Thus, reduce the cost and time taken to launch new products to the market that are customer tested to serve their needs and wants. Mikkola (2017) has also mentioned that the previous literature that was focusing on product development has also described multiple success product introductions as well as reasons to failure for the company using this innovation. For example, companies that use Simulation-driven process could easily transform customers into an important source for product development, that could be achieved by involving customers into the development process by using digital tools, in this case, it would be RTS tools. In this process the customers would be co-creators of products which serve their wants and needs, that would also give the company fast feedback and customer value definition, as well as saving it from expensive and time-consuming physical prototypes. The prototyping process needs a detailed design, parts procurement, prototype assembly, verification, and validation testing, results assessment, and redesign (Mikkola, 2017). Using RTS for testing is cutting most of these steps, which saves time and money, that leads to an earlier market introduction for new products and less expensive product development while increasing sustainability and providing more configurable product families for multiple market niches. It can also test certain attributes or changes, and investigate all the results following that action, without the need to encounter the consequences in real life.

Many previous studies have been tackling the impact of this industrial evolutions on the German market, due to the thought that Germany is leading the transformation towards the 4th generation industrial Revolution (Lee et al., 2014, Rubmann et al. 2015, and Sommer, 2015). However, many of the previous functions of the simulation listed in the previous

literature is emphasizing the use of simulation during the design and development stage in the business process as noticed from the chapter above, other uses were mentioned but not properly tested and applied in the companies. Thus, in the next chapters, the researcher is going to introduce the value chain model that is going to be used and moving on to discuss multiple uses of RTS over multiple activities of the value chain.

2.2 Value chain

In the previous chapter the researcher has defined RTS and similar concepts, its abilities and importance, trends and challenges influencing RTS, and finally, we covered some of the uses mentioned in previous literature. The aim of the following concept chapter is to find useful benefits of RTS for different actions of the value chain. Hence, this chapter will discuss the value chain from its definitions and types, choose the model that works best for this study, and understand the effects that technology had on value chain from the perspective of previous researchers.

2.2.1 Value chain definitions and types

The value plays a huge role in defining the value chain, Value could be interpreted from a competitive point of view as the amount of money that the customers are willing to pay in exchange to the corporation's offerings (Lee and Yang, 2000). The value chain could take many shapes and definitions according to its use and complexity; it could be simple or extended, one or multiple, and for one or multiple product lines and brands (Kaplinsky and Morris, 2000). Kaplinsky and Morris (2000) defined the simple type of value chains as a tool that "*presents full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and input of various producer services), delivery to final consumers, and final disposal after use".* The simple value chain by Kaplinsky and Morris (2000) shows different actions inside the company, starting from the R&D by designing and developing the product, moving to all the required production actions depending on companies' activities, then moving on to marketing, and finishing with the consumption and after-sales services. This model also shows links between activities, where each link can present the value-added and transformed to the next activity.

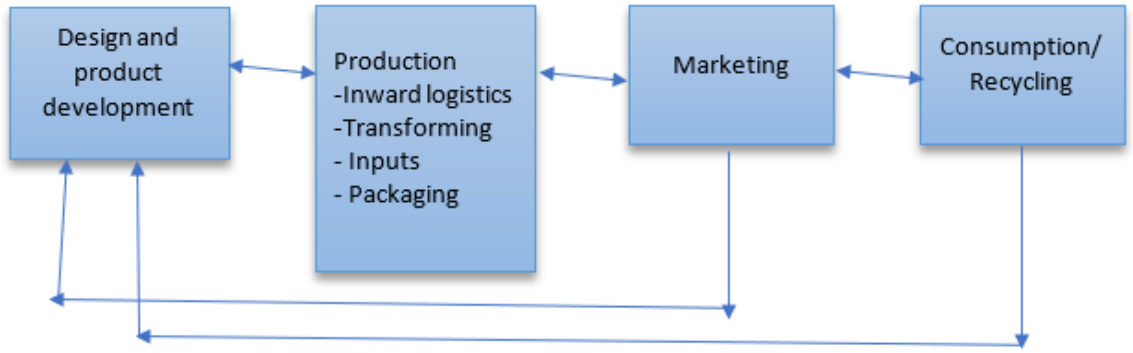

Figure 1- Simple value chain (Kaplinsky and Morris, 2000)

As for the extended value chain, it is similar to the simple value chain, but it contains more links because the value chains in real life are much more complex (Kaplinsky and Morris, 2000). The simple model changes a lot depending on companies' activities, some the production is the main activity that adds value, some are depending more on services, some do not even provide any after-sales services. There is also the possibility for more than one value chain especially if there is an intermediary producer in the value chain who feeds into several different value chains. Some companies depend on knowledge as its main value provided by its employees, for such cases, Lee and Yang (2000) were able to introduce a Knowledge value chain model. Therefore, this concept varies a lot depending on the type of activities that the company does. However, the purpose of the value chain remains the same, which is to locate the activities that add value to the end customer.

Porter's value chain

It is hard to describe the value chain attempts without discussing Michael Porter's work (1985) where it all started. All the previously mentioned models were inspired by Porter's model which was introduced in his book "Competitive Advantage", Porter's idea was that the company would build up value in its product and sustaining the cost in a series of functional activities, so he introduced his model that is set in the context of a traditional manufacturing firm (Porter, 1985). He tried to distinguish different elements of the value chain analysis, including the activities that were performed by the company and the intra-link activities. The activities were consisting of the primary activities of inbound logistics, operations, outbound logistics, marketing, and after-sales service. As well as the supporting activities which help in

accomplishing the tasks, and it consists of the firm's infrastructure, human resource management, and procurement (Porter, 1985). Kaplinsky and Morris (2000) noted that it is important to separate these two functions, as it keeps the focus away from the physical transformation of the product and brings more recognition to the value that is often added by the complementary and supporting services. Thus, this model is called a chain for a purpose as these activities are not independent, they are connected in the value chain by links.

Porter displayed linkages between the primary and support activities, or between primary activities themselves. The traditional method of outsourcing through suppliers and distribution channels were described as vertical linkages. As for the multinational or diversified firms, he suggested that they have horizontal linkages that might be overlooked, by sharing activities with different businesses in other geographic locations (Porter, 1985). Ensign (2001) further classified these linkages according to the participants in the linkage to 1. internal and external linkages 2. network linkages 3. type of strategy performed. These linkages create an opportunity to build synergy with different parties in the value chain and it creates a better competitive advantage for the company (Ensign, 2001). Regardless, Porter's model has been and still is considered the base for all value chain related researches. It contained links between different activities in the company which was necessary to display the value-adding pattern.

Other attempts to develop the value chain model

Porter's value chain was followed by multiple concepts to describe the value chain, one of them was Gereffi's global commodity chains (1994), and his study focused on the global spread and linked production chains, whether it is buyer-driven or producer-driven. His contribution to the value chain concept has allowed important advances to be made in the field of analytical and normative usage of the value chain, especially due to its focus on the power relations and the factors influencing buyers (Kaplinsky and Morris, 2000). Another concept is the one introduced by Bernstein (1996) about Filiere (which means strings in French), his approach was used to study the new political dispensation in South Africa, and understand the powers affecting the maze industry at the end of apartheid. This method tries to investigate the journey of the food products from the farm until it makes its way to the consumer's plate; this trip is represented in different stages from forming the conditions of production, farm producing, marketing, processing, distributing and consumption (Kaplinsky and Morris, 2000). The main goal of this approach was to examine the change of price over the different stages but in order to do that the value added until the final stage has to be explored. It is noticed that later on the researchers attempt to come up with value chain models were getting more

complicated and specific to answer certain research questions or to represent a particular group of corporations with similar attributes.

Globalization of the industry has opened the doors for companies to coordinate on a global scale, they were motivated to restructure their operations internationally through outsourcing and offshoring. Thus, a globalized version of the value chain was needed. OECD has defined Global value chains (GVCs) as a value chain that links different stages of the production process when they are located across different countries, as firms nowadays try to optimize their production process by locating the various stages across different sites. This GVC methodology links different geographically spread activities and players in a single industry. Thus, providing a holistic view of the global industries from both the bottom-up and top-bottom (Gereffi and Fernandez-Stark, 2016). This allows the policy makers to make knowledge-based choices determined by several conditions illustrated in the value chain. Gereffi and Fernandez-Stark (2016) have added six dimensions to the GVC model, expressing local and global elements. However, this type of value chains is also complicated and has so many participants from different countries depending on the company's situation.

The role of stakeholders

It is important for companies to understand the value added from different parties and how stakeholders are participating in each activity of the value chain. Some value chain models were specified to demonstrate the effect that certain stakeholders have on the value added to the product, one of such is customer value chain maps, which signify important stakeholders in the product design process, their value proposition, and their relationship to the product or process being designed (Donaldson et al., 2006), by doing so design teams will be able to identify the products that are closest to the market and their customers' needs. Analyzing the main stakeholders in the company and their effects on the product design are of high importance. Ignoring the effect of stakeholders and their value propositions result in a series of disastrous misadventures and lead to a failure in implementing the decisions (Bryson, 2003). This importance of the customer value chain requires the company to define the roles and values at an early stage in the value chain, this will ensure that major decisions concerning product and service development were made based on customer needs, this way faults and weaknesses could be identified and fixed at an early stage before the company makes major funding commitments and spend extra costs on remodeling. Donaldson et al. (2006) examined during a case study of designing pacemaker alert system, using customer value chain enabled the designers to uncover unanticipated customer needs that resulted in reframing the initial business model and design statement. It is noticeable that the company is not the only

responsible side of creating or receiving value, as stakeholders play an important role in the chain, cooperation between them creates harmony and benefits for all participants, one of these actions is the co-creation and co-design of the products between companies and customers.

Another model that takes into account the stakeholders is Reddy's value chain map (2013), which consists of the value chain actors whether they are consumers, traders or farmers. And the enabling environment with its infrastructure and policies, alongside the institutions and processes that shape the market environment, including other relevant service providers in the chain. Therefore, it makes it easy to understand the linkages between successive stages in the value chain.

All these previous attempts of exploring the value chain contribute to the realization that there are different activities and links in the value chain, and it varies from company to another. However, most of the companies that fall under the same category, share similar activities and links. Thus, for the purpose of this research, the study will focus on a simple value chain model. Other models that we mentioned were derived from the simple model if a more complex model was chosen it could resolve in some inconvenient outcomes. Considering that no previous research was conducted in this field, it would be wiser to start exploring value added by RTS in a simple model, bearing in mind the importance of the different stakeholders and their influence and participation in value creation and decision making. Different activities that are not specified in the simple value chain could be explored and specified more in this study depending on the outcomes.

2.2.2 Importance of the value chain

After porter's study on the competitiveness and value chain, many researchers have followed his path to explore it further, develop it and employ it for the purpose of answering the research questions. The model got a lot of attention and that proves that previous scholars agreed on the importance of analyzing the value chain, especially with today's daring markets and the challenges of globalization.

Many companies are competing in a global market where there are a lot of players involved, consequently analyzing what are the company's core values, and how it provides them, the company's position and the role of the stakeholders who are included in the value chain would help criticize its position and current strategy. McCormick and Schmitz (2002), emphasized that analyzing the global value chain is really helpful when it comes to understanding the global positioning, as it can identify the winners and losers resulting from the globalization of product

markets, and it can also help in finding ways to spread the advantages of globalization. Kaplinsky and Morris (2000) also noted the importance of systemic competitiveness with the growing division of labor and the global cooperation of the production of components, and the crucial role of efficiency in production for penetrating global markets successfully, as well as understanding of dynamic factors within the whole value chain is essential for interring a new global market.

Reddy's (2013) recent study on the value chain of agricultural commodities also mentioned additional points concerning the importance of the value chain 1. Analyzing the value chain would help to identify the constraints and opportunities in the market. 2. Understanding the production and consumption system we are able to determine how marketing and value-adding activities take place. 3. Efficient value chains would reduce the use of intermediaries in the chain and 4. strengthen the value-adding activities by better technology and inputs, upgraded infrastructure, processing, and exports. Many researchers were focusing on the benefits

It was also considered that analyzing and building strategies with the help of the value chain does not only benefit the company itself but it also has results for the whole nation (Gereffi and Fernandez-Stark, 2016). Analyzing the value chains by linking multiple sides from the firm, to workers, and consumers have given the chance to major firms to capture the benefits in international markets in order to compete gainfully. Hence, it is not a matter of whether to participate in the global economy, but how to do so successfully.

Taking all these benefits into account the researcher chose this model in order to explore the benefits of using RTS through different actions, as it could help in unfolding the values that this technology could offer to the company with all the parties involved in its value chain.

2.2.3 The effect of technology and innovation on the value chain

Every business today is trying to compete in two worlds; One is the physical world with touchable and seeable resources, where managers can interact with it. And the other is the virtual world made out of information. The latter must have an effect over the value chain causing it to innovate and evolve. This paragraph is going to search the effects of recent technology on the value chain, in order to explore how previous scholars comprehended the changes that technologies bring to the value chain, followed by an estimation of the RTS technology's own in the upcoming paragraph.

Rubmann et al. (2015) estimated that industry 4.0 will have a great effect on the entire value chain from design and R&D until the after-sales services. The production processes will be

optimized through an integrated IT system, as the manufacturing will be done through an integrated and automated production line (Rubmann et al. 2015). This will enable more control throughout the whole process, and give the chance for actions to be done faster and more accurately. They also mentioned that the number of physical prototypes will be reduced to the minimum, as producers and suppliers will cooperate for automated design and commission of the product. On the other hand, RTS could also participate in reducing the number of prototypes through its adjustable system. The user of RTS would be able to change the settings and try different models in one machine. Another prediction by Rubmann et al. (2015) is that the manufacturing process will be self –optimizing, for example, this will allow it to self-adjust the parameters if an unfinished product is sensed. In the future -through the exchange of supply chain and design data between suppliers and producers- we could have automated logistics, that will adjust automatically according to the production needs (Rubmann et al. 2015). All of this will increase flexibility in the manufacturing process, the flexibility will be provided through the communication and connection between smart machines, robots, and humans. RTS would help in making the data available and shareable for multiple stakeholders in the value chain.

Having a higher rate of innovation and creativity will ensure the firm's ability to compete. However, innovation itself is not adequate to survive in these emerging markets, as everybody is working on improving and evolving their use of technology, companies need to update and upgrade the technology in order to exceed the competitors. Kaplinsky and Morris (2000) referred to upgrading the value chain as the ability to innovate faster than competitors, they ensured that if the firm wasn't able to exceed the competitor's innovation a reduction in the value-added and reduction in the market shares will be a result. The previous literature assured that upgrading the value chain encompasses the technology, and updating could also be understood as the technology in generating higher value, added improving processes, products, and functions interrelated in the chain (Armando et al., 2016). Thus, upgrading the technology must be followed by upgrading to the value chain, for the purpose of assessing the value from this technology and taking full benefit out of it. In other words, companies that decide to adopt RTS should know how to benefit from it and integrate it to the whole value chain, this will give it a superior advantage to its competitors.

Upgrading of the value chain is referred to as is the event of firms moving up in the chain to perform more profitable activities, as a result of using more sophisticated technologies, knowledge or competencies (Armando, 2016). So the upgrading in the value chain is when firms move to a higher value activity in order to increase the benefit (Gereffi and Fernandez-Stark, 2016; Kaplensky and Morris, 2000). The upgrading is necessary as the firm grows, the

goal of creating greater value and making benefits will become clearer, thus upgrading is needed for the purpose of surviving and competing, especially in the third world countries.

To upgrade there are many ways to differentiate different types of upgrading, the first is focusing on the core competencies of the firm. Hamel and Prahalad (1994) explain that firms need to examine their capabilities to determine which of its attributes provide value to the customers, and which of those are relatively unique in the sense that few competitors have them, and which are difficult for the competitors to copy and they form barriers for entry to that market. However, this method has received some criticism for not being applicable in dynamic markets as the competence turns into core-rigidities. Another criticism is that it stops at the level of the firm and it fails to upgrade when a group of firms are involved and linked together in the value chain (Kaplensky and Morris, 2000). Hence, comes the need for another type of upgrading. Kaplensky and Morris (2000) offered a solution by upgrading the process, product, functions, and the chain by moving to a better value chain. This method would provide an upgrade to many aspects, transferring the company to a better level, but there was no proof that adopting RTS would affect the company to the point of changing the whole value chain. This strategy could be beneficial if the company wants to change its whole strategy in order to survive, but upgrading technology alone will not have that huge of an effect.

We arrive at the conclusion that the key ability to survive in these new markets created by technology is the ability to innovate and be creative in finding new ways to do the firm's operations in a faster, more flexible and productive way. Thus, continuous improvement is needed in the company's products and process development, as well as the ability to learn and understand the fast changes in the market. This has implications not only for the manufacturing sector but also for the market as a whole. The previous literature was interested in the effect that the new technology has on the value chain, although it was not RTS specific it would play a role to help to explore more about RTS and its effects towards the value chain.

2.2.4 The use of RTS during different activities of the value chain

In the previous paragraphs, the researcher was able to review the abilities of RTS what was found in the previous literature, the importance of the value chain model and the effect that the newest technologies had on it. This would help the researcher review some of the applications of RTS with the help of the value chain model, which will be the purpose of this paragraph.

