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Towards a Framework for Identifying Digital Improvement Opportunities

- Utilizing Information Flow and its Stakeholder Value

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PREFACE

Before you lies the master thesis of Andreas Rosell & Ludvig Salomonsson, the last scientific report to fulfill our Master of Science degree in Industrial Engineering and Management at Linköping University. This report was performed at the request of Propia AB and with the collaboration of Paper Province and several case companies, during a period of 20 weeks, starting in January 2018. The research was challenging but rewarding, since we had the opportunity to contribute knowledge to the research area and practical advice to the organizations involved in the study. However, the study would be difficult to complete without the assistance of certain individuals.

To begin with, we would like to extend our sincere gratitude towards Mathias Henningsson, our university supervisor, who brought guidance through valuable discussions during the study.

We would also like to express our gratefulness to the employees of Propia AB, whose involvement made the study possible. We are especially thankful for the assistance given by Johan Hall, our company supervisor, for his advice, time and knowledge. Furthermore, the involvement of the case companies, Nykvist Skogs AB and Bäckebrons Sågverk AB, as well as Paper Province, Cybercom Sweden AB and the external innovation partner, has provided useful and practical knowledge. Therefore, we extend our appreciation and thankfulness towards the employees of these organizations.

Last but not least, we would like to take a moment to express our great appreciation towards ourselves and each other, for an outstanding performance and collaboration throughout the whole study.

Just as all good things must come to an end, it is with a tear in our eyes that we write the last sentences of this report, which constitutes the final countdown of our five-year academic journey. As we are leaving together, to meet new adventures and challenges, we reminisce the good times and experience while studying, but still it is farewell.

Will things ever be the same again…?

Linköping, 30th May 2018

Andreas Rosell

Ludvig Salomonsson

ABSTRACT

Keywords: *Digitization, digitalization, digital transformation, systematic change, information management, process management, improvement work, information flows, digital improvement opportunities.*

Humanity is at the starting point of a new industrial revolution, affecting our daily life, work and way of thinking. New technologies and breakthroughs drives the fourth industrial revolution, transforming the structure of the world economy, society and its people. The key component of these changes is the rapid technological development, which relies on the high degree of digitalization.

The work with digitalization is a highly discussed topic, but no general or standardized method for digital improvement efforts has been established. In order to face the challenges associated with the technological development, which forces organizations to invest time and resources to create their own methods for working with digital improvements.

This study focus on the common characteristics or elements found in previous digital improvement efforts, in an attempt to summarize and identify the success-factors. These elements were further analyzed and evaluated against established theory, to assess the element's trustworthiness and generalizability, resulting in a conceptual framework. The conceptual framework was tested and evaluated in a case study concerning two case companies to achieve practical applicability, leading to the final framework.

This final framework, focusing on information flows connected to an organization processes, was found capable of identifying, analyzing and prioritizing digital improvement opportunities, by utilizing external and internal factors. Thus, answering the research questions:

RQ 1: *How would a framework capable of identifying digital improvement opportunities, based on common characteristics found in literature, be presented?*

RQ 2*: How can digital improvement opportunities be prioritized and evaluated, to create value for an organization, whilst being practicable?*

RQ 3: *Which information is necessary to retrieve, to successfully implement digital improvements?*

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1 INTRODUCTION

The following chapter introduces the theoretical background, where relevant areas and ongoing developments are described to position the study and identify the research gap. The research gap, stated in the Problem Description, further progresses into the Purpose and Research Questions of the study.

As development leaps forward at an all increasing pace, and technologic components becomes smaller and more powerful, experts claim that the world stand in the brink of a new technological revolution that will fundamentally change the way we live, work and relate to each other. At this stage, industries face new challenges associated to new technological innovations, customer awareness and global environmental challenges. As a result of these circumstances, organizations have transformed their business and operations leading to a new *Industrial Revolution*. Europe, driven by the manufacturing giant Germany has developed a new concept of manufacturing, called *Industrie 4.0*. The concept generally focuses on connectivity, where products, business functions and machines are connected and collaborating together, often autonomously. (Schwab, 2016)

The following chapters introduces the underlying factors resulting in the master thesis, illustrated in *Figure 1*.

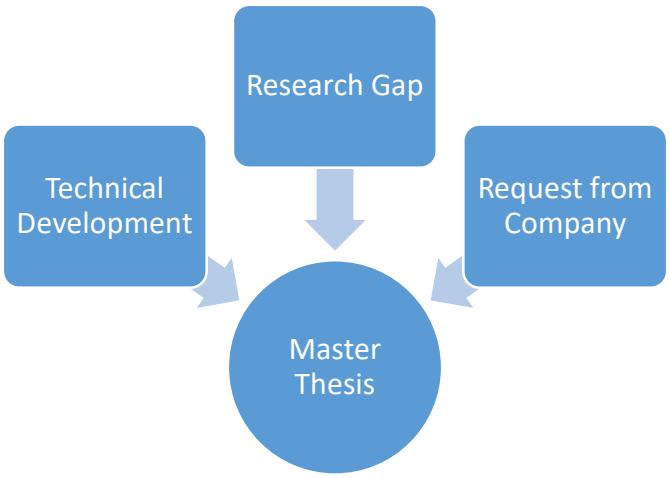

Figure 1 Illustration of the underlying factors leading up to the master thesis (Authors' image)

1.1 Theoretical Background

The strategic importance of computer-aided functions became obvious during the 1990s. Administration, resource planning and operations planning etc., handling an immense amount of information, became easier to manage and interpret with the assistance of computer software, such as *Enterprise Resource Planning* (ERP) systems. Nowadays, these systems play a role as an integrated part of the day-to-day operations, in almost every organization. However, with the current trend and developments in the area of digitalization, the level of technological advancements demands more knowledge from the people around it. A majority of the companies are therefore investing in IT-departments tasked with developing, maintaining and supporting these competence heavy processes. Thus, the focus has shifted from a purely support perspective, where digital solutions aided a company, to a development focus, where digital solutions further develops a company. (Cöster & Westelius, 2016)

When focusing on the manufacturing sector, one often mentions "*Cyber-Physical Production System*" (CPPS), which is defined as a system built up by connected and collaborating autonomous entities, throughout all levels of production, from individual components of machines to logistic networks. Such a system would be able to handle an immense number of individual operations and make real time decisions to reach optimal and/or robust results for any given situation. Other advantages such as increased safety, self-maintenance, predictability and full transparency are also some of the expected benefits of CPPS. (Monostori, 2014)

As a result of the ongoing trend towards digitalization, companies can transform their businesses to create new business opportunities. Enabling new connected product functionalities that are integrated in the operational processes, co-creating value with customers through new service offerings. These products or services change the industry structure and the competition environment, leading to new competitive opportunities. As an example, traditional truck manufacturing companies has gone from selling only trucks to their customer to sell rental contracts, maintenance or fleet management services. This imposes companies to integrate their products, services and operations using digital platforms and components. (Porter & Heppelmann, 2014)

The potential benefits of digitalization are high, by implementing digital solutions in information-intensive processes, cost can be cut up to 90 percent and turnaround times improved drastically. Further on, process performance, cost drivers and risk analysis can be improved by collecting data automatically using software solutions, instead of performing tasks manually. This allows managers to react directly and base decisions on real-time repots. (Parviainen, et al., 2017)

Traceability and safety can increase by augmenting products with digital solutions. As an example, remote monitoring, using radio frequency identification (RFID) transmitters attached on products, packages, pallets or containers. This allows companies to track their items through the production flow, value- or supply chain. In this way, information such as performance, condition and destination can be analysed in real time, which lead to instantaneous responses and control. From a health and security perspective, especially within the food- and pharmaceutical industry, traceability is a necessary aspect, to avoid and prevent contaminations to enter the processes. (Schwab, 2016)

1.1.1 Digital Technology Areas

A higher degree of digitalization is often achieved by combining established technologies with new, innovative thinking. In recent years, the development of new technologies has mainly taken place in four core areas of development: *Digital Data*, *Automation*, *Digital Customer Access* and *Connectivity*. The

picture provided by Bloching, et al. (2015) illustrate these core areas of development, their enablers and resulting propositions. The enablers are the technologies that are believed to bring these resulting propositions, digitally transforming a company and its functions, as shown in *Figure 2*. (Bloching, et al., 2015)

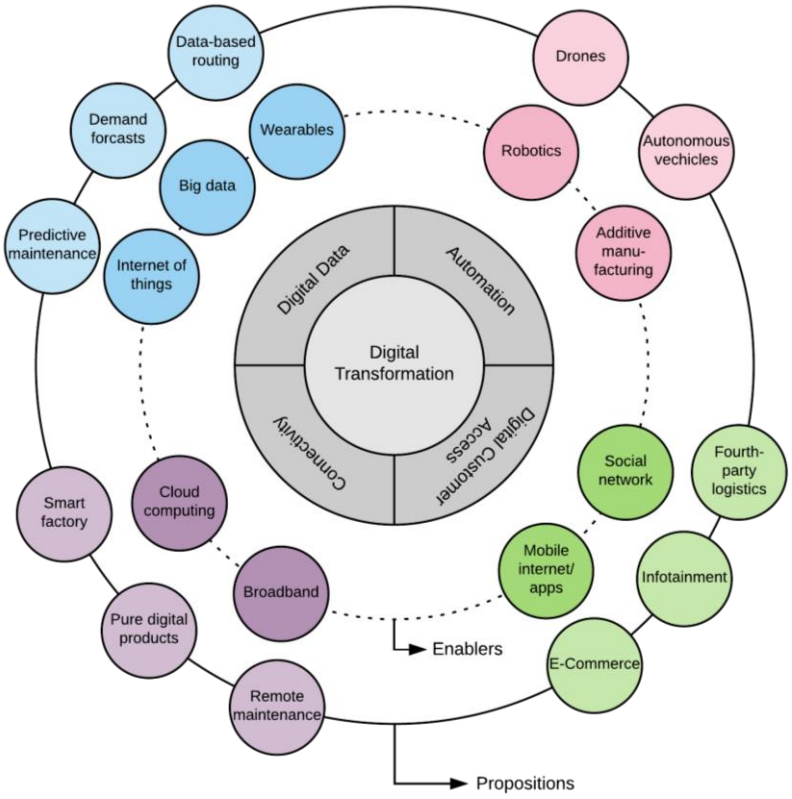

Figure 2 The four main areas of digital transformation as described by (Bloching, et al., 2015)

1.1.2 Sweden and Digitalization

Sweden has played an important role and been successful in the areas of IT and digitalization. This is confirmed by the World Economic Forums' index ranking Sweden as number three after Finland and Singapore. Some of the reasons for this success is the high technical maturity among Swedish companies and their will and ability to adapt new digital solutions. Other factors which is of importance when speaking about digitalization is the high level of education, cooperation between industries and collaboration with the academy and public sector. The majority of Swedish manufacturing companies are small or medium sized and the digitalization take place within the technical areas that are new for them. Therefore, companies face the challenge to gain access to knowledge and skills in the field of digitalization. (Bossen & Ingemansson, 2016)

The Swedish government has ordered Vinnova, which is a government agency that administers state subsidy for research and development to carry out efforts to promote a digitized Swedish manufacturing industry, with the aim of strengthening Swedish innovation and competitiveness. Vinnova has conducted a study called "*Digitalisering av svensk industri*". The main purpose of the study is to highlight for the technology areas that are of major importance for the digitization of the Swedish manufacturing industry.

A successful digitalization is essential and will lead to increased customer value of their products, service and business. (Bossen & Ingemansson, 2016)

Digitalization of the manufacturing industry will give the opportunity for new innovative products, processes, services, work methods and business models. A study commissioned by the European Commission and performed by the German industry association BDI, shows that about 600 billion euro can be lost if, the European countries fails with a successful digitalization. This could also inhibit Europe from reaching the goal of increasing the manufacturing industry's share of GDP to 20 percent by 2020. (Bossen & Ingemansson, 2016)

1.2 Company Backgrounds

Propia AB

Propia AB is a Swedish consultancy firm that are specialists in the areas of process management, change management and business development. The head office is located in Norrköping, and a minor office in Stockholm. Propia's customers are represented throughout the whole country, mainly in the middle parts of Sweden. Today, there are around sixteen employees, as well as some subcontractors, four students that are writing their master thesis in the field of digitalization. The company was founded in 1995. (Propia AB, 2018)

Propia AB states, "*We are inspired by change and driven by creating long-term sustainable solutions with our customers. With our expertise, our working techniques and our methods, we have ensured strategic development, efficiency and customer satisfaction since 1995.*" (Propia AB, 2018)

Propia AB have collaborations with several universities around Sweden, the reason is to create a foundation for future development, and cooperation between business and academia. Propia has a history of applying students after finishing master thesis at the company, several of the models/framework that are used originates from students' master thesis. (Propia AB, 2018)

Cybercom Sweden AB

Cybercom is used as an external innovation partner for the study, which stands for the technical expertise and in the end deliver the technical solution.

Cybercom is an IT consulting company that helps companies and organizations to take advantage of the connected world's capabilities, leading to a higher degree of competiveness. Cybercom's expertise covers the entire system of communication services. The majority of their customers are located in Scandinavia. Cybercom was founded 1995 in Stockholm and has today around 1300 employees in five counties. (Cybercom, 2018)

Nykvist Skogs AB

The first case company used in the study, called Nykvist Skogs, is a small forest company which offer sustainable forest management, such as timber extraction, planting and replanting, and timber trade direct to sawing mills. Nykvist Skogs is a small company with around 7 employees, and a couple of sub-contractors. The company was founded in 1979 and is mostly active in Värmland, Sweden. (Nykvist Skogs AB, 2018)

Bäckebrons Sågverk AB

The second company used in the study, Bäckebrons Sågverk is a small and flexible sawing mill. The company mainly handles timber with top diameter 10 cm to 22 cm. Therefore, their product can be easily customized, with small series and series of special dimensions. The residues from manufacturing are used to produce pellets. Bäckebrons sates that they stand for high quality, personalized service and delivery on

time. The company is located in Värmland, 50 km northwest of Karlstad, with around 24 employees. (Bäckebrons Sågverk AB, 2018)

1.3 Problem Description

As the world transitions into an era, which utilizes more advanced technology for operations, organizations are struggling to keep up with the technological development. Previous studies have shown the benefits of incorporating advanced technology in processes and activities, and on the other hand, the dangers of neglecting development. Several case studies have been performed at companies in different industries regarding implementation of digital solutions and the management of the digital information flow that stems from it, but a general path or method has not yet been defined. Furthermore, the methods used in previous work is often specifically designed for a unique company. (Bossen & Ingemansson, 2016) (Markovitch & Willmott, 2014) (Monostori, 2014)

Therefore, the underlying problem is the absence of a framework able to, in a standardized way, identify digital improvement opportunities, utilizing valuable information flows. This framework should be independent of the organization and sector, leading to a high degree of generalizability. A digital information flow is further defined, in this report, as data gathered or created at one location and transferred to another location and/or stakeholder (Business Dictionary, 2018). The value of the digital information flow should be determined by a specific company's interest, values and/or objectives.

