UNIVERSITY OF TURKU

ABSTRACT

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Supervisor	Prof. Reima Suomi		

Abstract

The term industry 4.0 has seen some use in recent academic literature, but its definitions vary quite a bit in their relation to matters such as industrial revolutions and what technologies the term refers to. Technologies typically classified under the term, such as industrial internet (IoT) and business intelligence (BI), have become commonplace in companies and nowadays every other production company seems to have their own “SmartFactory”-system. However, it is not all that clear what is the added value of implementing such industry 4.0 systems.

The fundamental research problem, that this thesis tries to solve is to find out what value does an industry 4.0 system called "SmartFactory" provides to the company in which the research takes place. This research problem is approached by comparing previous literature on information systems value creation, mainly from business process reengineering (BPR) perspective, to data collected via case study. In addition to discussing value creation, the term “industry 4.0” is discussed in detail and its distinct properties of an industry 4.0 information system are discussed in the literature review part of the thesis.

By comparing different approaches to value creation and data collected, it was concluded that the case system has created value through BPR concepts. Seemingly the implementation of an industry 4.0 system as defined within the thesis leads to value creation through changes in business processes. This value creation is limited by the success of the system implementation process. The case system has not achieved its potential, since even if its implementation is over it is not utilized by all of its intended end-users.

Key words	Industry 4.0, Business process reengineering, Value creation
Further information	

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VALUE CREATION OF INDUSTRY 4.0 SYSTEM IN MANUFACTURING WITH BPR AS VALUE CREATION BASIS

Master´s Thesis
In Information Systems Science

Author:
Valtteri Nättiaho

Supervisor:
Prof. Reima Suomi

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Turku

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1 INTRODUCTION

1.1 Aim of this thesis

The term industry 4.0 has seen some use in recent academic literature, but its definitions vary quite a bit in their relation to matters such as industrial revolutions and what technologies the term refers to. Technologies typically classified under the term, such as industrial internet (IoT) and business intelligence (BI), have become commonplace in companies and nowadays every other production company seems to have their own "Smart-Factory"-system. However, it is not all that clear what is the added value of implementing such industry 4.0 systems.

The link between information systems (IS) and business process value creation is traditionally quite hard to demonstrate, but it can be said that IS aims to change how people do their work by enabling efficient ways to do their work tasks. Thus, the added value of a system, if existing, might be found in the way these systems affect the thinking and practices, work processes, of people they involve. The main literature basis for value creation this thesis studies is business process reengineering (BPR).

The justification for selecting BPR as a value basis for this thesis can be argued by the overlapping areas of industry 4.0 and BPR. BPR, as understood within the context of this thesis, describes how utilizing information systems can lead to development of new processes and ways to operate within a company. Industry 4.0 systems often aim to change the manufacturing process by utilizing an information system based on advanced digitalization. The similarities in these definitions justify observing industry 4.0 from the BPR's point of view.

It is relevant to acknowledge that the terms BPR and industry 4.0 are perhaps not "trendy" in academic context and their selection for the main terms used in this thesis might seem questionable. However, the concepts of BPR are present in literature to this date even if the names of the terms used have changed. Additionally, the selection of industry 4.0 is important, since the term is nowadays commonly used by companies to refer to various technologies.

By using the concepts defined within BPR and topics under industry 4.0, this thesis studies how these work processes change in relation to these kinds of systems. The empirical part of the thesis is done this by conducting a theme interview with employees at Stera Technologies Ltd, whose work roles are intertwined with industry 4.0 system. The aims of this thesis are to observe the value creation process of an industry 4.0 system and while doing so to determine if the seemingly overlapping definitions of industry 4.0 and BPR function together, even if they industry 4.0 is not prevalent and BPR is not topical in academic literature.

1.2 Research question and research problem

The question this thesis aims to answer is related to the value creation to IoT-data based BI system. This kind of system can be associated with the umbrella term industry 4.0 and the term is used going on, while referring to such systems. The term itself can be seen to refer to the "fourth industrial revolution", which is supposed to take place in the near future. Diversely, it can be seen to refer to the modular and efficient manufacturing systems in which products themselves control the manufacturing process (Lasi et al. 2014, 239). This term is a key part of this thesis and it is defined in the second chapter.

The main research question of this thesis can be formulated as follows: *"How does implementation of an industry 4.0 system generate value with business process reengineering concepts as value basis?*". The main research question is supported by following sub-research questions:

- What industry 4.0 means as a term?
- Does the case system create value through business process reengineering?

The fundamental research problem, that this thesis tries to solve is to find out what value does an industry 4.0 system called "SmartFactory" provides to the company in which the research takes place. At the moment, the company has developed and implemented the information system, but they are not clear about what tangible benefits it does provide. The system and the company are described later on the thesis.

1.3 Prior IS literature

To answer the research questions posed, this thesis studies prior IS literature on industry 4.0 and work processes. Key theories to consider are how value is created through IS and how business process reengineering creates value. Hammer (1990) claims that the usual methods of boosting performance via automation and rationalization have not been as effective as companies need. Especially IT investments have lacked in terms of results. His proposed solution to this problem is business process reengineering, in which company's business processes are rebuilt from scratch to create value. This idea of reorganizing business processes and models is supported by the ideas present in industry 4.0 literature. For example, Matthyssens (2019) argues that industry 4.0 and IoT solutions force companies to break their industry model and remodel their business. This idea is very similar to the idea of reengineering business processes.

Several well-cited articles, such as Brynjolfsson & Hitt (1996), define the lack of investment effectiveness as “IS productivity paradox”. This term has been discussed widely in literature and it is one of the key problems regarding IS investments. This paradox is related to the main research question of this thesis, since in essence this thesis is trying to solve how a business case can be made for an IS investment.

Investments in IT have often dissatisfactory results to companies, since IT is used to automate old processes instead of creating new ones (Hammer, 1990, 2015). This thesis focuses especially on creation of new work processes is related to value creation. Man (2001) describes the value creation of changes in work processes by presenting how “mindsets” can lead to cost saving in production. In more recent literature “mindsets” are discussed, for example by Metallo et al. (2018). They describe how IoT mindset enables value creation through distinct capabilities of new technology.

This thesis draws on existing literature to define how value creation is viewed when it comes to IS. Peppard et al. (2000) view value creation in IS to stem from information exploitation. Value creation in IS is a complicated issue and authors like Peppard (2000) have defined it in multiple different ways. BPR was selected as the basis for value creation in this thesis to limit the scope of the literature reviewed.

The main connections this thesis aims to discover between IS literature and research results is evidence on how work processes have changed in a meaningful way when they are influenced by industry 4.0 systems. The goal of the literature review is to present frameworks similar to Peppard et al. (2000) ideas regarding information exploitation and then integrate the models into a clear framework which is then used to as a basis for conducting and analyzing interviews. The selected literature is discussed more on the literature review part of my thesis.

1.4 Research method

The research uses qualitative methods to pursue its research questions. The selected research methodology of this thesis is case study. This approach can be justified because there is a limited amount of people using the case system. Because of this, quantitative methods are difficult to apply. The research combines interviews and ERP data for its research material. The methodology is further described and justified in the methodology section of the thesis.

1.5 Study design

Like discussed earlier, this thesis aims to utilize work process and value creation models in order to inspect whether implementing industry 4.0 system changes work processes of people who are involved with system, in a meaningful manner. Hopefully, this research can add to the existing research by reinforcing or debunking results found regarding industry 4.0 systems and their definitions. Research governing this topic is at the moment still quite limited. Because of this, it is beneficial to add to the existing research.

The data collection was done by conducting interviews with selected interviewees. The interviews were based on a semi-structured questionnaire. The interviews were recorded in adherence to the agreement of the interviewee. Before the interviews, permission to conduct interviews with the intended interviewees were asked for. In addition, the necessary documentation and agreements regarding data collection and its usage were presented to the interviewees.

In addition to interviews, data gathered from the company's ERP was included in the data collection. This data concern key performance indicators (KPI) regarding the case environment and they depict how the efficiency of the production has changed after the system implementation. The data gathered and interviews are discussed later on the methodology and analysis sections.

1.6 Expected results and contribution

The intended benefits of this research were mainly focused on demonstrating the benefits or lack of benefits for the company hosting this research, Stera Technologies Ltd. The results can aid in the strategic planning regarding the future of industry 4.0 solutions within the company. They can also deepen the company's insight in the options regarding their system architecture.

The benefits for future research are related to the term definition made earlier and providing new research data on a relatively uncharted research territory of industry 4.0 system benefits. The main research gap concerning this thesis has to do with the elusive definition of the term industry 4.0. The term is not well defined in academic literature or practice. The lack of clarity in academic definition of the term industry 4.0 can be seen in the recent articles, such Sung (2018) and Perales, Valero & García (2018), in which defining the term is one of the main goals of the article. In even more recent literature, authors, such as Erro-Garcés (2019), call for a common terminology regarding industry 4.0 to be formed.

This thesis demonstrates one way to use this umbrella term and hopefully it adds to its definition in a meaningful manner. The thesis also aims to define how industry 4.0

systems create value. This area of research is somewhat poorly defined and researched considering the several uses of the term. This thesis studies one kind of industry 4.0 system, but the approach taken in the term definition should be applicable to the research of other industry 4.0 systems. All in all, the research gaps this thesis tries to answer are the discourse in literature and organizations when it comes to terms like industry 4.0 and IoT and how industry 4.0 systems lead to value creation.

The societal implications of this research are furthering the understanding regarding industry 4.0 solutions and by extension their implementation. If we understand the benefits of adopting systems more clearly their adaptation will be easier and faster.

1.7 Structure of the thesis

The thesis begins by presenting the relevant literature concerning term definition (chapter 2). Chapter 3 presents the theoretical background for thesis. Chapter 4 discusses BPR as a term and introduces the interview questions used in data collection. Methodology and the research process are described in chapter 5. This chapter of the thesis also discusses the analysis and the reliability of the research results. After the methodology is clarified, the research results are described in detail in chapter 6. The results of the interviews are analyzed based on the literature review in the chapter 7. Finally, the results are compiled and further discussed in the conclusion chapter (8).

2 THEORETICAL BACKGROUND

In this chapter of the thesis, the relevant terms and prior literature are explained in detail. In addition, some thoughts on how value creation is approached in this thesis is discussed. However, the main goal of this chapter is to define the terms industry 4.0 technologies, industry 4.0 system and industry 4.0. This definition is done by discussing, some of the literature concerning the term and how industrial revolutions have been defined in the past. The origins of the "4.0" in industry 4.0 are in the potential fourth industrial revolution and because of this defining the term requires discussion about both the current definitions of the term as well as prior industrial revolutions.

2.1 Term definition

In order to set the ground for further discussion in this thesis, the following terms are defined: IoT, BI, BPR and information system. IoT refers in this thesis particularly to industrial internet. The term has other common interpretations such as internet of things and internet of everything. Internet of things is perhaps the most commonly used term, but this thesis will use the definition of industrial internet. In practice, this refers to a network of industrial machines which are capable of communicating with each other.

Lee and Lee (2015) argue that the true value of IoT is realized when the devices in a network are able to communicate with each other and integrate with systems such as business intelligence and business analytics systems. Business intelligence has as a term replaced decision support, executive information systems, and management information systems (Thomsen, 2003).

The term business intelligence has been discussed a few times thus far, but it is good to define how it is exactly perceived within this thesis. To do this a definition of the term information systems is required.

Piccoli & Pigni (2008, 25) defines information system as a combination of two elements of two parts. These aspects of information system are social system and technical system, which in combination make up the information system. The social system consists of structure and people while the technical system consists of technology and processes. The people refer to the users and stakeholders of the system and structure refers to the way these people interact with the system. The technology refers to the technological components which are part of the system. Finally, the process refers to the way the system is used.

The idea behind this definition is that information systems are the combination of technology and people. The people using the technology create and share information provided and stored within the technological system. Without technology there cannot be a system and without people there is not any information.

The social components of information systems are usually overlooked, but their effect on value creation is especially impactful. Peppard (2011, 23:20-24:40) argues that organization's IS competencies are derived from the different roles organization's employees take in its structures and processes. These roles are the culmination of an employees' business competencies, technical competencies and attitudes. Based on this definition it is reasonable to argue that organization's IS competencies can actually be more dependent on the social components of IS than the technical components.

Peppard (2011, 24:40-30:23) further elaborates the importance of social components of IS by referring to "social capital" and how it creates the required environment for IS competencies. He argues that social capital is formed when people are connected to each other, they trust each other, and they understand each other. By having these three qualities organizations gain social capital as an emergent phenomenon. As a result, the organization's IS capabilities develop. Peppard's focus on IS competencies being an emergent property is relevant, since the approach highlights the importance of social components of an IS.

In recent IS literature the focus on information systems' social components has been highlighted further. This is apparent in Koivisto & Hamari's (2019) article in which they discuss research on how gamification can be used to design information systems. The majority of the articles they discuss have focused on the psychological implications of making certain decisions in IS design. This trend pays homage to the approach in which the end-users are focused over technology while designing a successful information system.

The following example clarifies the way these components are interpreted in this thesis. The company involved with the case uses "an electronic Kanban" information system to manage the inbound logistics within its premises. The system is used by the manufacturing employees, forklift operators, a handful of white-collar workers and foremen. In addition, the system is managed by its system architect. These employees make up the people of this particular information system. The system's structure is formed by the different work habits and rights the employees have to the system. For example, the architect manages the general layout of the system while as the manufacturing employees only use the "manufacturing window" of the system. Even this simple system uses a variety of technologies such as tablets, software, computers and WiFi routers.

The overarching process related to this system has a start point and an end point which are not directly related to the system. The start point is when an employee notices a need to restock a part and the end point is when the part is delivered. The process refers to everything that happens in between of these two points.

Now that information system has been discussed about, it is good to ponder what special characteristics business intelligence system does have as an information system. As described earlier, BI systems have replaced different decision support systems. Decision support systems are used to help people make informed decisions. As their replacement, business intelligence systems aim to do the same. Business intelligence systems can be divided into three different components. Negash (2004) states that BI's three components are data collection, data management and data analytics. These components help to gather data relevant to the decision-maker using the system, manage it and analyze it, this process helps the user to make informed data-driven decisions based on vast amount of data, which would be impossible to analyze directly by the user due to the amount of data. It can be stated that the special characteristics of a BI system are aimed towards decision-making.

This thesis focuses on the value created through BPR. Because of this it is important to discuss the term and argue its selection as a basis for value creation. Business process reengineering became prevalent during the 1990s. Especially Hammer's (1990) article where he called for BPR was impactful in establishing the term.

Hammer (1990) claimed that BPR is the process of using modern information technology to radically redesign business processes in order to achieve significant improvements in their performance. In order to understand the concept of BPR it is necessary to define business processes. Davenport & Short (1990, 4-5) suggest that business process as a set of logically related tasks performed to achieve a defined business outcome. Additionally, they define that process has a customer and crosses organizational boundaries. These in mind, Hammer's (1990) definition of BPR is rather suitable for this thesis and it is used as a basis for discussion. To complete the definition, it is important to state that in this thesis BPR is seen as a project by its nature. In practice, this means that, BPR process has a start and an end. BPR is not seen as an ongoing process.

Before BPR was established as a term in literature there were several different attempts to refer to concepts behind BPR. These alternative definitions of the term are used respectively when they are referred in this thesis and if their definition of BPR is drastically different than the one presented in this thesis the definition is included and its scope are explained from this thesis' perspective. Since the terms related to the topic have changed so drastically the literature concerning BPR leaves a significant room for interpretation.