2.2.4.1 Application of RTS in Product development

During this activity of technology development or product development, most of the researchers were emphasizing the importance of using simulation in a testing (Moon, 2016. Lakkala and Vehmas, 2011. Muroyama et al. 2011. Shen et al. 2005). Whether it is about testing the researchers' own ideas or customers' demanding their customized model, RTS could provide the possibility to test the products before launching. This feature has gained the awareness of some companies such as Siemens, it developed a simulation machine that uses data from the real physical machine (Rubmann et al., 2015). According to them, this procedure has allowed the operators to test and optimize the machine settings for the upcoming products in the virtual world before doing the actual makeover in real-life, thereby lowered the setup time for the real machining process by as much as 80 percent and increasing the production quality (Rubmann et al., 2015).

Product development is essential because it can influence the competitive success, adaptation, and renewal of organizations (Brown and Eisenhardt, 1995). The vast amount of literature focusing on product development has described numerous reasons for successful new product introductions as well as reasons for failure. A few of these reasons are addressed here. Ancona and Caldwell (1992) discovered that the most successful product-development teams engaged in a wide-ranging external communication strategy, combining so-called ambassador and task-coordination behaviors, that helped these teams to secure resources, gain task-related information, and eventually enhance performance. When the company involves other stakeholders and especially customers, to ensure that the developed product is offering value needed by the customers. RTS process is expected to help the company in involving the customers as an important resource for their product development efforts (Von Hippel, 1982). Djelassi and Decoopman (2013) reported that crowdsourcing can be helpful in mobilizing selected customers. Crowdsourcing can be defined as "the act of a company or institution taking a job traditionally performed by employees and outsourcing it to an undefined, generally large group of people in the form of an open call" (Howe, 2006a, 2006b). Crowdsourcing is a form of user-driven innovation and value co-creation through which companies can apply individual innovation (Hopkins, 2011). Thus, there is a value provided from using RTS in product development with the help of customers, by involving them in a co-creation of the product.

Receiving customer feedback effectively during the early phases of product development is an important benefit of a simulator-driven process. It enables involving a large group of potential users in the development process. To better involve potential users, game-like elements can be added to the testing platform. Gamification can boost the commitment of test users and can even encourage the participation of a larger number of participants. (Hamari et

al., 2014) Therefore, using RTS in gamification has helped in involving the users. Another example of using a “virtual machine” in product development might be its application to the development of a new car model. Taking a simulator-driven approach would enable the recruitment of a large number of test drivers that could then test-drive several (virtual) prototypes and/or beta versions. The approach combines the classic idea of testing various product versions with customer-driven innovation. If this “virtual machine” approach is well executed, test users could experience virtual driving in different conditions and with different vehicle features over a substantially shortened schedule.

The R&D approach offers benefits for both the product development cycle and the product itself. For example, two important benefits have been improved: concept design and materials savings for the final design, which has been optimized based on data taken from a larger pool of potential users, comparing it to the outcome provided from the data collected using classical marketing research methods. This type of RTS benefit is very common in companies that have a complex and expensive production process. Factories that are responsible for developing agriculture machines, for instance, require a lot of effort and resources during the model development process, so a tool that is able to minimize the risk and test the machine settings before producing the actual model is needed. This is where the role of RTS shows during the R&D process. RTS has proven to be an effective tool for machinery design, as the simulation model makes it possible to quickly understand how a machine’s dynamic behaviors are affected by changing design variables. It can replace experimentation and can consequently accelerate product development. Mevea(b) (2018) discuss that the virtual prototyping in RTS achieve significantly shorter lead times and decrease the cost of prototyping by reducing the need for numerous physical prototypes. It also tests the individual components of the product and how it all works together in the environment and the task it was designed to operate on. Operator experience is critical when considering the dynamic performance of machinery. In RTS, a machine operator can actively engage with the dynamic performance of the machinery, and the training simulator should feel and behave as realistically as possible. RTS was mentioned to do prototyping and rapid prototyping as well, this allows testing, modifying, fixing the designed product (Guillaud et al. 2015). This would save time and effort put into physical prototypes.

RTS can be used to design and model new concepts or devices, this use would provide a faster modelling and greater accuracy from the modelling that is done offline. (Guillaud et al. 2015) The use of RTS during this process will help in reducing the time needed for developing the products and launching it to the market, leading to a better competitiveness.

2.2.4.2 Applications of RTS in predicting the faults

The production process in the value chain involves many actions in which RTS would improve, one of these actions would be predicting the fault, logistics, and assembling the systems. However, these functions do not only occur in the production process but it also involves other actions, such as after-sales services. Therefore this paragraph will not be divided as actions of the value chain, but mainly the benefits from RTS.

In the previous literature, most of RTS related articles are focusing on the computational aspects of the subject, while only a little attention is aimed towards the problem-solving aspect (De souza et al., 2014). RTS could be used also for computational purposes, such as developing systems and algorithms. Some researchers have discussed the use of simulation in order to induct real-time tests. De Souza et al. (2014) explain that these tests are for the development of new embedded algorithms and control techniques for dynamic systems, for example, motors, industrial processes, automobiles, and aircraft. On the other hand, it would also solve problems in different processes of the value chain including designing and production, as well as after sales services while the machine is already operating. Trcka and Hensen (2010) mentioned how RTS could be applied in a way that makes the production process more flexible, as they were able to prove that RTS tools can be used during building operation to predict and monitor the performance and/or to detect and identify abnormalities in the system behavior. The RTS would enable the system to predict the errors in the machines, this capability could be benefitted from in the R&D stage as explained earlier or after while using the machine. For instance, when RTS is used on a machine when operating, the faults could be tracked in order to predict when will the machine breakdown. In order to stop this accident before it happens, the machine could be fixed in a short time after contacting the service provider and prepare him for the preventive maintenance action. This process would save time, effort, and most importantly the machine will not be extracted from productive revenue-generating work for a long time. The company will not be exposed to a panic situation as if the machine suddenly breaks down, and that is why companies are going towards predictive maintenance with the use of RTS.

Mattera et al. (2018) have explained in their study how simulation could be used in order to reduce the energy consumption in buildings by predicting the fault. The simulation, in this case, would be used to predict the optimal amount of used energy during different environmental conditions, so that any deviation from the optimal case would be noticed to maintain a sustainable and environmentally friendly consumption.

2.2.4.3 Applications of RTS in training

RTS is being used also to develop advanced operator training simulators, as it could perform instead of the real machines. Compared to traditional training methodologies, simulation-based user training provides a number of advantages. Mevea-a (2018) mentioned that simulation could be used to generate training data as well as test solutions that can be used after training in various scenarios. For example, while training the operators, it gives them experience with likely operating environments subject to a variety of adverse environmental conditions such as wind, rain, or fog. In each case, the simulator can teach the operator how the machine “feels”. Accidents and/or injuries to personnel or property that might otherwise occur as an inexperienced operator learns on an actual machine can be avoided.

Moreover, the simulator can be used to take operators through various accident scenarios and instruct them on the most appropriate responses. This application is less dangerous in jobs that have a high risk. For example, Finnair Flight Academy is using a real-like simulation to train their pilots and crew members, who carry the risk of harming theirs and their passengers’ lives (Finnair flying academy, 2018), with this technology they would be able to simulate the physics, the process, the system, and the environment. RTS also provides live feedback and allows the students to experience how the system reacts, reducing the gap between theoretical and field studies. (Guillaud et al. 2015)

Thus, a training that has a zero possibility of any negative causes is needed, and that is where RTS is needed the most, as it provides the actual experience, with genuine real-time data provided in order to prevent such accidents. The traditional training process requires the use of real-machines, in order to make it available the machine is extracted from the real usage in producing outcomes. Therefore, another reason for using RTS in the training process is the fact that the real machine is still in full capacity and it does not take out of the revenue-generating work. Thus, simulation-based user training frees up existing machine capacity making it available to carry out productive revenue-generating work, while saving cost and environmental damage at the same time.

2.2.4.4 Applications of RTS in sales and marketing

Schneider and Hall (2011) reported that the 'biggest problem' in a problematic new product launch is 'lack of preparation'. They suggested that because companies are often so focused on designing and manufacturing new products, they do not put enough effort into marketing them until it is too late. An immediate and more realistic idea of different value-drivers can be gained by introducing community-based, real-time tools that simulate real-world functionality for potential customers. Simulation can substitute for real-life observation and provide voluminous realistic data. More information on how potential users may cope with different situations can help marketers and salespeople to optimize the products for their intended customer base.

A product with a catalogue of value-creating features serves as a practical example of using simulation to enhance marketing and sales. For example, a car dealer could use a simulator to give potential customers the opportunity to test the effects of a car's various available options (more effective engine, etc.). The ease with which customers could try out the extras in real-life scenarios would result in more of them being sold, which would boost the bottom line for the dealer. RTS can also provide information about intangible attributes such as feel, which are less frequently addressed in customer surveys, for example. This would also lead to cost savings for a car dealer, who would be able to stock fewer cars for test drive purposes.

In general, the advantages for marketers and salespeople can be found in customer value analysis, user training, and product demonstrations. More people can participate in the testing phase, as well as in further phases of product development life-cycle. This provides information for various marketing activities and market research. RTS data can be 'topped up' with interviews after the simulation experience and user-behavior can also be observed real-time in the premises of the marketer.

2.2.4.5 Applications of RTS in logistics

Logistics play an important role in the value chain, as it creates value for customers in B2B and B2C business. The value is created through the availability of the product, timeliness, constancy of the delivery, ease of placing the order, and other elements that the customer appreciates (Langley and Holcomb, 1992). This logistics are part of the supply chain, whether it is represented in the supplies needed by the company to complete its production or the delivery of the products to the end customers. It would also be called inbound logistics and outbound logistics (Kaplinsky and Morris, 2000). Both types require the help of technology in order to organize the delivery and get the maximum value out of it. Previously, while discussing the value chain and the technology's influence on it, the possibility to use RTS in logistics was

discussed. There is a possibility to have automated logistics, that will adjust automatically according to the production needs (Rubmann et al. 2015). If RTS could analyze the production process and know the amount of the materials needed in each stage of the production. Therefore, it could predict the time and the place where the product would be needed, and if the data is being shared among the parties involved in the value chain and the supply chain, the suppliers would be ready and alarmed to know the amount needed, where it is needed, and when. This use of RTS in logistics during the production process would ensure that the company's production will not stop because of the lack of supplies. The same mechanism would apply for the logistics of the materials going outside of the company, especially if it was B2B business. In that case, if the company was providing after sales services or selling parts of the machine, RTS would be able to predict the failure of the machine and the time needed for certain parts.

This predicting method would ease the logistics and help plan it and prepare for it, without being surprised by the order or stressed to meet a close deadline, it would also remove any damages caused by the lack of the materials. As well as involving other stakeholders in the value chain and share the data among them would increase the value shared while involving RTS would make organizing the activities among those stakeholders with prediction much more controlled.

After exploring the literature and the past attempts of previous researchers this study has arrived at the five mentioned applications of RTS. However, the study is aiming to discover more uses from gathering primary data and doing interviews with professional correspondent people to get their opinion about the matter. This would be explained further in the methodology part.

After discussing the use of RTS in different activities of the value chain, The study will move on to the third concept which is the business model.

2.3 Business model

In this chapter the researcher is aiming to study the effect that RTS had on the business model, guided from the knowledge obtained and the uses discussed in the previous chapter. In order to do that the chapter will examine the business model, starting with understanding the business model and the canvas that is going to be applied for this study, and finally relating the business model with the technological advances and its innovation from the perspective of previous scholars.

2.3.1 Definition of business model

In recent years the business model has got the attention of researchers and practitioners, thus many articles have been published in the matter. However, it appears that scholars have not yet been able to agree upon a common definition that would be used to further examine the business model concept, as Zott et al (2011) explain that scholars did not agree on what the business model is, and researcher are adopting idiosyncratic definitions that fits the purpose of their studies, but that makes it difficult to reconcile with each other's definitions. Ovans (2015) agrees that managers and scholars can define the term depending on how they are using it, as there are researchers interested in defining the model depending on the assumptions that are not fulfilled by the companies, causing them to fail in keeping up with changing markets. Others are interested in the money aspect of the definition and what does the company get paid for, from the value creation perspective.

Over time, the existence of business model related research has increased. DaSilva and Trkman (2014) have connected this phenomenon with technology-based companies, as business model seemed to be the answer for explaining any form of the unclear but potentially profitable concept. An example would be Pets.com, where the company's business model was used as a justification for its high evaluation, as it believed that extravagant marketing expenses and continuous brand awareness that it did, was covered by a great number of purchases. DaSilva and Trkman (2014) further explain that only 5 papers containing business model in the title were introduced in the 1990s, but with the emergence of information and technology companies, and the appearance of internet companies. The number of researches in this field had risen, it reached 83 papers for the year 2010 alone. DaSilva and Trkman (2014) have linked this to the fact that companies have started to adopt business strategies and networks, as well as adapting innovations faster.

Many researchers explained the business model as the way that the firm does its business (DaSilva and Trkman, 2014). Teece's (2010) definition of a business model is the design or

architecture of the value creation, delivery, and capture mechanisms of a firm. In other words, he said that the business model articulates the logic, the data and other evidence that support a value proposition for the customer, and a viable structure of revenues and costs for the enterprise delivering that value (Teece's, 2010). In his definition, he was linking the business model with the resource-based view and a cost economic perspective. DaSilva and Trkman (2014) have linked both concepts resource structure and the business model, where multiple types of resources are combined and transacted in a way that delivers value to the customers, and that's how the latter defined the business model. Zott et al. (2011) used the business model to explain three phenomena such as 1. E-business and the use of IT in companies 2. Explaining some strategic issues, like the competitive advantage and value creation 3. Innovation and technology management. However, DaSilva and Trkman (2014) argue that this approach to the business model is limiting the applications of the model, which is clear from his assumptions. However, that does not disclaim the fact that the business model was able to solve some research problem and questions even if the use of it is limited.

In the previous literature, some researcher has tried to link the business model with the value chain. The business model as Ovan (2015) has mentioned, that it has been defined from the value chain perspective, including two types of actions, the first is the activities related with creating something, from the design to purchasing raw materials and manufacturing, so all the activities that make the product ready for selling. The second type is the activities related to selling something, from creating the customers base to making a sale until the customer gets the product or receives a service. Thus, those two concepts are linked in a way that both are aiming to show the value that is being offered. The value chain reveals the value from the perspective of the actions, links, and stakeholders who participates in creating the value, as for the business model it aims to show the idea of the business, the value proposed, and the main activities that creates his value, alongside other factors that creates the business concept. Another interesting suggestion by Zott et al. (2011) is with presenting the business model with a value map that explains how the business is presented, as the value map shows all the participants of managers, customers, suppliers, and partners. It also shows how the value is being exchanged among them, including visible and intangible benefits. They also mentioned that their research revealed that the business model always revolves around customer-focused value creation, it delivers to its stakeholders the essential details of value proposition and what are the activity systems for creating and delivering value to the customers (Zott et al. 2011). The value mapping of the business model is presenting the concept with a lot of similarity to the value chain. The business model is being associated also with other concepts such as competitive advantage, value creation, value proposition, and performance.

DaSilva and Trkman (2014) noted that constantly upgrading the business model is of high importance, they agreed with Porter's technique in order to keep the competitive advantage, the business model of the company and its strategy must not be in isolation. Therefore, the business model represents the firm's activities, strategies, partners, and how it all work together in order to propose a value for the customers and gain revenue, and this is an important part of the future strategy if the right tactics and mechanism were exploited. Thus, the company must always look forward when it comes to updating the current business model according to the long term strategy, by keeping up the innovation. This is especially important for software companies. As an example, Rovio, the company that developed Angry birds, after the huge success of the game the company has offered several updates at first to keep their existing customers engaged, then it has launched Angry Birds Rio and Angry birds seasons, as well as other clothing and toy lines related with the game, this has kept their customers happy and enabled the company to reach a wider range of customers (DaSilva and Trkman, 2014). Later on, the company kept on developing more angry birds sequels, and by doing so the company is able to strategically update its business model and create more revenue streams.

Researchers have tried to create business models, depending on certain attributes that they found important. Starting from Chesbrough's and Resenbloom's (2002) six attribute business model, leading to Osterwalder's (2010) book, who has developed a very comprehensive template on which to construct the business model's previous hypothesis and assumptions. This model will be used to answer the study question on how does the application of real-time simulation affect the business model. In order to do that this study needs to examine the nine pillar business model and how does the innovation effect it.

2.3.2 The business model canvas

"The business model describes the rationale of how an organization creates, delivers, and captures value" that is how Osterwalder (2010) described the business model in his famous book Business Model Generation, where he came up with the business model canvas. His idea is to have the 9 building blocks which are:

Customer segments represents the type of customers that the company wants to attract and target by offering its value proposition (Muhtaroglu et al. 2013). Those segmentations could be 1. Mass market 2. Niche market 3. Segmented market 4. Diversified market 5. Multi-sided platforms (Osterwalder, 2010)

Value proposition represents what the company is offering and makes customers consider buying. It also can be described as products of services delivered by the company to fulfill the needs and are of value to the customers (Muhtaroglu et al. 2013). Osterwalder (2010) mentioned some elements that contribute to the creation of value 1. Newness 2. Performance 3. Customization 4. Getting the job done 5. Design 6. Brand 7. Price Reduction 8. Cost reduction 9. Risk reduction 10. Accessibility 11. Convenience /Usability

Channels are the way that the company is intending to reach its customers and deliver its products and /or services he has value to the customers, by different means of communication, distribution, and sales channels (Osterwalder, 2010).