1.4 Purpose and Research Questions

This report will create a framework able to identify and evaluate digital improvement opportunities for companies and organization, in the context of digitalization, by utilizing perspectives on data and the digital information flows that can be created. The framework will be based on common characteristics regarding digitalization efforts found in literature and further developed with two case companies in the forest sector.

This report will therefore explore previous digitalization efforts, with the aim of finding common characteristics and patterns, which acts as the theoretical foundation of the framework. The framework's main function is to find digital improvement opportunities, in the context of a company's internal or external information flows. The technical solution, involving the software and/or hardware, is provided by a third party. The third party is therefore in need of a certain amount of information regarding the digital improvement opportunity, as to enable a successful implementation of a digital solution.

Therefore, to construct a framework, the study aims to answer the following research questions:

RQ 1: *How would a framework capable of identifying digital improvement opportunities, based on common characteristics found in literature, be presented?*

RQ 2: *How can digital improvement opportunities be prioritized and evaluated, to create value for an organization, whilst being practicable?*

RQ 3: *Which information is necessary to retrieve, to successfully implement digital improvements?*

Figure 3 provides a brief illustration describing the research questions and the corresponding research methods used. A detailed description is provided in chapter *2.4 Analysis and Research Procedure*.

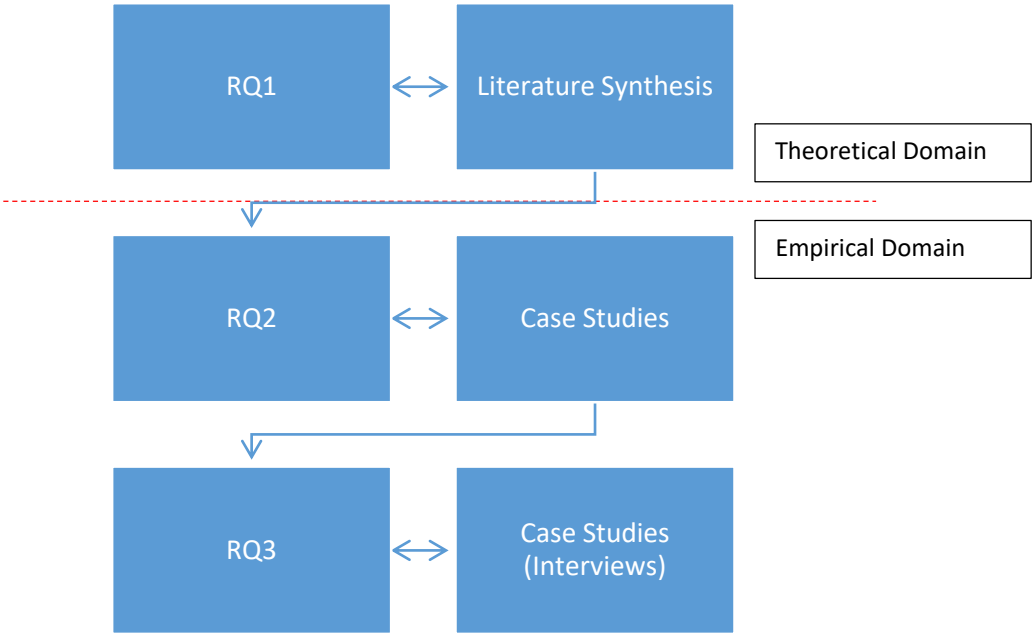

Figure 3 The three research questions, their domain and the research methods used to answer them (Authors' image)

1.5 Delimitations

- The study will only concern the testing phase of the framework, no actual implementation, since the timespan between implementation and result is often long.
- The technical solution or hardware and software ultimately needed for a company is outside of this thesis' scope.
- The case studies will be performed at two small sized companies, in the forest sector, located in Sweden.

1.6 Definitions

Below follows the definition of important and frequently used terms, as to prevent misinterpretation. Other terms are defined continuously throughout the report, where it is discussed.

Digitization: "*The action or process of digitizing; the conversion of analogue data (esp. in later use images, video, and text) into digital form.*" (Parviainen, et al., 2017)

Digital transformation: "*The changes associated with the application of digital technology in all aspects of human society*" (Parviainen, et al., 2017)

Digitalization: "*Integration of digital technologies into everyday life by the digitization of everything that can be digitized*" (Business Dictionary, 2018)

Information flow: "*Path data takes from its original setting to its end users*" (Business Dictionary, 2018)

2 METHODOLOGY AND METHODS

The following chapter provides an explanation and motivation for the research methodology and methods used in the project, as well as the report structure and framework creation process, in order to answer the three research questions stated in 1.4 Purpose and Research Question.

The study had an exploratory purpose, based on the intention to find common characteristics distinguishing a successful digitalization effort. The project had a qualitative research method, initialized by a literature review to explore previous digitalization efforts and the management of information in organizations. This phase served two purposes, to create an improved understanding around the subject, and as the foundation for the preliminary framework, depicting the implementation prerequisites. Further on, a literature synthesis was performed in an attempt to identify, gather and aggregate the common characteristics of digital improvement efforts. The literature synthesis focused on articles regarding the subject. The findings from the literature synthesis, constructing the conceptual framework, was crosschecked with findings from the case study, developing the conceptual model framework in the process. Therefore, as defined by Patel & Davidson (2011), the logic of the report utilized abductive reasoning.

Below, in *Figure 4*, follows an illustration of the research questions and their theoretical or empirical connection. However, some elements of the research questions are connected to both domains.

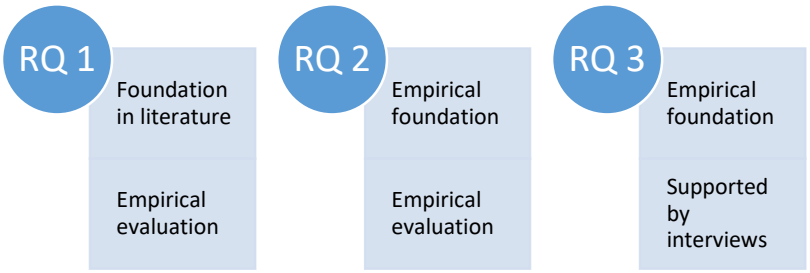

Figure 4 Research questions and the general methods used to answer them (Authors' illustration)

2.1 Qualitative Research Method

"*Quantitative research is empirical research where the data are in the form of numbers. Qualitative research is empirical research where the data are not in the form of numbers*." Punch (cited in Blaxter, et al., 2006, p. 64)

The quantitative approach is characterized by its data, which is a quantity, and the means of measuring this data. Quantitative methods often involve measurements performed with physical tools to examine physical variables, but can also investigate psychological traits and characteristics, commonly believed to belong to the qualitative methods. The distinction lies in the outcome, where quantitative methods aggregates the data to reach a generalizable conclusion from the population, whereas qualitative methods focus on in-depth understanding and causality of one or a few conundrums. (Leedy & Ormrod, 2009)

A quantitative study is often based on a clearly defined hypothesis, the variables of the study are isolated, and the data is collected through standardized methods. The collected data are filtered through different statistical analyses tools and a conclusion is made based upon the results from the analysis, this either verifies or disproves the hypothesis. Therefore, a quantitative method seeks to predict behaviors, and to test existing theory. (Leedy & Ormrod, 2009)

On the contrary, a qualitative study starts with general research questions, rather than a clearly defined hypothesis. The collected data is often verbal, and the population is relatively small. Furthermore, the analysis phase searches for common patterns or themes in the collected data. The conclusions drawn from the data should describe and portray the events leading up to the studied phenomenon. Therefore, the qualitative method's purpose is to describe, explain, explore or interpret a phenomenon, coupled with building theory. (Leedy & Ormrod, 2009)

According to Leedy & Omrod (2009) qualitative studies are often built up by verbal or written data, and the analysis phase attempts to draw conclusions regarding patterns or themes in the collected data. Furthermore, the qualitative approach's purpose is to describe, explain, explore or interpret a phenomenon, coupled with building theory. Therefore, a qualitative research method was chosen.

2.1.1 Research Approach

The logical line of reasoning when conducting research relies, in general, on three different perspectives regarding how the relationship between theory and reality are viewed upon, *deductive*, *inductive* and *abductive* reasoning, showed in *Figure 5*.

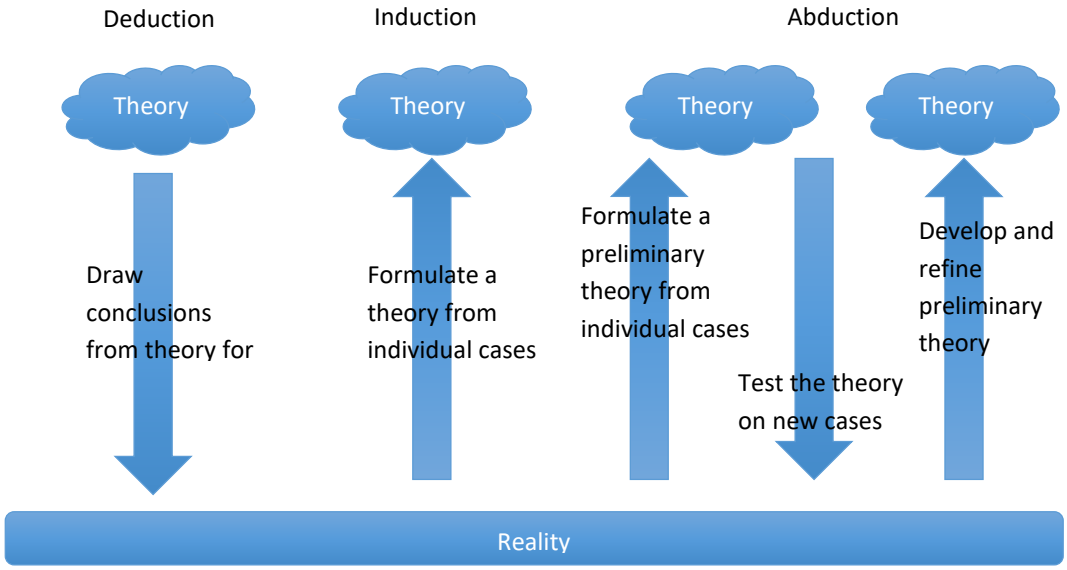

Figure 5 Deduction, induction, abduction and the relationship between theory and reality (Patel & Davidson, 2011)

Deductive reasoning, described by Blomkvist and Hallin (2015, p. 48), begins with existing theories to create premises, statements and arguments about a phenomenon which are believed to be true. The premises are later studied and tested, and either verified or falsified. (Blomkvist & Hallin, 2015) The logical line of reasoning in the deductive approach relies on the conviction that if all premises are true, the conclusion must be true (Leedy & Ormrod, 2009).

Inductive reasoning, in contrast, is the empirical observations of events to draw conclusions about entire classes of objects or events. Thus, inductive reasoning is circumstantial, relying on the studied material and its context. (Leedy & Ormrod, 2009)

The third option, *abductive* reasoning resembles an aggregation of inductive and deductive reasoning and can be illustrated as three consecutive activities, 1) Formulate a preliminary theory from empirical findings 2) Test the preliminary theory on new cases 3) Adjust and develop the preliminary theory. (Patel & Davidson, 2011)

Research Approach

To create a framework, with sufficient theoretical foundation and practical applicability, an abductive approach was chosen. The relatively unexplored area of digitalization frameworks and digitalization efforts based on information flows indicated that a purely theoretical approach (deductive) could compromise the practical applicability of the study's result. Whereas the broad scope of the subject in combination with an inductive approach could harm the theoretical foundation and generalizability of the framework. Thus, the iterative abductive approach was believed to provide theoretical foundation and practical applicability for the resulting framework.

2.2 Exploratory Research Design

According to Blomkvist and Hallin (2015), a scientific work and its research design can vary between four different types, *Exploratory, Descriptive, Explanatory* and *Predictive.*

- Exploratory research design is defined as the act of researching a phenomenon, hitherto relatively or completely unexplored. The intention is to identify previously unknown dimensions or to investigate underlying themes or patterns of a problem.
- Descriptive research design tries to increase the knowledge of a phenomenon, which is previously documented but with limited knowledge.
- Explanatory research design seeks to study the causal links between something, why a certain action has a certain consequence.
- Predictive research design wants to predict the consequences of an action, which certain action leads to which certain consequence. (Blomkvist & Hallin, 2015)

The nature of the study was built around an exploratory research design, which sought to explore the patterns and common characteristics of the phenomenon "*successful digitalization efforts*".

2.3 Data Collection Techniques

The collection of primary data involved the data from observations and interviews during the case study. The interviews were semi-structured and "*face to face*" regarding the perception of digitalization efforts within the company, known information flows and the estimated value of this information, both inside and outside the company's operational domain.

The observations were performed on the value creating processes in the companies. As to create knowledge regarding the current state and to map the existing data and information flows in the system.

The collection of secondary data involved the documents studied during the literature review and literature synthesis, performed before the case studies. The results from the literature synthesis were later used to create the preliminary framework.

2.3.1 Literature Synthesis

The work procedure for secondary data collection will follow the structure of Backmans (2016, p. 75) framework describing the steps involved in a literature synthesis, showed in *Figure 6.*

Figure 6 The literature synthesis process (Backman, 2016)

According to Backman (2016, p. 75), a literature synthesis has two main strategies, either *Combinatorial* or *Comparative* approach. The combinatorial approach intents to describe, summarize and integrate the current research. Whereas the Comparative approach seeks to explain differences and/or similarities between multiple cases.

Based on the research *questions* and *problem*, a literature synthesis following Backman's (2016) framework consists of these steps. *Searching* for literature, a strategy should be constructed regarding terms, which database(s) to use, searching tools and search syntax. *Evaluation and selection* are based on a predefined protocol, which filter the findings and evaluates their inherent quality. *Analysis* methods tends to depend on the problem of the study; however, problems can occur when different methods yield the same result. *Interpretation* attempts to explain why the investigated objects differ from each other or share certain characteristics. *Report* and summarize the findings of the literature synthesis. (Backman, 2016)

Lastly, an important element of a literature synthesis, and any research, is source criticism. Generally, three source criticism criteria, defined by Eriksson & Wiedersheim-Paul (2014), are relevant when performing a literature review or literature synthesis. These are *authenticity*-, *tendency*- and *dependency criticism*, essentially used to prevent unreliable results from entering or influencing the study. *Authenticity criticism* evaluates the truthfulness of the read literature, to prevent fabricated results from influencing the study. *Tendency criticism* evaluates the objectivity of the read literature's result, to prevent biased results from entering the study. Lastly, *dependency criticism*, which evaluates whether the research is independent or dependent on other sources. (Eriksson & Wiedersheim-Paul, 2014)

Literature review and synthesis procedure

The literature review initialized the report by indicating the prerequisites for successful digital improvement efforts. Here, articles and reports regarding previous efforts at different companies was studied. The first phase, called the "*Preliminary literature review*" had multiple functions, to provide knowledge of the subject by defining certain terms included in the study, forming the basis for keywords around the subject, in addition to creating the preliminary framework. The preliminary framework underwent further testing in an iterative way, by continuous comparison against new literature findings in the literature synthesis.

Following the literature synthesis framework

Approach: The approach used in the literature synthesis was comparative, where the similarities or differences in multiple cases was studied to find common patterns. These common patterns later acted as the foundation for the preliminary framework.