This thesis bases its discussion on value creation on BPR literature, but it isn't limited solely to it. It also discusses other approaches to value creation which are prevalent in literature. BPR was selected merely as the basis for approaching this complex issue to reduce the scope of literature reviewed. This approach was selected, since the potential research question, "How do information systems create value?", is classically quite impossible to approach, thus a reduction in the question scope seemed reasonable. The difficulty of answering, how do information systems create value, can be seen in the prevalence of the previously mentioned IS productivity paradox. Recently, for example, Kijek & Kijek (2018) state that neither empirical nor theoretical approaches to this paradox have provided convincing solutions to the problem. Kijek & Kijek (2018) tried to answer the paradox from an innovation perspective. A similar limitation of approach seems reasonable and thus, BPR was selected for the basis of value creation, but not as the sole answer.

Because there exist several terms related to processes in organizations it is beneficial to state which terms and concepts are not discussed in this thesis. A common term used in literature, related to BPR is business process management (BPM). This thesis does not discuss BPM and its relation to industry 4.0 systems. Kohlbacher (2010, 136) states that the differences between BPM and BPR is that BPM refers to continuous management of an organization's processes while BPR is a temporary endeavor by its nature. Unlike BPM system implementation is a temporary matter and thus it is not reasonable to observe them together. While BPM practices are not discussed some articles, which discuss BPM are cited, since they often discuss BPR alongside BPM. An example of this is the abovementioned Kohlbacher's (2016) article.

Industry 4.0. is challenging to define, but from this thesis' point of view it is imperative to do so. The term was already referred earlier, but it is beneficial to define it in detail, since it is connected directly to this thesis' research question.

Ever since industrialization begun, the paradigm shifts in mechanization caused by leaps of technology, which have been known as "industrial revolutions" (Lasi et al. 2014). As this thesis covers industry 4.0 which is seen to refer to the fourth industrial revolution, it is necessary to study the three prior industrial revolutions. By understanding the history behind the formulation of the term industry 4.0, we can reflect whether or not the term is adequately linked to the revolutions which happened beforehand.

2.2 The first industrial revolution

The first industrial revolution is considered to refer to the emergence of mechanization, which happened during the turn of 19^{th} century. The main components for this evolution were the usage of coal as an energy source and the invention of steam engine. It is commonly accepted that the first industrial revolution started in Great Britain due to the rise of various inventions related to the utilization of steam engine and coal (Mathias 2013).

The manufacturing process has become more efficient from the moment humans first started to manufacture things. Mathias (2013) points that the key difference between the first industrial revolution and changes in industry preceding it is the scale of change. According to him, the difference in the scale of improvement considering manufacturing process between 1750 and 1850 is greater than changes between 1650 and 1750 or 1150 and 1250, for example.

Why did the first industrial revolution happen? This question is quite important, since understanding the history behind the first industrial revolution can be used to explain the revolutions that came afterwards. Horn, Rosenband & Smith (2010, 24) present several well-grounded reasons to answer the question posed. These reasons include Great Britain's responsive and productive agriculture, access to certain minerals like coal, trade-routes, naval power and technological innovations. They also note that Great Britain had legislation practices, which were a significant enabler for the smooth transition from agricultural nation into industrial nation.

Without the several enablers of the first industrial revolution, it would have been difficult or perhaps even impossible for this leap in productivity to happen as quickly as it did. The naval capabilities and established markets of Great Britain allowed it to transport the goods its industry manufactured. These specific and various enablers of industrial revolution are a recurrent theme in the three existing industrial revolutions. Coupled with the notion of supply and demand it becomes apparent why it is difficult to revolutionize industries.

The macroeconomic effects of the first industrial revolution were substantial. The improved efficiency in production allowed wages to increase massively over the period of industrial revolution starting from approximately 1760 and ending approximately 1851 (Horn, Rosenband & Smith, 2010, 36). This in turn amplified the demand, because workers could buy the products, which were manufactured in quantities previously unfathomable.

2.3 The second industrial revolution

The second industrial revolution concerns several innovations rivalling those of the first industrial revolution. First is the comprehensive usage of electricity in manufacturing. This usage become possible due to the advances in the energy field. These innovations were related to producing a stable current of electricity, communication through advanced telegraph network, lighting via modern lightbulb and transferring electricity.

The second innovation or innovation group concerns new sources of energy enabled by the advances in engine technology. The most relevant examples of this are gas and oil, which were used more intensively as energy sources due to the innovation of combustion and gas engines.

These innovations related to usage of these fossil fuels were also relevant concerning innovations related to transportation. With the advances in power source technologies railroads and especially ships became more effective and safer. The new energy sources also enabled the innovation of automobile in 1893. Due to the advances regarding transportation supply chains could grow larger than ever before, since resources required for production and finished goods could be transported in large quantities.

The final group of innovations concerns the advances in metallurgy, which made steel production more affordable, thus making it an economically sound material to use in place of inferior iron in construction and manufacturing. Steel played an integral part of enabling some of the previously mentioned advances, such as manufacturing ships, but additionally it enabled production upscaling.

Mokyr (1998, 1) argues that the second industrial revolution is often dated between 1870 and 1914. Although according to him some events related to it can be dated back to 1850s. Similarly, to the first industrial revolution Mokyr (1998, 2) claims that the degree of technological advancement is what differentiates the second industrial revolution from the time periods preceding it.

According to Mokyr (1998, 2) especially the process improvement and the emergence of economies of scale in previously uncharted industries were significant in terms of improvement. In addition, he emphasizes the advances in marketing were meaningful for the revolution. The importance of marketing can be explained with the relations between supply and demand, similarly to the first industrial revolution. The advancements in production volumes and product qualities led to the worker's salaries increasing significantly. The practice of marketing played a key role in capitalizing on this increase in end customer purchasing power.

Shaw & Jones (2005, 241) acknowledge that the turn of the 20th century marked a turning point in marketing where marketing paradigm shifted from pre-academic line of thought into traditional marketing paradigm. Shaw & Jones (2005, 242) cite Bartels (1988), who justifiably claims that the first marketing courses were taught in American universities during 1902. During this time supply chains had evolved to a point where suppliers were connected through wholesalers and retailers to the customer (Shaw & Jones 2005, 242).

2.4 The third industrial revolution

The third industrial revolution is not as well defined as its two predecessors. The third industrial revolution has been claimed to concern topics such as the introduction of nuclear energy, advances in electronics which enabled widespread digitalization of previously manual labor, the automation of manual work processes through robots and the usage of internet in supply chains.

Academic literature does not seem to have a consensus whether or not the third industrial revolution has ended. This is apparent in messages of authors such as Gordon

(2000), who concludes that the scale of improvement of the so called “new economy”, referring to the third industrial revolution, is considerably smaller when compared to previous revolutions and as such it cannot be referred to be a revolution. In more recent literature authors such as Rifkin (2015) have stated that the groundwork for the third industrial revolution is being laid out currently.

On the other hand, some authors such as Smith (2001, 4) argue that the third industrial revolution was still ongoing at the start of 21st century and according to him it concerns the usage of internet and this usage became possible due to the advances in low-cost computing circuits, advanced computer software, high bandwidth telecommunications and development of World Wide Web. Finally, authors such as Schwab (2017, 1-3) claim that the third industrial evolution has ended, and we are on the brink of the fourth industrial revolution.

2.5 The fourth industrial revolution and industry 4.0

Industry 4.0 is claimed to refer to the potential fourth industrial revolution, which is supposed to happen due to the advances in digitalization and other technologies. Several researchers define different technologies that can be included under the fourth industrial revolution. Schwab (2017, 1) mentions that the fourth industrial revolution concerns technologies, such as IoT, AI, nanotechnology, autonomous vehicles, biotechnology, energy storage, quantum computing and 3D printing. Supporting this, Lasi et al. (2014, 239) argue that particularly the advanced digitalization combined with “smart” objects will lead to the fourth industrial revolution. The general theme that can be identified from the articles of researchers, such as Schwab and Lasi, seem to be that industry 4.0 is supposed to lead to fourth industrial revolution and it includes technologies involved with advanced digitalization.

Lasi et al. (2014) definition of industry 4.0 and the topics covered under the term is the most widely accepted in academic context at the moment of writing this thesis. They argue that industry 4.0 can take two different paths in the future. On the one hand it can refer to the application pull which means the various ways industry 4.0 is “needed” in manufacturing, such as, shorter development periods and individualization on demand. On the other hand, industry 4.0 can refer to technology-push related to the development of innovations similar to those listed by Schwab (2017). According to Lasi et al. (2014, 239) the production process will become more efficient due to the modular and potent manufacturing systems. They state that this supposedly will lead to the possibility of producing individual products in mass quantities.

Based on the previous revolutions it would seem to be rather presumptuous to only include one category of technology under industrial revolution. In part, it can be argued that the term industry 4.0 is milder than industrial revolution and in time it might be viewed to be only a part of the fourth industrial revolution. Because of the various implications of the term industry 4.0 it is important to define the scope of the term in this thesis.

In this thesis, the term will consider only the technological push aspects of industry 4.0 as defined by Lasi et al. (2014, 239). These "push aspects" concern technologies mentioned before by Schwab (2017). To elaborate, in this thesis industry 4.0 concerns technologies, such as IoT, AI, nanotechnology, autonomous vehicles, biotechnology, energy storage, quantum computing, business intelligence and 3D printing. In essence, industry 4.0 technologies refer to these kinds of "future" technologies. It can be argued that this definition is rather vague, but it is necessary, since terms like IoT does not consider the various aspects of industry 4.0 information systems.

Figure 1 depicts visually what technologies industry 4.0 can include. The key factor in the figure is the X marked in its middle. This X represents how industry 4.0 cannot currently be limited to a set of technologies, since by nature the term refers to technologies, which can result to an event in the future.

The open-ended nature of the "X" is can be seen to be problematic, however judging by the technologies commonly classified under industrial revolutions it is problematic to limit industry 4.0 to currently known technologies. Horn, Rosenband & Smith (2010, 36) defined that the first industrial revolution took place between 1760 and 1851. Mokyr (1998, 1) argues that the second industrial revolution is often dated between 1870 and 1914. If we compare these time-windows to the potential fourth industrial revolution, which is supposed to happen in the future, we have realistically no way of knowing which technologies it concerns, thus defining industry 4.0 technologies is impossible.

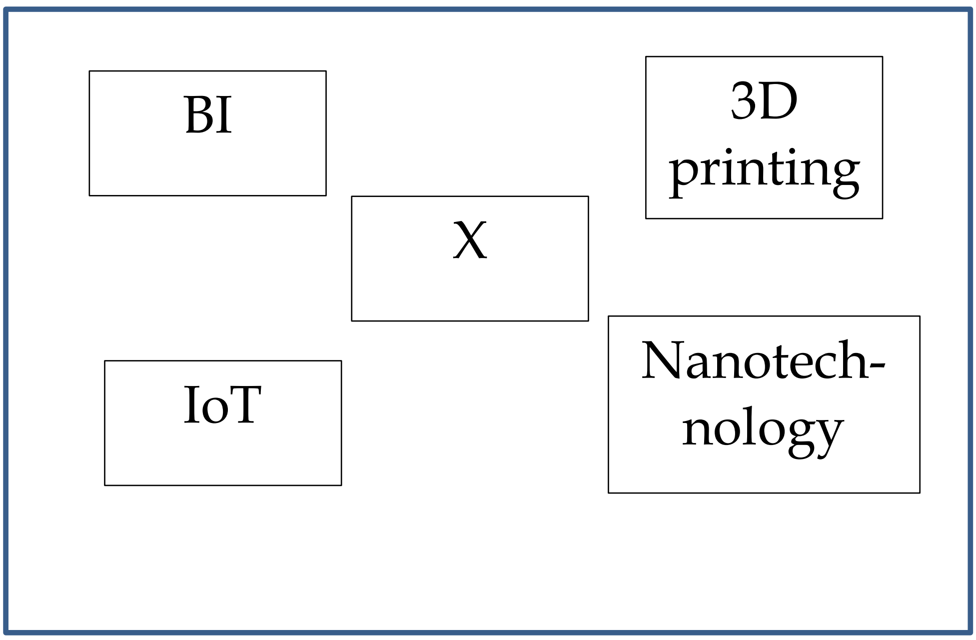

Figure 1: Industry 4.0

Before finalizing the industry 4.0 definition it is good to discuss industry 4.0 systems. Industry 4.0 system can be defined to be a system that containing one or more technologies classified under it. However, this might cause confusion, since it is more appropriate to refer to a system only consisting of one of these technologies by using that technology. For example, a system utilizing only IoT technology should be referred to as IoT system, while a system combining IoT and business intelligence can be referred as industry 4.0 system. Additionally, since industry 4.0 technologies were defined in an open-ended manner if any information system containing industry 4.0 technologies can be defined to be an industry 4.0 system, the scope of the definition is too broad.

Industry 4.0 system can be defined as follows: *"Industry 4.0 system is an information system combining two or more industry 4.0 technologies."* The value behind this definition is that it highlights the combinatory value of the information system. For example, a BI information system can consist of a BI tool, a data source and an end-user. The second reason industry 4.0 system is defined to included two or more industry 4.0 technologies is to limit its scope. This is necessary for reasons discussed in previous paragraph.

Figures 2 and 3 depict visually the difference between an IoT/BI system and industry 4.0 system. In Figure 2 standalone IoT and BI information systems are depicted. Figure 3 presents combined industry 4.0 system consisting of IoT and BI systems. Connecting two information systems can have benefits, for example, in terms of reporting, data analysis and network effects. The goal of the figures is to represent how a difference in defining the term industry 4.0 can have a meaningful impact in understanding what such a system contains.

The figures were created with IS components as defined by Piccoli & Pigni (2008, 25) in mind. In short, the "people" are the various users in the figures, the structure is marked with the "active" and "passive" depictions, the technology contains all of the objects besides the users and the process is depicted with the various arrows in the figures.

The idea that IoT is a part of industry 4.0 idea supports the IoT value creation basis presented by Lee & Lee (2015). The idea that this integrating IoT with other systems the "true value" of an IoT system supports the notion that IoT and industry 4.0 systems are two different matters, of which industry 4.0 encompasses more within its definition

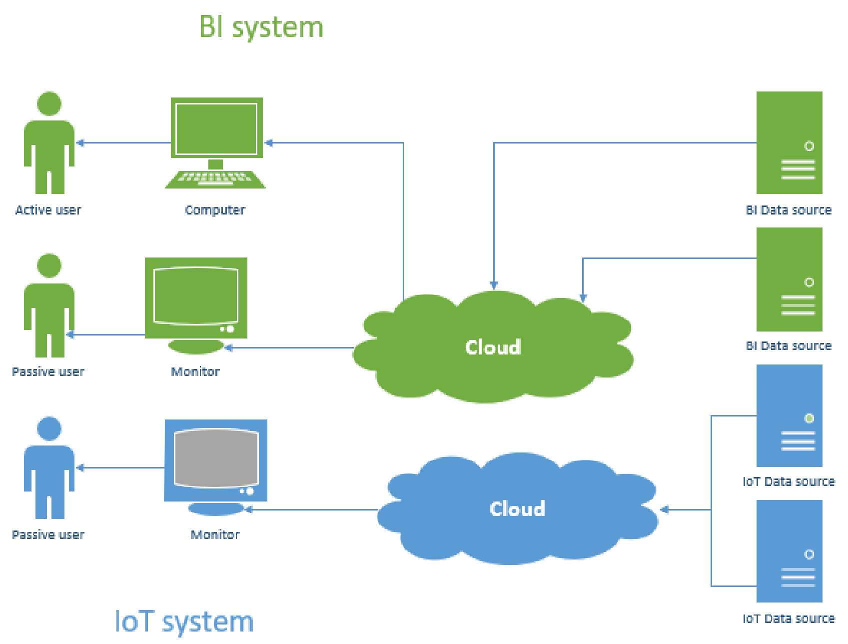

Figure 2: Standalone IoT and BI systems

The data sources depicted in figure 2 differ even though they are marked with the same icons. The IoT data sources depicts devices equipped with IoT capabilities, e.g. IoT sensors. The BI data sources can be practically anything e.g. servers or files. The data gained from these data sources is sent to cloud in both of the systems. The cloud icon in Figure 2 is a bit misleading, since it represents both the cloud storage and the BI cloud services/IoT UI respectively. The cloud storages between the systems might be able to communicate with each other, but in the case of the systems presented in figure 2 the systems do not communicate with each other. According to the definition of industry 4.0 system made in this thesis, the moment the systems change from two separate information systems into one industry 4.0 system. The data is processed in the respective systems to a degree and afterwards distributed using displays of some sort.