Customer Relationships represent the relationship that a company establishes with each of its customers (Osterwalder, 2010). This relationship could be automated or personal, for the purpose of creating a customer base, retrieving the customers or increasing its sales. This can be considered as the lifeblood of the company's business (Muhtaroglu et al. 2013).

Revenue streams represent the way that the company makes money. In this block managers have to determine what do the customers value and what are they willing to pay for, and in the previous example of Rovio the makers of Angry Birds game (DaSilva and Trkman, 2014), it was mentioned that they made sequels in addition to toys and merchandise related to the game, that way Rovio has created more than one revenue stream, after discovering what each customer segment would value.

Key resources are inputs and capabilities that the company needs in order to deliver value to its customers. These assets are important to offer value for the customers, build relationships and gain revenue, it could be in a physical, intellectual, human or financial form (Osterwalder, 2010).

Key activities represent the most important activities for the company's business, in order to deliver value, maintain customer relationships and make revenue just like the key resources. They vary so much depending on the type of business model. However, Osterwalder was able to put them in different categories. 1. Production: including all the activities to design make and deliver the products. 2. Problem solving: involved coming up with a new solution for problems that the customers are having. 3. Platform /Network: for companies that are dominated by a platform or network, such as eBay.

Key partnerships include the partnership network with suppliers and partners, these partnerships take the shape of cooperation, joint ventures, alliances, and buyer-supplier relationship. The partnership network is important, as it optimizes and creates the economy of

scale, reducing the risk of uncertainty as well as the privilege of acquiring a particular resource or activity needed by the company.

Cost structure is understanding what the company will have to pay in order to create and deliver the value proposition. The cost structure creates two different types of business models, either cost-driven, where the company thrives to reduce the cost and offer their products at a low price. Or a Value driven model, the company here focuses on providing the best value for customers regardless of the cost.

This business model has made the previous assumptions into a coherent and understandable model, researchers such as Dudin et al. (2015) has been encouraging companies to use this model and control their strategies from a financial point of view. In order to do the assessment the company needs to define the way it creates, delivers, sustain and enhance the value (Muhtaroglu et al. 2013). This has made it easier for companies to follow these steps and compare with other companies models. The model template has quickly been spread around the world and been used by P&G and Nestle in order to create new strategies for earning money (Muhtaroglu et al. 2013). It also opened the door for the researcher to develop it and try to come up with innovative business models.

2.3.3 The importance of business model innovation

There have been many attempts to the original business model canvas by Osterwalder, in order to innovate it to serve a certain purpose, for example, to make it more sustainable (Joyce and Paquin, 2016), to help the success of open innovation strategies (Saebi and Foss, 2015) and technology management (Zott et al. 2011. Muhtaroglu et al. 2013). The latter would benefit this study, as the aim of this chapter would be in the end to discover the changes in the business model when the company adopts RTS technology and embraces it in the whole value chain, for the purposes found in the previous chapter: R&D, Predicting the fault, Training, Marketing, and Logistics.

Chesbrough and Rosenbloom (2002) also mentioned that it is important to have a proper business model that works with the new technology that the company is using, in order to create value from it and manage not only the technological uncertainties but also the economic and market uncertainties. This will ensure that the market needs are discovered and the customers are receiving the full value from it. Chesbrough and Rosenbloom (2002) were also able to prove -in their Xerox case study- how employing an effective business model to commercialize a technology can make the company grow, as they offer a new business model that works with the technological perspectives. Zott et al. (2011) were able to go through

previous case studies, and they came to the conclusion that the business model has an important role of unlocking the potential values of using technologies and converting it to potential outcomes. Companies could benefit from creating its own business model for its technological usage if it was able to understand the role of the business model and adapting it to the adopted innovation. This way the company would be able to compete and make full benefit out of the technology. After knowing this potential that new technology has provided for the business model, we will explore these potentials for RTS specifically.

2.3.4 The effect of RTS on the business model

The applications of RTS in multiple actions in the value chain were discussed earlier, and it is proved in the previous paragraph that technologies would cause changes in the business model. A simple example would be that when RTS is used during the R&D process, it would affect the effort and time. The use of RTS would reduce the need for physical prototypes, the fast prototyping allows modifications and testing to be made before implementing the real model (Guillaud et al. 2015). This will consequently affect the cost and the need for resources to produce prototypes that might not work. In the same manner this paragraph is going to discuss how RTS is expected to affect the business model in the light of the possible different uses in the value chain. The aim of this paragraph is to predict how RTS is going to affect the business model on the light of the previous collected data and applications mentioned earlier in the literature review. The empirical part of the study going to either confirm or deny these effects.

Key Resources

Massive streams of real-time data would create storage and memory resources (Kaufmann, 2019). The storage of real-time data could be considered as a resource that would be benefitted from later to serve customers.

If the company is using new technologies, it will need further human resources that are knowledgeable and experts in this field. Therefore, it is a way for the company to adapt to the competitiveness of the market, by modifying the human resources, as well as the financial resources needed to supply the simulation used in the company. Thus, the key resources in the enterprise would be affected as well.

Key Activities

The business model would face some changes related to the key activities that the company does. When it starts using RTS, more data could be gathered from those machines, leading to a greater possibility of incorporating activities that takes benefit of this data. Providing a training possibility for the customers that are interested in training would enhance the creativity of the users (Guillaud et al. 2015), thus increase the offerings of the company.

Cost structure

As mentioned earlier in this paragraph the cost structure would be affected and reduced, one reason for that would be the reduction in the number of prototypes needed (Guillaud et al. 2015), another reason would be the testing of ideas and designs before making the product and discovering some faults later, so it would reduce the costs needed for production materials.

Key Partners

Combining the gains of real-time data some B2B companies could benefit from certain partnerships with other firms that provide services with these data, so the use of RTS provides opportunities to network and cooperate with other partners and increase its activities and value proposed to its customers.

Earlier Mevea was mentioned as a reference two times in the literature review, as a RTS technology provider. When companies decide to make partnerships with this company for the purpose of getting introduced and provided with this technology, this action affects the partners and stakeholders of the company.

Value Proposition

The Value proposition could be the most affected block of the business model, as RTS allows many benefits to be transferred to the customers. One of the benefits is the chance to give feedback and participate in developing the products and services so that the value could transfer to a wide audience of customers. Training, and testing of special features was made possible with RTS (Guillaud et al. 2015). leading to an improvement in the current value propositions. RTS could also create more values, when the company is able to offer more services with the use of RTS, Wang and Lu (2018) have mentioned the possibility for an

optimization of the system with the use of RTS, where the system would send an error if the absolute value is not occurred. If this application would be implemented on the production machines that are in use it would leverage the performance of the machine and add value to the user.

Customer Relationship

RTS could affect the relationship with the customers, as when they are involved during different processes -from the R&D till the product or service is already in their hands and being consumed- due to the ability to share the real-time data. This would increase the customers trust and loyalty towards the company after being able to track the data through the product life cycle, which will make them feel safer. Cocreation of the product or a value strengthen the customer supplier relationship (Payne et al. 2007), This co-creation is boosted through machine testing, as well as marketing for the product through RTS machines.

Peusaari et al. (2009) mentioned that direct communication ease the transfer of data needed for RTS, and shorten the time needed to collect this data. Therefore, the relationship between the customer and supplier is affected by the use of RTS, and a good relationship and sharing of data ease the work of RTS.

Customer Segmentation

Customers segmentation could be divided due to the introduction of RTS into the company, by the ones who are in favour of utilizing such new innovative technology, and those who are not. This technology could also add new segmentation according to the demand on the services and benefits presented from the usage of RTS. If the company was targeting one of the previous mentioned segments or more, the new technology will emerge a new type of customers who are interested in the benefits that RTS has to offer before and after the buying action. For instance, customers who are interested in the data collected from the bought machines and want to use it for different purposes to achieve their goals in predicting the fault (Mattera et al. 2018), or finding the optimal use of the machines (Wang and Lu, 2018), would be a new segment. However, it depends on how the company wants to segment its customers.

Channels

Stakeholders of the company could communicate and share the real-time data. Thus, come the need for new and effective communication channels to distribute information between the HQ and dealers for instance. It was mentioned earlier that The direct communication is effective while using the RTS, as it reduced the time and the obstacles for data sharing (Peusaari et al. 2009), so the communication channels would also have an effect on the RTS.

As for the physical channels the simulation could use its optimization ability (Wang and Lu, 2018), and optimise the distribution channels to cover as much area as possible with the right timing and amount of products when needed, if storages and vehicles status real-time data is available, the company could be able to optimise logistics and the distribution process.

Revenue

All the overall mentioned benefits of RTS eventually would affect the revenue of the company. Directly, by adding more activities and services to the business model, for example aftersales services that concern predicting the fate of the machine, its breakdowns and the parts that needs changing, -if the customers agrees to buy the services- it would add additional revenue to the model. The use of RTS for training the customers would offer a great experience (Guillaud et al. 2015), this will add more value to the propositions and optimizing the offerings, which could increase the sales of these offerings. RTS could also affect the finances of the company, by decreasing the costs during the R&D, marketing, and other processes of the value chain.

2.4 Summary findings from the literature review

RTS has been proven important and effective in many fields. However, not so many studies were found concerning this technology from the business perspective. Thus, comes the need to test the areas that RTS has been applied to, and its value that has not yet been properly employed.

Rubmann et al. (2015) predicted that the actions throughout the value chain will be done faster and will be more flexible under the effect of recent technologies, Lee el al. (2014) agrees that processes over the value chain would be fast, flexible and efficient, allowing the companies to reduce costs and improve productivity. Therefore, This study is aiming to discover the uses and benefits of RTS in the value chain, as shown in the second figure

The real-time simulation is a complicated concept to non-specialised managers. Thus, they have to properly understand its functions and applications in order to employ it the right way, throughout the business process model, for the purpose of getting full benefit out of it. Advanced simulation technologies make it possible to describe increasingly complex mechanical systems, the possible benefits and uses of these technologies should be considered. The theoretical part of this study showed some results of the application of RTS through the value chain, and the results were five main uses in R&D, prediction of the faults, training, marketing, and logistics. Mevea-c (2018) mentioned the possibility of analysing the machine use data in the digital twin to gain valuable insight into the product behaviour. This would enable operators and consulting companies to find ways of improving the machine use. Training as a part of the companies services to its customers or for its own employees, could benefit from simulating training scenarios in different environments. Predicting the fault was another benefit that RTS could provide, whether it is during the R&D or while operating the machine, this feature was proved -in earlier parts of the chapter- to save time and resources. The chapter also mentioned the use of this technology during R&D, sales and marketing phases as well as in the service field, aiming to guide managers and researcher and give awareness on the use of this innovation.

This study was able to come up with a research model that involves the business model, see figure 2. It has been proven that the use of RTS throughout the value chain of the company would have an impact over the business model canvas with its nine blocks. The changes on the business model were listed in a general manner. However, the changes in the business model will differ from one company to another depending on its original business model and the business strategy, the industry and the market that the company operates in. This chapter

was able to display a general idea, which will be tested through the primary data collected for this purpose.

The figure 2 below shows links between three concepts, starting from real-time simulation, and showing its one-way effect to the value chain. In this half of the model the study of the primary data is going to reveal the current application of RTS in the value chain for related business as well as future plans or possible applications. In the study model those applications are expected to affect the business model in a one-way effect. Each of the applications alone could affect certain blocks of the value chain. The previous part of the study has shown the process leading to the study model, and the researcher was able to explore the study model in theory. However, this study will continue in its empirical part by drawing the attention on what is happening in real life. Thus, with the help of primary data collected from professionals and corresponded people, this study will further explore the research questions at its empirical part.

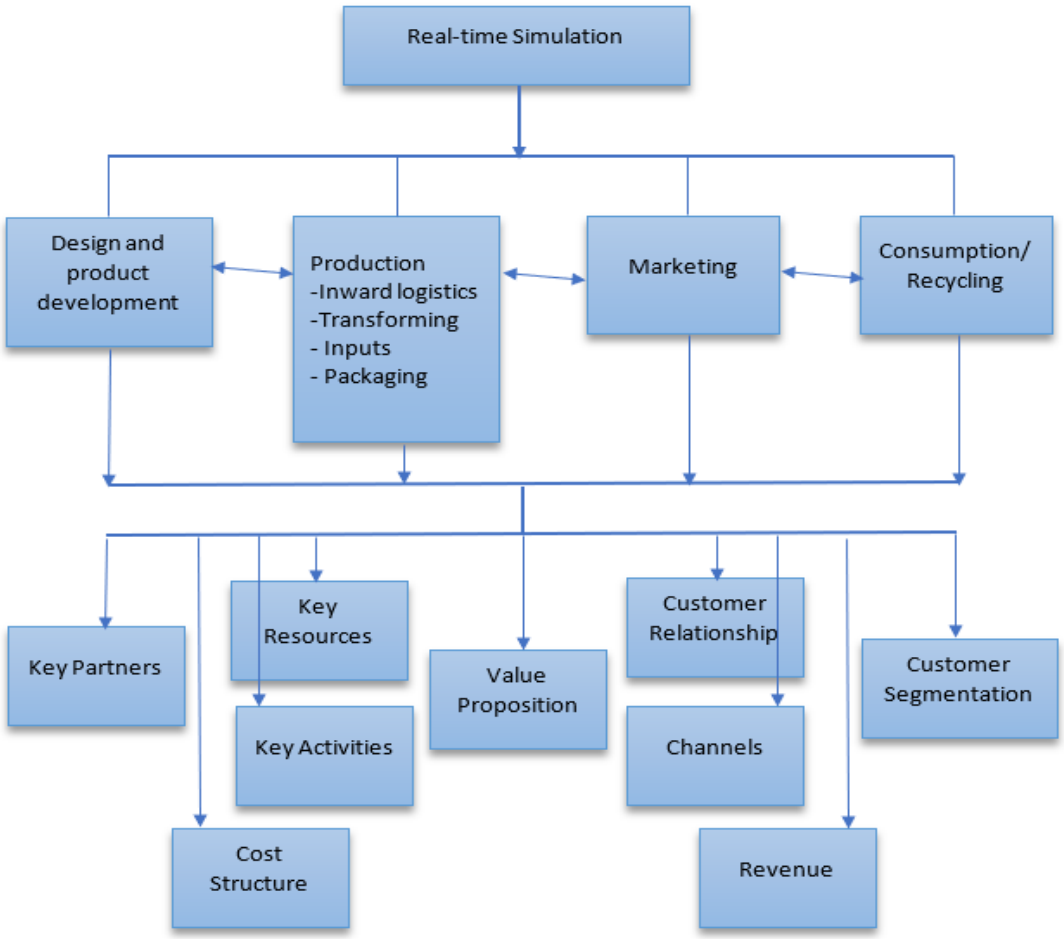

Figure 2- The study model

Methodology

In this chapter of the study, the research methodology is going to be explained, the data collection and data analysis methods will be discussed in detail. The challenges of the process and the validity and limitations of the research will be mentioned.

3.1 Qualitative data collection process

To ensure the reliability of qualitative research, two different methods are used in order to obtain both primary and secondary data. Secondary data, which refers to data that has already been conducted for other previous purposes, it has been done to cover a long period of time spent on researching the concepts of this study, some references are related to researches conducted in the 1980s and others were are recent as 2019. This data was collected through trustworthy sources of scientific journals, books, scientific conferences. These resources were chosen depending on its availability and relevance towards the topic, for the purpose of getting familiarized with each of the subjects, and understanding how previous researchers arrived at their conclusions. Since researchers have already done a reliable work in relevant topics, there was no necessity for abducting primary research in some topics.

Applying the innovation of RTS to enhance product development is a novel idea, and the novel technologies that will come along with it will have a great impact on the Finnish industries (Hannula and Pirttimaki, 2003). However, these technologies at the beginning of its lifecycle do not have a sufficient amount of information or research related to it, and it would be challenging to find some specific subject related articles about these novel innovations. Thus, the secondary data would not be enough or sufficient to get a satisfying result for this research. Therefore, the primary data was needed for this research, in order to answer the research questions. Through qualitative methods, by conducting semi-structured face to face interviews the researcher was able to acquire this type of data. Primary data refers to the data that has been self-collected for the exact purpose of this paper ensuring that the objectives of this research are the closest to be achieved. Collecting the primary data is thought to be more expensive and take more time than collecting secondary data, for the reason this data does not exist and need to be properly planned in order to get subjective results. This primary data enriches the research with fresh unused data made specifically for the purpose of the paper, arriving at certain conclusions.