Searching: The literature was derived from Linköping University library database, which connects several databases. The search terms are presented in *APPENDIX A.*

Evaluation and selection: Following criteria evaluated the found material.

> *Time relevancy*: The material was prioritized by time, where up-to-date research was seen as more precise. This criterion was used due to the quick development in the technology sector.
>
> *Authenticity evaluation of sources*: To prevent fabricated results from entering the study, peer-reviewed articles was prioritized. However, some articles created by known consulting companies in collaboration with research institutes, and governmental authorities was allowed in the study. These sources were used carefully.

Tendency evaluation of sources: The research methods of the literature and the authors' objectivity was evaluated. Here, a close investigation of the material retrieved from consulting companies was performed to prevent marketing and self-promoting strategies from entering the study. The majority of the results was analyzed by triangulation, where multiple independent sources pointing in the same direction was seen as more reliable.

Dependency evaluation of sources: To evaluate the dependency of sources, literature from different authors, using different perspectives and research methods was prioritized. The credibility of the conclusions was believed to increase, if these independent sources reached the same conclusions.

Analysis: This phase and onwards had a thematic approach, further explained *2.4 Analysis and Research Procedure*. In brief, the analysis can be summarized into three main steps, described below as:

1. Read the material to get an overview
2. Place into different categories based on content and other aspects
3. Thorough study to assist the interpretation phase

Interpretation: The findings from the analysis phase provided the foundations for the interpretation. Here, findings were documented and triangulated to evaluate if the differences or similarities were dependent on certain parameters or circumstantial. With this aggregated view, the explanation for successful digital improvement efforts was believed to be the result of the "*correct methods*".

Report: The resulting conclusions, previously called "*correct methods*", created the preliminary framework.

2.3.2 Case Studies

"*A case study is a history of a past or current phenomenon, drawn from multiple sources of evidence. It can include data from direct observation and systematic interviewing as well as from public and private archives. In fact, any fact relevant to the stream of events describing the phenomenon is a potential datum in a case study, since context is important*" Leonard-Barton (cited in Voss et al., 2002, p.197)

Case studies, as a research method, is according to Voss et al. (2002, p. 198) used for four different research purposes. These purposes *Exploration, Theory building, Theory testing* and *Theory extension/refinement* are further defined in *Table 1*.

Table 1 The research purposes of case studies (Voss, et al., 2002)

Purpose	Research question	Research structure
Exploration Uncover areas for research and theory development	Is there something interesting enough to justify research?	In-depth case studies Unfocused, longitudinal field study
Theory building Identify/describe key variables Identify linkages between variables Identify "why" these relationships exist	What are the key variables? What are the patterns or linkages between variables? Why should these relationships exist?	Few focused case studies In-depth field studies Multi-site case studies Best-in-class case studies

Theory testing Test the theories developed in the previous stages Predict future outcomes	Are the theories we have generated able to survive the test of empirical data? Did we get the behavior that was predicted by the theory or did we observe another unanticipated behavior?	Experiment Quasi-experiment Multiple case studies Large-scale sample of population
Theory extension/refinement To better structure the theories in light of the observed results	How generalizable is the theory? Where does theory apply?	Experiment Quasi-experiment Case studies Large-scale sample of population

A case study starts with a research question, often drawn from a perceived real-world problem, where a phenomenon is observed but not clearly described. This phenomenon is further broken down to identify the entities, populations or events etc. that should be under investigation, as to clearly define the variables of importance. The chosen variables are later examined, by various research methods, in its natural context to reach conclusions regarding the initial research question (Backman, 2016).

Case study procedure

The case study phase of this report, initialized after the literature synthesis, served a *Theory testing* and *Theory refinement* purpose. The findings from the literature synthesis, constructing the conceptual framework, was tested against several case companies to evaluate the conceptual framework's practical applicability. The question to be answered by the case study was therefore "*Can the conceptual framework, constructed from previous digitalization efforts, survive in a practical situation*" and the variables of interest was "*The data and information flows existing in the system*", "*The management of the data and information flows*" and "*The value of the data and information flows*".

The procedure followed four phases, *introduction, presentation of conceptual framework, implementation and data collection, evaluation* and *development.* A short description is provided below, whilst a more detailed explanation is presented in *5 Findings and Analysis: Case Study.*

1. *Introduction:* Served the purpose of introducing the thesis, its scope, purpose and the involvement of the case companies.
2. *Observation and interviews:* To gain an understanding of the organizations, processes, information and the individuals involved.
3. *Workshop: Conceptual framework evaluation:* Used as an evaluation tool after the conceptual framework, based on literature, was finished. The workshop provided knowledge regarding the conceptual framework's practical applicability. The workshop was divided into three main phases.
    a. *Presentation*
    b. *Implementation with a test case*
    c. *Continuous evaluation and feedback*
4. *Development:* The feedback was taken into consideration and the input was used to further develop the conceptual framework.

2.3.3 Interviews

All interviews are based on a set of questions asked to a respondent. The interview can be performed face-to-face, direct contact or by a dialogue contact like e-mail, mail, telephone and SMS etc. How the questions are asked can vary and there are mainly three types of structures when designing an interview:

- *Structured interviews*
- *Semi-structured interviews*
- *Unstructured interviews* (Björklund & Paulsson, 2014)

In a structured interview, all questions are decided before the interview take place, and there are usually no additional follow-up questions. The equivalent, an unstructured interview is more open and customizable and can be similar to a conversation where the questions can arise during or after the interview. Semi-structured interview is mixture of the previously mentioned, the main topic is determined in advance and the questions can be formulated during the interview along with the respondent's answer and reactions. (Björklund & Paulsson, 2014)

Interviews can be performed with one, several persons or in a whole group, the same applies for the interviewer. The number of questions and the time duration for the interview differs depending on the purpose. Favorably is to record the interview or take notes to prevent the loss of any important information. By using interviews as a data-collecting method gives an opportunity for a deeper understanding due to questions that can be modified depending on the previous answer. During a personal interview signals such as facial expressions and body language can be detected which in some cases gives more information than the answer itself. A disadvantage with the method is that it is resource demanding in terms of time consuming. (Björklund & Paulsson, 2014)

It is important to consider the design of the questions depending on the type of interview. Closed-ended questions can be answered by either "*yes*" or "*no*", while open-ended questions require a deeper explanatory answer. (Björklund & Paulsson, 2014)

Interview procedure

This study utilized semi-structured and unstructured interviews to collect primary data. Two interviewers were present at each session, documenting the interview and cross checking the result, to minimize the chance of misinterpretation and memory bias. The majority of interviews were held at the case companies to gain an understanding of the organizations involved and the existing information flows. The interviews were divided into three parts, each performed on different dates due to time limitations, explained below.

1. *Introduction phase*: The thesis, its scope, theoretical background and definitions were introduced. This phase was used to bring a fundamental understanding of the concept, as to prevent misunderstandings regarding the topic. This part was primarily semi-structured, where the necessary information and questions where already in place, but follow-up questions relied on the respondent's answer.
2. *Data collection phase*: The preliminary framework was tested on the case companies to assess its practical applicability. The interviews involved in this phase focused on the organization, its processes and the information flows between a certain process and the department(s), which utilizes the information. This phase was semi-structure, where the preliminary framework acted as a guide for the questions, depicting the required data.

3. *Conclusion and evaluation phase*: The conclusions drawn from the conceptual framework was, in collaboration with the case companies, evaluated. The conclusion and evaluation phase were unstructured, assuming the form of a workshop session.

However, some unstructured interviews focused on the framework, where system experts in different areas and third parties could apply an opinion to the practical applicability of the framework. These sessions were held sporadically during the whole period of the thesis.

2.3.4 Observations

The method, observation, allows behavior and events to be studied in a wider context. Therefore, information can be collected without being affected by an individual's memory image, as to prevent memory bias. However, it can be difficult to determine whether events during an observation are representative or if they happen by chance at the time. (Patel & Davidson, 2011)

The observer can be involved in the investigated movement, so called "*participant observation*", or by observing the event from the outside, objectively. Observations can be carried out secretly, without notifying the participants, or alternatively by informing about the observation. (Björklund & Paulsson, 2014)

Observations procedure

The observations during the study focused on the case study companies' current way of working, to map the processes involved in the study. This led to deeper understanding and knowledge of how the companies operates. Each observation session was accompanied by both authors and at least one system expert. An interview with the system experts followed the observations to ensure reliable results.

During the company visits, an information- and process map were made for each company, describing the selected processes. The information- and process map was constructed by a combination of interviews and observations, where the observations provided the authors with an understanding of the process flow. The resulting map was later crosschecked with representatives from each company, to ensure accuracy.

2.4 Analysis and Research Procedure

The study, which sought to find patterns regarding successful digital improvement efforts, utilized a thematic analysis approaches during, and across, different stages further described under *research procedure*. The thematic analysis is defined as the act of identifying patterns, or themes, within a qualitative data set. The whole process of thematic analysis can be summarized into six steps, illustrated in *Figure 7*. (Miller, 2016)

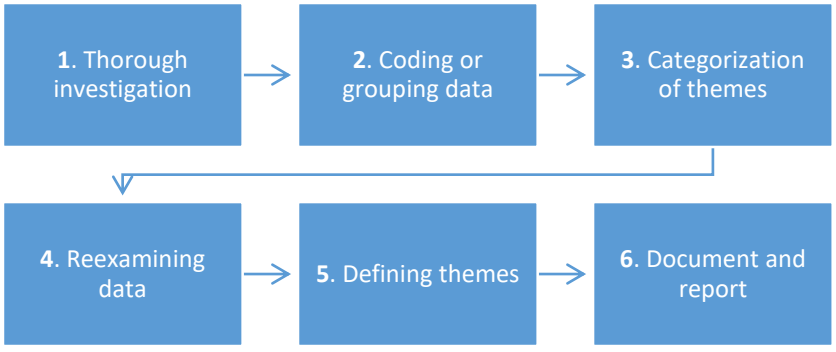

Figure 7 Thematic analysis process (Miller, 2016)

1. The initial step, which involves a thorough investigation of the collected data, creates the necessary foundation for further analysis.
2. After the thorough investigation, the continued work involves the coding, or grouping, of data by accentuating themes and patterns relative to the research questions.
3. The found themes are grouped together in categories, where each category contains a set of data with the same themes or patterns. This step visualizes the general themes or patterns related to the research.
4. Reexamining the data in each category, ensuring that each data point fits in its current category.
5. When the general themes are separated and categorized, the defining of themes acts as the logical line of reasoning and should explain the connections between the found themes or patterns.
6. Lastly, the document that summarizes the findings and conclusions. (Miller, 2016)

Research procedure

The Framework creation process, illustrated in *Figure 8* , is divided into several steps and two domains, theoretical and empirical. The theoretical domain sought to bring the theoretical foundation, whereas the empirical domain evaluated the practical applicability of the preliminary framework, resulting in the final framework. Below follows a short description of each step, the analysis performed in and between steps, as well as the connections between steps.

1. The study was initialized by a purpose and a research question based on the requirements stated by Propia AB, found in chapter *1.4 Purpose and Research Question*.
2. The preliminary literature review gathered the background information and created the initial knowledge necessary to perform the study. Here, key concepts related to the research question and purpose was found and defined, as to enable further and deeper research. This step underwent a brief analysis, since the understanding around the topic was limited. Thus, the results were treated with caution.
3. The preliminary literature review resulted, after the brief analysis, in a preliminary framework. This preliminary framework was constructed from the newly found patterns to act as the foundation for further research. The preliminary framework is not included in the report, since it was changed drastically by the literature synthesis. The preliminary framework's purpose was to serve as a starting point for research.
4. The literature synthesis, procedure described in *2.3.1 Literature Synthesis*, further developed the preliminary framework. This step underwent a deeper analysis to provide a credible conceptual framework through several iterations. After each literature synthesis session, the found patterns were documented and slowly adjusting the preliminary framework. This step sought to answer *Research Question 1* by continuously developing the framework until a sufficient amount of evidence had been found. This analysis phase of the literature synthesis was divided into two parts. The first part focused on the common characteristics or elements, which the articles and studies had in common. Whilst the second part attempted to align the findings with established and proven theoretical methods and tools.
5. After the literature synthesis, when the findings had been analyzed, the preliminary framework entered the conceptual framework phase. This phase was believed to be the answer to *Research Question 1*. Thus, the study entered the *Empirical domain*, where the focus shifted to its practical applicability.

6. The case study, performed at two Swedish companies in the forest sector, was used to test the preliminary framework. This step includes the interviews and observations, described in *2.3.3 Interviews* and *2.3.4 Observations*, utilized to answer *Research Question 2*. The case study focused on bringing value for the case companies, by utilizing the conceptual framework as a tool. By evaluating the conceptual framework in collaboration with the case companies, the strengths and weaknesses were identified to assess the practical applicability. This phase was performed in several iterations.
7. *Research question 3* was answered by interviews with the external innovation partner, Cybercom, and additional supplementary partners in the same sector. When the conceptual framework had undergone evaluation against the theoretical and empirical findings, it was estimated to be practically probable.
8. The study's conclusion resulted in the final framework, now containing theoretical and empirical evidence, as well as the input from the external innovation partners, considered as system experts.

The box denoted "*Collection of secondary data*" illustrates where documents and articles were gathered, to ensure the theoretical foundation of the preliminary framework. Whereas the "*Collection of primary data*" involves the empirical data used to develop the framework in a real-world environment, as to increase the practical applicability of the framework.