It could be argued that either one of these information systems is an industry 4.0 system, but it might feel counter-intuitive to refer to a system which consists of only one technology with something other than the technology itself. Because of this it is somewhat natural to refer to the systems depicted in figure 2 as BI system and IoT system respectively. Alternatively, these systems could be classified to fall under to the definition of industry 4.0 system, but at least within the context of this thesis this definition is reserved for systems combining two or more industry 4.0 technologies.

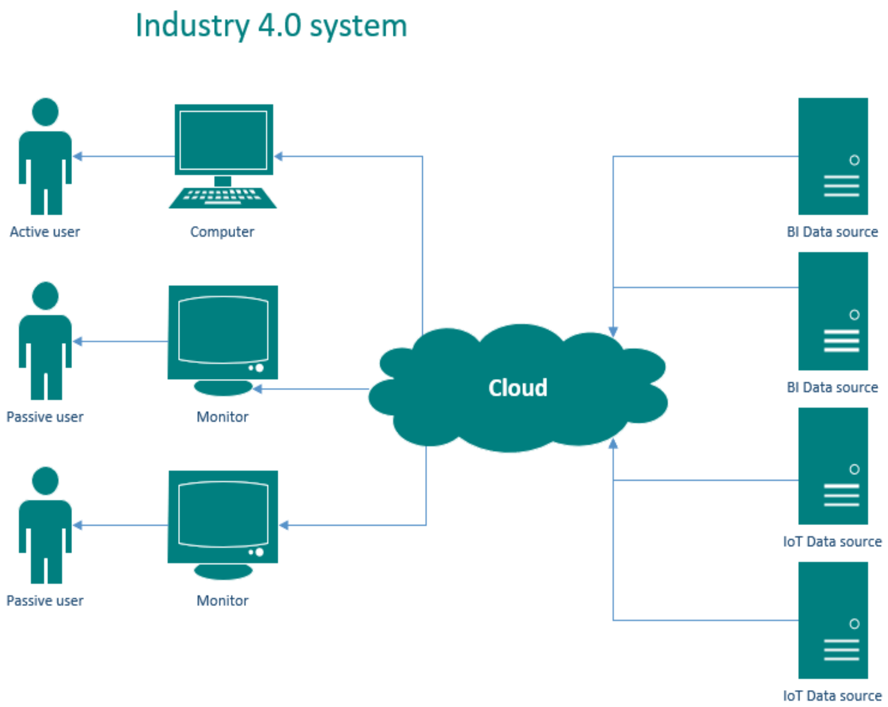

Figure 3: Example of an industry 4.0 system

The information system presented in figure 3 depicts a combined information system consisting of BI and IoT systems. This depicting is just one of many possible information systems, which fall under the definition of industry 4.0 system made in this thesis. Another example could be an information system combining AI and IoT.

The industry 4.0 system definition made in this thesis is based on this definition is supports

Lasi et al. (2014, 239) claim that industry 4.0 is used “ex-ante” to fourth industrial revolution. However, in this thesis industry 4.0 is defined to refer to new technological innovations, which are a part of the fourth industrial revolution. Key wording here is “part of”. It can be argued that due to the historical evidence innovations alone aren’t enough to garner the title of industrial revolution, even if they happen abundantly.

The first and second industrial revolutions saw advances in multiple disciplines and their combined effect lead to macroeconomic phenomena, which became known as “industrial revolutions”. The third industrial revolution saw similar advances, but due to its effects being smaller when compared to the previous revolutions, some scholars are arguing whether or not it can be considered to be an industrial revolution.

Considering the concerns around the third industrial revolution, it is too bold to claim that there will be a fourth industrial revolution and soon at that. Industry 4.0 is beneficial as a term, but it should not be used as a step-in for the fourth industrial revolution. Instead it should be used to refer to technologies, which will likely impact manufacturing process in a meaningful way in the future, thus paving the way for industrial revolution, but not enabling the revolution by themselves.

The industrial revolutions thus far have had a time period they have been associated with. Because industry 4.0 refers to technologies that are potentially part of the fourth industrial revolution, which has yet to happen, assigning a time period to these technologies is not currently possible. This notion might change in the future and the definition of industry 4.0 made below should adapt to it.

The final definition of industry 4.0, that this thesis will use moving on, is as follows: *"Industry 4.0 is an umbrella term that covers technologies, such as IoT, AI, nanotechnology, autonomous vehicles, biotechnology, energy storage, quantum computing, business intelligence and 3D printing. These technologies are part of the fourth industrial revolution that supposedly happens in the future, which will increase manufacturing efficiency."*

This definition is supported by recent literature, such as Müller & Voigt (2018), who define industry 4.0 as follows:" Industry 4.0 hereby describes the expectations of politics and industry associations that industrial manufacturing is heading towards the fourth Industrial Revolution. This revolution is intended to be realized via a high-grade digitization as well as the horizontal and vertical interconnection of industrial value creation, leading to intelligent and self-aware, smart industrial value creation."

The difference between the definitions is that Müller & Voigt (2018) highlight high-grade digitalization as the main technological source of industry 4.0. The difference is quite significant. Limiting the scope of industry 4.0 to concern only advanced digitalization and not for example 3D printing goes against the idea that industry 4.0 can lead to the fourth industrial revolution. If the same line of thinking would be applied to, for example, the second industrial revolution a statement like this could be made: "The second industrial revolution is intended to be realized via a high-grade metallurgy as well as the horizontal and vertical interconnection of industrial value creation, leading to efficient and productive value creation." The previous example is obviously not true and thus limiting industrial revolutions to consider only one kind of technology seems to be foolish.

2.6 Value creation

In this section, different approaches on how value can be created through IS is discussed. Peppard et al. (2000) argue that information technology has no inherent value for companies. They argue that information competencies are the basis for value creation and that these competencies are an emergent property of both business and IS functions. In essence, they claim that the basis of value creation for any particular IS is the result of utilizing the information created, integrated and shared by the system.

This idea is the same one that originally led to the BPR movement which recognizes that merely implementing an information system is not enough in terms of value creation. The thesis covers several approaches to how BPR can lead to value creation. This value creation can be linked to the research questions presented earlier by making the hypothesis that industry 4.0 solutions enact value creation unintentionally through BPR.

There is a fundamental conundrum in this hypothesis, which should be acknowledged before moving further. BPR is by definition a conscious process, which requires the redesign of processes. The challenge is especially visible when BPR is defined to start from a "clean slate" or "blank canvas" setting. Examples of this can be Davenport's (1993) definition of BPR or Abreu, Freitas, Porciúncula and Lisboa's (2010, 79) definition of BPR. Especially the latter definition argues that BPR process starts from defining "as-is" and "to-be" scenarios. Afterwards, the BPR process tries to realize the shift from "as-is" to "to-be" situation.

The picture that Abreu et al. (2010, 79) paints claims that BPR has to follow a meticulous planning process in order to be successful. The value creation of industry 4.0 systems should be the result of manufacturing processes becoming more efficient due to the implementation of technology. This premise is derived from the definition of industry 4.0 made in this thesis. If the implementation of industry 4.0 leads to value creation using the same value creation principles as BPR, Abreu's (2010) claim about the meticulous nature of BPR should be at least partly wrong. The next paragraph of the thesis discusses these "BPR value creation principles". This is done in order to determine if the value creation of the case system and BPR are similar.

3 BENEFITS OF BPR

This chapter discusses BPR as a term, how it has been approached in literature and introduces interview questions, which were based on these different approaches. The section follows a very peculiar writing method in which several questions are abundant, and answers are sparse. The following clarification should be made in order to make the section more readable: the questions presented with cursive are actual interview questions while general discussion in the form of questions describes the philosophical approach on basis of which, the practical questions were formed.

3.1 BPR and value creation

Along the years there has been a considerable amount of research regarding business process reengineering and how it enables value creation. Limam Mansar & Reijers (2007, 193) argue that even though focus on business processes have become commonplace in industrial thinking BPR is still more like an art form. In this section of the thesis relevant literature considering BPR is reviewed and their approaches discussed.

BPR gained momentum in literature especially during 1990s, but there have been more recent studies with different approaches on BPR value creation. Hammer (1990) recognizes that rather than improving the old processes the reengineering work should focus on the components of the process which provide value. This can be done by relentlessly asking questions Why? and What if? He also points out that information technology should not be used to automate current processes but enable new ones. If we turn this line of thinking into question format it would be as follows: "*Has the process become more efficient?*" and "*Has the IT used enabled the creation of new process?*". If the answers to these questions are positive it can be argued that according to Hammer's (1990) article there has been value creation from a BPR perspective.

The answers to the questions presented in previous paragraph can likely be observed by asking questions related to the work processes of people related to the implemented system. For example, we can first identify the value creating parts of employee's work by researching what is the primary goal of their work. Afterwards, we can research if the work processes related to achieving this work have become easier thanks to the system implementation, i.e. has the process become easier while maintaining its primary purpose. Regardless of the answers to these questions we can pursue the topic further by asking questions related to the way system implementation has changed things, or how employees perceive the systems operations.

Supporting Hammer, Davenport (1993, 2-4) argues that companies should not construct major systems to support sub-optimal processes. In his book he uses the term process innovation as a replacement for BPR. Davenport (1993, 11) states that the approach for process innovation should start with a "blank canvas" in terms of the process where only the business objectives are determined. This approach is similar to Hammer's (1990) approach where BPR should focus on the value creating parts of the process. Davenport (1993, 24) argues that process innovation enables radical improvement with a project approach. In fact, he presents that other process-based improvement endeavors only enhance the process incrementally. This is relevant from this thesis' point of view since a system implementation project, such as industry 4.0 implementation project, is a one-time application in its nature. This notion can be criticized, since Davenport (1993, 24) does not really pursue his argument further and merely states that it would seem that process innovation is the route to radical improvement in project context. However, it is relevant to recognize this argument, since it is supported by other literature.

The ideas presented by Hammer (1990) and Davenport (1993) are discussed under the topic of "process creation" moving forward in this thesis. The ideas presented by them suggest that information systems should aim to create new ways of doing things, i.e. new processes, that create value instead of automating old ones.

The reason for including this topic under the areas of special interest is to determine if the system has created value through the most fundamental BPR principle of creating new processes or way of operation, which make the process more efficient. It can be argued that to a degree all of the topics defined after this are trying to support or enhance the findings made related to this topic.

Küng & Hagen (2007, 484-485) propose that reengineering processes can improve the quality and performance of processes. Key areas of improvement are cycle time, output per employee and quality of products. Their arguments are based on a case study in which BPR was utilized to reengineer processes of a Swiss bank. Based on this we can formulate the following questions: *"Has the cycle time of a process improved?"*, *"Has the productivity per employee improved?"*. The case study presented in the article is an excellent example of how BPR can lead to a radical improvement in processes. This does not prove causation between BPR and radical improvement like Davenport (1993) suggested, but it supports his hypothesis.

The difference in approach of Küng & Hagen (2007) and for example Hammer (1990) is that while Hammer (1990) discusses about creating and forming new processes Küng & Hagen (2007) propose that BPR can lead to what can be called "measurable process improvement". This is relevant since the KPIs mentioned by them, such as process performance, can be obtained rather easily in the case system's case. Because of this, it is reasonable to include this topic under the areas of interest. If a clear process improvement can be observed after the implementation of the system and the principles behind BPR are executed with process creation, not automation or cost-cutting, in mind, it can be argued that the system creates value through BPR concepts.

Ranganathan, Balaji & Coleman (2011, 81-82, 90-91) note that after years of cost-cutting senior executives are turning to product innovation as a source for competitive advantage. In order to enhance the product development process, they propose that instead of tweaking existing processes new processes need to be reengineered. In their article, they propose that IT should be utilized in clever ways to improve existing processes. According to them IT should be the driver behind business innovation initiatives. The terms and topics discussed in their article agree with the topics discussed in earlier BPR articles such as the ones presented in this thesis thus far. More recent literature supports the view that IT should be used as the basis for innovation. Matthyssens (2019) argues that the new era we are living in requires open information exchange and unprecedent usage of information technology to achieve value through innovation.

One of the key insights that the case study presented in Ranganathan, Balaji & Coleman's (2011, 84) article is the way IT functions are typically fitted into organizations existing operations. Instead of changing the processes the IT functions have to change, framing IT as a support function. Peppard (2011) agrees with the view presented by Ranganathan, Balaji & Coleman (2011, 84) that IT should not be viewed as a mere support priority, i.e. the system should not merely be fitted into existing solutions, function and instead it should be viewed from cross-organizational perspective, if the goal of the system is value creation. Based on this it can be argued that from a value creation perspective it is important to understand the reasons why a system has been developed in a first place. The reasons behind the system development can tell us whether or not the system was seen as a support function or whether it was seen as an enabler of new processes. If the reasons are based on old processes, it is likely that the value creation of the systems remains abysmal. Thus, the question, "*Why the system was developed?*", is relevant.

The question formulated earlier is relevant for several reasons. First, it tells how information is regarded inside the organization. If the system was implemented for the sake of automation or cost-cutting IT's role is likely that of an support function, but if the system was implemented to enable new ways of operation IT's role is seen in a different light. Secondly, the motivation behind a system implementation will tell a lot whether or not BPR thinking was used as a basis for value creation. This question however reveals the discrepancy between industry 4.0 and BPR. The thinking behind industry 4.0 solutions is that by adopting advanced digitalization the manufacturing process will evolve and become more efficient similarly to industrial revolutions before industry 4.0.

The idea that just by implementing an information system, in this case industry 4.0 system, a company can create value does not consider IT's role within the organization the system is being implemented into. It is possible that many of the industry 4.0 solutions do not consider the information needs of the organization and are implemented because it is trendy to do so. This does not exclude the possibility that these solutions have resulted from a meticulous project. It is important to note that some of the industry 4.0 projects will definitely fall under the thinking that these solutions are efficient as vanilla solutions. Soh & Sia (2008) define "Vanilla" solutions as systems without modifications. The term is used often in connection with enterprise resource planning (ERP) system implementation literature. Because this kind of thinking is possible the question, "*Why was the system developed?",* becomes even more important, since if it is not addressed it is possible that the organization will fall under the impression that it is not relevant.

Guillemette & Paré (2012, 532-534, 541-543) argue that organizations can be classified into five different categories based on the chief information officer's (CIO) views on his/her strategic influence, his/her view on top executives' thoughts on IT centrality for the organization and CIO's views on top-management IT knowledge. The categories in question are partner, systems provider, architecture builder, technological leader and project coordinator. They claim that these categories have different sources for unique value creation and that they have certain characteristics. These value creation principles and system characteristics can be seen in Table 1.