3.2 The data collection sample and data analysis

This research takes part in a bigger project, this project's steering group consists of ten real-time simulation forerunner companies to collect enough feedback to direct and guide the researcher for the best exploitation of the results. However, five out of the ten previously interviewed companies have been decided to take part in this research. Some data has been already collected and is ready to be used for this research. However, the questions in previous interviews were asked for the purpose of digitization and had so little relevance for this research topic, there is a need for missing data in this research. The companies that were chosen are big companies, which use this innovation for different purposes and in diverse industries.

Those Five companies were chosen with the help of the professors and their knowledge of Digi pro project and the level of operations. The companies that were chosen, have similar value chain actions for different industries, and are selling manufactured machines, mainly B2B businesses, using RTS in different levels, and are interested in future development of the business using RTS.

Primary data was collected through semi- structured in-depth interviews. The purpose of these interviews is to have rich and detailed data to answer the research question. The meetings were tried to be face to face meetings for most of the companies when the conditions helped, and if the other party agreed on it. These meetings took places in different parts of Finland (Lappeenranta, Joensuu, Tampere). However, some meetings were done online due to travel or schedule issues.

The first meeting was scheduled on the 10th of September 2018, and the last one took place on the 5th of November in Joensuu, as explained in table -1-. It is important to note that some companies were met more than once, and the reason was the lack of data gathered from the first meeting, this approach is hoped to add credibility to the research. The data was collected via a recorder and it was saved in personal devices and moved later on to the university's own cloud system.

Table 1- Primary data collection

Company	Position	Date
Company A	Managing director	10.09.18
Company B	R&D Manager	14.09.18
Company C	Global Business Development Manager of BU Automation	21.09.18
Company D	Manager, Engineering Systems and Adm.	26.09.18
Company E 1	South-American Area Director	08.10.18
Company E 2	Director, Customer support	05.11.18

After collecting the data, the first step that follows is creating transcripts based on the recorded meetings. The transcripts were raw and messy. Therefore, a data reduction process helps to clear the data without losing any essential information.

Choosing a general analytical strategy, that best fits the study and data at hand is an important part of the analyzing process. The purpose of the analytic strategy shows in linking the case study data to important concepts of interest, and then the concepts would give a sense of direction in analyzing the data (Yin, 2018). Thus, relying on theoretical propositions seems the closest to this research. This research was based on a theory, presented in the assumption that companies in Finland are depending more on Real-time simulation, without taking full benefit out of it. Finnish companies are interested in technology and believed that it benefits the business (Hannula and Pirttimaki, 2003), still as explained earlier the use of RTS is not yet clear for managers. The theory was assuming that this technology was conducted throughout some actions of the value chain and accordingly influencing some changes in the business model, in order to adapt the business to the use of this new technology. In this strategy of analyzing the original objective and design of the case study were based on theoretical propositions that led to it. (Yin, 2018) This theory has already shaped the study since the beginning and the data collection method was based on a certain targeted outcome, the selected companies and the interviews were planned accordingly. Yin (2018) showed examples of how the theoretical orientation has guided the study analysis depending on the

preceding proposition. The latter has helped to organize the entire analysis, by pointing to relevant contextual conditions to be described as well as explanations to be examined.

The analysis was conducted by summarizing the data from the interview and the key changes in the business model and the added value perceived from the interviewed company's experience were added to the results. Managers need to have a vision towards the future if they want to satisfy their customers' needs, resulting in different timelines concerning the data collected. Some answers were reporting the current situation in the company and the current use of RTS. Due to the novice use of RTS, some of the answers were describing the interviewees' own vision and ideas of future benefits from this technology. Therefore, these two timelines needed to be pointed out during the analysis of the data.

3.3 Limitations and validity of the data collection

This study is aiming to collect the needed primary data through interviews, while conducting those interviews the researcher was aiming to be as unbiased as possible, in asking the questions and making contact with the interviewees. The questions asked were related to the companies' business and the research model, and the interviewees were expected to answer from their experience. They were also proposing their opinions whether it was with or against the use of RTS.

The data collection was limited to six correspondents from five relevant companies. The interviewees were chosen from the people who have knowledge in two fields, the first is the company's use of RTS in all fields, and the second is the company's business from the management point of view.

Customers of the chosen companies were desired to take part in the study to get a closer insight into the value chain of the company and include the key stakeholders. However, this idea was not possible due to the early use of RTS in most of these companies, customers have little knowledge about this technology and its benefit. Nevertheless, Company A as a supplier of this technology was able to recommend Company E as an example of a well-involved customer, integrating RTS in most of the lifecycle of its products. Customer feedback was also discussed during the interviews, to make sure that stakeholders were not overlooked in the analysis process.

3.4 NVivo

The researcher decided to use this program in order to help analyze the case companies. Nvivo is a trusted, well-programmed software designed for helping qualitative research. The researcher has completed an online course in the software called From Zero to NVivo and obtained a certificate of completion after passing the course.

The software has helped in importing the interview transcripts and turning them into cases. Comparing the case companies by having attributes and values given to each case. Coding each case according to the current use of RTS and future uses possible effects and no effects on the business model blocks depending on the answers, the main codes sample could be found in Appendix 2. The overall sorting and managing the data was made easier due to the use of this program.

The study analysis

In this chapter the researcher will be analyzing the conducted interviews, each company will be analyzed as to its own case, due to the differences in the value chain and the level of RTS usage. At the end of each case, there will be a summary of the findings, followed by a cross case analysis, summarizing the main findings from these cases. The following Data in each case is referenced to the discussion during the interview. It reflects the interviewee's interaction and opinion, alongside the researcher's understanding of the interview. The companies will be referred to in numbers, in respect for the companies' data privacy.

4.1 Company Case A

The discussion during the interview has started with an introduction about Company A and its business in relation to RTS applications. This interview was rich with data related to RTS, due to Company A's business and its strong dependency on RTS. In this analysis the researcher is going to refer to the first company as Company A.

Company A is a Finnish high-tech company and one of the leading digital twin and RTS technology providers. The RTS in Company A helps to improve the whole product lifecycle, they help to utilize the existing product design and manufacturing knowledge on a new level by enabling the digital twins. The main activity in Company A is developing digital twins, and RTS is the software used for these machines.

Company A's Simulation Software is a tool for developers to test new features and designs of a working machine. The core of the software is Company A's own physics engine, which accurately simulates the mechanics, hydraulics, power transmission, and the operating environment of the machine. Mathematical calculations behind the dynamics are scientifically proven. Company A would be the source for RTS related inquiries, its business model is based upon selling this technology. Thus, it would be impossible to separate it from any of the blocks in the business model. However, the applications and the effect would be examined during the interview, due to the deep knowledge in this high-tech and its abilities.

4.1.1 Benefits of RTS

During the interview conducted with the managing director, the emergence of this technology and its importance to solve ongoing business problems was introduced. RTS was mentioned to have a huge influence, due to complexity in current machines and the huge amount of data shared. *"10 years ago we had more physical products and its complexity was with mechanical parts and electrics, after that the machines got smarter and more complex, with a lot of sensors, user interface, software, intelligent control systems. The product starts to communicate by sending data to cloud and machine groups start communicating together so the complexity even increased higher, this is a problem, and customers were asking for help."*

Similar to the literature review, the discussion of complexity had led to the dilemma of having multiple stakeholders that have access to the data, but understanding this data and using it to optimize the operations is mostly not achieved in most of the companies. The idea behind using RTS is to make a benefit of the real-time data coming from different sources and share the results, in order to control and optimize the operations between different stakeholders of the value chain. He mentioned that *"educating all the shareholders from engineers, maintenance staff, users, customers, operators, and salespeople, and teaching them how they can understand and optimize the operations...so that they can use this data for designing better machines in the future."*

The problem with having complex machines is that *"the data does not come together with different departments."* RTS benefit in detecting the faults and testing, in a way that the data would be analyzed and the problems would be detected in a faster manner, *"this is something that simulation can speed up a lot,"* rather than constructing the model and discovering the error later. In that way *"the product reaches the market faster"*.

Another challenge emerged in finding proper use from the data gathered from different resources. He mentioned that RTS helps in understanding the data and explain what the numbers are implying. Thus, it helps in employing the data for the benefit of the company. *"The digital twin we can make more calculations in order to understand better what the numbers mean."*

The complexity in the data gathered from different machines, different departments, and sharing with multiple stakeholders could be reduced with the use of RTS. The interviewee also mentioned that the health risk in some companies alongside the previous challenges was the main reason behind adopting this technology, *"In some companies, they use simulation tools to optimize the human work so they don't get any injuries during work*". RTS's applications in testing would reduce the number of errors, resulting in a lower risk for the workers.

The interviewee stressed the possibility to use RTS during the whole product lifecycle, starting from the making of the machine and it continues even after the machine is sold. Thus, multiple actions of the value chain were mentioned. *"It accompanies the product in the lifecycle starting from the designing and R&D, training and marketing, and it also exists while the machine is operating, and then getting the data in order to prevent the faults"*. These issues were discussed in depth in the following chapter.

4.1.2 The use of RTS in the value chain

During the research and development process

The interviewee insured that RTS's use during the R&D phase would have so many benefits and effects on the business model, including the cost and the resources. And the outcome would be the room for more design ideas to be tested. *"It speeds up the engineering phase and enables to test more ideas, as the engineers have lots of ideas but only a few must be selected for testing, the testing process is much faster and it doesn't cost much...during this phase, we don't need to order the physical components."*

During the production process

As for the production stage, it is not expected of RTS to help much in this area, the interviewee had to think about this application before answering. However, if this technology was given a chance, *"It allows designing the production line"*, especially if it was a big manufacturing factory, he mentioned an example about a car manufacturing factory, where there would be a movable production line with a lot of machines involved. RTS could help in organizing the

production line in a way that would generate an outcome with optimal use of resources and in the shortest time possible. *“It allows to recognize the fault in the production line and improve it to get more product out of the line.”* However, this type of simulation is different from simulating physics and different forces. *“So it is possible, but it is not what Company A does”*.

During the marketing process

The interviewee also encourages the use of RTS in the marketing area. Especially in small spaces, where the machine cannot drive distances. It also reduces the risks accompanying the buying decision, making it easier for customers to choose the right product for them. He mentioned that *“In exhibitions, it is not allowed to let people drive big machines, but we can use the simulator in order to show the real and new features of the product, and let the customer sit and experience the benefits, compare it with the previous model or let them try and test different options. This would ease their buying decision”*.

During aftersales services

After selling the machine the role of digital twins does not stop. *“It can create more information for the control system about the status of the machine, without putting extra sensors”*. This data collected from the machine helps to monitor the situation of the machine even when the operator is not inside the machine. At this point, the interviewee mentioned used the collected data from the operating machine to predict the fault. *“This data can be used by the engineers at the beginning of the chain”.* When this data is available multiple controlling and managing benefits could occur.

The interviewee mentioned that there is potential from combining RTS and the machine while creating it. This way the state of the machine could be analyzed and monitored for safer use, *"it gives information about it without using more sensors, as it calculates the values”.* If the machine is controlled, there would be a better chance to optimize the machines work in a way that saves time and effort, it could also optimize the amount of fuel or input invested in it, which leads to saving resources and costs as well. If the machine is monitored, any breakdown or error could be predicted and managed in order to prevent major losses, and calculating the values could result in a better outcome from the machine.

4.1.3 Potential future applications

The use of AI and RTS

The interviewee also saw a benefit from using RTS in machine learning, while AI is the main controller of some machines, it also helps in the predictive maintenance. Cars and some harbor machines are using this technology, but RTS's role in this operation is that it could teach AI in its predictive maintenance action. AI is capable of predicting the third or even the second fault, but it is not able to predict the first one as there is no previous data collected. the interviewee discussed that *"AI can only predict the second or third fault as it is capable of learning but it doesn't help the first breakdown because there is no previous data obtained, but what we can do is use the digital twin to help the AI learning system. so it can teach the AI so it can predict the first fault even before it happens"*.

RTS could help in teaching AI by creating different scenarios in the virtual world, so when it comes to real life AI would be able to predict even the first fault. The possibility of having fully automated processes was also discussed. With the dynamic interaction between AI and RTS, as an example, the AI would be able to learn how to operate a driving machine with the help of teaching rounds from RTS. AI then would be able to know the optimum fuel consumption and the capability of the machine, combined with its ability to change hydraulics and different engines, no human assistance would be needed, and the process could be optimized.

4.1.3 The effect on the business model

It was mentioned that the feedback and the results from using RTS were showing a huge improvement and effects to the business model. *"-50% of the need for physical prototype, -30% reduction of lead time, -90% reduction of software implementation time. The improvement of operator efficiency was 25% that varies depending on the task"*, and it is different in different industries. The reductions affect the cost and resources directly, and the reduction in time could affect the key activities, value proposition, and customer relationship indirectly.

The business model in different industries differs a lot. Nevertheless, the idea behind digital twins is that it could be used in different industries as the laws of physics are the same everywhere. *"We have customers in many different fields. The idea is to use the same software in different industries, and it is possible because the physic laws are the same."* However, it is arguable that this type of innovation would benefit companies that have a traditional production business with heavy machines involved, where the resources, the costs, and the risks are high.

Bearing this idea in mind we can further analyze the effect on the business model from the interviewee's perspective. Company A as a RTS provider, it is hard to evaluate the business model without this technology. However, the discussion during the interview took a turn towards describing Company A's customers' case and their business model.

The effect on cost structure and resources

It was mentioned on many levels during the interview that RTS affects the cost in the business model by reducing it. The interviewee considered that the cost is reduced when *"companies don't have to buy the different possible components"* when they can test all possible options virtually and buy components for the models which have been proved to work the best in real life. Cost reduction was also mentioned earlier in the interview while describing the use of RTS during the design stage, for the same purpose.

The resources inside Company A would be affected by RTS of course, being its main business. Its main resource is the knowledge of *"our core people who are all involved in this technology"*.

The effect on channels

There was no obvious effect for the RTS over the channels in the business model. However, in Company A's case some *"hardware setups are needed for the motion platform, and designing the machine that moves the operator to fill the real machine with different types of masses"* needs the assistance of RTS. This use could help in planning the distribution of different masses, with the optimal way possible. The benefit that would be gained from this operation for Company A and its partners was not discussed with the interviewee.

The effect on revenue, key activities, and value proposition

RTS clearly had an impact over Company A's own revenue, as it is Company A's main source of revenue. Still, the revenue of their customers needed to be discussed. RTS generates revenue through helping the business in offering more services, *"providing services to our customers' customers"*. One of these services could be training, so if Company A's customer, for example, is selling complex machines, then they can sell training services through simulation to teach the customers how to operate the machine. *"Some of our customers are also selling simulators, forestry machines producers are selling simulators of their machine to*

forestry schools." And that is another way to generate revenue directly. It is noticeable that this way of generating revenue is through Affecting the activities of the company, either by selling the technology or offering services with this technology. And the same applies to the value proposition.

The effect on customer segmentation

The segmentation of Company A's customers is depending on the use of RTS. However, it was not seen that it would have a direct effect on the customer's own segmentation of the market. The interviewee has observed that *"The bigger the company is the more difficult it is to use the same tool over the whole product life cycle where many departments are involved"*. wherein smaller companies it would be easier to manage the cost.

The effect on customer relationship

The customer relationship's effect on RTS works both ways. The interviewee mentions that the use of RTS requires getting access to the data and some control systems and for that *"it requires deep trust between Company A and the customer company".* In this way, customer relationship affects the use of RTS. On the other hand, RTS builds trust and longer relationships with Company A's customers, as it creates more value for the customers.

4.1.5 Summary findings from company case one

1. RTS use in R&D would help in testing the models before actual producing of the machines, this leads to fewer materials needed to produce failed products and more ideas to be tested, and this affects the cost and the resources in the business model.
2. It is possible to use RTS in the production activities, this use is for certain type of factories with a movable production line. This would benefit from finding the best solution, leading to an optimal outcome.
3. The bigger the company is, the harder it is to use RTS through the whole company, because it is harder to organize between different departments. The size of the company and the size of its produced machines affect its need for RTS, it benefits companies that have a traditional production business with heavy machines involved, where the resources, the costs, and the risks are high.
4. The marketing use of RTS is beneficial in exhibitions for companies with big machines and no space or resources to display the machines, it eases the buying decision.

5. The discussion of the aftersales services uses resulted in the idea that collecting the data from the machine while in use results in multiple applications and service offerings. Real-time data is a valuable source of information, if employed well it can help engineers in designing better machines.
6. Predictive maintenance use as an aftersales service results in saving cost, optimizing the outcome, saving the resources.
7. RTS is effective in machine learning and when combining with AI systems it could result in a beneficial outcome for the future. This would optimize the whole process of the controlled machine.
8. RTS could have a triple effect on the business model if the company is selling it or providing a service that needs this technology (training service). In this case, RTS affects the value proposition, the key activities and the revenue directly.
9. Company A's customer feedback showed an improvement in their business model. The results manifested a direct effect on the cost and resources, and indirect effect on the key activities, value proposition, and customer relationship through time reduction.
10. The results showed no direct effect on the channels, partners, or the customer segmentation in the business model.
11. The relationship between RTS and customer relationship are both ways. Customer relationship and trust effects the use of RTS, and this use would build more trust and longer relationships with customers.