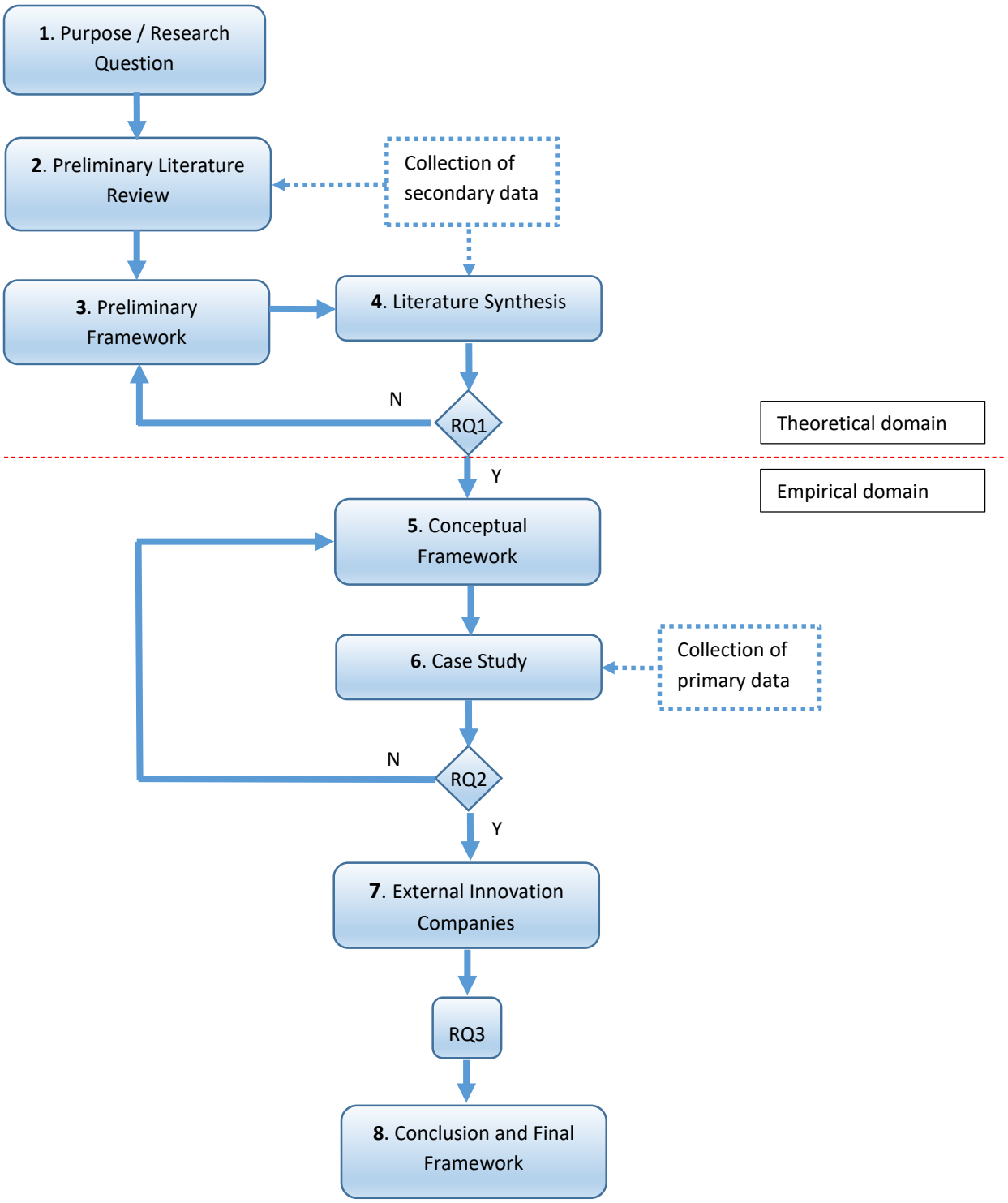

Figure 8 The framework creation process (Authors' image)

2.5 Expected Generalizability

Important to the study, and consequently the framework, is the practical generalizability. Whereas the framework is developed with assistance of companies in the forest sector, the resulting framework should show practical applicability without concern to sector, industry or company. Therefore, this chapter was created in an attempt to discuss its generalizability.

The three main areas building up the report and framework are; *Organization- and Process Management*, *Improvement Work* and *Information Management*, illustrated in *Figure 9.* The logical line of reasoning then follows: *Every organization, independent of size, sector or location, handles a set of processes. These processes either gather, consume, refine or create information and data. The processes and/or the management of the information and data can be improved, with focus on digital improvement opportunities.* This reasoning concludes that the three areas can involve any organization. Therefore, the study and the framework should contain a high degree of generalizability.

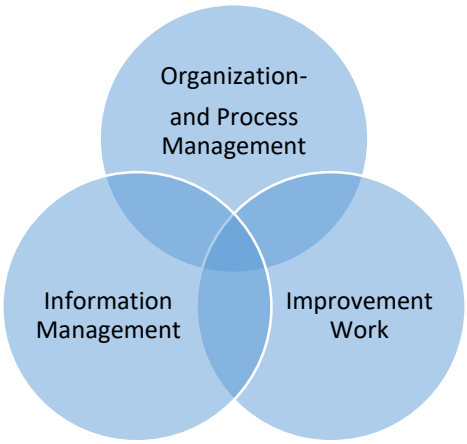

Figure 9 Representation of the three main areas of the report (Authors' image)

2.6 Reliability and Validity

"*Reliability: The degree of operational reliability of the measuring instruments, i.e. the extent to which you get the same values if you repeat the investigation.*" (Björklund & Paulsson, 2014, p.66)

"*Validity: the extent to which you truly measure what you intend to measure, i.e. the absence of methodological or systematic errors.*" (Björklund & Paulsson, 2014, p.66)

Proper documentation of the methods and findings, and standardized ways of working was believed to increase the reliability of the research. Whilst data triangulation, where multiple independent sources were used to explain the same phenomenon and a clearly understood purpose during interviews, increased the validity of the research. (Björklund & Paulsson, 2014)

Below follows the reasoning regarding the reliability and validity, for each data collection stage, in *Figure 8.* As to visualize how the authors sought to increase the repeatability and minimize methodological errors. However, there are certain amounts of stages in the study where the authors' interpretation could influence the result. Supposedly, the authors' own interpretation is believed to decrease the reliability and validity of

the study; hence, this chapter attempts to show self-awareness of where the authors' interpretation could harm the study.

Preliminary literature review: The preliminary literature review served the purpose of enhancing the knowledge regarding the study's research area. Therefore, a brief analysis coupled with the interpretation of the authors was deemed appropriate. The authors' interpretation had the same weight as the brief analysis since a clear definition for certain keywords were not yet established. It could be argued that a deeper analysis and less interpretation would yield different results, but due to limited topic knowledge, a brief analysis (heuristic approach) was accepted.

Literature synthesis: The search terms were documented as well as the analysis and findings, showed in chapter *4 Findings and Analysis: Literature Synthesis.* The method and procedure are described earlier in *Figure 6 The literature synthesis process* ; this standardized way was used to minimize procedural errors. This stage involved less interpretation and deeper analysis; however, total neutrality is hard to accomplish. Data triangulation was used, as part of the thematic analysis, to increase the validity of the research and found elements. Actions harming the reliability and validity, in the literature synthesis stage, are believed to be the parallel lines drawn between the literature findings and established tools, tools later incorporated in the framework. The analysis leading to this, where similarities and reasoning is shown, is described in *4.2 Findings from the Analysis with Respect to Established Theory.*

Case study, Interviews: Since interviews and answers from respondents can be influenced by several factors, a choice was made to minimize the amount of questions that could be altered depending on emotional or other circumstances. The interviews rather focused on facts, and subjects under investigation were mapped and embodied collectively, with the respondent, to minimize misunderstandings. However, some parts of the interviews, such as the introduction phase where the aim was to increase the respondents understanding around the subject, depended on the respondent's initial understanding. Although a standardized introduction session was created, the scenario where the respondent already had a deeper understanding than the introduction phase provided, would result in an uneven knowledge distribution amongst the respondents. Nevertheless, this was not believed to harm the study's results, but could ultimately harm the reliability, if the respondents whom had deeper knowledge, provided result altering opinions. Therefore, it should be mentioned, that a study where the practical applicability regarding a framework is evaluated by individuals, is highly dependent on the individuals' own knowledge.

Case study, Observations: The observations were used to provide the authors with an understanding of the organization. The process flow layout did not influence the study and is therefore not included in the reliability and validity chapter. However, both authors were present at each observation session, and the results were crosschecked with a system expert to ensure accuracy.

2.7 Objectivity

"*Objectivity: The extent to which values affect the study.*" (Björklund & Paulsson, 2014, p.66)

By avoiding personal opinions and values from influencing a study, whether it is subjective selection of material or results gained from an external party, one can increase the objectivity of a study. However, total objectivity is hard to obtain, but measures such as clear motivations for choices, full presentation of methods and method criticism allows the reader to reflect upon the results and objectivity of the report. (Björklund & Paulsson, 2014)

In this report, the authors attempt to explain the research process and choices made. However, as previously mentioned, a certain degree of interpretation is inevitable. Therefore, the stages subject to, or at risk of, being influenced by subjective values are exposed in the previous chapter.

3 Frame of Reference

The following chapter describes the relevant theories and methods, which the conceptual framework consists of. Concepts related to the study are defined to provide a basic understanding of the study's scope, whilst appropriate methods and tools are explained to support the conceptual framework.

The chapter Frame of Reference consists of three main areas, *Organization and Processes*, *Improvements* and *Information Management*, as illustrated in *Figure 10*. These three areas were considered central for the purpose of the study, which intends to answer the research questions, and constitutes the theoretical foundation for the report.

With the research questions in mind, the logical line of reasoning follows, by investigating an organization's processes, through the perspective of information management and with theory regarding improvement work, enabling an organization to identify digital improvement opportunities. These digital improvement opportunities, ought to develop an organization, leading to a higher degree of digitalization, which is associated with the concept of *Industrie 4.0*.

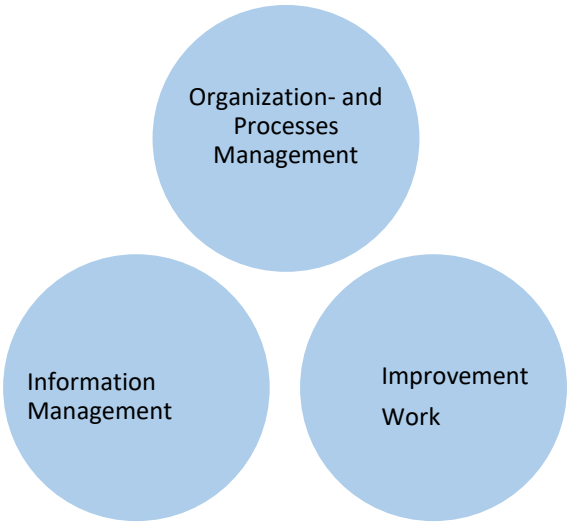

Figure 10 Representation of the study's three main areas, as to visualize the theoretical position of the study (Authors' image)

3.1 Organization and Processes

Any set of entities, handling organized activities and striving for a common goal can be considered as an organization (Child, 2015). These organized activities, either the whole set or parts of the set, if connected and repeated in time, are processes (Bergman & Klefsjö, 2001).

3.1.1 Vision, Objectives and Strategies in an Organization

One of the most important responsibilities for top management in an organization is to create a common vision for its future. Furthermore, the vision needs to be broken down into long-term objectives and complemented with strategies to achieve the objectives. (Bergman & Klefsjö, 2001)

In every organization, it is important to clarify the role that the organization plays/want to play in society or on the market, i.e. to answer the question "*why do we exist?*". The company's *mission* statement needs to answer the question. A company's mission statement is a brief description of the organization's fundamental purpose. It should also describe what the company offers its customers and how they want to be recognized. By clarifying the organization role, it is possible to find the most important customer segments. (Bergman & Klefsjö, 2001)

The fundamental concept for companies that strives to achieve improvements in any form requires a stated *vision* that clarifies the organizations future purpose. The vision should answer the question: "*What do we want to be*" or "'*where do we want to be, now and in the future*". The vision should contain a picture of where the organization strives to be in the future, and preferably also when to reach it. The vision statement is the inspiration and guidance for strategic and operational planning. On the other hand, a vision does not state how to reach the future state, but rather in which direction to focus. (Bergman & Klefsjö, 2001)

When formulating a vision, organizations should keep in mind that it should be innovative and make the employees think innovative and wide. Bergman & Klefsjö, (2001) states guidelines for creating a solid vision, it should include and answer the following areas:

- *Visualizable*
- *Desirable*
- *Clear*
- *Flexible*
- *Communicable*
- *Stable*

According to Bergman & Klefsjö (2001), in order to reach the stated vision, an organization requires long- and short-term objectives. These objectives need to be aligned with the company's vision. An objective should be clearly defined and within a limited timeframe, to be able to evaluate the outcome of. The foundations of an effective objective can be categories after five main building blocks. This goes under the acronym called "*SMART-objectives*" which includes:

- *Specific*: The objective should be clearly defined and specified
- *Measurable*: In order to evaluate the result, the objective should be measurable
- *Attainable*: To be able to reach the objective, everyone involved in reaching the objective needs to accept it
- *Relevant:* To reach the objective, a sufficient amount of time and resources must be available, making it reasonable/realistic

- *Time-bound:* In order to reach the objective, a time limit is essential as to not allow the work go on forever (Bergman & Klefsjö, 2001)

Forslund (2013) states several reasons why organizations need to have established objectives. First, without clarifying objectives, planning and prioritizing work tasks becomes more problematic. Objectives leads to delimitations and knowledge of where to distribute resources on, to be resource efficient. Further on, objectives can quantity the company's effectiveness by measuring the degree of achievement, set by the objective. The overall motivation and engagement in the organization can also be affected positively. (Forslund, 2013)

To achieve the stated objectives, companies need to carry out certain actions or *activities*. The plan that describes these activities are called *strategy*. Considering the business world, strategies are overall, general structural activities that extend over a longer period. In other words, "*what the companies want to achieve*". The relationship between the *Mission, Objectives and success factors* and *vision* is described in *Figure 11* (Bergman & Klefsjö, 2001)

Figure 11 The relationship between a company's mission, process objectives and vision (Bergman & Klefsjö, 2001)

3.1.2 Process Definition

"*A process is a network of activities, repeated in time and whose purpose is to create value for external or internal customer*" (Bergman & Klefsjö, 2001, p.416). The concept *process* originates from the Latin word "*processus*", which means "*going forward*", "*advance*" or "*progress*". The word process is often described as different types of procedure that develops over time, and often slowly. A process is often defined by the characteristics it consists of, with a clear starting point that triggers the process (costumer needs) as well an end point (satisfied customer). A process requires some kind of information exchange in order to properly function, feedback is also a key element for managing and controlling the process. The repeatability of a process makes it especially meaningful to analyze, small improvements can generate great results. (Bergman & Klefsjö, 2001)

An organizations processes can be grouped according to different criteria, such as where the interference exists. The category is also linked to the position and number of people involved in the process. These processes are divided into:

- *Individual Process*
- *Functional Process*

- *Core Process*

Individual processes are only connected to one person. Functional processes are linked to a particular department, function or item. The core process intersects an organization across multiple functions or departments, which generate value for the company in terms of revenue, illustrated in *Figure 12*. (Bergman & Klefsjö, 2001)

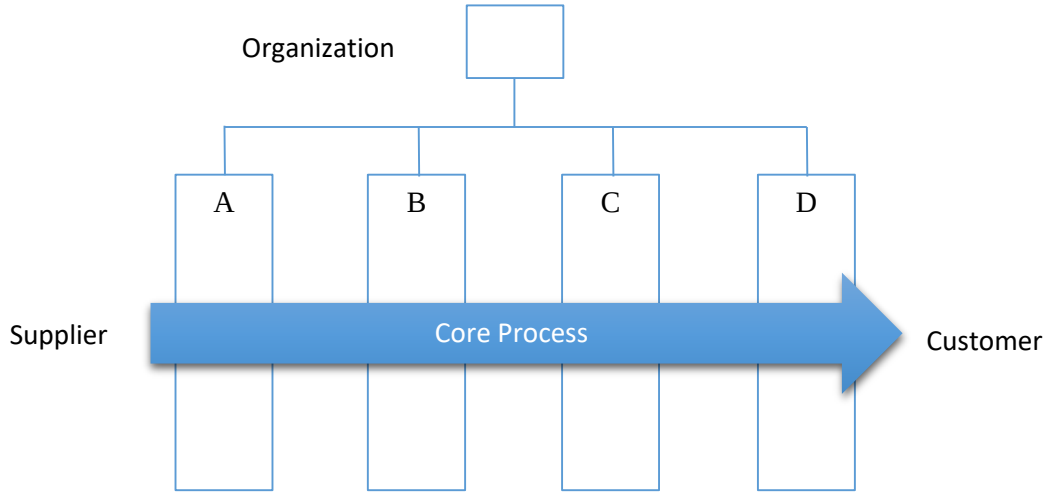

Figure 12 The core process exists horizontally though the whole organization (Bergman & Klefsjö, 2001)