Table 1: Minimum Contribution and Unique Sources of Value Associated with Ideal Profiles (Guillemette & Paré 2012, 541)

Unique source of value to the organization *(only when the IT function perfectly or closely matches the ideal profile)*	Improving productivity by reengineering the business processes and facilitating change in the firms' activities	Lowering the firm's operating costs by reducing the cost of IT operations and selecting IT projects that minimize costs	Implementing a single, integrated and flexible architecture, which enables the firm to benefit from unfore-seen opportunities, and to improve integration in the organization through better collaboration and knowledge transfer	Facilitating the transformation of the organization at the strategic level by implementing emerging technologies with high strategic potential	Introducing a flexible and efficient outsourcing strategy with improved project management, and improving the business's ability to make better decisions regarding IT
	Partner	**Systems Provider**	**Architecture Builder**	**Technological Leader**	**Project Coordinator**
Minimum level of contribution	Response time of system applications and reliability of technological infrastructure + Delivery of projects within budget and on time + User satisfaction				

Based on the way IT is perceived within the organization Guillemette & Paré's (2012) model presented in Table 1 can be utilized to categorize IT structure of the organization and its unique source for value. Judging by the sources of value creation and the definition of industry 4.0 made earlier, the IT's role that fits an organization using industry 4.0 solution the best is that of a partner. The profile that seemingly fits the worst to an organization trying to implement an industry 4.0 system is that of a system provider. Industry 4.0 projects are generally speaking quite costly and if the main goal of the IT organization is to reduce IT costs this becomes problematic.

To study which of the IT's roles defined by Guillemette & Paré (2012) is prevalent in the organization the following chart provided by them can be used as the basis for interview. After the IT's role within the organization is defined, it can be used to reflect if the potential discourse between the seemingly optimal role (partner) and the actual role have had an effect in the system development/implementation.

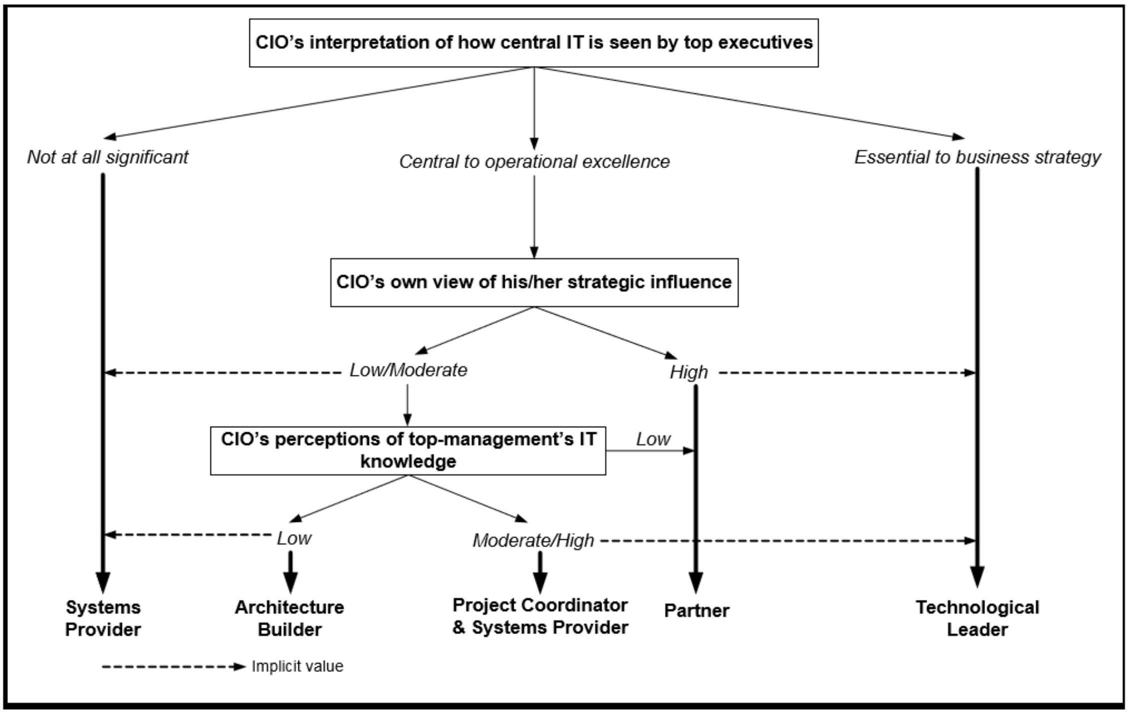

Figure 4: Contingency Factors Influencing the adaption of Particular IT management Profiles in Organizations Guillemette & Paré (2012)

Peppard (2000, 291) argues that the technology aspect of IT is far too often over focused while the information part of the term is often forgotten. It is important to remember this while the term industry 4.0 is discussed. Currently literature is focused on defining the term and describing what is included in industry 4.0 from a technological perspective. An example of this could be Qin, Liu and Grosvenor (2016) article in which they envision the technological roadmap for achieving industry 4.0. This line of thinking could be seen to be exactly what Peppard (2000) proposes.

Limam Mansar & Reijers (2007, 194) propose that BPR value creation can be observed through a set of best practices which the BPR practitioners have implemented in their work. These best practices can be observed in the Table 2.

Table 2: Best BPR practices (Limam Mansar & Reijers 2007, 199)

	Best practice	Definition
1.	Task elimination	Eliminate unnecessary tasks from a business process
2.	Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks
3.	Integral technology	Try to elevate physical constraints in a business process by applying new technology
4.	Empower	Give workers most of the decision-making authority and reduce middle management
5.	Order assignment	Let workers perform as many steps as possible for single orders
6.	Resequencing	Move tasks to more appropriate places
7.	Specialist-generalist	Consider to make resources more specialized or more generalist
8.	Integration	Consider the integration with a business process of the customer or a supplier
9.	Parallelism	Consider whether tasks may be executed in parallel
10.	Numerical involvement	Minimize the number of departments, groups and persons involved in a business process

The majority of these best practices are covered in the discussion had thus far in this thesis, but the best practice number four has yet to be discussed. According to the article empowering has the highest impact on the project flexibility. It will also increase the workers motivation. It is reasonable to formulate the question: *"Has the level of employee empowerment increased?"*, since this covers an area of value creation not addressed thus far in this thesis.

The question regarding employee empowerment is quite relevant when it comes to defining the term industry 4.0. Proenca, Torres & Sampaio (2017, 189) define employee empowerment through organizational decision-making structures and perceived degree of control. Outside this thesis, industry 4.0 has sometimes been defined to include processes automation. For example, Qin, Liu and Grosvenor (2016, 174) state that industry 4.0 factories will control the production process via automation. Additionally, Qin, Liu and Grosvenor (2016, 194) state that there is a consensus among many researchers that industry 4.0 includes the aspects defined by them, such as process automation, but do not pursue their argument further. Automation limits both the structural and the perceived decision-making capabilities of employees. Because of this inherent negative impact on decision making instead of asking has the employee empowerment increased it is more reason able to ask the question: "*Has the level of employee empowerment decreased?"*. Since negative impact on value creation is as interesting as value creation in itself.

In practice however, this question is hard to ask as is in the interviews due to its rather vague and distant nature. It can be argued that "perceived control" as referred by Proenca, Torres & Sampaio (2017, 189) should be visible in the reactions people have regarding the system after its implementation. Based on this reasoning the question, "*Has the level* *of employee empowerment decreased?",* can be answered by asking questions about organizational reaction toward a system and studying, whether or not the perceived control, people have on their work, has decreased.

Müller et al. (2017, 174) discuss matters related to BPR under the term business process transformation (BPT). This term includes continuous incremental improvement to processes as well as radical process improvement under its definition. The radical improvement part of BPT is the BPR process referred in this thesis. They present their findings from literature that there is evidence that BPT breeds political tension. Their sources supporting this argument: Grint, Case, & Willcocks, 1995; Kelley, 1976; Knights & McCabe, 1999, 2002, do not directly refer to the term BPT. Yet, their sources did refer to BPR, so their findings are applicable from this thesis' perspective.

The argument that BPT, or in this case BPR, leads to political tension within companies, i.e. power shifts, is interesting, but causation between political tension and BPR as next to impossible to prove. Even if BPR will cause political tension, we cannot prove that political tension observed in any situation are the result of BPR. The changes in power structures are together with questions related to employee empowerment and reasons behind the system implementation related to organizational culture. Detert, Schroeder & Mauriel (2000, 851) define organization culture as "combination of artifacts, values and beliefs, and underlying assumptions that organizational members share about appropriate behavior."

Because of the recurring theme of organizational culture further questions related to it are ask questions related to it. Since it is claimed that BPR leads to political tension it is worthwhile to ask: *"How do you feel about the system?".* The answer to this question will likely lead to discussion about organization culture and whether or not the system implementation caused political tension within the organization.

The questions considering changes in power structures and employee empowerment are somewhat overlapping. They can be answered by asking questions related to thoughts the system implementation has caused. For example, if the changes are seen as oppressive, according to Müller et al. (2017, 177) the system implementation has caused political tension. The question related to employee empowerment is related to the same topics as the one related to political tensions, but it can be observed by asking if the employees feel that the data is helpful in planning their work.

Moving forward the questions related to organizational culture and the employee reactions caused by the system implementation is discussed under the topic" organizational reaction to the system". This topic encompasses the ideas behind system development and how people reacted to the system implementation. Based on the ideas discussed and related to this topic, it seems that the implementation of a new information system can cause various negative reactions within the organization. Additionally, the system should be implemented with information transfer, integration and sharing in mind or the value creation of the system is diminished.

The goal of including this topic under the areas of interest is to determine if the system implementation/development was done "correctly", so to speak, and if it has caused negative reactions, such as change resistance or decrease in employee empowerment. The reactions to system implementation are relevant, since a lack of negative emotions is a slight indicator that the system has been properly adapted. If this is the case, it is more likely that the system will be used to realize the goals behind the system implementation.

Man (2001) mentions three kinds of potential mindsets when it comes to processes. These mindsets, albeit not discussed directly under BPR term, are useful in observing how new technology, such as industry 4.0 system, is adopted. These mindsets are current, alternative and innovative mindset.

The current mindset describes a situation where the end goal is to keep things as they are and to "fight the fires" as they appear. In the alternative mindset the theme is to enhance the process by reaching a set goal in relation to a variable being measured. In this mindset the goal is to preemptively think about problems that might occur and prevent them. Finally, in the innovative mindset the theme is to optimize the process by thinking about the end result of the process and how to improve upon it. For example, if the goal of the end result of the process is measured in terms of machine utilization, this kind of mindset would aim to improve this KPI. The innovative mindset would instead try to optimize the whole process. The difference here is whether the goal is to optimize the process or its result.

Man (2001) argues that the most optimal mindset in terms of value creation is the innovative mindset followed by the alternate mindset. Based on this definition, the following questions can be formed, to determine if innovative mindset has been applied: *"Have you set any goals regarding utilization levels?"* and "*What kind of goals have you set?"*.

The case study system has not been described yet, so it is good to mention that the system collects production machine utilization levels and displays them as one of its functions. The former question refers to these KPI's.

These questions can be researched by asking the production workers, managers and officers: "*What do you think about the utilization KPI's and their usability*?" This question and its potential follow-up questions should reveal if the system information is helpful in goal setting or work planning in general. The goal of these questions is to answer what kind of mindset is present in the organization regarding the system. The overall topic regarding how people view the system in terms of goal setting is discussed under the topic called "mindset**".**

Regarding mindsets, Metallo et al. (2018) propose that IoT mindset, connected closely to industry 4.0, should allow for value generation by enabling the distinct characteristics of new technology. Metallo et al. (2018) list multiple different ways technology can be used to create value. The combining factor seems to be that technology is used in real-time to affect the manufacturing process to provide more personalized service for customers.

The inclusion of "mindset"-topic aims to determine if the system is used as a fundamental part of the production process or if it is just an afterthought. Additionally, it enhances and builds upon the topic of "organizational reaction to the system", since the mindset prevalent regarding the system can give a more clear-cut answer whether or not the system has been properly adapted.

The matters presented in Table 3 are based on the theory discussed during this chapter of the thesis. These questions represent the topics that were deemed to be interesting. It should be noted that some of the questions might be difficult to understand as they are, or they might lead to a situation where the question is "shot down" with a negative answer. Because of this the right-hand side of the Table 3 presents some additional questions which can be used to answer the questions. Some of the topics were difficult to research using interviews. For those topics, instead of using additional questions other data sources were used. These instances are marked with "ERP data and system data, coding." in the right-hand side of Table 3.

Each of the topics present in the Table 3 were included for a different reason. The idea behind these different reasons is that together they can indicate if a system produces value thought BPR concepts. The first topic determines if the system was developed with the "correct" ideas in mind. The second topic determines if there has been measurable improvement after the system implementation. The third topic discusses if the system has resulted in new processes being formed. Finally, the fourth topic discusses if the system has been properly adapted.

Table 3 has three columns, which are from left to right: category, question formed during discussion and additional questions. The first column indicates the category based on the following abbreviations: process creation (PC), measurable process improvement (MPI) and organizational reaction to the system (ORttS). The second column depicts questions which were marked with cursive during the discussion had along chapter 3. The relevant references regarding the discussion are marked below the questions. The third column has additional questions which are meant to support the question depicted in the second column within the same row. For example, the question, "Do you feel more motivated due to the system information?", is meant to support the question, "Have you set any goals regarding utilization levels?" This approach to interview questions is admittedly a bit irregular, but hopefully the idea behind it is comprehensible.

Table 3: Theoretical interview questions and topics of interest

Categories	Questions formed during discussion	Additional questions
Mindset	*Have you set any goals regarding utilization levels?* Man (2001)	*Do you feel more motivated due to the system information?*
Mindset	*What kind of goals have you set?* Man (2001)	*What do you think about the utilization KPI's and their usability*? and *Do you follow the KPI's in the system?*
PC	*Has the process become more efficient?* Hammer (1990), Davenport (1993)	*Does the SmartFactory system help you in your job?* and *How could the SmartFactory system help you in your work?*
PC	*Has the IT used enabled the creation of new process?* Hammer (1990), Davenport (1993)	*Why do/do not you use the system? and Has your work changed, and can you give an example of this?*
MPI	*Has the cycle time of a process improved?* Küng & Hagen (2007)	*ERP data and system data, coding*
MPI	*Has the productivity per employee improved?* Küng & Hagen (2007)	*ERP data and system data, coding*
ORttS	*Why the system was developed?* Peppard (2011), Ranganathan, Balaji & Coleman (2011)	*Can you describe some of the problems that the system is trying to solve?*
ORttS	*Has the level of employee empowerment decreased?* Qin, Liu and Grosvenor (2016), Proenca, Torres & Sampaio (2017)	*Has the system affected the working atmosphere in some way?*
ORttS	*How do you feel about the system?* Schroeder & Mauriel (2000)	*Can you say why do you feel like this?*

4 CASE DESCRIPTION

In this section the case company and the case system are described in detail. sources for this part of the thesis are mainly https://www.stera.com/, appendixes and the researcher's personal knowledge as an employee of the company.

4.1 Company history and description

Stera Technologies Ltd. (Stera) is a Finnish contract manufacturer, which operates as a subsidiary for a variety of different companies. Stera was formed during 2007 when Elektromet Yhtiöt Ltd. Levyosa Ltd. and Hihra Ltd. were merged. All of the companies were involved in sheet metal manufacturing and it is one of the key competencies of Stera. Nowadays the company has extended its key competences into other areas. These areas are design & engineering services, electromechanical systems, mechanics, IATF 16949 certified contract manufacturer for automotive, welded structures and machinery, electronics and wire harnesses. Besides the IATF certificate Stera holds the following certificates: ISO 9001, ISO 14001 and ISO 3834-2.