Table 2- Case company A, current and future use

	R&D	Production	Marketing	Training	Maintenance	Logistics
Current use	Yes	No	Yes	Yes	Yes	Not mentioned
Future use	Yes	Yes	Yes	Yes	Yes	Not mentioned

Table 3- Case company A, business model effect

Business model block	Effect
Key activities	Training and after sales services
Value Proposition	All uses
Customer relationship	Marketing
Customer segmentation	No effect
Resources	R&D and testing
Channels	No effect
Cost structure	R&D and testing
Revenue	Training and aftersales services
Partners	Not mentioned

4.2 Company case B

Company B is a high-tech global engineering group, it has a strong commitment towards enhancing customer productivity, profitability, and safety. Continuous advancement in R&D is the aim in its different domains: 1. tools and tooling systems for industrial metal cutting, 2. stainless steel products, and 3. equipment and tools, service and technical solutions for the mining and construction industries. However, the interviewee informed that RTS tools are being used in *"the mining and rock technology inside Company B, we do everything from design and engineering of the products, as well as manufacturing, as we got our own factories, and then we sell globally and do our own marketing"*, that's how the Global Business Development Manager of BU Automation in Company B described the activities of the value chain inside Company B.

As for the services that the company offers, the interviewee described it as *"we can cover the whole lifecycle in term of starting up and maintenance*". In the mining industry, Company B offers a wide range of services from setting up, training, and maintenance. The interviewee mentions that *"sometimes customers prefer to have a fulltime Company B presence in their mines*", this way the services cover the whole product lifecycle. In this case, the company could provide the research with a lot of insight about the possibility to use RTS in some or all of these actions in the value chain.

The interviewee also discussed the presence of stakeholders in the value chain. *"The customers have a strong existence in the value chain, as for suppliers when it comes to product development as well as manufacturing, we have an extensive network of suppliers."* He also mentioned the importance of having *"software developers, mechanical and electrical engineers"* in the value chain, because of the complication in the high-tech that it uses.

4.2.1 Current use of RTS in Company B's value chain

During the Research and development process

The first use that was mentioned during the interview was utilizing RTS in the designing and development stage, when the customer suggests a business plan by selecting the desired mining method, using RTS would help in predicting *"how many equipment's, what type of systems are needed, and what would be the expected production output of the mine".* Thus, the use of RTS during the R&D process is helping in testing the models developed with the customers.

During the aftersales services

If the customer signs a full contract with Company B, then after the simulation and the planning, while deploying the plan, Company B offers information management related services, this includes *"tracking the progress in real time, which means that all the data will be recorded in a database where it is possible to run a report to analyze what happened in the past, what is happening now, and our solution predicting the future".* Predicting the future of the machine using real-time data opens doors for exceeding customer expectations and offering remarkable aftersales services like *"preventive maintenance and potential of machine failure*". This gives control over the machines even after selling them, for the whole lifecycle of the machine.

The interviewee explained that predictive analysis is applied mainly for the sold equipment, in order to provide a predictive breakdown maintenance service. He provided an example of how this idea could be applied when Company B sends its customer a message provided from the system *"there is a 70% chance that the machine would most likely breakdown in the next three days if a certain part is not changed in the machine"*. In this case, Company B and its customers would be aware of the situation and ready to provide the service at the right moment and the right time, resulting in less unfortunate surprises for any of them.

Training is another field mentioned in the current uses of RTS and is targeting equipment operators

"The benefit is being able to train people how to operate without having the real machine, system, or environment available. This kind of a training simulator responds to the user's commands in real-time similarly as a real machine would, and it visualizes the machine in its environment to the user."

4.2.2 Potential future applications in Company B

For optimizing the operations

If the real-time data is available through RTS, in this case, the interviewee sees potential in benefitting from this data to the maximum level. Accordingly, the system will not only predict the future of the machine, but it would also recommend *"the optimal way of operating to achieve an optimal production output"*. In the interviewee's opinion, this could be possible through collecting information from different resources, including *"equipment, people, mining environment, processes, external interfaces such as human resources and maintenance systems"*. If the access to these resources is available, and the system is already capable of predicting the future, then recommendable actions for optimal outcomes could be the next step as the interviewee argues *"we have already taken steps towards that direction"*.

For predictive maintenance

The Predictive maintenance is being applied to the equipment and sold machines as mentioned before. However, Company B is having plans in applying this service also to production operations, so that they would be able to advise by comparing the current situation to the target state, there would be an optimal path to be taken in order to achieve the target state. The interviewee suggest that *"if the system could automatically find that path by simulating different scenarios and applying the analytics, to be able to suggest or predict what to do to get to that target"*, if RTS system would create this optimal solution *"that would have a great business value"* for Company B and multiple companies that work in a similar field.

For marketing

In marketing, the RTS is not yet used in Company B. However, the interviewee sees the benefit of applying RTS in the marketing field. He mentioned that most of the high-tech equipment that they sell and its capabilities are hard to comprehend, and "*difficult to explain for people outside the industry and even within the industry if they were not exposed to this kind of high tech before*". Using traditional marketing is a hard and expensive option for Company B, he explains that *"one way of approaching customers is to go with all the equipment, set it up there and demonstrate it live, but this solution requires time, effort and investment"*. Company B at the moment is using simulation as a pre-sales tool for marketing, this tool is mainly *"just to demonstrate the capability of the system"*. He explains that *"it is not real-time simulation quite yet, but we can expand from there to be able to promote and demonstrate the capabilities of the systems"*. In other words, Company B is not yet applying RTS tools to aid in its marketing it is mainly simulation visualization tools. However, the benefit of RTS in this field is comprehended and there are plans to start expanding its use for marketing purposes.

The use of AI and RTS

Company B's concern with customers safety during the mining operations, challenging the company to develop ways to reduce human involvement in dangerous work underground. AI learning is the next solution in the mining industry. Sending the robots to the mines without having any human existence is the goal. RTS in this process would have a strong influence, as mentioned during the discussion with Company A's managing director, RTS is capable of machine learning through simulation environments and different scenarios. The interviewee mentions that this would happen through "*Integrating the machine learning with some elements of the real-time simulation to make the machine able to recognize the environment, think through different scenarios, find the likely outcome from it, and what would be the most efficient solution without damaging the equipment in the most productive way".*

The interviewee discussed that using real-time data would not only help in training the machine for real-life situations but also analyze the options and the outcome from each option, in order to select the optimal choice. By predicting the outcome and choosing the best option a reduction in time and cost would occur,

"Machine learning is about collecting a large amount of data in order to identify patterns from it…the machine, in this case, will automatically attempt to do different things and it will get different data sets and patterns of where it would lead to, and from there having intelligence in decision making by choosing the best way that will lead to the ultimate effectiveness."

Reducing the gap in the mining industry

The interviewee has mentioned a problem in the mining industry, represented in the lack of efficiently using the mining machines, he discussed that *"typically the utilization rate of the heavy mobile equipment is 25%-30% efficiently (in the mining industry)....., compared to the gas and oil industry, the machines are operating up to 95%-98%, so one could easily realize that there is a great room for improvement*. If the machine's efficiency would *"double from 30% to 60% for example... if we would double the output with a small cost, then obviously there is a huge profit"*. Discussing this issue with the interviewee shows that there is a lot of room for improvement when it comes to the efficiency of companies working in the mining industry or Company B's customers.

For the purpose of this study, knowing the role of RTS in offering the solution is a step in the right direction. There are a lot of factors causing this phenomenon *"including processes, equipment, and people and all those factors need to be taken into account".* However, he explains that the most interesting solution presented by previous studies is *"short interval control"*. Howes and Forrest (2012) describe short interval control as a tool to improve production during a shift, it seeks to achieve seamless and more efficient operations in terms of shift time and use of assets. The lack of efficiency that might happen due to delays or interruptions during the shift, leaving the scheduled tasks unfinished (Howes and Forrest, 2012). An example given by the interviewee, about the delays or interruptions that might happen is that *"a worker would leave the machine somewhere underground at the end of the shift and go for a vacation, so it takes about a week to find it again"*. Those cases would cause a production loss, due to miscommunication and lack of data.

The solution would be to generate real-time data and have it shared between different parties, those types of losses could be avoided. The real-time data could be collected through RTS, and with its help a plan for the desired outcome would be made and executed. He explains that *"when there is a deviation to the process, the worker in a remote operation center would immediately know about it through digital systems, and have tools to steer that processes, and that is where simulation comes to play"*. Using the predictive tool of RTS would help assist in making future plans, and it is up to the control of other digital systems and the managers to keep that plan going.

4.2.3 The effect on the business model

The effect on cost structure and revenue

As mentioned earlier, the interviewee has discussed a potential for using RTS in predicting the outcome for certain solutions and choosing the optimal scenario for the future. This ability would *"save in cost and time, which leads to productivity."* In this case, the effectiveness of the machine would be increased. The interviewee has also mentioned the cost multiple times in the interview while discussing the efficiency gap, in the context of increasing the cost a bit in exchange of improving the productivity to a great extent would result in an increase in the profits.

While also discussing the use of RTS in marketing, the cost was mentioned in the context of discussing future goals of using RTS instead of traditional marketing efforts would reduce the costs for marketing. Thus, the interviewee believes that RTS use would affect the cost, either reduce it or increase it a bit in exchange of a huge improvement in productivity, both effects are positive for the company's finance. As for the revenue, he explained that "if you double the number of tons of what is produced it doubles the revenue". Referring to the positive effect on the revenue by increasing the efficiency of the machines.

The effect on value proposition and key activities

The value proposition of Company B would be affected by many factors discussed earlier: Productivity and efficiency of the machines, machine learning, and security, choosing the optimal way of operating. He explained that *"the value proposition lies mainly in information and operation management solutions, around increasing machines productivity"*. These values are depending mainly on finding the best way to use real-time data generated by RTS, this use would result in increasing the solution offerings, which could affect the activities in Company B. The key activities in the company are already being dependant on RTS as already mentioned earlier in the current use of RTS in Company B.

Training the customers would offer value for the customers and attract the ones who are interested in training their operators. Thus, doing a training activity with the use of RTS effects the activities in Company B alongside the value proposition for its customers.

The effect on customer relationship

The interviewee discussed the relationship with customers by describing the challenges in Company B's offerings for the reason that the development and the novelty in their solutions

went to the point that *"even if we (Company B) knew that it works we couldn't get credibility in the customer's minds"*. Customers have a fear of change which is affecting their buying decisions. He analyzed the problem with customers that it is *"not in understanding that there is a room for improvement and the potential, but in being concerned whether they (customers) will realistically achieve those targets"*. The marketing tools that are used in this case are failing to convince the customers, Company B has future plans to use RTS in marketing but it has not yet been deployed in this field. Thus, the use of RTS could be the link to affect Customer relationship to the better. He mentioned that *"the better tools that we utilize to prove that the machine works better for their environment and they will achieve greater results with it, the less risk they take for their decision making".* Which could result in a better trust in the relationship with customers.

The effect on customer segmentation

As for the customer segmentation, the interviewee expressed that *"different customers have different readiness to adopt those solutions (RTS solutions) in their operations".* In the mining industry, there are different types of customers *"there are mines that are considering mechanization and others have gone through digitalization and now automation and looking even further into the cyber network".* In that sense, the customers' readiness to adopt RTS effects this technology in the business model, and not the other way around.

The effect on partners

The interviewee thinks that RTS affects Company B's partners to a great extent. He mentioned an example of this influence *"we are in partnership with Company Y with predictive analytics, where I see the greatest opportunities with real-time simulation"*. It gave more opportunity to plan with Company B's customers on how to deal with the extracted materials, this relationship is benefitting RTS, *"we are developing the algorithms predictive models photos that could be fitted for the real-time simulation"*. As for the effect of RTS on the partners, he mentioned that "*we got our product family "X" for mine sites on short term analytics and operation optimization*" RTS could benefit the product resulted from this partnership by helping in the analytics and offering solutions on optimization by predicting potential outcomes resulted from certain series of action. In the case of Company B's partners, the effect of RTS on partners is mentioned as well as the effect of partners on RTS.

The effect on resources

The resources are being affected by RTS in two ways from the interviewee's point of view. First is the human intelligence that could understand this technology and work with it, the second is other technologies that could link RTS with different sources of data and distribute the data and analytics resulted from RTS to the concerned parties.

"we need a lot of people with different types of backgrounds and understanding to all the different elements, and people in the system architecture level that puts it all together and make different teams work together"

"Real-time simulation pulls information from various resources...to simulate outcome scenarios of what might happen, so to link to all those different functions…there are a lot of technologies that interact with real-time simulation"

The effect on the channels

The interviewee stated that now the extent to which the RTS is being used does not yet affect the channels in the company. However, he mentioned that there would be an opportunity if RTS is used for aftersales services for spare parts sales, the customers need to keep their machines running and their equipment in a good condition, for that reason "selling spare parts plays a significant part in our business". Thus, if RTS could simulate and predict the consumption and failure in those parts then it could predict the need for buying. In this case, if RTS would be used for logistics and spare parts selling it would affect the key activities and the value proposition, alongside the channels He discussed that:

I can see an opportunity in simulating the consumption of the parts and having the right parts in the right place at the right time, so forecasting the need based on real-time inputs from the customers and how much they are operating their equipment,...that would bring a significant value when the customers don't have to stop the operations just to wait for a spare part to arrive."

4.2.4 Summary findings from company case Company B

1. There is a room for improvement when it comes to the efficiency of the machines in the mining industry, and RTS could help with that by providing planning tools with real-time data and improve the gap in the mining industry.
2. RTS is being used in R&D and aftersales services with predictive maintenance. This has affected the key activities, value proposition, cost, and the revenue of the company.
3. The use of RTS in training effects the value proposition and the key activities.
4. There is a huge potential to use RTS in optimization and machine learning (AI), which would result in great benefits for the mining industry.
5. The Optimization of the process would affect the cost and time and leads to productivity.
6. Increasing the efficiency of the machines would increase the revenue for customers.
7. Future use of RTS in marketing could affect customer relationship in a positive manner though building trust and reducing the risk in the buying decision. Marking use of RTS has a direct effect on the customer relationship. It also reduces the cost
8. The effect of RTS on the partners and customer segmentation are both ways.
9. The effect of RTS on resources is on human resources and technological resources.
10. The future use of RTS for spare parts selling (logistics) would affect the channels, the value proposition and the key activities.

Table 4- Case company B, current and future use

	R&D	Production	Marketing	Training	Maintenance	Logistics
Current use	Yes	No	No	Yes	Yes	No
Future use	Yes	No	Yes	No	Yes	Yes

Table 5- Case company B, business model effect

Business model block	Effect
Key activities	By the use in training, future use in logistics, and aftersales services
Value Proposition	Training, future use in logistics, and fixing the gap in mining industry
Customer relationship	Future use in marketing directly effects it
Customer segmentation	The effect goes both ways
Resources	Affecting human and technological resources
Channels	Spare parts selling
Cost structure	Future use in marketing, optimization of the activities
Revenue	Increasing the machines efficiency and fixing the gap
Partners	The effect goes both ways

4.3 Company Case C

Company C is a technology provider company for wood producers. It takes part in the wood processing value chain; it provides its customers with wood production and processing machinery.

As for the company's value chain, it is similar to the simple form, starting from developing new products, he described that *"our own ideas that are developed in-house...but we get also ideas from our customers"*, the customers are involved since the first step of the value chain, *"the customers as stakeholders have a big role in the value chain, in order to create more value in the products"*.

The company also offers aftersales services, by advising and helping the customers run their businesses, he mentioned that *"the value from aftersales services is in advising customers"*. *"We try to follow the product until the end of its lifecycle"*, with that the company offers maintenance services and also spare parts sales, depending on the contract with their customers. *"Simulation done for the papermill machine has enhanced its work during its life*

cycle". The analysis of this interview would help in realizing the changes that RTS had on Company C's business and shed a light on future possibilities for this technology.

4.3.1 Current use of RTS in the value chain of Company C

During the research and development process

The use of RTS in the value chain is still in its early phase in Company C, compared to the previous case, *"we are at the beginning of using the real-time simulation but we are getting there"*. The interviewee mentioned that the use is mainly focused in the R&D stage, *"it was used to study how the machine really works before manufacturing it"*. In this case, RTS is used for testing some product designs in order to discover the errors before manufacturing. The use in this stage has benefited the company *"by finding some issues of the design that we needed to improve before putting the design to manufacturing"*. It has also helped in keeping the production machines working so it will not cause any losses "it saved us from keeping the machines off the production process".

Modeling the whole process

RTS has also been used to model the whole process, which would have been so hard to measure accurately and fast without RTS, because of the differences in the shapes of the wood logs, he mentioned that

"We also made one research when we modeled the process and the logs and we run the peeling phase with the peeling model...now we have the code of how to calculate and know how the machine reacts with different shapes of wood and different materials properties."

During the Marketing process

The RTS was also mentioned to be used to serve marketing purposes, *"it was also used in one affair... where the customers were able to try the new model...show how our machine works and reacts with the controls"*. This application has served many marketing purposes, starting by showing the new model and its added features, by trying out this machine and see its effect in real-time. It has also served in delivering a message for the customers that Company C is using advanced technology to develop its products, *"it also proves that we are using these technologies for the R&D process"*, which effects Company C's image as a technology provider. Using RTS in promoting events also helps in getting instant feedback

from the customers and leave the room for some improvement to the model, *"we got some feedback...by collecting the data from the user"*. As mentioned in the theoretical part, for some manufacturers of big machine, it is impossible to move the machines and place it in the exhibitions for customers to try out the machines, the interviewee agrees *"instead of coming with the whole line to the fair which is impossible"* they were able to use RTS for customers to experience different options and models.