An organization can be described as a network of processes, the functional processes utilizes from the core processes, every process can be broken down to sub processes. Another way of distinguishing processes is to structure them according to their main task, they can be categorized after:

- *Core Process*
- *Support Process*
- *Management Process*

The *core process* main purpose is to meet the needs of the external customers by transforming/producing the product or service, which the company offers. An example of a core process is the *research and development process*, with purpose is to create value for the future costumers. The *support process* role is to provide the necessary resources to the core process, support processes therefore have internal customers. Examples of support processes are human resources, maintenance processes and administrative processes. The last but at least as important is the *management process*, which is responsible for deciding the organizations objectives, strategies and improvement work. Management processes has internal customers, examples of these processes are strategies planning, target palling and audit department. Common to all processes is that all strive to satisfy their customers, with as little resources as possible, these are illustrated in *Figure 13*. In order to be effective, the processes require some kind of resource like, information, energy, workforce or time. Accurate planning and the right amount of resources is essential for the process to meet the customer demand. It is also important to identify the suppliers, so the processes know what is required from them. (Bergman & Klefsjö, 2001)

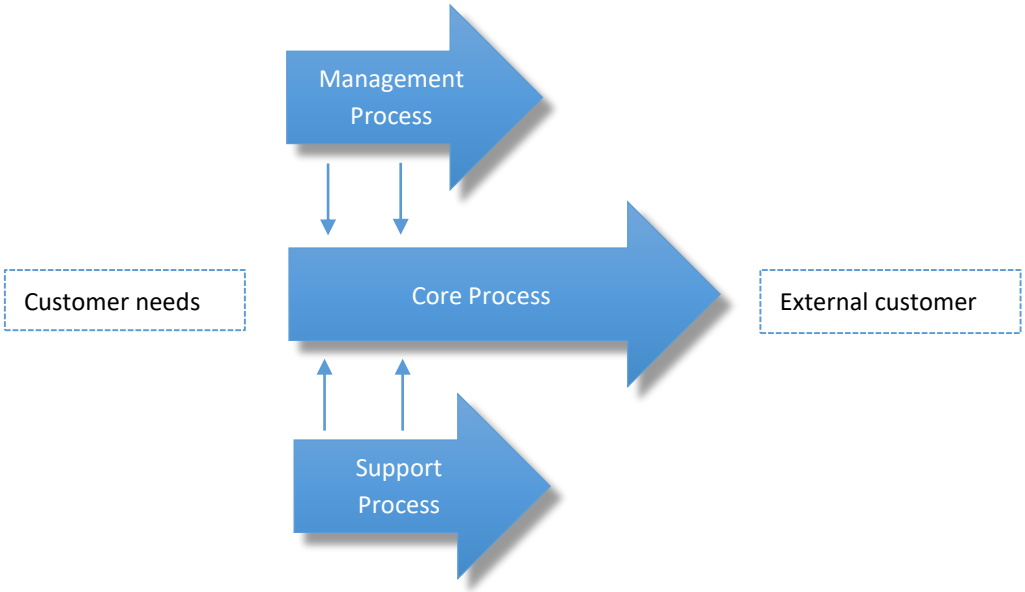

Figure 13 Illustration of an organizations different process categories based on the processes purpose (Bergman & Klefsjö, 2001)

3.1.3 Process Management

The value of process orientation and constantly improving the organizations processes has led to *Process Management*. Bergman & Klefsjö (2001) argues that the focus is to ensemble the activities of planning and monitoring the performance of a business process. Process management can be summarized in the following steps:

1. *Organize for improvements*
2. *Understand the process*
3. *Observe the process*
4. *Continuously improve the process*

The first step in process management is to *Organize for improvements*, which starts by nominating the *Process owner* and *Process improvement group*. The foundation of improvement work is to have the right conditions and the involvement of the concerned members. Managers in the organization are responsible for selecting a process owner, which has the strategic responsibility for improving and developing the process. In the beginning, it is important to focus on a few processes, often the core processes. The second step, *Understand the process*, is essential before you can start with the improvement work. To get a clear picture of the process, one must first define the interface, investigate the customers and suppliers, and map the process by documenting the workflow and the activities in it. (Bergman & Klefsjö, 2001)

The knowledge created by identifying and mapping a process is essential before entering the next phase, *Observe the process.* This phase is initialized by determining measurement points and performing measurements continuously. The basis for any improvement work is to have historical data about the process's previous performance. Therefore, the process results should be measured in quantifiable units e.g. quality performance, resource use, lead time etc. (Bergman & Klefsjö, 2001)

The previously described steps will eventually lead to, *Continuously improve the process.* A holistic perspective and an eye for simplifications are essential parts of process management. Process improvement

can either be performed in an existing process, through minor adjustments or through radical changes, which often result in a new process, also called process innovation. (Bergman & Klefsjö, 2001)

3.1.4 Swim Lane Chart

A swim lane flowchart, is a visual tool used in process flow diagram, the main purpose to in a visualize way get an overview over a specific process and its activities included. By mapping the process through a swim lane chart, enables an easier identification and appropriate measurement point for the process, it also clarifies the responsibilities for each sub-process. The method is preferably when a business process includes more than one department, and to identify delays, mistakes or gaps in communications. (Sörqvist, 2004)

The method can also be used for analyzing an administrative process and clarifies the possible connections between the different departments that a process concerns. The mapping procedure starts with identifying the different departments involved in the process, therefore it is possible to divide them into respective swim lane, preferably vertically. The activities that concern the current department can be placed in either a row or column. Each activity is further sorted after time, and in the order of occurrence in the flow, as shown in *Figure 14.* (Sörqvist, 2004)

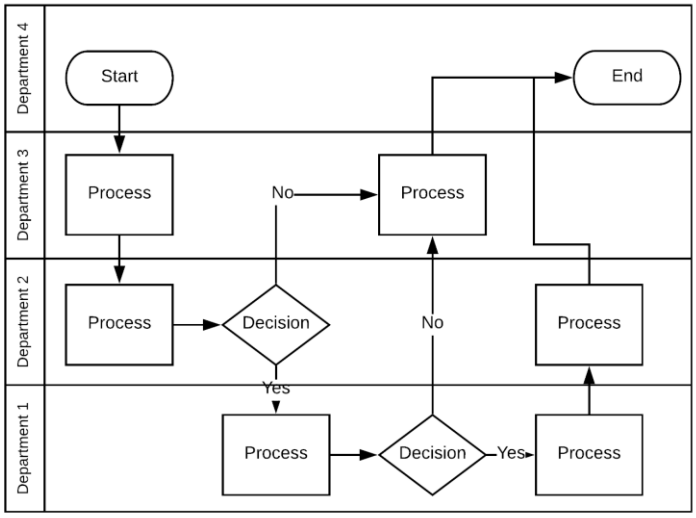

Figure 14 An example of a swim lane flowchart (Authors' image)

3.2 Improvement Work

The term "*improvement*" is, according to Langley et al. (2009), the result of successful change measured by one or several parameters, such as time, money, quality etc. Where the change moved the measured parameter from one stage, to a stage considered better. Furthermore, the authors Langley et al. (2009) states: "*All improvement requires change, but not all change will result in improvement.*" (Langley et al. 2009, p. 9)

3.2.1 Six Sigma & DMAIC

Sex Sigma is a methodology for improvement projects, which mainly focuses on cutting cost by reducing defects product and variation in the manufacturing- and business processes. The method originates from the electronic enterprise Motorola Inc. and was first introduced in the 1980s. Today, Six Sigma is used

primarily by producing companies, for instance in the manufacturing and automotive industry, with the aim of becoming more cost effective. The framework that Six Sigma is bases on is called DMAIC, and stand for *Define*, *Measure*, *Analyze*, *Improve* and *Control*. The core components of the framework are especially suited for improvement work in frequently repeated processes. In recent years, a developed method of DMAIC has also been used in the service sector, the tools is illustrated in *Figure 15*. (Bergman & Klefsjö, 2001)

The first phase *Define* consists of defining the scope of the project and processes involved, calculate a budget which shows if it becomes profitable. The project investment involves resources such as time, funds and human resources. In order to plan the project, it is crucial to identify the affected processes and to have an overall overview of the project. The second phase *Measure* refers of collecting the necessary data included in the project, the data creates a baseline or starting point for the further analyzing phase. A starting value is important in order to measure the difference between the current state and the future result, after the improvement work has been implemented. The *Analyze* phase involves analyzing data and investigate the relationship between different factors, to determine root causes of variation and poor performance (defects). The potential root causes can be identified by root cause analysis tools such as fishbone diagram or "*5 Whys*". Performance objective, sources of variation and value/non-value-added process steps are identified in analyze phase. The main purpose of the *Improve* phase is to identify, test and implement the proposed solution to the problem. In order to eliminate the root causes and prevent process problems an optimal solution is required, thus, the implementation of the solutions is not vital, it is more important to identify the potential solutions. Important to keep in mind, usually the simplest and easiest solution is often the best. The last phase *Control* includes sustaining the accomplishments from previous steps. To ensure continued and sustainable achievement, it is crucial to monitor and document the improvements. Useful tools are control charts, which controls and evaluates the stability of the improvements over time. Control charts can detect when the process becomes unstable and enables managers to react in time. (Magnusson, et al., 2003)

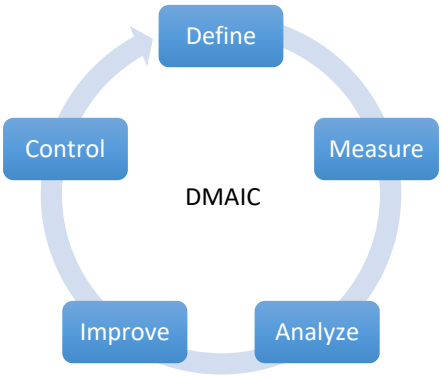

Figure 15 The five steps included in the improvement tool DMAIC (Magnusson, et al., 2003)

3.2.2 Benchmarking

The main purpose of benchmarking is to identify the opportunities for improvement work in an organization. By accurate comparison between one's organizations processes and other, identical or similar processes. Benchmarking can also be performed against other organizations or divisions, usually divided into internal or external benchmarking. (Bergman & Klefsjö, 2001)

Robert C. Camp explains benchmarking as, "*In today's business application, the benchmark is that performance objective which incorporates the best practice, the epitome or standard of excellence; and adapt best practices to your organization. Benchmarking is finding and implementing best practices*" (Camp 2003, p. 12).

Benchmarking strives against a proactive and positive approach, which can change operations in a structured procedure, to achieve superior performance, which finally leads to competitive advantages. (Camp, 2003)

3.2.3 GAP Analysis

The GAP analysis is an analytical tool that enables companies to compare its current performance with its potential or desirable performance. The main purpose of the method is to identify the gap between the present allocation and the optimal distribution and integration of efforts. This provides insight into the areas in which there are room for improvements. The analysis can be performed at a strategic or operational level in an organization. It involves documenting, determining and eventually visualizing the difference between stated requirements and current capabilities. The GAP analysis is often used in cooperation with the benchmarking process. First, it is important to understand the overall expectations of performance in an industry, in order to compare it with the organization's current performance. Usually, gaps occur in three areas in an organization; *People, Processes* and *Technology*. Further on, a GAP analysis can serve as a prioritization tool, clarifying the areas in need of improvement by comparing the gaps. The GAP analysis consists of five basic steps, illustrated in *Figure 16* below. (GTS Learning, 2014)

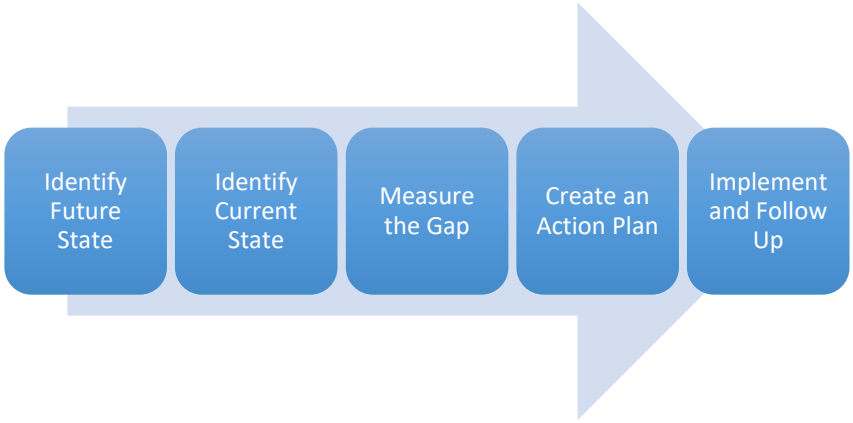

Figure 16 The main steps in GAP analysis (GTS Learning, 2014)

The GAP analysis method can also be cyclical, once the first study has been done, and preferred action plan implemented, the procedure can repeat/loop, which leads to further improvement work. (GTS Learning, 2014)

3.2.4 Challenges with Implementation

The digitalization of society is changing industries and businesses more quickly than ever before. It is difficult to find market domain which have not been affected by the evolution of digitalization.

"*Our organization has become a software company. The problem is that we haven't realized that yet*" Fitzgerald et al. (2017, p.17), stated by a top manager for a market leading manufacturing company. Further

on, he argues that traditional hardware products are now replaced by software solutions. This creates challenges in the design and development phase, especially "*designing for reuse*". (Fitzgerald, et al., 2017)

According to Kotter and Schlesinger (2013), changes in an organization often manage to fail due to some circumstances. It is always difficult and uncertain to implement a new system, order or working method etc. The main challenge is often based on people's resistance to accept change; therefore, reducing the resistance for change is a crucial initial step. This is a widely known and researched subject, and any organization can face these challenges. Kotter and Schlesinger (2013, p.3) identified the four main barriers of change, followed below:

- *The ability not to lose something of value*
- *A misunderstanding of the chance and its implications*
- *Thinking that the change does not make sense for the company*
- *An overall low acceptance for change*

3.3 Information and Information Management

The authors, Laudon & Laudon (2010) defines data as "*Streams of raw facts representing events occurring in organizations or the physical environment before they have been organized and arranged into a form that people can understand and use.*" (Laudon & Laudon, 2010, p. 629). Stating that data, in its purest form, does not contribute to the understanding of a phenomenon, behavior or event. However, by analyzing, sorting and comparing data, the transition to information has begun. Information is therefore defined, by the same authors, as "*Data that have been shaped into a form that is meaningful and useful to human beings.*" (Laudon & Laudon, 2010, p. 632).

Pearlson & Saunders (2009) further describes the concept of knowledge as "*Information that is synthesized and contextualized to provide value. It is information with the most value*. (Pearlson & Saunders, 2009, p.14). Stating that to create value, information must be handled correctly, in the right time, by the appropriate entity, leading to information systems.