In addition to services provided Stera has their own products, such as SteraLux LED illumination systems, Stera cabinets and enclosures and finally Stera SmartFactory, which is the industry 4.0 system discussed in this thesis.

Stera has multiple key customers to which it supplies different services and products from seven different factories in Finland and Estonia. The customer base of Stera is complex and its customers operate in various different fields such as automotive, medical and machinery manufacturing. The CEO of Stera, Jussi Ohlsson (2017), places emphasis on Stera's capability to offer services throughout the supply chain of its customers. This is reflected in the various roles Stera takes on its customers supply chains and its products/services.

According to Stera's marketing presentation (2017) Stera employs 800 people in Finland, Estonia and India. Additionally, Stera's turnover was 80M euros during 2017 and it had 65 000 m^2 production space in seven factories. Based on these KPI's Stera classifies as a large company.

Stera's organization is quite hierarchical. This is reflected heavily, for example, in appendix 2 where Turku's business area's is depicted. Business areas are the base building blocks of Stera's organization, and they are more or less similar with each other. The management is organized in a top-to-bottom manner. The way Stera is organized from company governance perspective is meaningful, since the various roles within the organization affect the way information is formed, managed and distributed within its information systems.

4.2 Case focus

From an organizational perspective, the focus of this thesis is specifically Stera's Turku business area (BA) and the actors who are involved with the "SmartFactory"-system (SF). This is justified, since the project started in Turku's factory and it is the physical place where its production and system development take place. In a way it can be dubbed as the home of Stera's SmartFactory.

As seen on appendix 2 the production of Turku's business area is divided into two sections, automotive and mechanics. Since SF is a meant to support production these division are of interest from the research's perspective. The production areas are vastly different and the utilization of SmartFactory is on different stages in the production areas. The automotive production is ahead when it comes to utilizing the SmartFactory system, so it is of special importance. Besides the production areas, the production development division and the personnel involved in the development and maintenance of SmartFactory are interesting from this thesis' point of view.

The automotive production revolves around operator-monitored robot-welding. The mechanics division revolves around different kinds of human assisted machinery, such as punching-, bending-, spot welding-, pressing- and pemming machines. In addition, it has assembly lines. The automotive division is fully equipped with SmartFacory system. The mechanics division only has SF sensors in about 50% of its machines.

SF system is divided in to three main parts: IoT sensors, Azure web storage and BI reports/dashboards. In addition, the system is supported by digital signage/info screen system, which expands the report/dashboard distribution. The systems technical details are found in appendix 1. These three main functions are supported by other technologies and functions, but these three components form the core of the system.

In practice the end-user can view the SF data either by actively using a BI report or passively through an info screen. The two different functions are adopted differently, and the active side of SF system is used more than the passive side, since the info screen system is still in development and it hasn't been fully implemented.

Besides end-users the development team behind SF is interesting from this thesis perspective, since the discourse between the two groups is interesting. The goals and development visions the two group have for the system usage and benefits can differ greatly and this can cause issues in the value creation process. As argued by Peppard (2011, 24:40-30:23) the value creation of an information system is related to the social capital a company possesses, which in turn is the result of people being connected to each other, trusting and understanding each other. The final remark here is especially relevant since product development and end-users' opinions can vary greatly.

The industry 4.0 system that this thesis observes is an advanced digitalization system, which combines smart objects (IoT) and business intelligence, and by doing this provides vital information about the environment in which the system is implemented in. The case system uses only a part of the technologies mentioned earlier by Schwab (2017) and Lasi et al. (2014, 239), but nevertheless the system is classified as an industry 4.0 system in this thesis. This is due to the fact that the term is used as an umbrella term for various technologies.

The system used as case study uses IoT sensors mounted on production machines. These sensors collect data and send it to API which makes basic some calculations based on the data. Afterwards the data is sent into a cloud storage from where the data is transferred into a BI program which visualizes and analyses the data. The data collected consists of temperature, humidity, time, utilization and movement. The combined object consisting of an IoT sensor and production machine is classified as a smart object. The goal of this system is to provide relevant data about the machines, which are part of the system. The data collected can be used for various tasks, such as to calculate the production capabilities and utilization of a factory in real-time. This data can be used reactively or preemptively to improve the production process. For example, if the foreman can observe in real-time that a machine is not running and start figuring out what has happened. This information flow streamlines the process and improves upon it. The system's functionality is depicted on the general level in figure 5 depicted below. More detailed technical description of the system can be found in the appendix 1.

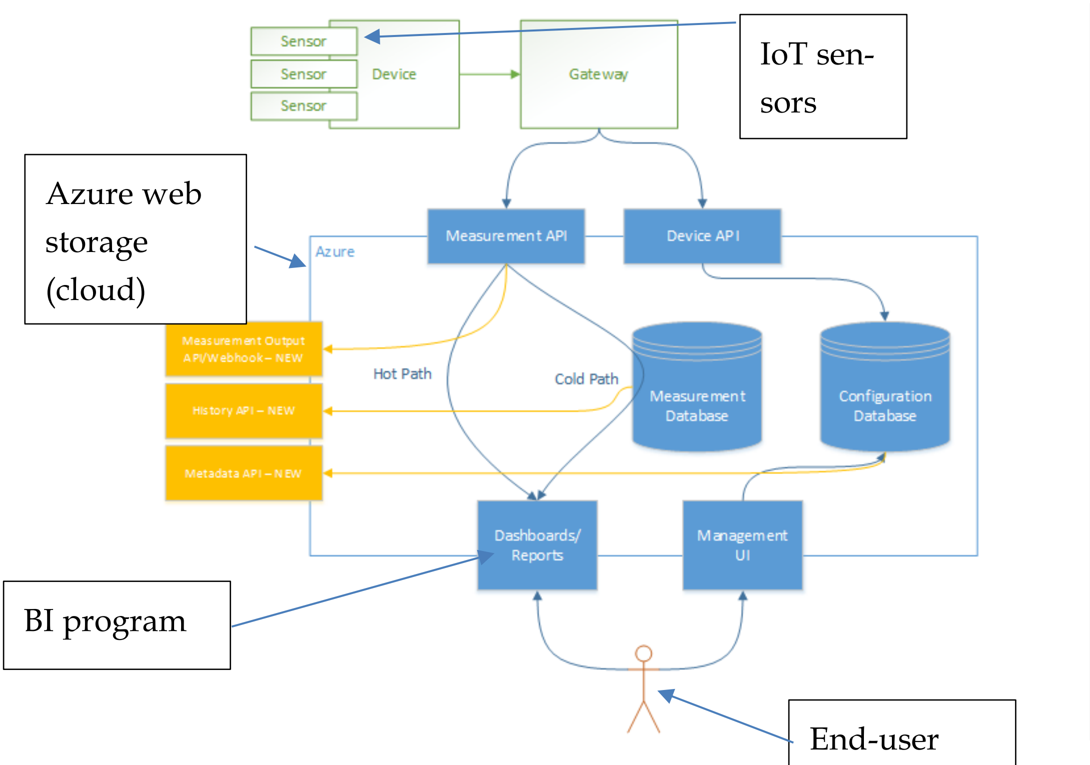

Figure 5: Case system description

Figure 5 depicts how the case system functions. Starting from top the figure depicts the "smart objects"/devices referenced earlier. An IoT device called SF sensor combines multiple different sensors, such as utilization, humidity and temperature sensors. This SF device is the combination of the "sensors" and "device" present in the figure. The various sensors attached to SF device collect data about the production machine, e.g. welding robot, the device is attached to. After collecting this data, the sensors send the data forward to the "gateway" linked with the SF device. A single gateway can be linked to various devices, but a device is only linked to one gateway.

The gateway sends the data it receives forward to the different the application programming interfaces (API) where simple calculations based on the data are made. These APIs are described further in the appendix 1. From these APIs the data is collected into databases, which are linked with Microsoft PowerBI application. The collected data is analyzed within the BI tool and distributed through reports and displays. The sensors and their settings are managed with a management UI.

The benefit of including different types of viewing the data help the potential end-user group of the system expand. The benefits of doing this can be explained by using network effect, according to which the value of product/service increases with number of users (Parker, Van Alstyne, Choudary 2016, 352).

This claim can seem a bit far-fetched, but it can be argued that indeed in a small scale the system does provide network effects. The case system gains network benefits when its user base grows, since the data produced by the system is divided to more users. This enables faster knowledge creation, sharing and integration between the users. This in turn enables the better delivery of internal services, which in the case systems situation would be production efficiency. Because the information is available the same format on the displays the communication between the end-users should be better.

5 METHODOLOGY

As described earlier the methodology selected for this thesis was qualitative in its nature. More specifically the research was done as a case study. This methodology was supported by using semi-structured interviews as data collection method. In addition to semi structured interviews ERP data was used to supplement data collection. The qualitative approach selected for this thesis can be justified, since the research environment and the research target are near impossible to study using quantitative methods.

During the discussion the key aspects of suitable articles were first grouped into general topics of interest and afterwards questions aimed to help to understand these topics were formed. These questions were used as the basis of conducting interviews and ultimately this process provided the basis for answering the research question, “How does business process reengineering concepts translate into value generation?”, presented in the thesis.

The questions were not necessarily asked directly during interviews, but instead they were integrated into table-format framework, which was used as the basis for conducting the interviews. When these questions were formulated in the literature review some thoughts on how they could be used in the formulation of interview questions was also discussed.

The data collection aims to support the theoretical topics discussed prior to Table 3. The interviews were conducted with these topics in mind and the questions used were prepared based on the topics and themes identified/collected in Table 3.

The people interviewed for the research included people from product development, top management, production management and production. Table 4 depicts the people interviewed and their role within the organization.

Table 4: Interviewees and their roles

Interviewee	**Role**
Alpha	Business area director responsible for Turku's business area
Beta	Project manager responsible for "SmartFactory" development
Gamma	Project manager responsible for maintenance and automation in production
Delta	Lead system developer for SmartFactory
Epsilon	Production manager responsible for automotive production
Omega	Production employee

The scope of the research was limited to the automotive production, since the maturity level of the system is “suitable” there. To elaborate, the system has been fully implemented in the automotive production. This differs from the other division in Turku's factory where the system implementation is still in progress. Since this thesis aims to discuss the value creation of the system, a more mature environment, in terms of the implementation, is preferable.

The questions presented in the interviews varied to a degree based on the role of the interviewee within the organization. This was done in order to gain a more detailed understanding of the system from all perspectives. The interviews were recorded with the permission of the interviewees and the recordings were later transcribed. Afterwards, the transcriptions were analyzed and coded. The interviews were conducted in Finnish. Additionally, a trial run of the questions revealed that some additional questions were required. All of the question used are detailed in the appendix 3.

The grouping of the answers gained from the interviews was done following the topics presented in the Table 4. Afterwards, the analysis of this data was done by searching for patterns within the answers and reflecting these trends to the theoretical background. The interviews didn't use the terms industry 4.0 as a basis for questions, instead the term was substituted by referring to the SF system or just using the word "system". This was done to keep the terms used within the interviews more aligned with each other. For example, while the management might relate to the term industry 4.0 the production employees might not. This would affect the answers and the tone of the interview.

The term substitution is justified within the term definition made in this thesis, since industry 4.0 was defined to concern only the technological push aspects of industry 4.0 as defined by Lasi et al. (2014, 239). These "push aspects" refer to the various technologies listed by Schwab (2017, 1). In the case systems case the core industry 4.0 technology is IoT, but other technologies related to the listing mentioned are also included within the system. In addition to the interviews described thus far the CIO of the company was interviewed based on the flow chart presented in figure 5. E.g. "CIO's interpretation on how central IT is seen by top executives" was formed into "How central IT is seen by top executives?"

The data collection for the ERP data was done by utilizing Microsoft Excel report integrated with the ERP in place within the company. The Excel report depicts the production history and efficiency trends. The data present in the Excel report was filtered to include a 11-month time period after the system implementation was finished.

6 RESULTS

6.1 Measurable process improvement

The case company follows its processes intensively to keep track of any changes in process effectiveness. Due to this it is rather easy to determine if there have been radical changes after the wide-scale implementation of the system. Figure 6 depicts the measured process changes on production sectors C1 and C2. The areas represent the number of products completed divided by work time. The SF system usage has been steadily increasing during the time period depicted in the chart. More sensors have been implemented and the BI program has seen an increase in the amount of people using it to observe system data.

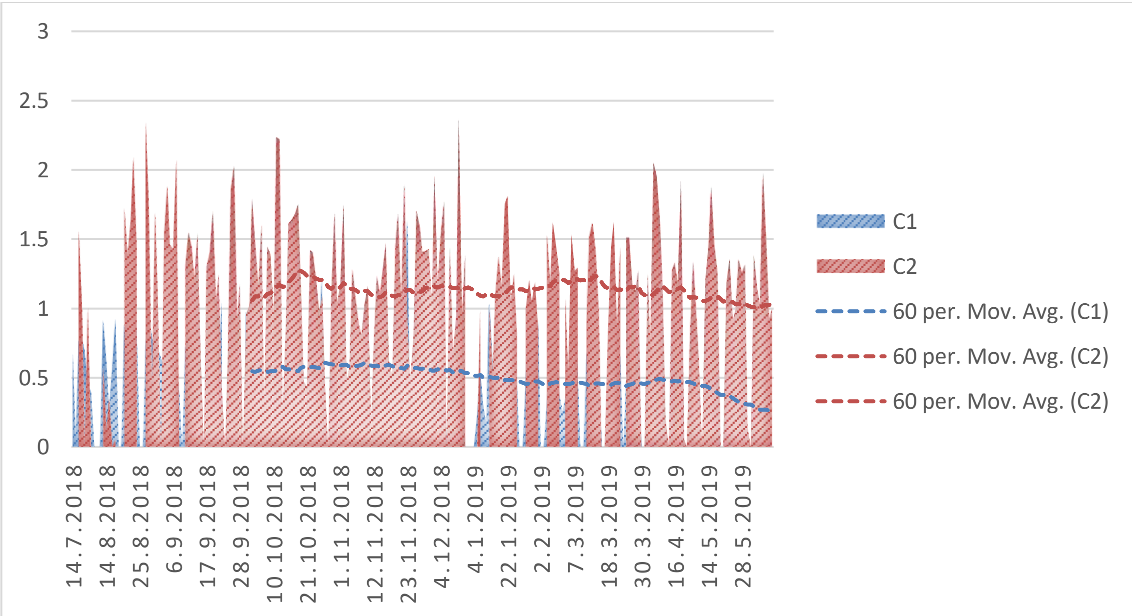

Figure 6: Process effectiveness (time consumed divided by completed products)

The products depicted in figure 6 have not changed during the observation period so the datapoints are comparable with each other. From the moving average lines, depicting the time consumed for completing a product, we can observe a slight downward trend. These average lines are marked with the red and blue lines in figure 6. This means that the time it takes for a product to be completed has been going down. In other words, it can be stated that the cycle time of the process has improved. The change does not seem significant at first, but a change from 0.5 to 0.35, which can be observed from the changes in C1 production efficiency, is quite significant.

The employee turnover rate has been quite limited during the time period depicted in figure 6. The turnover rate was gained by asking a production manager about it. Figure 7 depicts the amount of completed products, grouped by production location, during this time period. We can observe from the average lines that there has been changes in production volumes, but this fluctuation visible in the average lines can be explained with changes in demand concerning the products. This fluctuation in demand has been compensated during the observation period by increasing and decreasing production shifts. Because of this, it can be argued that changes in production volume do not explain the change in production efficiency depicted in figure 6.