4.3.2 Potential future applications in Company three

Predictive maintenance

The use of RTS is limited to R&D and process simulation and it has also been used in the marketing stage, after the machine is being sold the RTS does not have any role for now. However, the interviewee sees a lot of potentials if there would be RTS for the machines that the customers buy, and with combining RTS with the data from the customers' machines then Company C can predict what could happen to the machine. The interviewee mentioned that this opportunity *"this would be beneficial for us and the customers as well in order to provide a better maintenance service".* As mentioned in the previous case real-time data has a lot of benefits for the company and its customers if employed while the machine is already in use, and the interviewee realizes that, and he sees a future use for Company C's aftersales services, which accompanies its products through its whole lifecycle.

Future use in Marketing

The interviewee predicts that there would be a need to use RTS for sales purposes, it is true that RTS is being used in exhibitions and marketing events and that leads to an increase in sales. However, RTS is also needed when the customers are making the purchase decision. It would make it easier to understand the features if the customers could just try the RTS and see how the machine reacts and work in different situations. The interviewee also mentioned that there is the possibility to change the control system inside the RTS model depending on the customer's desire, otherwise if the trial was with the real machine, the whole machine needs to be changed in order for the customers to try different options of the machines (automated, non automated models). This would add more value to the customers and ease their purchase process. *"In the future I think that the customers would want to test the machine and how it works before signing the contract, and they want to have more knowledge about*

the machine especially if it is a new model,.... and it could attract potential buyers in the future and reduce the risk of making the buying decision".

Future use for the production process

The interviewee also mentions that there might be a need to simulate the whole process, if the customer had a lot of changes to the process, *"in that case we can test the machine with the project specifications and see how it works, so we could use real-time simulation to be part of their project engineering delivery, in order to approve of the design and check for defaults. so it helps the manufacturers to get it correct from the first try without having to rework on the machine and assembling all over again"*. Thus, the loss of time and efforts would be avoided by using RTS for testing the machine and how it would work in the production line.

Future use in training

There is a possibility to use RTS for training in Company C, the interviewee expressed that *"Company C is wanting to use the simulation for training as well"*. Due to the demand from the customers, if RTS was used for training the operators the efficiency of the machines would be increased, as well as building up the plywood mills.

4.3.3 The effect on Company C's business model

The effect on key activities

Analyzing the effect that the early stage of usage had on Company C's business model would help in anticipating how strong of an impact the RTS has on the business in general. The interviewee mentioned that RTS has affected Company C's key activities, not by adding an additional activity or the possibility to have an extra offer as it was in Company B. However, it affected the current offers inside Company C*, "it has helped in speeding up the time to market, it affected the whole process by speeding up the R&D".* Therefore, RTS has helped in doing current activities more effectively.

The effect on resources and channels

If Company C is going to expand its use of RTS, then it has to invest in experts. The interviewee agrees that *"we need some expertise."* However, at this early stage, RTS did not seem to have a great effect on resources. The same goes for the channels, as there has not been any effect over Company C's channels with the current use of RTS.

The effect on customer relationship and customer segments

The customer relationship effect was limited to the use of RTS in exhibits and event, as customers have not yet worked on co-creating the products in the R&D stage. However, the customers' feedback was taken in the marketing stage, and letting them try the new models using a novel technology gave a good impression of the company. These activities if managed well, it could strengthen the relationship with the customers. As for the customer segmentation, The interviewee thinks that it would be affected depending on the use of RTS, *"It depends on how are we going to use the simulation, quite many customers are waiting to have training simulators for the operator*". If Company C was able to provide RTS for training, that could affect the customer segment that wants to provide their employees with training services.

The effect on cost structure and revenue

The interviewee mentioned that the use of RTS was able to reduce the cost, *"In R&D it saved some cost, the use of RTS was cost and time effective"*. He mentioned that the manufacturing of the machine takes more than six months to built and if it was not for the virtual model, the error would have been discovered after the manufacturing and assembling of the machine. Thus, the discovery of the error at an early stage reduced the cost and time for manufacturing and assembling the machine. This would also have an effect over the value proposed to the customers, with this technology the machines were produced in a faster manner and with a zero chance of malfunctioning during the assembly. However, if RTS would be used for training and offering aftersales services then the value proposition would be affected on a higher level.

As for the straight effect on the revenue, it has not yet occurred, it depends on Company C's future decisions to use this technology on a wider range.

The effect on partners

Due to the use of RTS, Company C has made partners with related correspondences, such as Company A which provided them with Digital twins that operate on RTS software. Company C also wanted to study the impact of RTS on its business, therefore they worked with researcher student for this purpose.

4.3.4 Summary findings from company case C

1. The level of RTS use is at an early stage, it was used in the R&D process to simulate the machine and the cutting process, it helps in testing the models developed, and it prevents losses in this stage.
2. RTS has been used to model the whole process, it helped in measuring the interaction of the machine with different material properties.
3. RTS was used in certain events for marketing purposes, it helped in delivering marketing messages and letting customers test the models. Otherwise, it would not have been impossible to bring the real machines.
4. Although RTS is already being used for marketing purposes, there is still a need to use it for allowing the customers to test the machines when making a purchase decision. This would affect the value proposition and ease the selling process.
5. The future RTS training of operators would increase the efficiency of the machines.
6. Due to this use of RTS during the R&D process, the greatest impact was on the cost, which was mentioned multiple times during the interview.
7. The use of RTS in marketing influenced customer relationship.
8. There were also minor effects on the Customer relationship, Partners, key activities, and value proposition.
9. There are great benefits from expanding the use of RTS in Company C to include aftersales offers for control and error prediction, training, and sales.
10. Future use in training might affect the customer segments and attract customers that are interested in training their operators.
11. The simulation for the whole process line would be beneficial in some special cases to see how the machine would work in the line. That would save time and effort.

Table 6- Case company C, current and future use

	R&D	Production	Marketing	Training	Maintenance	Logistics
Current use	Yes	Yes	Yes	No	No	No
Future use	No	Yes	Yes	Yes	Yes	No

Table 7- Case company C, business model effect

Business model block	Effect
Key activities	R&D, it helped doing current activities more efficiently
Value Proposition	R&D
Customer relationship	Marketing
Customer segmentation	Future use in training
Resources	Future human resources effect
Channels	No effect
Cost structure	R&D
Revenue	No effect
Partners	Gained partners

4.4 Company case D

Company D is a manufacturer of tractors and agricultural machinery, the tractors are manufactured only after ordering and operations are based on the mass customization strategy. The customers get to choose from different options for their own configuration. Company D is able to deliver a pre-equipped tractor directly from the factory.

The company uses a lot of technological advances, and it has shown interest in using RTS and started using it in some fields. Thus, the conducted interview -with Company D's manager of engineering systems and administration- alongside the analysis of the qualitative data would unfold the current uses and benefits of RTS in different parts of the value chain.

Company D develops the machines, manufactures it, markets it, and provides the needed services for it. Similar to the previous cases, Company D tries to follow its products until the end of its lifecycle, and it tries to use the latest technologies including RTS for that. During the interview, there was a great emphasis over the aftersales services that Company D provides, as a great value provider for its operations, *"services include: distribution, training, and maintenance for the customers".* The interviewee also mentioned some important stakeholders in Company D's ecosystem value chain, *"our customers and their customers play a very important role… we have also dealers and independent service providers in that value chain".* Company D's customers are very involved in the value chain and their feedback through the service providers is an important asset for the R&D process *"there is also the feedback from the service providers to the engineering and product development".* These are the main distinguishing characteristics of Company D's value chain.

4.4.1 Current use of RTS in Company D's value chain

During the research and development process

Similar to the previous case the use of RTS in the development process is the first to introduce. The interviewee mentioned that using it at that stage helps in finding problems at an early stage as well as exploring different options to the model by testing different ideas, all that occurs before the actual building of the prototypes. However, the interviewee still believes that RTS cannot yet replace the prototypes as they are still needed, *"I still strongly believe that we still need to have physical prototypes, but we can reduce its amount".* The benefit from that as the interviewee mentioned is *"shorter lead times, and in the long run, it reduces the expenses of prototypes as the number of prototypes is less*". The reduction of time and cost seems to be a common expression from the previous interviews, as a result of using RTS in the R&D process.

During the production process

In the production process, the RTS is not utilized. Nevertheless, some other simulations and visualization tools are used at this stage, in order to "*visualize the assembly of the whole production line… it shows the results of the assembly without having to move it actually".* Thus, only visualizing the end results from moving certain parts in the production line does not need the help of RTS. However, it was mentioned earlier in Company A case that if the case was a big manufacturing company where there are a lot of machines interacting and affecting each other's settings then the need for RTS would show, due to the necessity of showing data results and not only visualizing results.

During the aftersales services

As for the aftersales services, Company D is using RTS for training its own employees on providing maintenance services for Company D's customers, they are training the technicians on how to serve the customers and change some parts of the machines without having the real machine available for the training. There are multiple benefits from that as the interviewee mentioned: *"This is quite cost-effective because we don't have different variants of our tractors that we can use for training, so we can train our technicians earlier without having the tractors available, and we can easily train different variants and we can supply this training material for different locations and different service places without shipping tractors to different countries. It will reduce the cost and for some areas, it will be quicker to do the training this way, and then different people will be ready for when the customers get their first tractors"*.

Training the technicians without having the real machine available also prevents doing any harm on the machines while learning how to fix it. Previously training using RTS was mentioned in the context of training the employees or the customers on how to use or drive the machine, in Company D the case of training the technicians on fixing the machines and serving the customers was explored and it shows a lot of values for its user.

4.4.2 Potential future applications in Company D

Future use in marketing

In Company D the RTS is not yet utilized for marketing purposes, during the marketing events two devices are used to increase the customers' knowledge, one is VR for the new products that have not yet entered the market, and traditional marketing devices for the already launched products, which includes the real machines.

The interviewee believes that it is still important to use the real machines especially when the customers are test driving*, "I still believe that it is important for us to get our customers to drive our real tractors to get the real feeling"*, the customers could test drive the machine in RTS but it still will not replace the feeling of the real machine that they will eventually end up buying. He mentioned that *"for marketing purposes at the moment we have plans to have a more general use for real-time simulators...as the real machines are heavy and costly"*, consequently the use of RTS would reduce the costs and the efforts to get the real machines off production and ready for testing. In the case of Company D RTS has a benefit in being used for marketing purposes such as reducing the cost, but from the interviewee's point of view RTS *"would not fully replace the test trucks, but it can help a lot*".

The interviewee also mentioned the possibility to use RTS in helping the customers during the buying process, *"it is possible to utilize it in a broader way,... the customers will be able to choose the right models for them and the right horsepower labels and configurations"* This way the customers can together with Company D design their own machines, and this will make them feel involved and affect the relationship with them.

For the purpose of benefiting the development and the marketing processes, Company D organizes events called *"voice of the customer",* where they invite key stakeholders to demonstrate the new designs and get the feedback for it, other events NPI (new product introduction) where they test new features in the product development. The interviewee mentioned that RTS is not yet used in these types of events, but the researcher sees that there would be multiple benefits from utilizing RTS in that field, mainly for marketing the products and getting accurate feedback on it.

Future use for training customers

It is also possible since RTS is used for training Company D's employees, to use this technology to offer training services for Company D's customers. The interviewee mentioned that *"will also add the training activity to train them (Customers) how to utilize certain new features".* This would add a new revenue for the company. However, this suggestion was mentioned briefly by the interviewee. Thus, the willingness to start a new training service is not confirmed.

4.4.3 The effect on Company D's business model

The effect on key activities and value proposition

It was mentioned that Company D's services play a huge role in providing value for the customers and they are one of the key activities in the company. Thus, with using RTS in training the service providers, they are ensuring an improved service for their customers, this leads to an advancement in the key activities and the value proposed to the customers. However, if RTS was used more intensively in the future the interviewee believed that RTS would affect the value proposed by Company D in a more noticeable way.

The effect on the cost structure

The effect of RTS on the cost was noticed in two processes. The first is during the R&D stage, where RTS has been reducing the lead time and the cost of prototypes by minimizing the need for them. The second is during the training for the aftersales stage, where the real machines are not needed for training, and it also saves transportation costs on the machines, when it needs to be delivered for different training locations.

The effect on the revenue

As for the effect on the revenue, RTS is not yet used that intensively. Therefore, it does not affect the revenue directly. In order to have a great impact on the revenue the tractor sales or the services need to increase, the interviewee mentioned that *"I can see some potential benefits...we can maybe sell more accessories, and convince more customers that they should have our tractor models",* in the long run, this might happen.

The effect on the channels and the partners

It has also not proved to affect the channels yet at this stage. However, the interviewee mentioned that during the organized feedback events, where representatives from different channels are invited, *"their feedback is that they see real-time simulation quite positively"*. Other than helping in representing the new models and getting feedback from channels representatives, it is not yet clear how RTS would affect the channels in Company D. In these kind of events, some of the key partners also get invited, and if RTS would be used in those events there is a possibility that RTS would allow *"better collaboration with some key suppliers during product development projects, that they can give better and earlier feedback,...they can better understand the new design".* In that way, it would affect the key partners.

The effect on the resources

RTS will affect the resources in Company D by increasing the need for professional human resources. He mentioned that *"I strongly believe that we need to have few experts and broader knowledge for more people that they can effectively utilize the new tool"*.

As well as the use of RTS during the R&D process has affected the need for resources to build numerous prototypes.

The effect on the customer segmentation

In the interviewee's opinion, the customers and their needs are the factors that affect the use of RTS and not the other way. The interviewee expressed that *"I strongly believe that we should start from the needs of our customers and the needs of different segments and this will lead us to different types of simulation tools".* For Company D, there are a lot of different segmentation criteria, such as the geographical and the type of the farm. Regardless, there is a factor that plays a role in the need for RTS, which is the education factor, he mentioned that *"in some areas, customers might have very high education and they are capable of understanding complex simulators and give well evaluation feedback"*. Customers perception of RTS and their ability to interacts with its tools affect the possible benefits from it. For that reason, the demographic and the psychographic segmentation of the company's customers play an important role in defining its use and benefits.

The effect on the customer relationship

The customer relationship and the RTS have an effect in both ways. The interviewee continued by discussing that RTS could affect the relationship with customers in different ways, depending on the customer and if they are willing to interact with novel technologies, *"some (customers) are very traditional,... there are also some progressive farmers who would like to compare different alternative products, and with the last type of customers simulators can help and promote the creation of trust".* The use of RTS affect the relationship and builds more trust, in the same way, the customer's willingness to cooperate also affects the productivity of the technology.

4.4.4 Summary findings from company case D

1. The use of RTS in the R&D process has a straight effect on the cost.
2. There is no need for using RTS for the production process at this stage in Company D. It would be needed in a bigger production plant.
3. Company D also started utilizing RTS in training their own employees, this has affected the value proposition and key activities in the business model.
4. The RTS is not yet used for marketing purposes, as there is still a strong belief that it will not replace the prototypes in test driving, as there is still a need for the customers to sit in the machine feel it and smell it before buying it. Nevertheless, there is a potential of using the RTS instead of the visualization tools in some of the marketing events, which leads to a stronger stakeholders interaction and it could affect the partners/customer relationship. It would also reduce traditional marketing costs.
5. The use in training and R&D has reduced the cost.
6. Customer relationship effect on RTS works both ways in the case of Company D.
7. The demographic and the psychographic segmentation of Company D's customers affect the use of RTS, as it depends on the acceptance of the customers and their ability to understand the technology.
8. The level of RTS use in Company D did not have a great effect on the revenue, channels, or resources.

Table 8- Case company D, current and future use

	R&D	Production	Marketing	Training	Maintenance	Logistics
Current use	Yes	No	No	Yes	No	No
Future use	No	No	Yes	Yes	No	No

Table 9- Case company D, business model effect

Business model block	Effect
Key activities	Training
Value Proposition	Training
Customer relationship	Future use in marketing, effect is both ways
Customer segmentation	The demographic and the psychographic segmentation affect the use of RTS
Resources	R&D
Channels	No effect
Cost structure	R&D, future use in marketing, and training
Revenue	No effect
Partners	R&D through their feedback

4.5 Company case E

Company E provides solutions for bulk handling, it has two business units, logistics services and materials handling machines. Company E is one of Company A's key customers, utilizing RTS and integrating it to the whole product lifecycle, for that reason it was interviewed as a great benefiter of RTS and one of Company A's key customers. The first interview was conducted with the Director of South-American area, who was involved in the operation of selling two RTS training machines to one of Company E's customers, this interviewee would be referred to as "first interview" or "first interviewee". In order to get more data and information from Company E's main operations in Finland, another interview needed to be scheduled with a Director, with his close experience in dealing with Company E's customers and RTS the researcher was able to get the needed data for this research, this interview will be referred to as "second interview " or "second interviewee" in the following analysis.