An information system is a set of collaborating entities that gather, process, store and allocates information to assist decision making in organizations. Thus, three main activities performed by an information system can be identified, *Input*, *Processing* and *Output*. Where *Input* gathers data from a specific source, *Processing* converts the data into useable and relevant information, and *Output* allocates the information to the areas of concern in the organization. This information can assume any form or shape that is of use for a specific company, depending on the design and function of the information system. (Laudon & Laudon, 2010)

An information system can therefore be seen as "*The combination of technology (the* "*what*"*), people (the* "*who*"*), and process (the* "*how*"*) that an organization uses to produce and manage information.* (Pearlson & Saunders, 2009, p.15)

3.3.1 Information Quality

"*The meaning of information quality lies in how the information is perceived and used by its customer*. A*lthough absolute attributes are important, it is the perception of those attributes, now and in the future, that defines information quality*" (Miller, 1996, p.79)

Miller (1996) argues, that the quality of information is defined by its customer, whether the information meets the customer's requirements. Furthermore, the author states that certain attributes or dimensions are relevant when considering information quality. However, depending on the customer's needs, the prioritization of these dimensions tends to differ. The ten dimensions of information quality follows:

- *Accuracy*: How well the information reflects the reality; however, depending on the purpose, various levels of accuracy is needed. If the information accuracy exceeds the customer's processing capability, it may strain the system and ultimately lead to confusion.
- *Timeliness*: To what degree the information is still current. This dimension depends on the systems capability of replacing old information, as well as the rate of change in the system's environment.
- *Completeness*: The level of information completeness depends on the level of detail. However, as with accuracy, a higher level of detail requires more processing.
- *Coherence*: Whether or not the information is consistent, logically. Incoherent information can be a combination of *Accuracy* and *Timeliness* errors.
- *Format*: How the information is presented, this dimension depends on the customer's requirements. Hence, the information context and usage is of relevance.
- *Accessibility*: Put in relation to *Timeliness*, the *Accessibility* of information depends on whether it is obtainable and still relevant when needed.
- *Compatibility*: The degree to which the information is compatible with other information, information systems or users.
- *Security*: The level of security depends on the information being handled. This dimension involves the physical aspects, in the event of an accident or disaster, and the cyber-security aspect, such information system breaches.
- *Validity*: The resultant of a combination of dimensions, here, the customers need is put into perspective. Meaning that information which lacks certain dimensions can still be valuable and valid to a customer, if these dimensions are of no importance to the customer. (Miller, 1996)

Although multiple interpretations regarding the dimensions exist, all resembles the dimension presented by Miller (1996).

3.3.2 Enterprise Architecture

Graves (2009), defines an *Enterprise* as, "*… an organization or cross-functional entity supporting a defined business scope or mission. It includes interdependent resources – people, organizations and technology- who must coordinate their functions and share information in support of a common mission or set of related missions.*" (Graves, 2009, p.9)

Furthermore, the term *Architecture* is explained as, "*…the structure of components, their interrelationships, and the principles and guidelines governing their evolution and design.*" (Graves, 2009, p.10)

Today, *Enterprise Architecture* (EA) has become a key competence for a majority of large organizations worldwide. The founder of the concept EA, John Zachman first introduced the method in 1987. The main purpose was to illustrate the relationship between different enterprise layers, in the context of business processes and information usage, to reduce the complexity while developing Information Systems (IS). EA enables companies to control and manage enterprise analysis, design, planning and implementation, using a holistic perspective, in order to successfully reach the mission and execute the strategy. Furthermore, EA

divides an enterprise into four layers, *Business architecture*, *Data architecture*, *Applications architecture*, *Technology architecture* as shown in *Figure 17.* (Behrouz & Fathollah, 2016)

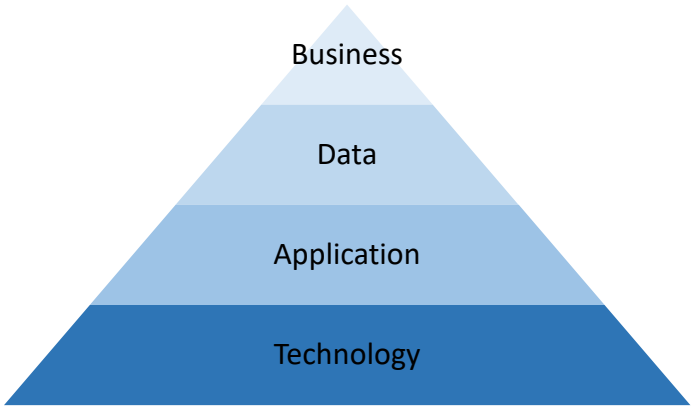

Figure 17 The four layers of the enterprise architecture (Behrouz & Fathollah, 2016)

Where *Business Architecture* involves the business strategy, business process and activities. These processes or activities use *Data/Information* collected and analyzed by *Applications*, such as analysis software. Further, the analysis software is supported by the necessary *Technology* or hardware. This technology involves systems of computers, sensors or network of components. (Behrouz & Fathollah, 2016)

3.3.3 Business Intelligence

"*The ultimate goal of Business Intelligence is powered by the ability to manage access and availability of necessary information – to assess business needs, identify candidate data sources, and effectively manage the flow of information into a framework suited for reporting and analysis needs*" (Loshin, 2013, p.5)

The term Business Intelligence (BI) can be seen as the compilation of processes, technologies and tools necessary to transform data, regarding a company and its environment, into value. It is a managerial tool involving the identification of valuable data sources, the transformation process from data to information and the analysis process to transform information into knowledge. Further on, the knowledge acts as the foundation for future planning, capable of illustrating the current state of business and predicting outcomes of future actions. The process of transforming data to value is showed in *Figure 18.* (Loshin, 2013)

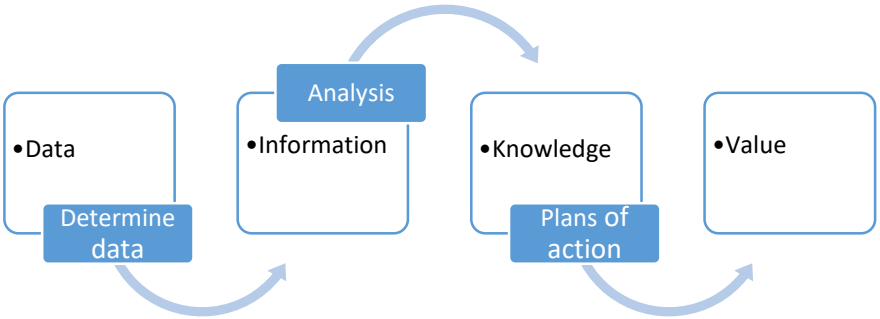

Figure 18 Transforming data (Loshin, 2013)

The process of turning data into information, assuming the data is available, is initialized by determining the data that is of importance, how it should be managed and its context. Loshin (2013, p 8) states that individual bits of data without context or specific recipients, are of little value. The compiled information needs to pass through different analytical tools to sort out and create bits of knowledge. Several types of data mining techniques and analytical tools are often used in combination to find critical relationships, patterns or trends within the information. This in turn creates knowledge, enabling a company to create plans of action, capable of creating value when properly utilized. (Loshin, 2013)

3.3.4 Productions Control Systems

An organization, when scaled up sufficiently, produces a massive amount of data from processes and activities. The produced data, in combination with environmental data, is often transformed to information as to assist in decision-making and planning operations etc. To enable management and control of the information, assuming it has been collected, organizations use different production control systems, usually divided into three control levels, *Strategic*, *Operational* and *Execution control*, illustrated in *Figure 19*. (Romanov, et al., 2016)

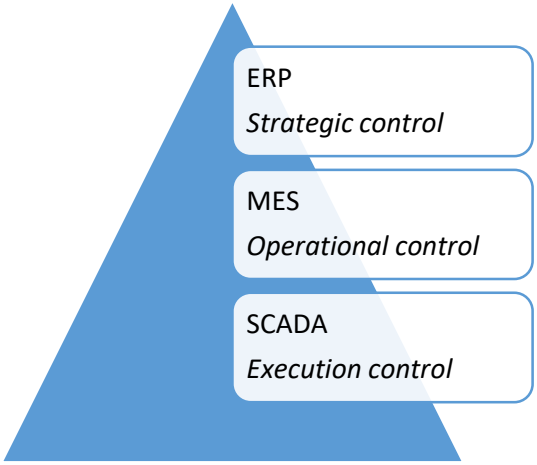

Figure 19 Hierarchy of manufacturing automation systems (Shanks, et al., 2003)

At the top level, *Strategic control*, organizations often use an *Enterprise Resource Planning* (ERP) system. An ERP system enables organizations to automate business processes, share data across the whole organization and produce or access information in real-time. Furthermore, an ERP system usually handles the central functions of sales and marketing, finance, human resources and purchasing. Thus, improving the productivity of a company by ensuring that the necessary information is accessible at the right time, automate time-consuming processes and provide instant reactions to environmental changes. (Shanks, et al., 2003)

The *Operational control*, concerns the area of production management, a *Manufacturing Execution System* (MES) stands for several functions in an organization including production planning and management, operations management and information management. It can be said that a MES synchronize production processes to reduce waiting times, storage and transport times. (Meyer, et al., 2009)

The *Execution control*, which includes the actual processes and devices within the organization, are often supervised by a *Supervisory Control And Data Acquisition* (SCADA) system. A SCADA system is used as a tool for process control, as an example, by collecting data from a process, processing the data to

information and presenting the information to an operator, whom can interact with or control the systems by transferring information the other way. (Bailey & Wright, 2003)

A SCADA system is, in its easiest form, built up by remote terminal units (RTUs) gathering data and transferring it to a master station through a communications system. The master station transforms the data into information and presents, enabling an operator to base decisions on the information and interact with the system. The RTUs, in this case, contains the sensors to gather data and actuators receiving inputs to control the process, and in combination with the software and interface hardware, creates the *Supervisory Control and Data Acquisition* system. (Bailey & Wright, 2003)

3.3.5 Road-map for process-oriented information mapping

To control the information management in an organization effectively, it is essential to acquire an understanding of the information an organization is dependent upon, and additionally, the systems or services handling the information. An information mapping provides understanding of this information and can further provide guidance for information management development. Furthermore, processes in an organization are the generators and users of information, indicating a relationship between information flows and process flows, thus, the process-oriented information mapping. (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012)

A process-oriented information map connects the processes, the information flows and information systems in three layers, *Operational-*, *Information-* and *Information carrier layer*. Where the *operational layer* depicts the processes, inputs and outputs, and the process's direction. The *information layer* illustrates the information set, which involves the type of information, direction and if the information is gathered or generated by the process. Lastly, the *information carrier layer* involves the system which handles the information, i.e. if the information is sent to, or gathered from, a paper document, a system or a cloud service etc. An example of a process-oriented information map is provided in *Figure 20* below. (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012)

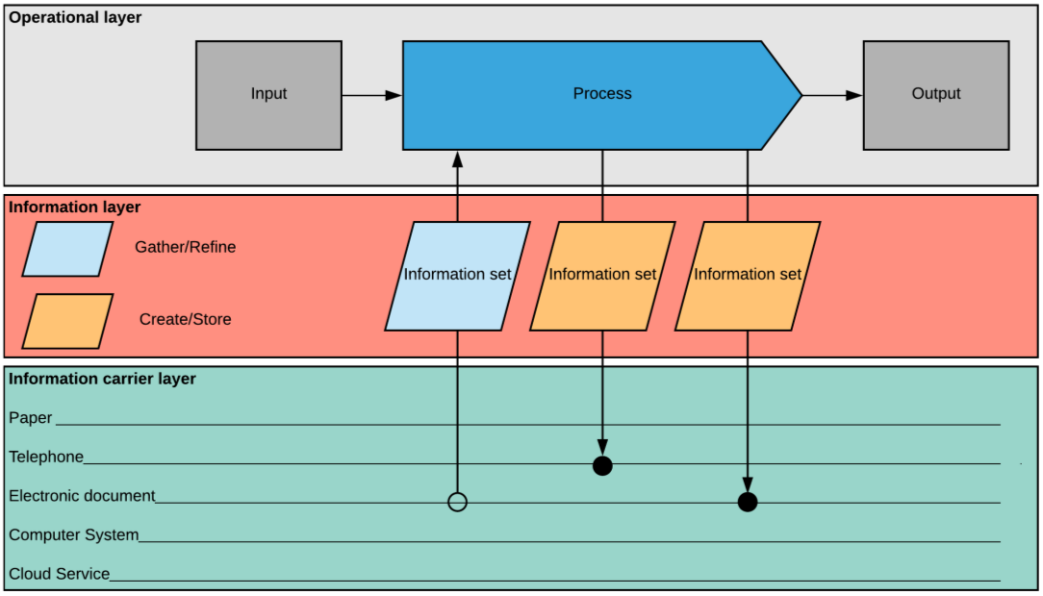

Figure 20 Process-oriented information map, depicting the three layers and content (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012)

Process-oriented information mapping, in practice
A workshop, as a tool, can be used to create a process-oriented information map rather than an investigation performed by a single individual. A workshop ensures that the issues at hand are being properly handled, by utilizing competence from different areas. Described below are some of the steps and key roles of a workshop, regarding process-oriented information mapping. (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012)

Defining the process and scope
An important step before initializing the workshop. Here, the process to be investigated is decided, its boundaries and the level of detail needed, and by doing so, indicating some of the participants of the workshop. (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012)

Defining the key roles and participants
The roles are often organization dependent; however, four key roles are appropriate when conducting a workshop:

1. Organization representatives: Often an individual called the information owner, i.e. the one responsible for the information management regarding the process, capable of estimating the function and importance of information sets. Alternatively, an individual with thorough knowledge of the process.
2. Specialists: Depending on the process in question, these roles can be represented by managers from IT, quality or information security departments, lawyers for juridical counsel etc.
3. Analysis-leader: The individual leading the workshop, a person with sufficient knowledge of information management and process mapping. Personal traits such as analytical ability, ability to lead and ability enthuse the participants are similarly important.
4. Secretary: To ensure proper documentation of the workshop. (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012)

3.4 Industrie 4.0 and Cyber-Physical Production Systems

During the past two centuries, the world has witnessed three industrial revolutions. Starting with the introduction of mechanical appliances, continuous production lines and automated systems, the manufacturing industry is on the brink of the fourth industrial revolution. This revolution, called "*Industrie 4.0*" in Germany, is based upon the concept of "*Cyber-physical production systems*" and "*Internet of things*". An illustration of the industrial revolutions is provided in *Figure 21*. (Drath & Horch, 2014)

A Cyber-physical productions system is a system built up by connected and collaborating autonomous entities throughout all levels of production, from the individual machines up to the logistics networks. Such a system would be able to autonomously handle a large number of individual operations and decisions to reach optimal and/or robust results for any given situation. Other advantages such as increased safety, self-maintenance, predictability and transparency are some of the expected benefits of Cyber-physical production systems. (Monostori, 2014)

The Internet of Things is the integration of physical objects' attributes and the internet. Here, each physical entity has computational or sensing capabilities, enabling the access of these entities in real time and globally, as to control or monitor it. The outcome will contribute to shorter setup time and lead-time, fewer errors, increased flexibility and less time-consuming programming. (Schwab, 2016)