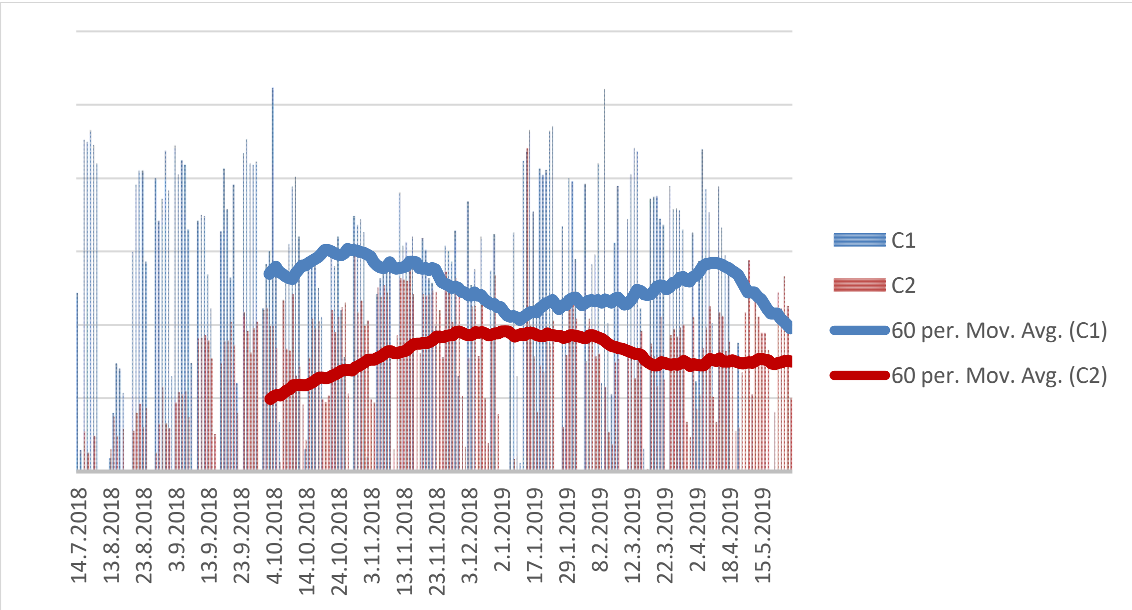

Figure 7: Completed products

It seems that according to the KPIs presented in figures 6 and 7, the process has indeed improved during the selected observation period, since the time consumed for completing products has reduced while the production amount has been relatively same. However, there aren't any drastic "spikes" in this process improvement. This would suggest that there haven't been any changes that have alone caused major process improvement. This efficiency doesn't account for quality changes, but according to one of the quality engineers working in this department: "*The quality KPIs have been more or less the same during the time period depicted in the chart*."

6.2 Process efficiency and process creation

6.2.1 Process efficiency and work roles

It seems that the efficiency of the process has improved, but this doesn't prove any causation between process improvement and the SF-system implementation. During the interviews various comments regarding the process efficiency and the SF systems effects to work roles were brought up. These comments are depicted in the Table 5 where they are divided based on how they seem to reflect the interviewees opinions regarding the process improvement.

It should be noted that the topic regarding processes proved to be quite challenging to inquire directly. Because of this the questions present in Table 5 and later in appendix 4 discuss about changes in work. The idea behind this approach is that changes in the way people do their work and reflect upon it resonate to process level. A limitation here is that a process can't be optimized by improving the efficiency of its parts. However, questions like, "Has the overall production process efficiency increased?", are extremely challenging to answer if the person interviewed is not in a production managerial position. Because of this the present approach was selected.

Table 5: Comments on process efficiency and changes in work interview answers

Comment type	Comment
Positive impact	Interviewee Alpha:" Yes it has changed… …So, if the question was how my work has changed? It has become much easier especially in terms of utilization measurement."
Positive impact	Interviewee Gamma:" Yes, the utilization measurement is transparent in the info screens. It is likely it makes the process more efficient when the operators see the utilization levels. These KPIs are also discussed to a degree in the weekly production meetings. So, it makes the processes more efficient."
Positive impact	Interviewee Gamma:" Yes. For example, bending utilization measurement has helped, because there has been problems and it is being developed. Thanks to the system we can see which shifts are working and which we have to focus on. So, where the bottlenecks are."
Neutral/Negative	Interviewee Epsilon:" Not really. It enables that I can look things remotely, but…"
Neutral/Negative	Interviewee Omega:" At least the system is not a bad thing. I am not sure if it provides any major benefits either."

Out of the six people interviewed five of them had clear answers regarding the process effectiveness or the topic came up during other questions. It is relevant to note that out of the six people only four were system users while two were system developers. This affected the answers and the questions to a degree.

Out of the five people who answered the question, two had positive experiences with the system and its effect on work effectiveness. The main benefit these people reported was the information transfer becoming easier. The previous way of measuring things was quite tedious to execute and thus required more time and effort to complete.

The three people who didn't report positive effects but commented on the systems effects had different reasonings behind their experiences. Interviewee Epsilon indicated that he/she hadn't really tried to use the system to the full extent due to a degree of change resistance. Interviewee Omega hadn't used the system to a degree so that he/she could comment on the usefulness of the system. Interviewee Delta was part of the system development team so he/she wasn't using the system in his/her daily operations and he/she couldn't definitely say how the system affected the other users.

The differing reactions reveal quite a lot about the implementation and the benefits of the system. People who have properly adapted the system reported that their work has become more efficient. Even though the system implementation has ended in Turku's factory people haven't adapted the system and due to this some people can't reap the benefits of the systems.

6.2.2 New processes

The table found in appendix 4 represents answers regarding whether or not the system implementation has led to new processes being formed. The answers are categorized based on whether or not the interviewees felt that the system has created new processes.

Out of the seven people interviewed six had definitive opinions regarding new processes created due to the system. Based on the categorization visible in the table five of the six people felt that the system has created new processes. Especially new processes regarding information transfer and information creation were stressed in the answers. The answers: *"Yeah, just like that. I don't see any other way this could have been done."* and *"From a reporting point of view, it works quite well as it is, we can get new information which we couldn't get earlier"* are especially indicative of this.

The main criticism the system faced was that its data wasn't displayed enough. This is visible interviewee Beta's the hesitancy regarding the system usage and interviewee

Epsilon's clear critique. Interviewee Beta stated twice that he/she wasn't sure if the system had created new processes before answering positively. Interviewee Epsilon stated the following: *"I don't think so. There are too few displays for the information. The system is too one-sided. There should be information all around the factory floor. The information should be available to everyone. Then it would have an effect."*

It seems that the new processes/ways of doing things were mostly related to information gathering/creation. Before the system information about production had to be produced manually. This meant that the information was scarce and it had to be collected in a project sense. Nowadays the information is available all the time and it is produced automatically.

It can be argued that this automatic and continuous production of information has enabled new processes, since the continuous flow of information enables reacting to anomalies within the production. The previous way of measuring production every now and then with a stopwatch did not allow for this sort of process.

6.3 Organizational reaction to the system

6.3.1 Reasons for system implementation

Table 6 depicts the answer given to the question: "Why was the system developed?" Based on the answers especially the costs of purchasing system externally and measuring the production process seem to be brought up repeatedly. The answers seem to point that the initial reason for system development was to measure the system production machine utilizations. The answers in table 6 do not state why this information was deemed to be important. This matter is discussed more in relation to table 7 which discusses the answers to what concrete problem the system tries to solve.

It seems that the system was built internally, since it was originally perceived to be cheaper than purchasing similar systems. In hindsight this can be seen to be the result of underestimating the resources required to build this kind of a system. Interviewee Beta stated the following, when asked about how the product development had succeeded: *"Well the scope of the project was perhaps seen too easy when compared to reality in terms of how much work this has required"*. Based on the reluctancy to purchase the system from markets it can be argued that prior to implementing the system the expectation regarding it were quite skeptical.

Table 6: Reasons behind the system development, interview answers

Why was the system developed answers
Interviewee Alpha:" The history behind the system is that we have thought for a long time that the utilization levels of key machines should be measured in real time. The first thing how this project started was with the current measurements for welding machines, which I discussed, and also especially for the punching machines especially in Paimio, which were measured there. So, there is the "RO machine track" system which was used. Through that we had positive experiences that these kinds of measurements are a good thing to be included in the utilization level tracking. In the beginning there were few offers made regarding similar systems to SF, but they were overly expensive. Because of this, we started to develop this on our own. Afterwards, we started to especially think how we can include the older machinery in the system we were building. So, how we could measure the utilization of the older machines and I think this is the core of this system. So, we can measure the utilization of any machines regardless of their age. "
Interviewee Gamma:" Well, I haven't been involved with that all too much, but it is our own product so I can see it is meant to be sold. If we think about the sensor itself… … Hard question. I think the long-term goal was to create a new product, but also the measuring aspect. So that we can use it in our own production…"
Interviewee Delta:" Basically the same things we have discussed. So, it was to get the information of what is actually going on in the production."
Interviewee Epsilon:" (jokingly) Well we got really good funding from the government… …I don't know. I wasn't involved in that... …The usage of the system is still quite limited, but I think there is potential."
Interviewee Beta:" I think this started when we noticed that these kinds of systems do exist, but they are too expensive for us. I wasn't here when these things were researched, but one example was Imonnit-system. That system was tested, and it was deemed to be expensive and since Stera does have its own electronic division it was decided that the system would be built. So, because we could do this by ourselves, we decided to do it in the first place. Was that the question, how was it formatted? … … Yes, cost factors. We noticed that… …We wanted to do this by ourselves. We noticed that the costs were high in the other system and the customizability wasn't good. Also, we saw that we could build the system by ourselves with reasonable costs and additionally we could sell it forward."

Related to Table 6, Table 7 depicts answers to what concrete problems the system aims to resolve. The focus of the answers is quite similar to the question regarding why the system was developed. A noticeable trend that appeared during the interviews was that the interviewees weren't certain what problems the system aims to resolve, and it took some time for them to name the problems the system resolves.

After the interviewees could think of a problem it was often related to the machine utilization monitoring. In addition to the utilization measuring topics regarding knowledge transfer were brought up. Examples of this can be seen in interviewee Gamma's and Delta's answers. It is especially visible in interviewee Delta's answer, since he/she explicitly stated that he/she believes the systems helps with knowledge transfer.

The topic of knowledge transfer aligns with the goals of the system since it was apparently intended to be used as a benchmarking/measuring tool. One of goals of the systems was to create more information and share it. This was mentioned earlier in the interviewee Delta's answer regarding system development. Interviewee Delta points out that the goal of the system is to find out what is "actually" going on in the production. This answers hints that it is not clear what is going on in the production and this is causing issues, which need to be resolved. This is to say; the production process was not functioning as intended and the system was developed to measure what might be causing issues for the production.

The question regarding why the system was developed partly aimed to find answers on how the IT is perceived within the company. If IT functions and IS systems are seen merely as costs authors like Peppard (2011) argues that the value creation of these systems isn't optimal. The answers presented in Table 6 suggest that the SF system was, at least partly, developed to cut system acquisition costs. Additionally, the system was developed to create new kind of machine utilization information.

New information enables the creation of new processes and thus it can be argued that while the cost aspects were definitely a reason for the system development in house, they were not the reason behind the system implementation. This distinction is quite significant, and it suggests that SF system is not merely a KPI. It allows for information creation and transfer, which was not previously possible. This aligns well with the value creation as defined by Peppard (2000), mentioned in the theory section. He argued that the value of IS is emergent utilizing the information created, integrated and shared by the system.

It seems that if we trust Peppard (2000) the system should create value at least in terms of the reasoning behind why it was developed. The system aims to create and share new kind of information, thus creating value. Here it is important to note that this doesn't translate to value creation directly. Even if the system was developed for the right reasons, it does not guarantee that these goals have been achieved.

Table 7: Concrete problems the system aims to resolve, interview answers

Concrete problems the system tries to resolve answers
Interviewee Beta:” Surely something like saving work time… …This Trello system that we have also implemented supports this system. We can check from to sources that when machine has stopped and why. Ideally the systems would be integrated, but at the moment we have moved rapidly forward with these two systems. Can you repeat the question? ... …A concrete problem, Surely, to answer if the machines are running during night when they are supposed to run. Are people sleeping during shifts or are the machines running even if there are fewer forklifts. So, to monitor the work. There can’t be as many people supervising work during night shifts as during day.”
Interviewee Gamma:” Well it helps with… …well from maintenance point of view it helps the most. We have really strict production and there is one workstation that has to operate all the time and now we have focused on that workstation, since its utilization level has only been 75% and normally it is over 90%. The system helps to focus on the problematic workstations. There has been a problem, since the utilization is 20% lower than it has been.”
Interviewee Gamma:” …a concrete problem… … … … I can’t think of anything just now… …Well I think that it is a problem if we don’t’ see how our machines are running.”
Interviewee Delta:” I believe it helps with the knowledge transfer. It is hard to say since I don’t directly use it.”
Interviewee Epsilon:“ I think it helps the employees to get feedback on how things have gone. The other part is that we can monitor the utilization and micro stops.”
Interviewee Alpha:” Umm… …The biggest driver was that when we do large investments and we calculate ROIs for them the machines have to run according to the calculated time. So, making sure this happens. If we are discussing about FML line investment, which costs 2-3 million, the machine has to run in three shifts in order for it to pay itself back. So, making sure this happens.

6.3.2 Feelings towards the system

This section discusses the answers regarding how the system has affected the organizational relations and how people feel about the system. Table 8 depicts answers related to the general feelings people have towards the system while Table 9 depicts how work "atmosphere" has been affected/ might be affected in the future by the system. This change in atmosphere is questioned by asking if the system has caused any major change resistance.

Table 8: Feelings about the system

Feelings about the system answers
Interviewee Alpha:" Well it is good, but we would need to shift… ... At the moment we have a lot of information and now we should think how we will really use the information. Like here we have discussed the parameter changes and other things. Additionally, we should build links between our ERP and the system. These are the next steps we need to consider... "
Interviewee Beta:" Well I believe there is great potential in this system. The challenge with this system is that now that we have exported it to external customers the universality of the system becomes relevant because the customer needs vary quite a bit. The sensors might not be effective as they are and they need calibrating. Additionally, the customers would want to see how effectively the machines are running. I think there is potential, but it is hard to say how it can be achieved. The sensors can be implemented in various environments and we should think how the sensor product group could be enhanced…"
Interviewee Delta:" (laughter) …mixed emotions… … …it is a smart system… …there is lot to develop in all aspects, but the idea is really good… …I think the more data there is the better we can develop things."
Interviewee Epsilon:" I think it has potential. When the system development was initiated, I was resistant to change, but now that there are more workstations to follow it is impossible to follow everything without a system of some sort. When there were below ten workstations you could observe the station yourself, but now that there are more it is harder… …the system brings transparency. Also, you can react and oversee the big picture and you don't have to "run around". The flip side is that then the personnel might feel you are not present."
Interviewee Gamma:" Of course it is a good thing… …It is beneficial to me and to others in maintenance, production and development planning. I don't have anything negative to say about it."
Interviewee Omega:" First when they were implemented people were a bit skeptical. People thought that now the management is following how productive people are and how well the robots are running, but the system is much more. At least I don't feel they are a bad thing."

An interesting trend regarding the answers can be noticed. It seems that even though the system is already in use, at least on paper, people aren't perhaps fully utilizing the system. The undertone present in the interviews suggested that the system is used, but the users don't fully trust the data it provides. To a degree this is visible in the transcript in the abundance of the future tense and the word potential. The word potential was mentioned four times in the answers shown in Table 7. These things together would suggest that the users are expecting the system to evolve and become more useful in the future. On the other hand, these positive expectations would suggest that the present usage might be lacking.