The simple value chain's activities resemble the operations in Company E. In the R&D process, the customers get to choose with the help of the salesmen the right model for their operations, the second interviewee said that *"80% of the product is standard and 20% is custom built"* to match the requirement of the site, the type of materials handled, and so on. The stakeholders of Company E include dealers and sales people who are in direct contact with the customers. The offered aftersales services by the company to the customers are mainly training services, customers use the training service to train their own employees on how to operate some of Company E's machines, as well as training the technician people to deal with the machine's errors.

The following analysis is aiming to uncover the uses and benefits of RTS in Company E, using the data from both interviews combined. Both interviewees are talking about the same company, but their opinions might differ due to different experiences.

4.5.1 Current use of RTS in Company E's value chain

During the research and development process

In order to codesign the product with the customers, the salespeople reach the customers, and with help of 3D configurator the requirements of the new machines are added to the basic product, and the suggested model with the possible outcomes are shown with the help of this tool. Then comes the need to test these configurations and if it works with Company E models before building the machine, and that is where RTS comes to action. Both interviewees agree that building a machine made of steel is hard to redo and some machines take half a year to

build. Thus, according to the interviewees, the use of RTS at that an early stage would save cost, time, effort and resources from the engineering and production process.

During the R&D process, not only the configurations are tested, but also the software. The second interviewee mentioned that *"when we make a new software version for the machine control system is always tested first on the digital twin before we put it on the real machine*". This testing provides safety for the machine and the operator, after the software has been tested with RTS the machine is tested in real-life, he mentioned that *"usually after the testing on the digital twin we are 90-95% complete with the software testing",* some errors or small bugs could be found later while operating the machine, the amount of those errors is really small and the operators are satisfied with RTS and its ability to discover most of the oversighted mistakes before it causes accidents in real-life.

The benefits for using RTS in testing the software were mentioned during the second interview, *"this does speed up the software development process...and the guy writing the code can test the software at their own working desk, they don't have to go to the machine, or occupy a machine for the testing period. So time and production effort are saved"*.

During the marketing process

Company E has been active in using RTS for marketing purposes. In the first interview, it was mentioned that *"it is impossible to bring real machines in the fares and stands",* the best option is to use RTS, and it has proven as a great digital marketing tool. It has an indirect benefit as the first interviewee mentioned *"it gives us a better image of the company and our capabilities of delivering big machines with training packages…The value is bringing a more efficient and realistic idea of the products and solutions".* When the customers get to try the machine and experience how it works and feels, it transforms the value offers of Company E in a comprehended way.

During training

The first interviewee focused on the importance of training as the second most used RTS after the one used to serve R&D purposes. The second interviewee mentioned that Company E offers training services for three parties using RTS, training for customers, which includes training the operators on how to use the machines, and the technicians from the customers and Company E's own employees on how to fix the machines, as well as training the dealers and the salespeople on selling and offering maintenance and other services. Thus, the training

service is offered for Company E's employees, customers, and partners. Training the customers is highly requested and it provides a lot of values for them, the first interviewee discussed that *"the ordered big machines take up to several months to deliver, the clients' employees can start learning to use the machine before the machine has physically arrived, when the machine is there they can immediately start to produce."* This saves time and cost for the customers by efficiently using the machines for producing an outcome.

The first interviewee was involved in the selling deals of the training simulators, he explained that the case is usually when customers buy big machines that take time to build and ship, and they have a big number of employees that need the training to operate the upcoming machines. The best solution for the companies and Company E, in this case, is to buy the training simulators, since the companies are located around the world it would be impossible resource wise for Company E to send its human trainers with the real machines to train the companies, and it would also be time-consuming to wait for the machines to arrive at its destination. Thus, Company E is not only offering the training service but also selling the machines and giving the customers a better solution for their situation.

4.5.2 Potential future applications in Company E

Predictive maintenance and selling of spare parts

There is a possibility to explore further services that could be offered with the help of RTS, in the second interview it has been discussed that this opportunity is possible by *"combining our collective data from our online monitoring of the machine, using that as the bases of a simulation with the digital twin"*. This plan is still in an early phase, and its results should be the ability to predict machine behavior using real-time data. The problem with the traditional way of collecting data is that it works in a reactive way, when the operator reacts after the problem arises. On the other hand, if RTS was used the second interviewee discusses that *"we have data coming from the machine and we start to predict what is going to happen and when, based on the machine use, and the whole data collected earlier,...This way we work proactively before an event occurs*".

If RTS is used for predictive maintenance customers would know in advance what would happen and when would it happen to prepare for it. The second interviewee mentioned that some customers would wait for the error to happen and react then, for others it is important to keep the machine running, for that they change a certain component, for example, to prevent the breakdown. This predictivity has other benefits, he discussed that *"It helps us when we plan the periodical maintenance, of the breakdowns, the capital maintenance, or the higher cost maintenance...We can stock the local spare parts storages with the components that we*

expect to fail in the next period of time, so if something happens we have the parts available locally where the customer needs them, that way the lead time to get the machine back up and running in case of a breakdown is as short as possible".

This would add value to the customers with a less unexpected breakdown and the least amount of time needed to stop the machine and fix it, the least damage would be made from keeping the machine off the production. As for Company E, this solution would help in planning their maintenance more accurately in terms of timing, the cost as well as the materials needed for fixing the machines, the second interviewee mentioned that *"we can stock the local spare parts storages with the components that we expect to fail in the next period of time, so if something happens we have the parts available locally where the customer needs them".* This could affect the channels of Company E's business model and the dealers, it would make the selling of the spare parts easier and predicted and the storage would be planned in the best way that saves effort, time, and cost for all parties.

Production process

Company E is currently not using RTS for simulating the production process, as their production line is not movable, and the production of their machines is one or two per week. Compared to car factories, where machines are produced by great qualities, in a movable production line. For these reasons, RTS is not needed at the moment in Company E's own production process. However, some of Company E's customers could have the need for it, as it was mentioned during the first interview, *"our clients in the pulp mill when they have several machines, and raw materials come to those machines in several phases, and they have to be fitted into the factory and several transport modes".* In order to help the customers in figuring the right size and characteristics of the machine, and the right order of the machines for achieving the best outcome. If RTS was able to analyze the data and give the best production planning option for the customers, this would add a new service and value for the customers.

The second interviewee also mentioned that it would be interesting to use RTS during the production planning, if certain machine models were moved into a line based production or if they need to do an assembly when there is a moving line. In this case, RTS would also benefit Company E's own production process in the future.

Future benefits for marketing

It has been discussed during the second interview that Company E has a great ambition for the future in making use for all the data that are surrounding the business, this way Company E would have a digitalized value chain including all stakeholders. This ambition would be achieved by *"simulating the life cycle of the machine in its way to the customer, so he can see and think what will happen with his machine, even before he has the machine".* If RTS could be used to help in making a prediction for the whole product lifecycle, there are huge benefits that go beyond predictive maintenance. One of these benefits is a marketing advantage, by showing the customers how secure it is to buy a machine for Company E, this could further develop and affect the relationship with customers. "In the future customers will not only buy the machine, but the whole lifecycle of the machine", this was mentioned in the second interview.

Using AI alongside RTS

During the second interview the future direction of using AI for data reading have been discussed, he mentioned that *"the amount of data is so big that the human eye can't handle or find the abnormalities in it, we need to have something that will not get tired from looking at the data all the time, and analyze it,..That will be the direction where we will be going to".* The amount of data generated will be overwhelming, for that reason many companies including Company E are considering getting the benefit of AI in analyzing the data. This would affect the technical resources of Company E in the future.

4.5.3 The effect on Company E's business model

The effect on key activities

It was noticeable for both interviewees how RTS was able to influence Key activities in Company E, by enabling it to offer multiple services, one of these services is training not only for the customers but also for its own employees and dealers. If it wasn't for RTS then the company had to do traditional training with real machines, the second interviewee expressed this by saying *"we don't always have the facilities or equipment to do the training and stop a customer machine after a test drive for a one or two weeks training"*, after having RTS training possible it is hard to go back from it and use the real machines.

Offering a predictive maintenance service was also made possible with RTS. They were also selling the training machines. However, it is not considered as a main resource of revenue at the moment.

The effect on value proposition

In a similar manner, training and doing aftersales services with the help of RTS have influenced the value proposition, it has offered values for Company E and the customers as well. In the second interview, the value of the maintenance with and without RTS was discussed *"offering a full-service contract is like offering an insurance to the customer, where we say that running a machine will cost this much and we will take care of everything that will happen to this machine, in this case, we really need to know what happens to the machine. Otherwise, this type of contract will be expensive for us".* For that reason offering a full service from Company E would not be possible without the use of RTS. The first interviewee added on the maintenance value proposition that *"it increases the value proposition of Company E when the predictive maintenance adds value to the customers by decreasing the number of unexpected breakdowns"*. Thus, the use of RTS has influenced the way of offering services, leading to an improved value proposition.

Another value proposed through the second interview when discussing predictive maintenance, would be towards the dealers, as they would be able to know beforehand the machines that need services in the area, plan the maintenance and allocate repair personnel remotely through sharing the data, the planning could be done without surprises or worry for the deadline. He mentioned that *"this is a more relaxed way of doing things".* Therefore, the predictive maintenance would offer value for Company E, customers and the dealers.

Selling the training simulators has offered benefits for the customers as well, as explained earlier. It gave them the option to choose between traditional or simulated training.

The effect on cost structure

Cost is the most obvious effect of the business model and was mentioned multiple times during both interviews. In the second interview, it was mentioned that RTS is "saving development cost, saving also in the project costs", while discussing the training used by the customers he raised the issue of cost-saving *"because having a real machine for training is extremely expensive, if we are taking the machine away from the production work to use it just for training, but when we can do that on a simulator the machine can keep on working and earning*

money for the customers." The first interviewee had a similar opinion and he added that when the real machine is not used *"there is no risk for the real machine of damaging it, and no consumption of diesel, so it was cost efficient".*

The effect on revenue

In terms of the revenue, there is still no clear link between RTS and the revenue. The only direct way that the RTS is affecting the revenue is by selling the training simulators, for customers who have bought the bigger machines and are interested in training their employees as fast as possible.

If we look at the bigger picture, the second interviewee mentioned that there are greater possibilities for RTS to attract customers directly, if the planned aftersales service and the digitized ecosystem were exploited well, this would bring a new revenue stream for Company E. He discusses that for now RTS is bringing *"new customers indirectly, by using advanced technologies in this industry, it improves our image. Especially when competing with big players from Germany we need to show that we are more advanced than our competitors"*. Indirectly the RTS is affecting the revenue by attracting more customers with the use of advanced technologies, especially in the marketing process. When the competition is strong in this industry the use of advanced technology is the decisive tool for attracting the customers, as he mentioned.

The effect on resources

The first interviewee mentioned that at the moment the use of RTS does not require employing specialist, although it provides training for the current human resources. Thus, it improves the current resources. In the second interviewee has introduced some future plans about the use of technology and RTS, affecting the way of doing business and the need of resources, *"using AI to analyze the data instead of having a human eye there...the customer service has to be done by a person"* professional people who are able to manage and understand the business are still needed, as well as human contact with the customers. In terms of analyzing the real-time data, he believes that in the future AI would be able to do so better than humans.

The effect on channels

Both interviewees agree that there is an effect on the channels. However, this effect is happening slowly. The second interviewee mentioned that there is a plan to move the data system on mobile phones as well in order to facilitate the communication channels with stakeholders, *"I think mobility and using mobile app in transferring the whole data into the mobile world is something that will come for sure, we have launched our first mobile app although it is still very basic, but we are planning on improving it".* Mobile phones are becoming the easiest way of communication, using the application to send error messages could ease the procedures of aftersales services. RTS is not the technology behind mobile application communication. Nevertheless, if real-time data sharing is possible on these applications, it would lessen the procedures required for the services and facilitate the channels and communication.

The effect on customer segmentation

There is no effect on Company E's customer segmentation at the moment. However, during the first interview while discussing the training use of RTS, he mentioned that *"it gives the company a greater opportunity in getting involved in big projects by selling several machines (including the training simulators), for customers who have a huge need for training",* it is possible that the use of RTS in training has attracted customers with a large number of employees and the need for a fast effective training, leading this segment to grow.

As for the second interview, while discussing the importance of real-time data, the second interviewee mentioned a small possibility of adding a segment with the help of RTS for the customers who are interested in purchasing the data. However, this idea is very far from Company E's current business model, he explained that the reason that this idea was mentioned because *"these machines (RTS and Company E's products) are becoming more and more intelligent"*. At the moment there are no clear effects over the business model, and there are no indications of the previous suggestion happening in the future, as he did not mention Company E having any plans to make it possible.

The effect on customer relationship

In the first interview, it was mentioned that the relationship with customers was affected in a positive way, especially in terms of the training they can choose between traditional training and RTS.

As for the predictive maintenance, in the second interview there was a discussion about the customers feedback, and he mentioned that what they are offering is still something new to the market, *"customers don't know what to expect, they don't know that they need the service, so we are building a service which we know that the customer needs and appreciates, but they don't know it themselves yet"*. Company E is creating the need in this case, in the future, they are planning to create *"the wow effect",* by exceeding customers' expectations and selling not only the machine but the whole lifecycle of it. As for now, Company E is creating the customer need and marketing for it with the help of RTS, creating a current effect on the relationship with customers.

In the maintenance field, RTS has improved the relationship with customers, in the future, it will even increase the point of communication with customers, the second interviewee discussed this possibility through creating an operation profile, *"by analyzing the data we can create an operation profile...we are able to improve the way we deal with customers, from only dealing with the customer when we sell the machine and after the sale when we have problems. Instead, we can move to a model when we can communicate with customers depending on the operator profile".* He explained that having a profile could monitor the machine in its whole lifecycle and this could provide an opportunity to give more services to the customers. An example would be noticing a bad performance of the machine and offering a training service in return the machine would produce on a higher level. He discussed that *"it becomes very easy to change the whole relationship with the customer. We are not only people who are only selling products when they need, but we are partners of the customers. Helping them develop their own operations while we develop ours".* This would change the relationship with the customers and turn it into partnership. In the future, if Company E was able to manage its business based on operation profiles, that would affect not only the customer relationship but the whole business model.

The effect on partners

Company E depends on local dealers in many countries. Thus, the first interviewee presumes a positive effect on the partners *"everything that has been said about Company E goes the same for the dealers".* Especially if RTS is providing a great marketing benefit, which would reflect on the local dealers as well.

The second interviewee listed a couple of ways that the RTS had an effect over the dealers and especially the inexperienced ones, the training simulator was able to prepare the dealers and improve their skills, as for the real-time data shared with different stakeholders "it helped the dealers to have a remote connection to the machine by being able to see what is going on with the real machine so that if there is a fault, we can access the machine remotely", the dealers are in direct connection with the customers and with RTS they are able to help the customers alongside Company E through sharing the machine data.

On the other hand, Company A and another company are Company E's suppliers of RTS and remote monitoring system, they are the ones affecting the use of RTS. Thus, the relationship goes both ways in terms of some partners.

4.5.4 Summary findings from company case E

1. The level of RTS use in Company E is higher than the previous cases, and there are many future plans for increasing the current use.
2. The RTS is used during the R&D process in testing the configurations and the software of the machine, leading to 90-95% of error discovery. This had a direct effect on the cost, effort, time, and resources of the engineering and production process.
3. The use of RTS in marketing results in a comprehended value offers for the customers, it also improves Company E's image. For Company E the traditional marketing is not an option.
4. The use of RTS in training helped to train customers, dealers, and Company E's own employees, this has affected the value proposition and the key activities. It saves time and cost for customers. It also saved time for all involved parties. Some cases in Company E are impossible to use traditional training.
5. The use of RTS is inspiring a future use for AI, for its ability to analyze the data. This would affect resources.
6. Selling RTS training devices has affected the revenue, value proposition, key activities, customer relationship, and the cost for the customers, and there is a possibility to affect

the customer segmentation for the future as the orders are getting bigger and there would be a possibility to gain more customers who are interested in training.

7. RTS use in Marketing had a slight effect on the business model, mainly affecting the customers relationship and partners. The revenue could be also affected indirectly.
8. There are future plans for marketing in selling the whole product lifecycle, this would affect customer relationship, value proposition, and key activities.
9. There are future plans that are being exploited in using the RTS for predictive maintenance, this use is expected to affect every block of the business model except for the customer segmentation. In the future, the use of data might lead to selling the whole lifecycle of the products.
10. There is a future need to use AI for analyzing the data with RTS, and that effects the technical resources.
11. The predictive maintenance in the future could help in planning the selling of spare parts. This would affect the value proposition, cost and time, and it would help Company E in planning the aftersales services.
12. There are possible uses in production. However, it was not mentioned to affect the business model.
13. The effect on partners goes both ways, affected by training activities and the sharing of data in predictive maintenance.