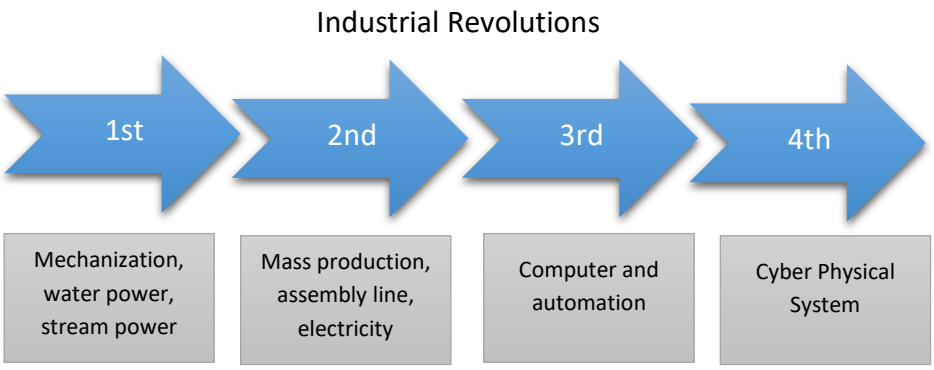

Figure 21 The Industrial Revolutions (Authors' image)

3.4.1 Drivers

Professor Klaus Schwab, founder and executive chairman of the World Economic Forum, has complied the most important drivers for the fourth industrial revolution. As mentioned earlier the new technologies and scientific innovations underpins the development of the revolution. Klaus states that all new developments and technologies have one key thing in common: *they are driven by the power of digitalization and information technology*. The main technological drivers can be categorized after three megatrends:

- *Physical*
- *Digital*
- *Biological*

All three drivers are deeply connected with each other, directly affecting the outcome. Physical technological are easier to identify due to their tangible nature; *autonomous vehicles, 3D printers, advance robotic* and *innovative materials.* The main connection between the physical and digital technologies is the so-called *Internet of Things* (IoT). IoT can be describe as a relationship between products, services, locations, systems, platforms and peoples etc. through sensors and other technical devices connecting objects in the physical world to virtual platforms. The continuous technological development has led to cheaper, smaller and smarter sensors which can be found in products, infrastructures, energy systems and manufacturing processes etc. All these products such as smartphones, computers, tablets and sensors can be connected to a system/cloud. The number of devices connected are increasing for every year; researchers believe that the next five will result in more than a trillion connected devices. (Schwab, 2016)

The digital revolution contributes to new approaches, revolutionizing the way entities collaborate and interact with each other. Remote monitoring applications has increased significant recently due to the development of the IoT. Pallets, package or container can be equipped with a sensor, transmitter, GPS or radio frequency identification (RFID) tags. This allows companies to track the products through the supply chain and gather valuable information such as conditions, performance and customer usages. (Schwab, 2016)

"On-demand economy" based on technology-allowed platforms is also an example of the digital development. These platforms can easily be reached from any device connected, such as smartphones, tablets or a computer, creating new ways of consuming goods and services. Uber Technologies Inc., which is a global taxi enterprise, has been a pioneer in the *sharing economy* and developed their business model

based on these technology platforms. These platform businesses are rapidly introduced on new markets and services worldwide. (Schwab, 2016)

Finally, the last technological driver is the innovations and breakthroughs in the biological area. With computer aid, scientists can simulate and verify the outcome of substances instead of physical tests involving medical trials. Thus, shortening the lead-time and eliminating obstacles related to the development of medical substances. (Schwab, 2016)

3.4.2 The Impact of Industrie 4.0

The authors Rüßmann, et al. (2015) found, when analyzing the prospect of the German manufacturing industry, four main areas that might benefit from future technological advancements. These areas, *Productivity*, *Revenue growth*, *Employment* and *Investment*, and the potential impact was quantified, where:

- *Productivity*: Productivity as the ratio between output and input will during the next five to ten years increase in the range of 15 to 25 percent, excluding the material costs. When accounting for the material costs, gains between 5 to 8 percent are expected for most of the German industries.
- *Revenue growth*: By utilizing new technologies and enhanced equipment, the German industries are believed to become more flexible, able to satisfy the increasing demand of customizable products. The effect of these actions will increase the revenue by approximately €30 billion a year, which corresponds to 1 percent of Germany's GDP.
- *Employment*: The technology and automation will affect laborers working with monotonous tasks. However, the overall employment will increase with approximately 6 percent. This is a consequence of the increased need for, mechanical engineers, software developers and other high technology competencies.
- *Investment*: To successfully adapt the industries to the new circumstances and remain competitive in the future, investments are required in the range of €250 billion for the manufacturing sector, over a period of ten years. (Rüßmann, et al., 2015)

3.5 Literature Synthesis

This chapter provides a summary of a sample of literature used in the literature synthesis to develop the conceptual framework. The common elements are further described and analyzed in chapter *4 Findings and Analysis: Literature Synthesis*.

3.5.1 Leading Change – Why Transformation Effort Fail

"*Guiding change may be the ultimate test of a leader – no business survives over the long term if they can't reinvent itself.*" *(*Kotter, 2007, p. 4)

John P. Kotter states that changes in an organization are often met with resistance from the people it effects. Further on, John P. Kotter has investigated more than 100 companies over the past decade, including large and small corporations such as Ford, General Motors, Landmark Communications and British Airways etc. These companies have faced many different challenges over the years, which requires a high sense of adaptability in order to meet new changes. John P. Kotter states, in nearly all cases; "*the basic goal has been the same: to make fundamental changes in how a business is conducted in order to help cope with a new, more challenging market environment.*" (Kotter, 2007, p.4). Through the studies, the author has compiled eight main steps of significant importance, when companies are undergoing any type of change or transformation. These steps are visualized in *Figure 22*, important to keep in mind is the order of the procedure. (Kotter, 2007)

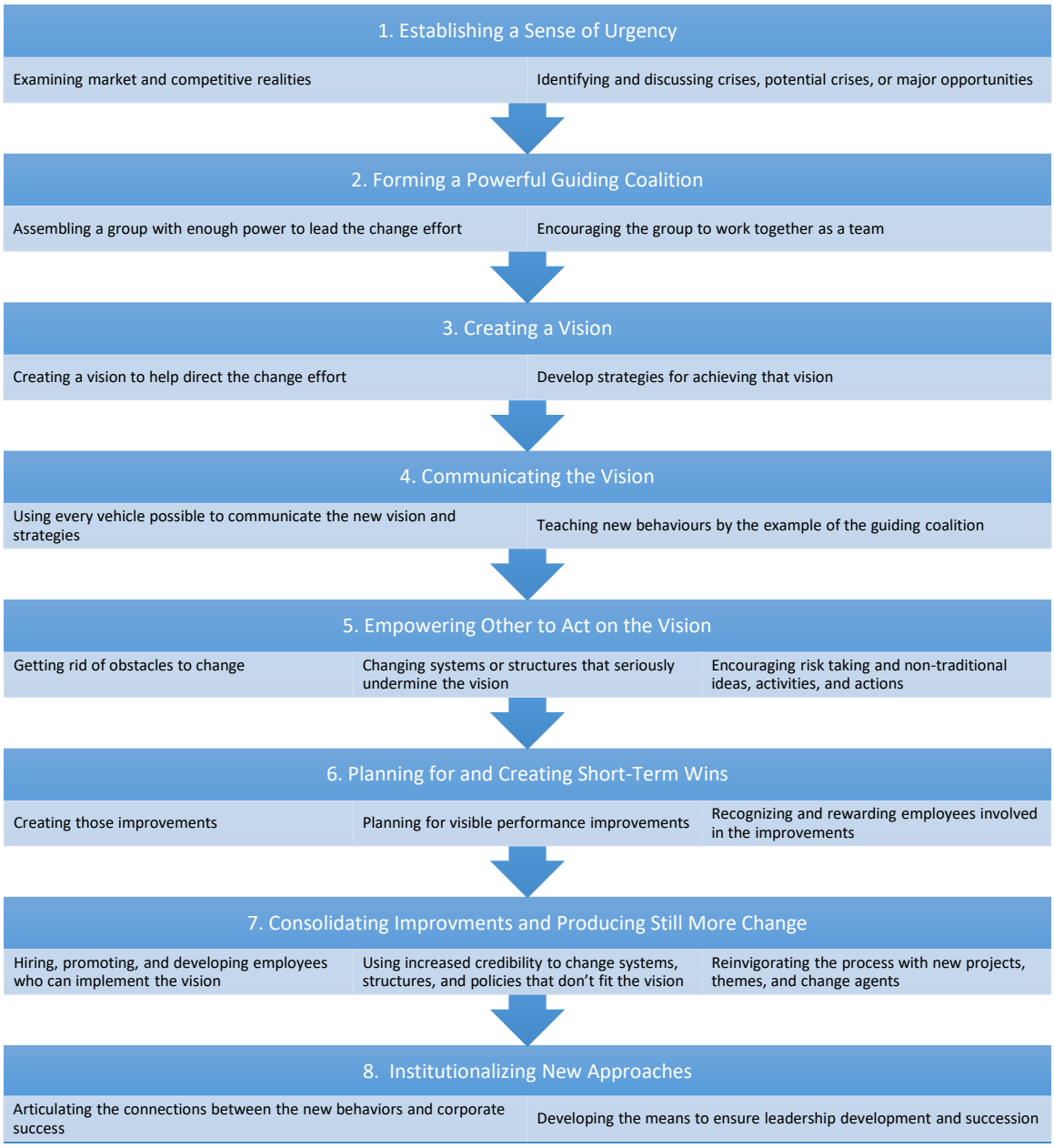

Figure 22 Eight steps of transforming an organization (Kotter, 2007)

3.5.2 Digital Transformation Strategies

Companies in almost all industries search to explore the possible benefits of new digital technologies. This demands companies to transform their key businesses and operations, affecting their products and processes, as well as the organization structure and management. The most important building block to successfully implement a digital transformation is to formulate a digital transformation strategy. The strategy will serve as a central concept in order to integrate the entire coordination and prioritization within the organization. The development and integration of digital technologies often effect many parts of an organization and can go beyond their boundaries, by impacting products, business process, sales channels

and supply chains. The potential benefits of digitization are many, such as increased sales- and productivity, time- and resource effective, innovation creation and new customers. (Matt, et al., 2015)

A digital transformation affects several different functions and department in an organization, cutting across other business strategies. Therefore, a separate digital transformation strategy should be designed and aligned with other existing business strategies, as shown in the *Figure 23* below. (Matt, et al., 2015)

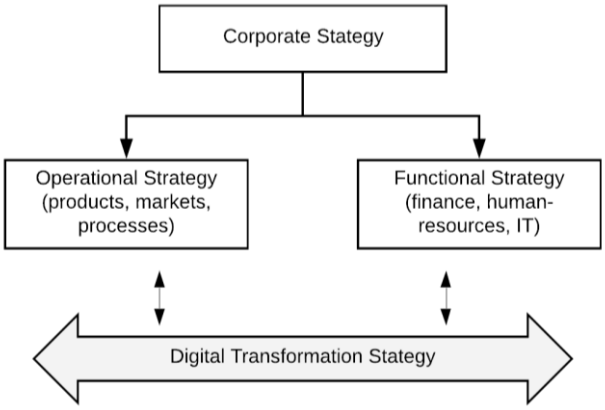

Figure 23 Relation between digital transformation strategy and other corporate strategies (Matt, et al., 2015)

According to Matt et al. (2015) regardless which industry or company, digital transformation strategies have some fundamental elements in common. These elements can be categorized into four different dimensions, described in the *Figure 24* as: *Structural changes, Changes in value creation, Use of technologies* and *Financial aspects.* The *Use of technologies* contributes an organizations attitude and degree of utilization towards new technologies. The authors state that companies need to decide if they want to be market leader speaking of technologies usage, which leads to new technological innovations. Alternatively, adapt and follow already established technology standards in order to achieve their business objectives. Positioning as a technological market leader might result in competitive advantages and contribute to new opportunities. This result in a situation where competing firms are dependent on the technological standards and innovations of the market leader. (Matt, et al., 2015)

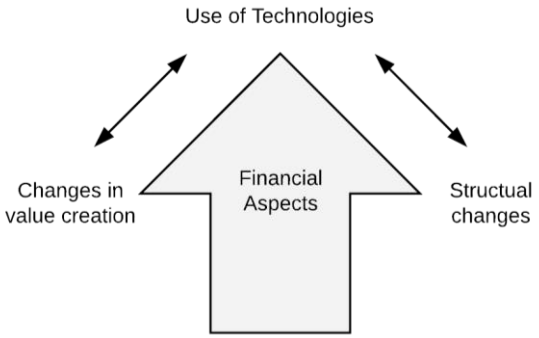

Figure 24 Digital transformation framework, connection between the four dimensions (Matt, et al., 2015)

3.5.3 The way towards the fourth industrial revolution

While analyzing the German manufacturing industry, its future and potential outcome in the context of Industrie 4.0, the authors Rüßmann, et al. (2015), found "nine pillars of technological advancement". These pillars, the authors argue, are the building blocks of Industrie 4.0. In addition to the pillars, the authors also suggest conceptual method for working with digital improvements. (Rüßmann, et al., 2015)

The method or the way forward, builds on growth for prioritized departments or processes. Where firstly, a company must decide which key area for improvement to focus on, since a widespread improvement effort can result in costly or non-optimal solutions. The key areas of improvement are defined as *production flexibility*, *productivity*, *speed* and *quality*. The area in question stands for the area that the company wants to improve, its needs. (Rüßmann, et al., 2015)

Further on, the needs of the company should be evaluated against the "nine pillars of technological advancement", to assess which pillar, or combination, that is able to bring improvements in the designated area. The pillars, as described by the authors, are; *Big data and analytics*, *Autonomous robots*, *Simulation*, *Horizontal and vertical system integration*, *The industrial internet of things*, *Cybersecurity*, *The cloud*, *Additive manufacturing* and *Augmented reality*. (Rüßmann, et al., 2015)

When the area has been defined, and the pillar able to bring improvements identified, the company enters the analysis phase. Here, a long-term impact on workforce must be analyzed, to estimate how the current employees will be affected. As previously mentioned, the fourth industrial revolution will bring a shift in required skills for employees, demanding a higher degree of IT related competence. Therefore, the first step before implementing improvements involves analyzing the organizational changes, such as the need for new roles, vocational education and recruitment. (Rüßmann, et al., 2015)

3.5.4 The new patterns of innovation

"*How can we create value for customers using data and analytic tools we own or could have access to?*" (Parmar, et al., 2014, p.88).

Parmar, et al. (2014) investigated how unexploited data in combination with analytical tools can be utilized to create new information flows, leading to new business opportunities and increased customer value. The study concerned clients of IBM and their digital development during five years, stating five distinct patterns in which companies utilize information technology to increase their business value. The found patterns, Parmar, et al. (2014) argues, overlaps each other and are often used in combination.