Table 9: Answers regarding change resistance and work organization

Change resistance and work organization interview answers
Interviewee Alpha:" I don't think so. To some degree, in our work facilities when we have incentive systems the driver and motivation to do more arises from there… (Confusing sentence. The intent behind it was that the system has not really affected to the way people organize their work, but it does have some minor effects.) … For example, in Tammela the level of performance between shifts is being reported on. So, from there also some motivation might arise from the competition between shifts, but I haven't seen that here in Turku."
Interviewee Beta:" Well, in the beginning there was change resistance, of course, people felt that this was "stalking" or something like that. I wasn't here in the very beginning so I have avoided the biggest change resistance, but now that we have delivered this to external customers…
Interviewee Epsilon:" Obviously, there is always some change resistance, but it has been quite mild."
Interviewee Alpha:" ...There was some change resistance of course and additionally questions about how a system which practically monitors the workers can aim to improve production on a general level. These kinds of problems were related to the implementation. In a way, not everyone experienced that the system was beneficial or reasonable from the employee side of things.
Interviewee Gamma:" It has been surprisingly low. (Level of change resistance) Of course, there were some complaints right in the beginning, but not much. In the last months or past year actually, there hasn't been much complaints."
Interviewee Delta:" Production personnel are quite change resistant. In the beginning there was quite a bit of resistance."

The answers depicted in Table 9 suggest that the system faced some amount of change resistance. This is outright stated a couple of times. However, the interviewees also suggest that the change resistance has since diluted. Change resistance is natural part of change and thus it is expected that some amount of it will arise whenever a change is present within an organization.

Jones & Van de Ven (2016) argue that change resistance has "festering" effects over time. They propose that employees' perceptions of organization and its effectiveness become stronger rather than weaker over time. This effect suggests that if the employees don't see the benefit of a change, they would oppose it in increasing amounts. However as noted by observing the answers in Table 9, it seems that the change resistance has indeed diminished. This would suggest that the employees have identified some benefits gained from the system.

6.3.3 IT organization's role

Out of the five possible roles for IT defined by Guillemette & Paré's (2012) the best suited role was defined to be that of a partner. According, to the answers given by the CIO, present in the table 10. Stera's IT role falls under this category.

Table 10: CIO interview answers

Category	CIO's answers (Parapharsed)
IT centrality to the business	Central to operational excellence: "Our organization is a contract manufacturer and substantial subcontractor to many of our clients. Because of this a seamless transfer of economic information is extremely important in terms of our mutual supply chains. Additionally, we have to have capabilities to provide production and quality information to our clients."
CIO's strategic influence	High: our IT decisions are made by me our CEO and my direct subordinate. Because of this my strategic influence on IT decisions is very high..."
Top managements IT knowledge	High: "Before me our CEO was the CIO so he has practical experience from IT. Our management group does not have any IT experts, but the interest they show towards IT is substantial."

6.4 Mindset, goal setting and the nature of goals

The topic of mindset was approached by asking the employees associated with the system set any goals regarding it. Table 11 present answers to the questions regarding goal setting. Most of the people interviewed claimed to have set goals regarding the system and only interviewee Omega did not claim to have set any goals. It should be noted that interviewee Omega did not explicitly state that he/she doesn't have any goals regarding the system. However, the tone of the answers given suggested that while he/she does follow the KPIs it is not an integral part of his/her work. Based on this it can be speculated that he/she hasn't set any goals regarding the system, but this result is not conclusive.

Table 11: Goals regarding the system

Interviewee	Goal set
Alfa	"In a way, whenever I look at the KPIs the automotive robot measurements have to be over 90%... "
Beta	"Well that isn't relevant to my work so I haven't set goals like that. The goals I have set are more like that the sensors function at all times. If there are sensors which are not working… …I have set those kinds of goals."
Gamma	" Not any exact goals. I follow the KPIs personally and for example in Estonia there are some unofficial goals that the levels have to be above 50%. These kinds of goals, but not any hard goals."
Delta	"Well actually, my goal is that the sensors work as well as possible."
Epsilon	"I haven't set any concrete goals. I have noticed that different workstations have different utilization levels on average. If there are dramatic changes then I react to them. It depends on what is the correct level on the workstations."

The noticeable thing in Table 11 is that nobody among the interviewees had set any concrete goals regarding the system. It could be argued that interviewees Beta and Epsilon had concrete goals regarding the system uptime, but since their answers were quite vague in their nature it is apparent that these goals aren't concrete. The general trend seems to be that if the system displays radical changes people will react to it, but minor discrepancies don't cause any direct measures from the interviewees. This is especially apparent in the word choices of interviewees Gamma and Epsilon who directly state that the goals aren't "concrete"/" hard".

It seems that the mindset prevalent in the answers can be categorized to be the current mindset as defined by Man (2001). As defined in the theory section, this is the least desirable mindset in terms of value creation, according to Man (2001), and it suggests that the system is not utilized all that well. The mindset can be identified in interviewee Epsilons answer where "fight the fires as they appear" mindset can be identified to a degree.

7 ANALYSIS

7.1 Results gained

This section of the thesis compares the results gained from the empirical section and the literature review and based on this comparison answers the second sub-research question presented in this thesis: *"Does the case system create value through business process reengineering?"*

During the literature review part of the thesis several different approaches to value creation were discussed. Based on these approaches the interesting topics in terms of value creation and this thesis were determined to be the following:

1. Process creation
2. Measurable process improvement
3. Organizational reaction to the system
4. Mindset

Based on the empirical results the following statements related to these topics can be made:

1. The system has led to the formation of new work processes, mainly regarding information creation.
2. The efficiency of the production process has increased after the system has been adapted into production.
3. The system was developed in order to create and share new information and because it was seen to be a cost-effective solution to purchasing as a system.
4. The IT organization's role within the company can be classified as a partner, following the categorization presented by Guillemette & Paré (2012).
5. The system has not been adapted fully even if the implementation phase is over.
6. The end-users feel the system is beneficial and the change resistance people had towards the system originally has since diluted.
7. The prevalent mindset regarding the system is that of a current mindset.

These statements are referred to as statements 1-7 moving forward.

7.2 Process creation

The goal regarding the topic of process creation was to determine if BPR thinking had realized itself thanks to the system implementation. The question regarding the topic was if the system had enabled the creation of new processes instead of merely automating old ones.

The fundamental idea behind the system, from a technical perspective, seems to be the automation of a previously manual process. However, the system has added new elements to this measuring process such as data visualization, business intelligence reporting and automatic calculations. Additionally, the system creates information which was not previously available, such as robot acceleration and temperature data. Referring to the statement 1 the system implementation has led to formation of new processes and thus it can be argued to have caused unintentional BPR. In other words: "The implementation of the case system has caused changes in the business processes of the organization."

This finding does not prove any causation that implementing industry 4.0 systems causes changes in business processes in the form of BPR, but it is interesting nevertheless, since it does align well with the observation made in the very beginning of this thesis where it was stated that:

" BPR, as understood within the context of this thesis, describes how utilizing information systems can lead to development of new processes and ways to operate within a company. While as, industry 4.0 systems often aim to change the manufacturing process by utilizing an information system based on advanced digitalization."

Based on the similarities of the term definitions and the empirical results, it can be argued that BPR can be an unintentional result of developing and implementing an information system, which aims to change the way information is created and used within the organization. The implication of this argument, if correct is, that BPR does not need to be a conscious project or process. Of course, anything can happen by accident and because of this a singular finding proposing that industry 4.0 system can lead to it is more or less obsolete. Because of this, the matter should be researched further to gain a better understanding of value creation through process change and creation. If the results of BPR can be achieved by focusing on the information creation and sharing elements of IS, BPR is more or less meaningless concept, since the value creation of these systems does not seem to arise from the actual process reengineering and instead supporting Peppard (2000) the value creation of information systems is ultimately the emergent result of information being created and transferred between users.

This supports the trend of developing information systems with end-users in mind as mentioned by Koivisto & Hamari (2019), since ultimately the information created and shared is used by these end-users and the intermediary systems they use. If the focus would be on business processes instead of end-users, the value creation process would likely suffer.

On the other hand, this shift in literature trend is not directly opposed to the original idea of BPR as presented by Hammer (1990), since it can be argued that the definition, “information systems should be developed to enable new processes instead of merely automating old ones”, does include developing information systems with end-users in mind within its scope. The problem with the traditional BPR approach is that developing information systems is often understood as developing technologies behind the systems. Perhaps a better definition capturing both the BPR idea and modern trends would consider this focus on users and information. This definition of good BPR practice could be as follows: “information systems should be developed to enable new processes which create relevant information for the end-users.”

7.3 Measurable process improvement

The statement 2 suggests that the process has indeed become more efficient after the system was implemented. The finding supports the arguments made by Küng & Hagen (2007), since they propose that BPR can lead to process improvement in terms of process efficiency and quality.

This finding does not prove any causation between BPR and process improvement, but in addition to Küng & Hagen (2007) it supports Davenport (1993) who proposed that BPR might cause process improvement. This trend seems rather reassuring and it can be claimed that BPR, or in the context of this thesis systems supporting BPR principles, lead to process improvement in terms of process efficiency, at least to a degree.

The counterargument to the logic present in the last paragraph is as follows: Even if the system has apparently caused process improvement through BPR, the scope of the effect is unclear. The observable process improvement was quite abysmal and because of this it still can be claimed that the system had nothing to do with the process improvement. This is a fair argument and perhaps the value creation of the system is not observable through quantitative methods.

7.4 Organizational reaction to the system

Statement 3 suggests that the company did not develop the system only to save costs. Instead one of the key aspects behind the system's development was to create and share new kind of information. According, to the theory discussed in this thesis this kind of thinking is likely to lead to value creation. This transfer of information was arguably the main reason behind the system implementation, since looking at the system from a purely cost perspective the cheapest solution would have been not to implement the system. The success of the system is seemingly measured on how well the system is used and how its information affects the business processes, instead of looking at how much the production costs have been lowered.

Statement 4 supports this notion of searching for information transfer and business process change, since the value proposition of a "partner"-type IT organization stems from improving productivity through business process engineering and facilitating change Guillemette & Paré (2012). Interviewee Delta mentioned that he/she believes the more there is data the better it can help develop things. This line of thinking aligns well with the "change-facilitation" part of the value proposition. It seems that the empirical findings gained from the interviewees support the categorization and the value creation proposition made by Guillemette & Paré (2012).

Even if the premise for value creation is suited for the partner-type IT organization, it is an entirely different thing if the value creation of the system has been actualized. Statement 5 points out that the system implementation of the system did not went perfectly. The system is not used by all of the users who are intended in its scope. Because of this the value creation of the system suffers and its benefits are only partly gained. This argument is supported by the following logic: if the fundamental goal of the system is to create and share information between its users, a lack of system usage will lead to less information being shared and created, thus limiting the benefits of the system.

As observable from the statement 6 the end-users feel that the system is beneficial. This proposes that the system has some benefits, since otherwise they would likely be indifferent towards the system. Even if the overall feelings the users had towards the system were positive, the indifference can be observed from the interviews. For example, interviewee omega stated, "at least it is not a bad thing". This indifference can be partly explained with the statement 5, since if the users have not adapted to the system, they would likely feel indifference towards it. The feelings toward to the system are likely affected by the fact that the system does not directly affect the users. They are not required to use it, nor does it influence their salary. Because of this the system can be described as a support system. It does not hinder its users and it might influence them positively by providing information.

The nature of the system might also explain why the change resistance has been reduced after the system implementation. Because the "monitoring" that the employees feared does not directly affect them there is really nothing to resist. The question that arises from the overly "soft" nature of the system is that can a system without any negative incentives be adapted well? From a Stera's customer point of view it is easy to imagine a situation in which a company purchases SF and implements it by enforcing the system upon its users. In such a situation the end-users might not be satisfied with the system.

7.5 Mindset

Statement 7 proposes that the mindset the end-users have regarding the system is that of a current mindset. Man (2001) proposed that this mindset is the least optimal for value creation, since it does not lead to process improvement. To a degree this seems to be the case, since the users do not use the case system to actively improve the processes. For example, the interviewees did not seem to have set any goals, like: "How could I improve the utilization levels displayed in the system?", for themselves.

However, it seems that the system has in fact created new processes and improved old ones. This would suggest that the innovation mindset proposed by Man (2001) is not required for process improvement. It can be argued that this might be the case if the system affected the end-users directly (e.g. salary), but in cases similar to case system, this kind of thinking is not required. Different mindsets might be beneficial for different kinds of systems.

7.6 Case system and value creation through BPR

The case system has seemingly led to unintentional business process reengineering as defined within this thesis. This finding supports the idea that BPR made in literature is not the answer to defining the value creation of information systems. At the same time, it partially supports the notion that value creation of an information system stems from information creation, integration and sharing. The case system was built from these premises and as an end result it improves the business processes of the case company, thus creating value. While information creation, sharing and integration were the reason as to why the case system was built, it seems that the value creation of the case system is ultimately the result of process change.

Even if the case system does seemingly create value, its potential has not been fully realized. According to the data collected, the system is not fully utilized by all its intended end-users.

Change is not always a positive thing and value is only created if the change improves the old way of doing things. This can be seen in the industry 4.0 definition made in this thesis. The final definition made went as follows: *"Industry 4.0 is an umbrella term that covers technologies, such as IoT, AI, nanotechnology, autonomous vehicles, biotechnology, energy storage, quantum computing, business intelligence and 3D printing. These technologies are part of the fourth industrial revolution that supposedly happens in the future, which will increase manufacturing efficiency."*

With these definitions in mind it can be said that the case system creates value through what can be called unintentional business process reengineering. The premise of effective information utilization leads to positive process change, which in turn increases manufacturing efficiency.

8 CONCLUSIONS

The aim of this thesis is ultimately to answer the following research questions

- How does implementation of an industry 4.0 system generate value with business process reengineering concepts as value basis?
- What industry 4.0 means as a term?
- Does the case system create value through business process reengineering?

In the literature review several approaches focusing on value creation was discussed. Most of these approaches were linked to BPR. In addition, value creation with information utilization as its premise was discussed and most importantly the vague term industry 4.0 was defined.

Before discussing the first research question it is good to discuss answers to the sub-research questions. After discussing the three industrial revolutions, which have taken place, and different views on how industry 4.0 means industry 4.0 was defined as follows:

"Industry 4.0 is an umbrella term that covers technologies, such as IoT, AI, nanotechnology, autonomous vehicles, biotechnology, energy storage, quantum computing, business intelligence and 3D printing. These technologies are part of the fourth industrial revolution that supposedly happens in the future, which will increase manufacturing efficiency."

In addition to this definition industry 4.0 system was defined as follows: *"Industry 4.0 system is an information system combining two or more industry 4.0 technologies."* Here the industry 4.0 technologies refer to the new and emergent technologies which are part of the potential fourth industrial revolution.

The value creation of the case system seems to be the end result of utilizing information effectively to enable business process change. This value creation was apparent in the attitudes and reactions the interviewees had towards the system and the measurable process improvement gained from the company's ERP. In the end the value creation could not be definitively proved, but there were some clear indicators that the system does provide value to the company. During the interviews it was stated that the cases system has changed the business processes of the company. Because of the previously mentioned matters it can be said that the case system does create value through BPR.

The most apparent limitation regarding the system's value creation was its limited adaptation rate among its potential end-users. If the system is not used it cannot create value. System implementation was not extensively discussed during the thesis, but its effect on value creation was apparent from the results gained. Based on this the link between value creation and system implementation should be researched more.