Table 10- Case company E, current and future use

	R&D	Production	Marketing	Training	Maintenance	Logistics
Current use	Yes	No	Yes	Yes	No	No
Future use	Yes	Yes	Yes	Yes	Yes	Yes

Table 11- Case company E business model effect

Business model block	Effect
Key activities	Selling RTS trainers, future selling of the product lifecycle, training, and predictive maintenance.
Value Proposition	Selling RTS trainers, future predictive maintenance, future selling of the product lifecycle, and training
Customer relationship	Selling RTS trainers, future selling of the product lifecycle, training, and future creation of operation profile
Customer segmentation	No effect, might affect in the future
Resources	Technical resources with the use of AI. In R&D and training use
Channels	Facititating the communication
Cost structure	Predective maintenance, R&D and training
Revenue	Selling RTS trainers, future use of marketing and selling the product lifecycle
Partners	Predictive maintenance, training

4.6 Results through a cross case analysis

The discussion in each company had shown that there are multiple differences and shared opinion. In the following analysis the researcher will point out the main points that were agreed on in most of the previous cases, and the results that stood out during the previous analysis of the cases.

4.6.1 During the R&D process and its effect on the business model

The results have pointed out that all of the cases were using RTS during the R&D process, see table 12. The usage in that stage was mainly for testing purposes, RTS allows the testing of different ideas and models, whether it is engineers ideas or the co-created models with customers.

The testing with RTS before the building of the real machine and prototypes has saved cost and resources for all the case companies, see table 14. The use of resources affects the cost in the business model, resources were consumed before the use of RTS in building machines that might not work in real life.

4.6.2 For training and its effect on the business model

The second most common current use is in training, see table 12. In the previous cases, we have seen training being used on multiple parties. Company E was the most active case in training, it was used to train customers, employees, and dealers.

The training was for multiple purposes. In some cases, it was used to train operators to use the machines in different conditions, others were training technicians on fixing the machines.

In the previous cases, when training was used it had an effect over the key activities of the business model, see table 14. Using RTS for training meant that the company is committed to this action and wanted to improve it with the use of RTS. In other cases, providing training services was not possible -in terms of resources- without the use of RTS. For all cases, the use of RTS in training had affected the value proposition of the company, see table 14, meaning that the companies felt that they are providing more value to the customers when offering RTS training services.

The case of Company E had heavy use of RTS in training offers and selling training machines. The effect of training was for the whole business model except for customer segmentation and

channels (table 14). It had even affected its relationships with customers and partners. In other cases, the use in training had affected the resources and cost structure, this result is due to the improvement in training the resources, and the reduction of cost caused by using RTS and not the real machines. This would save fuel costs and prevent production losses.

These effects on the business models have inspired four out of five companies to continue using RTS in the future and utilize it for different training purposes (table 13).

4.6.3 During marketing process and its effect on the business model

The use of RTS in Marketing was the third most current use and the most famous future use, see tables 12, 13. This use was mostly for the presence in events and exhibitions. In these events, the use of RTS was to introduce customers or dealers with the latest products and allowing them to try it. Other purposes for marketing was during the buying and selling process, when consumers do not know the right model for their operations.

The use for Marketing purposes has made it possible to display huge machinery in such exhibitions, otherwise, it would have been impossible. This action has saved costs, time, and effort for most of the companies, instead of moving the machine out of the production process and display it for marketing purposes.

This has affected mostly the relationship with customers (table 14), the previous cases have proved that the interaction of customers and RTS machines and giving feedback, has made the customers more engaged and activated the relationship between customers and the company.

The need for prototypes felt necessary in the case of Company D. This need might affect the use of RTS in the marketing field. From a marketing perspective, the driving of the real machine that the customer is going to buy eventually influences the psychological factor for the customers, which RTS cannot influence.

4.6.4 During the maintenance and its effect on the business model

The use of RTS for maintenance purposes has taken so many forms, predictive maintenance, selling of the product lifecycle, and predicting the fault. These uses were mainly in Company B and provided by Company A at the moment, see table 12. As for the future uses four out of five cases were interested in the future benefits of this use (table 13).

This application depends mostly on the use of real-time data and its predictive abilities. Some wanted to employ the data in order to predict the fate of the machine. Others wanted to find optimal solutions for some problems. Depending on the use, the effect on the business model has varied.

4.6.5 During the production process and its effect on the business model

It was possible to use RTS to simulate the production line. This has proved its efficiency for Company C by simulating the machine's interaction with different materials. Some cases were interested in future use for production purposes if the situation of the manufacturing process would change (table 13).

This use would benefit a certain type of factories with a movable production line. RTS would be able to find the best solution and combination of machines for the factory's layout, leading to an optimal outcome.

This application was not studied further due to the lack of use, and its effect on the business model was limited.

4.6.6 For selling spare parts and its effect on the business model

Although the use of RTS was expected to be more popular in controlling the logistics and selling of spare parts, there was no current use in previous cases in that field (table 12). The result could be linked with the fact that this application could be more beneficial for companies that sell the spare parts and use logistics as its main activity. In the previous cases, the aftersales had huge importance, but it was not the main activity.

Some cases were interested in future uses (table 13). Predicting the need for spare parts, and knowing the time, place, and the type of material needed even before making the order had a benefit for Company E and Company B.

The future use was mentioned to affect the channels, in Company B as it would make the distribution channels go smoother and in a controlled and predictive way, and it would increase the value for customers, by offering this service (table 5, 14). Company E had a different approach towards the business model, it was mentioned that this activity would affect the relationship with customers and extend the communication, from selling and error communication only, to advising and partnership, following up with this use would make this effect possible (table 11, 14).

4.6.7 Other findings concerning the effect on the business model

1. The interviewees felt a lack of relationship between the use of RTS in different fields and different blocks of the value chain, these blocks were the channels, revenue, customer segmentation, and resources (table 14).

The lack of relationship in the channels was mainly because RTS was not used in any of the cases for aftersales of spare parts. This was mainly the reason for the lack of effect on the channels.

There was no direct effect on the revenue, except for the case of selling the RTS training machines. All the previous applications could affect the revenue indirectly through a bundle of aftersales services included in the contract, or through marketing activities.

The resources were mainly affected in the use of RTS for R&D as explained earlier. Other applications had an effect on the resources, especially the use of data for aftersales services and it would affect the need for technical resources. Training would improve current human resources. Most of the companies felt the need to employ professional human resources that understand RTS, but they did not make any actions towards that direction yet.

The case of Company D proved that customer segmentation is the factor affecting the use of RTS and not the other way around, the acceptance of the customers and their ability to understand the technology were influencers of the use of RTS. Thus, demographic and the psychographic segmentation of Company D's customers affect the use of RTS.

2. In some cases, the effect on partners and customer relationships was both ways. Partners were influenced by the use of RTS and other partners were the providers of this technology, leading to both effects.

Companies care about the customers and their needs. Thus, the use of RTS in some cases was affected by the need and the relationship with customers. On the other hand, if the company decides to use RTS in marketing especially, that would affect the relationship with customers.

Table 12- Current use in all companies

	R&D	Production	Marketing	Training	Maintenance	Logistics
Company A	Yes	No	Yes	Yes	Yes	Not mentioned
Company B	Yes	No	No	Yes	Yes	No
Company C	Yes	Yes	Yes	No	No	No
Company D	Yes	No	No	Yes	No	No
Company E	Yes	No	Yes	Yes	No	No

Table 13- Future use in all companies

	R&D	Production	Marketing	Training	Maintenance	Logistics
Company A	Yes	Yes	Yes	Yes	Yes	Not mentioned
Company B	Yes	No	Yes	No	Yes	Yes
Company C	No	Yes	Yes	Yes	Yes	No
Company D	No	No	Yes	Yes	No	No
Company E	Yes	Yes	Yes	Yes	Yes	Yes

Table 14- The current use for all companies and its effect on the business model

	R&D	Production	Marketing	Training	Maintenance	Logistics
Key activities	Copmany C	Company C	Company C	All used	Company E	None
Value Proposition	Company C & A	Company A	Company A	All used	Company A & E	Future Company B
Customer relationship	Company E	None	All	Company E	Company E	Future Company E
Customer segmentation	Company D	None	None	Company D & Future Company C	None	None
Resources	All	None	None	Company E & B	Future Company E	None
Channels	None	None	None	None	None	Future Company B
Cost structure	All	None	Future Company D & B	Company D & E	Company E	None
Revenue	None	None	Future Company E	Company A & E	Company A & future Company E	None
Partners	Company D & C	None	Company C	Company E	Company E	None

Discussion and conclusion

After analysing the primary data and doing a cross case analyses of the results that stood out the most, it is important to merge these results with the findings from the literature review and point out the differences. The following discussion is aiming to answer the research questions that influenced this study.

5.1 main findings

The research with its literature part and empirical part was aiming to answer the research questions, starting from the first sub question.

How could the real-time simulation be used for different activities in the value chain?

After the literature review, this research resulted in five different uses for some actions in the value chain. The first use is during the R&D process, similar to the findings of Guillaud et al. (2015) after analysing the primary data it has proven that this use is for testing the ideas, models, and software before building the prototypes. It has also proved the most common use among the study sample (table 12).

Predicting the fault use was proven to be mainly for maintenance purpose, the sample was interested more in the future applications of this benefit and its potential in leveraging the service offerings (table 13). There was an ambition to use this application in arriving to a proactive behaviour instead of a reactive one, meaning that they do not want to wait for the problem to happen in the machine and fix it later, but predict the breakdown and prevent it, in a way that causes the least or no damage or losses.

If the use of Real-time data has enabled a predictive maintenance, then it could be used to sell more services related to controlling the machine in use, to maximise the outcome and improve the production. The data was also mentioned to be used in order to find an optimal solution for a challenge, by collecting and combining real-time data from different resources for that purpose. This finding meets Mikkola's (2017) definition of RTS being a predictive tool.

Marketing is another activity has proven to increase its results with the use of RTS, the literature part arrived to this conclusion, which has later been proven in the empirical study. It helps businesses with large products that are hard and expensive to move in participating in certain events with RTS of the machines. The sample has proven that this activity sends a good image of the company to its audience, helps in collecting feedback of the newest model, and reduces the risk in the buying decision.

The use of RTS in training is another activity has been proven benefitable for the business in the literature and empirical study, meeting Guillaud et al.'s (2015) research results. The sample has used training for different parties, employees, customers, and dealers. The simulation of different scenarios has helped in teacher trainers how to drive the machines as well as fixing it. Most of the companies were interested in this application and aimed to continue using it in the future to train different parties.

The use of RTS for logistic purposes, or for the purpose of selling spare parts, as the final result of the literature review, it was not proven as a current effective tool for the sample, only two of five companies were interested in the future benefit of this application (table 13). The reason could be related to the type of business model that each of the companies had, if this study was conducted on B2C business that is huge dependant on a supply chain and with multiple storages than needed managing, then the results might differ.

The results in the literature did not show any applications related to the production process. After analysing the primary data, it has been proven that RTS could be use to simulate a production line for the purpose of finding the plan that results in the best outcome. However, this application could benefitable only if the line was movable, and the production was huge, similar to a car factory.

What type of effect does these activities have over the different building blocks of the business model?

The second sub question was also answered in multiple stages during the research. The theoretical contribution as well as the study model have shown a one way relationship between RTS and the blocks of the business model, which is an effect from RTS on the business model. The blocks of the business model which involved another stakeholder (partners, customer relationship, and customer segmentation) had also a reversed affect on RTS. It has proven that these blocks affect the use of RTS as much as they get affected by it.

The use of RTS during the R&D process had affected the cost structure and the resources, in a positive way, by reducing the number of failed models. The use in the marketing process had a positive effect on the customer relationship, it builds the trust needed to share the data required for serving the customers. As for the use of RTS during the training, it has proved to have an effect on the key activities and the value proposition, companies felt that offering training services is valued by the customers, and it adds an activity to their offers.

The effect of RTS was not significant on the channels, customer segmentation, resources, and the revenue. These results are related to the fact that most of the companies are not yet

using RTS in an advanced level, the companies had future plans of increasing the use of this technology, and most of them took few steps toward that direction (table 13).

Answering the previous sub questions has helped in answering the research main question, “How is the real-time simulation adding value to different activities in the company?”, by understanding the different uses, its benefits, and effect on the business model. However, these results are related to a certain type of B2B businesses, that manufacture their machines, and offer services related to the machines. The level of RTS use had differed between the companies, and was mainly in an early stage, this factor had affected the results from this study.

5.2 Managerial implications

The outcome of this study has been practical more than theoretical. The results of this research are aiming to shed the light on the abilities and applications of RTS and the consequences on the business, for managers who are already using RTS or are interested in this technology.

Managers could employ the results of this study for their interests and needs, the case companies were chosen from the best in their field, and could be set as an example for companies that are interested in using different technologies for the benefit of their business.

As an example, Managers that have a need to reduce the cost or the resources of the company, should consider employing RTS in the R&D process. Companies that have customers with a need for training a high number of employees, investing in a training RTS would add value to the customers and effect the activities in the company. If managers are planning to invest in RTS for its ability to increase the revenue directly, they should be patient, RTS has proven to take time before having a direct effect on the revenue. There is multiple other managerial guidance that could be taken from this study, it all depends on the company’s situation and its needs. The research results are extracted from managers to help managers improve their business.

5.3 Limitations and further research

This research had a narrow focus on a certain type of manufacturing companies with similar activities in the value chain. Therefore, future research should study different sectors, and communicate the differences in applications and effects. The results of this study showed a big interest in applying RTS for the services, studying service or consulting sectors might result in interesting findings for the future.

The Artificial Intelligence is being used on a larger scale, influencing more research around the subject. According to Gartner (2018) 14.2 billion connected sources of data will be in use in 2019, and that the total will reach 25 billion by 2021, producing immense volume of data. This data is driving growth in artificial intelligence, leading to a greater possibility of the use of real-time simulation in teaching smart machines that are capable of learning. This study has also showed the interest of managers and directors in the application of RTS a long side the Artificial intelligence, by teaching it through simulating different situations. Future research should have a deeper analysis of this phenomena, and its benefits on the business.

Real-time simulation is a new concept, there are still a lot of un answered questions regarding its future potentials. Will it be able to predict the outcome of a strategy? Will it be able to simulate entire projects and chose the best to employ? And many other questions regarding the needs of different sectors. Further research should be conducted for the purpose of answering the remained questions to guide managers in different sectors.

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Appendix 1: Semi Structured Interviews

Topics: Value chain, the use of RTS in the value chain, the effect on the business model.

Language: English

Time: 35- 80 minutes

Medium: Face to face, Skype

The interviews are recorded

The goal of the interview is to

1. define the value chain from inside the company and extend it to include stakeholders

   1.A what is the value chain in the company
   The value chain would be obtained from the interviewee with the help of Kaplinsky and Morris's basic value chain and pre-interview research from the company's website

   1.B Can we recognize different stakeholders in that chain
   In this stage the interviewee is asked to pinpoint different types of stakeholders for each action

2. Understand the role and the value that real-time simulation delivers for each action in the chain

   The main questions could be:
   2.A How does real-time simulation add value in the design and development?
   2.B How does real-time simulation add value in the production stage?
   2.C How does real-time simulation add value in marketing?
   2.D How does real-time simulation add value in consumption?

3. Understanding if there are parts where the simulation is not used and the reason

   For some companies the answer would be that real-time simulation is not used for that purpose, for this the interviewee is asked to elaborate and explain why.

   Future use of real-time simulation for that certain stage how does it add value to it?

4. After starting to use the real-time simulation, how did it affect each block of the business model.

   The business model canvas blocks by Ostrwalder (2010) is the reference for the following questions
   4.A How did RTS affect the channels in the company?
   4.B How did RTS affect the cost structure in the company?
   4.C How did RTS affect the revenue streams in the company?
   4.D How did RTS affect the customers' segmentation?
   4.E How did RTS affect the customer relationships?

4.F How did RTS affect the key resources?
4.G How did RTS affect the value proposition?
4.H How did RTS affect the activities?
4.I How did RTS affect the Partners?

5. asking for important stakeholders from the first question for the purpose of finding out how simulation has added value for them and what is missing or how can it be improved.

Appendix 2: Example of the used codes for the collected data

- The value chain
    - Similar to the simple vale chain
    - Main activities
    - Role of stakeholders
    - Importance of aftersales services
- The current use of RTS
    - The use in R&D
        - The benefits / effects
    - The use in Production
        - The benefits / effects
        - The lack of need
    - The use in marketing
        - The benefits / effects
        - The lack of need
        - The replacement of using RTS in marketing
        - Direct/ indirect effect
    - The use in aftersales
        - The use in Training
            - The benefits/ effects
            - Benefitted party
        - The use in maintenance
            - The benefits/ effects
        - The use in spare parts selling
            - The benefits/ effects
- The future use
    - The benefits
- The effect on the value proposition/ future benefit
    - The related activities
- The effect on key activities/ future benefit
    - The related activities
- The effect on customer relationship/ future benefit
    - The related activities
    - Reversed effect
    - Customers feedback
- The effect on the customer segmentation/ future benefit
    - The related activities

    - Reversed effect
- The effect on Key resources/ future benefit
    - The related activities
    - Technical/human resources
- The effect on revenue/ future benefit
    - The related activities
- The effect on cost structure/ future benefit
    - The related activities
    - Production efficiency benefit
- The effect on the channels/ future benefit
    - The related activities
- The effect on partners/ future benefit
    - The related activities
    - Reversed effect
    - Partners feedback

These were the main codes. However, the codes varied depending on the transcript, some codes were added to deliver a clearer idea from the interviewees..