The implementation of industry 4.0 system is an undertaking which aims to utilize information effectively. This information utilization can lead to positive process change, which produces value by improving business processes. In short, industry 4.0 systems create value through BPR by enabling it.

This finding is not by no means definitive and it requires further research to hold any ground. This is the most pressing limitation of this research and it should be addressed by studying if systems implemented from the premise of effective information utilization lead to positive process change and by extension value creation.

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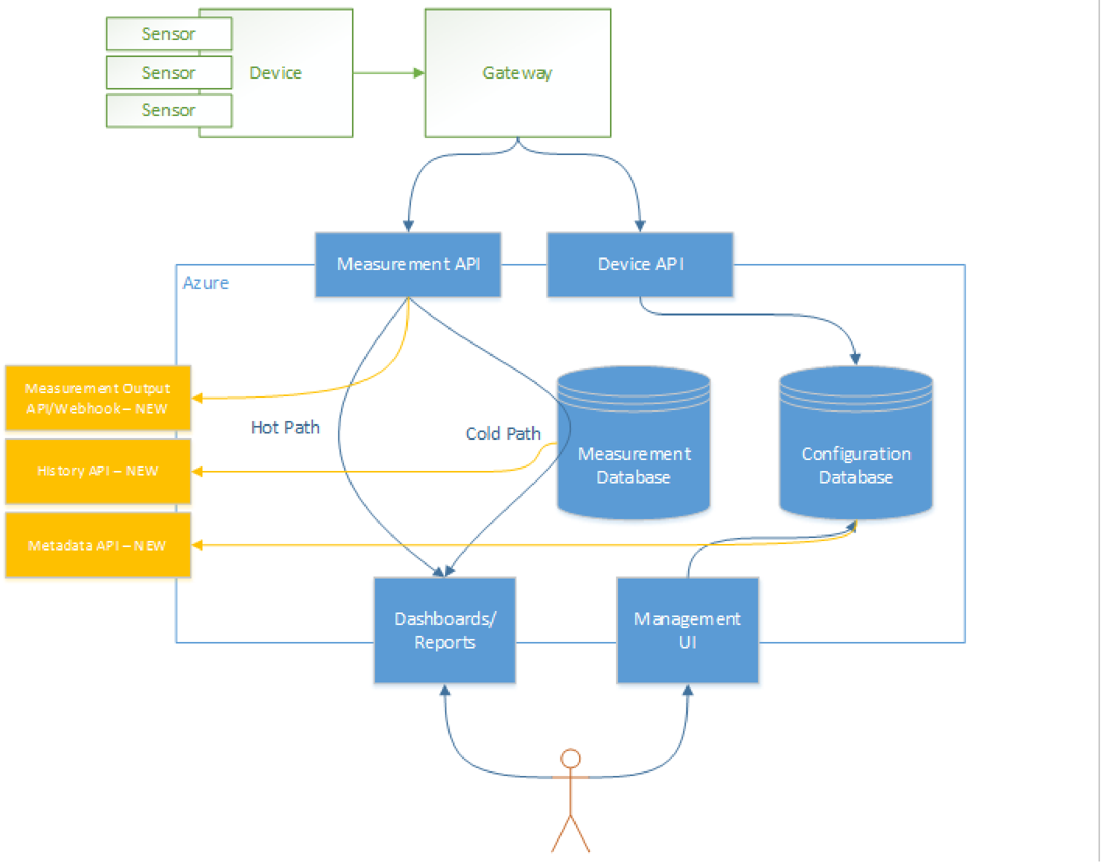
APPENDIXES

Appendix 1: Technical system description

Integration interfaces are described in the figure below



The system includes three different kinds of interfaces:

1) **Measurement Output API.** With API events can be exported to an external system in real-time (hot path).
2) **History API.** With API history data saved in the system can be queried.
3) **Metadata API.** With API metadata/configuration data saved in the system can be queried.

IoT-system sends messages arriving in the external interface in real-time (hot path). The interface is carried out as Rest API. The target system offers a predetermined interface in which the system sends events in real-time.

The usage of interface doesn't change of affect the normal usage of the system. All events sent outwards move normally within the system, are save in a database and can be directed to PowerBI-reports.

Interfaces are customer specific. The recipient interfaces contact information are determined separately for each customer. If the contact information hasn't been specified for a customer the events are not sent forward.

The events which are sent to the interface are specified sensor-specifically. Integration is enabled sensor-specifically through user interfaces Devices-tab in configuration-tab.

The system sends events in the same order in which they arrive to the system. The events are sent in sequence. The recipient interface has a maximum of one call per execution.

The system tries to send one event to the recipient interface only once. If the transmission doesn't function for one reason or another, the event is discarded, and the systems moves to handle next events.

The system tries to execute one call to the interface for 30 seconds, if establishing connection or execution of the call doesn't succeed within this time, the call and events send with itis discarded. Respectively, if the recipient interface sends an error the call is interpreted to have failed. If five consecutive calls fail, the system stops sending events for five minutes.

In connection with a transmission events are enriched in accordance to the following rules:

1) Events are added the sensor type's code value:
    a. COUNT_N – The amount of strikes
    b. HUM_PCT – Air humidity
    c. TEMP_C – Temperature
    d. UTIL_YN – The operation state (values 1 and 0)

The authentication of the interface is carried out using API Key -technology. API Key is sent with every call in the "IoT-API-Key"-field in the http-message's title. The system supports https-protocol.

The customer configurates the address (URL) of the API which receives systems events and the API Key value used, through the WebUI -user interface. Configuration takes place custom-specifically. The interface can also be disabled, if desired.

History API is a Rest API interface offered by the system, meant for observing the events saved in the system. History API authentication happens using API Key. The system is configured with customer specific API Key -key values, using which the customer's data can be read. API Key -key value is sent with every call in the "IoT-API-Key"-field in the http-message's title.

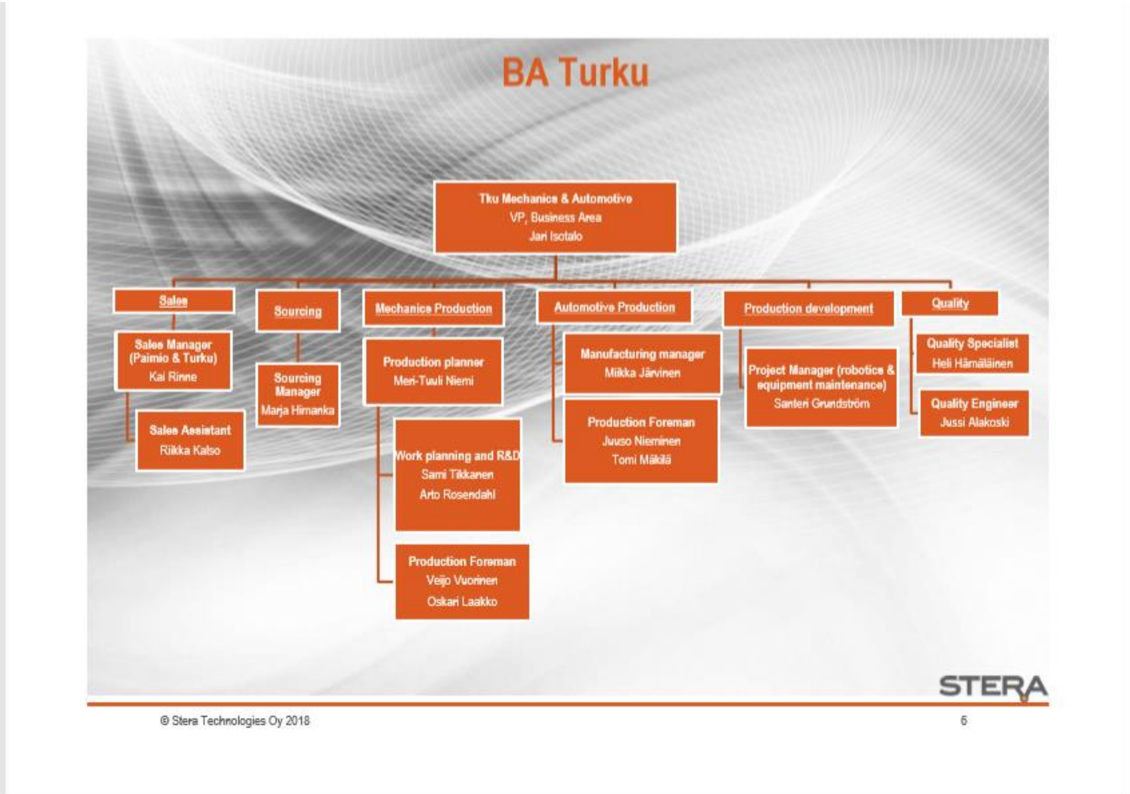
History API uses https-protocol. Fetching events is an asynchronic operation in which the service requests are used. Fetching events starts with creating a service request. This request returns immediately the service requests id. The fetching of data itself is started in background. By using the id of the service request the results of the search can be queried.

Completed query result is stored within the system for 30 minutes. Afterwards, the service request's results function returns an error.

The data saved within the database doesn't include SensorType-information. This information is enriched in connection with data transmission.

Through Metada API an external system can query the internal configuration and metadata information of the system. Authentication is based on the same API Key -key valye as with History API. The functions return only the information associated with the customers corresponding with the key.

Appendix 2: Organization chart of Stera and Turku's business area (2019)



Appendix 3: Interview questions

#	Question (In English / Englanniksi, base question)	Kysymys (In Finnish / Suomeksi, konteksti huomioon otettuna)
1	*Has your work process become more efficient after the implementation of the SmartFactory (SF) system? Can you give an example?*	Onko työtehtäväsi tehostunut SF -järjestelmän käyttöönoton jälkeen? Voitko antaa esimerkin tästä?

1.1	*Why do/do not you use the system?*	Miksi käytät/et käytä SF -järjestelmää?
1.2	*Has your work changed, and can you give an example of this? / Do you know if the system has changed somebody's work?*	Onko järjestelmä muuttanut työtäsi ja voitko antaa esimerkin tästä?
2	*Has the SF system enabled the creation of new process?*	Onko järjestelmän käyttöönotto luonut uusia prosesseja/tapoja tehdä työtä?
2.1	*How does the SmartFactory system help you in your job?*	Miten SF -järjestelmä auttaa sinua työssäsi?
2.2	*How could the SmartFactory system help you in your work?*	Miten SF -järjestelmä voisi auttaa sinua työssäsi?
3	*Why the system was implemented? / Can you say why the system was implemented?*	Miksi järjestelmä rakennettiin? / Osaatko sanoa, miksi järjestelmä rakennettiin
3.1	*Can you describe some of the problems that the system is trying to solve? / Can you imagine what kind of problems the system is trying to solve?*	Voitko kuvailla millaisia ongelmia SF -järjestelmä koittaa ratkaista? / Voitko kuvitella millaisia ongelmia SF -järjestelmä koittaa ratkaista?
4	*Has the level of employee empowerment decreased?*	Onko järjestelmä vaikuttanut päätöksenteko-mahdollisuuksiisi?
4.1	*Do you think you think you have less control on how you organize your work due to the system?*	Joudutko tekemään työtäsi eri tavalla järjestelmän takia, jotta esimerkiksi sen mittarit näyttäisivät paremmalta?
4.2	*Is your salary affected in some way on the system?*	Vaikuttaako järjestelmä jollain tavalla palkkaukseesi?
4.3	*If no, how would it feel if it was?/ How do you feel about this?*	Mitä mieltä olet tästä/olisit jos palkkauksesi olisi sidottu systeemiin?
5	*How do you feel about the system?*	Mitä mieltä olet järjestelmästä?
5.1	*Can you say why do you feel like this?*	Osaatko sanoa miksi olet tätä mieltä?
6	*Have you set any goals regarding utilization levels?*	Oletko asettanut tavoitteita liittyen järjestelmän mittareihin?
6.1	*What kind of goals have you set?*	Millaisia tavoitteita olet asettanut?
6.2	*Do you feel more motivated due to the system information?*	Koetko olevasi jollain tavoin motivoituneempi järjestelmän ansiosta?
7	*Do you think the system is useful?*	Koetko, että järjestelmästä on hyötyä?

7.1	*Can you give an example on how the system is useful?*	Voitko antaa esimerkin siitä miten järjestelmä on hyödyllinen?
Ex-tra	*Can you describe how the system could be utilized in the future?*	Voitko kuvailla miten järjestelmää voisi käyttää tulevaisuudessa?
Ex-tra	*How have you tried to pursue the goals you have set?*	Miten olet pyrkinyt saavuttamaan tavoitteita, joita olet asettanut?
Ex-tra	*How could/should the system be implemented?*	Miten järjestelmä tulisi jalkauttaa?
Ex-tra	*How could the system be of use to other actors related to the system? / How does the system help others currently?*	Miten järjestelmä voisi auttaa muita tekemään työtänsä? /Miten se auttaa parhaillaan?
Ex-tra	*Do you have any ideas regarding the system / how it could be used in the future?*	Miten järjestelmää voisi hyödyttää tulevaisuudessa?
Ex-tra	*Can you describe the (potential) "smart" elements of the system?*	Voitko kuvailla järjestelmän ennakoivia ominaisuuksia?
Ex-tra	*What problems there are/were regarding system implementation?*	Mitä ongelmia järjestelmän jalkauttamisessa on ollut/on?
Ex-tra	*How would you describe the system?*	Miten kuvailisit järjestelmää?

Appendix 4: Process changes table

Table 12: Process change interview answers

New process	No change
Interviewer:" Okay, so do you have any opinions on has the system changed the work of other people, so has the system created new processes?", Interviewee Alpha:" ...So, in practice in a process sense the operative process hasn't changed all that much... ...but if we are looking at things from investment point of view then	

the return on investment, which we discussed, and overall that we can get everything out of the expensive investment and the confirmation of the calculation, so that is it, what we have probably already done.	
Interviewer:” Do you think the system implementation has created processes or ways of doing things? For example, regarding information flow or functions.”, Interviewee Beta:”… I am not sure if this has caused any changes or if this data has been utilized to show the problems regarding the production. I am not sure about this. …, " Interviewer:” This question can be approached from thinking how this sort of information would have been gathered earlier.”, Interviewee Beta:” Earlier this kind of information would have been gathered manually. So, an operator would have marked down when a machine is running or not and what is the reason behind stops. So, manual registration. Another way could have been that someone would have monitored the process all the time.”, Interviewer:” Stopwatch in hand…”, Interviewee Beta:” Yeah, just like that. I don’t see any other way this could have been done. Of course, some machines had similar systems, but one of the reasons this system was implemented was to harmonize the data gathered. So, how bending machines are running… … So primarily for top level management. From there the system has been expanded downwards within the organization.”	
Interviewer:” Well can the system create new processes due to this?”, Interviewee Delta:” Exactly, when there is	

more information it is easier to create new processes and way of doing things.”	
Interviewer:” Well can you say if the system has changed the way you do your work in some way? In a way you answered this already, but when you think about how you had to do things earlier has the system changed the way you do things?”, Interviewee Gamma:” Yeah, for example there isn’t a need for a person to stand next to a machine around the clock and measure how the machine is running. We can see this directly from the system.”	
	Interviewer:” Okay, well do you think that the system has changed the way other people do their work?”, Interviewee Epsilon:“ I don’t think so. There are too few displays for the information. The system is too one-sided. There should be information all around the factory floor. The information should be available to everyone. Then it would have an effect.”
	Interviewer:” Okay, now we can move to the main questions. Has your work become more efficient duet to the system or changed in any way?”, Interviewee Epsilon:“ Not really. It enables that I can look things remotely, but…”