- "*Augmenting products to generate data*" – Incorporating hardware, such as sensors, in products to enable data gathering during the product's life cycle. This data can later be used for product development, operation optimization or maintenance.
- "*Digitizing assets*" – Transforming physical items, assets, resources or commodities to its digital counterpart, granting the same services as before but in a digital form. Often results in a reduction of distribution costs and improved flexibility towards customers.
- "*Combining data within and across industries*" **–** By using information from different sources, industries or sectors to create value in a new symbiotic way.
- "*Trading data*" **–** Utilize unexploited data in a new way by realizing its value to another organization.

- "*Codifying a distinctive service capability*"- Create software and platforms initially intended for internal usage and sell it to external parties. This is enabled with the help of cloud computing, allowing easy distribution of software. (Parmar, et al., 2014)

The method
When working with clients to uncover new business opportunities, the authors follow a process divided into six steps, described below:

Step 1. Knowledge
The initial step is to create knowledge around the five patterns, often with concrete examples, to visualize how previous attempts resulted in increased business value for a company. This fundamental step creates a deeper understanding of the subject, as well as allowing the client to engage in out-of-the box thinking. (Parmar, et al., 2014)

Step 2. Investigation
To evaluate the current situation in the company, regarding their data and potential opportunities, five questions needs to be answered. These questions are designed to position the company, assess the resources at hand and the current needs of the client, regarding data and information. The questions, as described by Parmar, et al. (2014, p.94) are shown below:

- "*What data do we have?*"
- "*What data can we access that we are not capturing?* "
- "*What data could we create form our products or operations?*"
- "*What helpful data could we get from others?*"
- "*What data do others have that we could use in a joint initiative?*" (Parmar, et al., 2014)

Step 3. Cycle the patterns
When the current situation has been mapped, the answers gathered from the previous step are cycled through the five patterns in a new set of questions. This step explores the possible solution areas and opportunities existing in the company. The patterns and related questions, as depicted by Parmar, et al. (2014, p94) are shown below:

Augmenting products

- "*Which of the data relate to our products and their use?*"
- "*Which do we now keep, and which could we start keeping?*"
- "*What insights could be developed from the data?*"
- "*How could those insights provide new value to us, our customers, our suppliers, our competitors, or players in another industry?*"

Digitizing assets

- "*Which of our assets are either wholly or essentially digital?*"
- "*How can we use their digital nature to improve or augment their value?*"
- "*Do we have physical assets that could be turned into digital assets?*"

Combining data

- "*How might our data be combined with data held by others to create value?*"

- "*Could we act as the catalyst for value creation by integrating data held by other players?*"
- "*Who would benefit from this integration and what business model would make it attractive to us and our collaborators?*"

Trading data

- "*How could our data be structure and analyzed to yield higher-value information?*"
- "*Is there value in this data to us internally, to our current customers, to potential new customers, or to another industry?*"

Codifying a capability

- "*Do we possess a distinctive capability that others would value?*"
- "*Is there a way to standardize this capability so that it could be broadly useful?*"
- "*Can we deliver this capability as a digital service?*"
- "*Who in our industry or other industries would find this attractive?*"
- "*How could the gathering, management, and analysis of our data help us develop a capability that we would codify?*" (Parmar, et al., 2014)

Step 4. Summarize and prioritize
The answers and ideas from the second set of questions are summarized to create an aggregated overview of the findings. Here, a prioritization between the various ideas is necessary since the analysis process is resource consuming. The prioritization should lead to a few rational choices. (Parmar, et al., 2014)

Step 5. Analysis
Subgroups are created and tasked with a deeper analysis of the chosen ideas. Here, a scenario is developed to analyze how an idea could play out. The objectives in this step are to evaluate how an idea can create business value for the company and identification of the key assumptions or conditions that needs to be in place, for the realization of the scenario. This extensive analysis, executed by the subgroup, is performed over a few weeks to ensure that all parameters important for the scenario is identified. (Parmar, et al., 2014)

Step 6. Conclusion
The resulting conclusions from the subgroup(s) are presented, and if deemed relevant, the ideas are implemented into the company. (Parmar, et al., 2014)

Success factors
In addition to these steps, the authors also identified four success factors, or prerequisites, present in the companies who successfully utilized data to increase business value. These factors were accompanied by the initial prerequisites, such as cross-functional teams, sufficient resources and support from the top management. (Parmar, et al., 2014)

- *Strong technology presence:* The project should involve individuals with the right skills as well as sufficient authority. Preferably, an individual with overall IT responsibility.
- *Inputs from external parties:* External perspectives and skills are often beneficial for innovation projects. This allows a faster way to obtain the necessary capabilities.
- *Motivated leadership:* A strong leader is necessary to overcome obstacles such as cultural or behavioral barriers.

- *Emotional commitment:* The involved individuals' emotional commitment was observed to be a success factor, creating a mutual mission. Thus, motivating the individuals. (Parmar, et al., 2014)

3.5.5 Tackling the digitalization challenge: How to benefit from digitalization in practice

Parviainen, et al. (2017) found a research gap in the area of digitalization and digital transformations. Although literature describes technological innovations and solutions, their implementation or realization methods were not clearly defined. Thus, the authors sought to create a framework capable of describing how a company can tackle a digital transformation. The framework is built up by case studies regarding digitalization to find a pattern, distinguishing a successful digitalization effort. Four main steps were identified, *positioning the company, analyzing the current state, creation of a roadmap* and *implementing the roadmap*, these are further described below. (Parviainen, et al., 2017)

Step 1. Positioning the company

Consists of four sub-steps, digitalization impacts, digitalization drivers, digitalization scenarios and digitalization goals:

- *Digitalization impacts:* Analyzing current or upcoming technological trends and their relevance for the company creates the foundation for positioning the company. This phase identifies the existing trends and evaluates how far the company, and the whole industry, is in adopting these trends.
- *Digitalization drivers:* Investigating the results from the previous phase to isolate the digitalization drivers. These drivers are later prioritized.
- *Digitalization scenarios:* Different scenarios regarding the company's future are developed, based on the drivers, which were deemed most important. Here, the potential costs, benefits and risks involved with implementing or not implementing scenarios are analyzed.
- *Digitalization goals:* By analyzing the different scenarios and their feasibility, digitalization goals are created. These goals should be properly defined and quantified, to enable evaluation of future improvements. (Parviainen, et al., 2017)

Step 2. Analyzing the current state

Assessing the current situation for the company, with respect to the defined goals. Several methods and tools are applicable in this step, but the result should again be quantifiable, as to enable the next step in the process. (Parviainen, et al., 2017)

Step 3. Creation of a roadmap

This step, divided into four sub-steps, creates the detailed action plan for reaching the defined goals. The sub-steps are:

- *Identifying the gap:* The initial step is to identify the gap between the current state and the designated goal(s). This enables the company to see its current position with respect to the desired position, which leads to the identification of shortcomings or improvement opportunities/areas.
- *Planning the actions:* The identified improvement opportunities indicates the actions necessary to close the gap. Here, actions such as investing in new IT tools to optimize processes, or redefining processes through digital opportunities, are developed.
- *Analyzing feasibility and prioritization:* After the actions, leading towards the goal(s), are identified, a feasibility study should be performed. The study can involve cost-benefit analysis,

impact analysis on existing practices, risk analysis etc. Parameters such as education of staff, maintenance and the company's ability to change can be included. The feasibility study should result in a prioritization between the actions, if more exists, with respect to stakeholders, resources or other parameters relevant to the company.

- *Creating the roadmap:* After the prioritization, the arrangement of actions into a roadmap is enabled. Describing in which order the actions should be executed, the importance and impact for each action, and the individuals' responsibilities and roles for each action. (Parviainen, et al., 2017)

Step 4. Implementing the roadmap

The final step, which involves the actual implementation of the solution, as well as the validation. It is often useful, the authors mention, to firstly implement a proof-of-concept to evaluate how the change affects the organization on a smaller scale. The validation phase should investigate whether the actions resulted in the desired outcome, and corrective measures should be considered if not. Furthermore, the researchers mention a few obstacles for a successful digital transformation such as lack of a digitalization strategy, different competing priorities and inability to perform change. (Parviainen, et al., 2017)

3.5.6 Digital transformation: A roadmap for billion-dollar organizations

When examining the behavior of digitalization efforts in 50 companies, with $1 billion or more in sales, the authors Westerman, et al. (2011) could identify three main areas, customer experience, operational processes and business model, where digitalization efforts were focused. These three main areas are further divided into three elements respectively, to create nine elements, leading to the digital transformation of a company, as showed in *Figure 25*. The authors further state the importance of knowledge regarding digitalization and a company's digital capabilities, which is an essential enabler for all areas of digital transformations. (Westerman, et al., 2011)

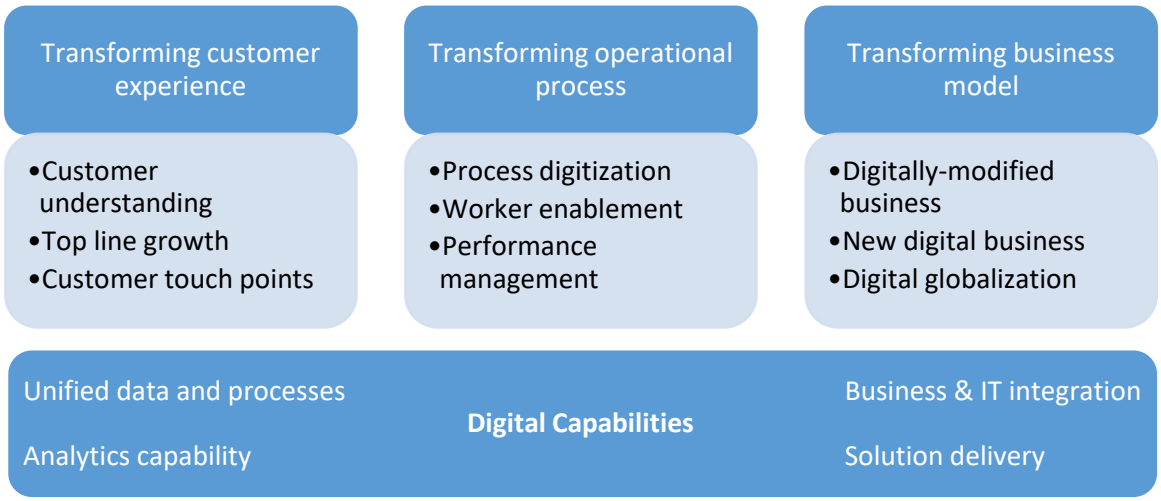

Figure 25 The building blocks of digital transformation (Westerman, et al., 2011)

1. **Transforming customer experience**
    a. *Customer understanding*: Organizations are utilizing and analyzing available data in new ways to gain more knowledge about the customers, knowledge that can lead to action plans regarding marketing for specific market segments etc. Other companies are using social media as a tool for evaluating customer satisfaction, customer behavior and self-promotion.
    b. *Top line growth:* The streamlining of sales processes creates an environment where the customers are more satisfied therefore more likely to purchase and return. This can be achieved by digitizing sales operations, substituting personal contact with virtual contact and storing purchase data to show frequently bought items.
    c. *Customer touch points:* Organizations explore new ways of reaching out and communicating with their customers for faster and more transparent service. Recent changes involve self-service via digital tools, transforming information and media from paper to electronic sources, social media address problems in a quick and transparent way, and smart phone applications.
2. **Transforming operational processes**
    a. *Process digitization:* Automation of processes and repetitive tasks enables a company to free resources, focus resources on strategic tasks and increase the overall productivity. The automation of processes can also create valuable data streams, enhancing process control by allowing real time measurements and adjustments of activities.
    b. *Worker enablement:* Connecting functions digitally separates the work process from a physical location, collects and archives data and enables an easy way to share information. Employees can communicate with individuals over vast distances and sent information can be stored, shared or adjusted instantly to inform important parties.
    c. *Performance management:* Internal data streams gathered from digitally transformed processes aids decision making by providing accurate real time information, whilst external data grants guidance for executives and managers when dealing with strategic decisions. However, an appropriate analysis method must be applied to ensure the integrity of the gathered data.
3. **Transforming business models**
    a. *Digitally modified businesses:* Digitally transforming or modifying sales channels, such as online shops, in combination with the existing physical sales channels, enables a company to serve more customers with less effort. In addition, the digital sales channels can utilize customer information for marketing purposes, presenting the right information to the right customers.
    b. *New digital businesses:* Expanding a company's product offerings where traditional products are complemented with optional digital products can benefit the customer. Optional or supplemental digital products, such as GPS trackers for sportswear, leads to new business opportunities. Other actors focus on transforming the customer's end-to-end experience, by offering an integrated platform on which the relevant information is gathered. Thus, facilitating the customer experience and co-creating value.
    c. *Digital globalization:* A company can, with the use of digital technology and integrated information systems, collaborate with distant internal or external facilities globally. Different departments can be strategically located instead of scattered around manufacturing plants, still accessing and providing the same information as if in close proximity. As an example, sharing local information regarding market fluctuations enables a manufacturer to shift production to facilities closer to the demand. (Westerman, et al., 2011)

Digital capabilities

Westerman et al. (2011, p 23) states that the digital capabilities are the enablers, or prerequisites, for transformation in customer experience, operational processes and business models. These capabilities are called *Unified data and processes, Solution delivery, analytics capabilities* and *Business and IT integration.* (Westerman, et al., 2011)

Unified data and processes

An integrated platform for data and processes is a fundamental prerequisite for digital transformation. These platforms enable a company to access and analyze data from the whole organization, whilst removing the need of consolidating data from several different systems. (Westerman, et al., 2011)

Solution delivery

The ability to modify and develop processes or systems coupled with the knowledge of key emerging technologies are some of the important traits for a company while undergoing digital transformation. These traits, which aids the solution delivery, are often acquired from external sources. However, Westerman et al, (2011, p. 24) states that over-reliance in external competence might result in a knowledge gap after a project is finished. (Westerman, et al., 2011)

Analytics capability

The analytical capability involves a company's ability to use analytics to makes sense of the immense amount of internal and external data concerning a company. Unified data platforms in combination with powerful analytical tools can bring a strategic advantage where decision-making is well informed and able to quickly act against fluctuations. (Westerman, et al., 2011)

Business and IT integration

The amount IT utilized by a company, in all areas, determines the business and IT integration. Companies that struggles with complex IT architectures, unintegrated data and processes, which are not well-suited or underequipped in terms of technology, are therefore at a disadvantage. (Westerman, et al., 2011)

4 Findings and Analysis: Literature Synthesis

The following chapter provides the reader with the results and findings from the literature synthesis, where the elements constructing the conceptual framework are described.

The thematic analysis used to answer *Research Question 1* focused on the themes and patterns, i.e. common characteristics existing in the literature involved in the study. These common characteristics, or elements, were further compared to established theory regarding *Organization- and Process Management, Improvement Work* and *Information Management* in an attempt to increase the trustworthiness and validity of the elements. This was performed to explore if methods regarding digitalization improvement efforts shared aspects with already established methods and theory. Therefore, the analysis of the literature synthesis provided common characteristics or elements, whilst the analysis with respect to the established theory provided the elements' validity. Below, in *Figure 26,* follows an illustration of the literature synthesis analysis.

> **RQ 1***: How would a framework capable of identifying digital improvement opportunities, based on common characteristics found in literature, be presented?*

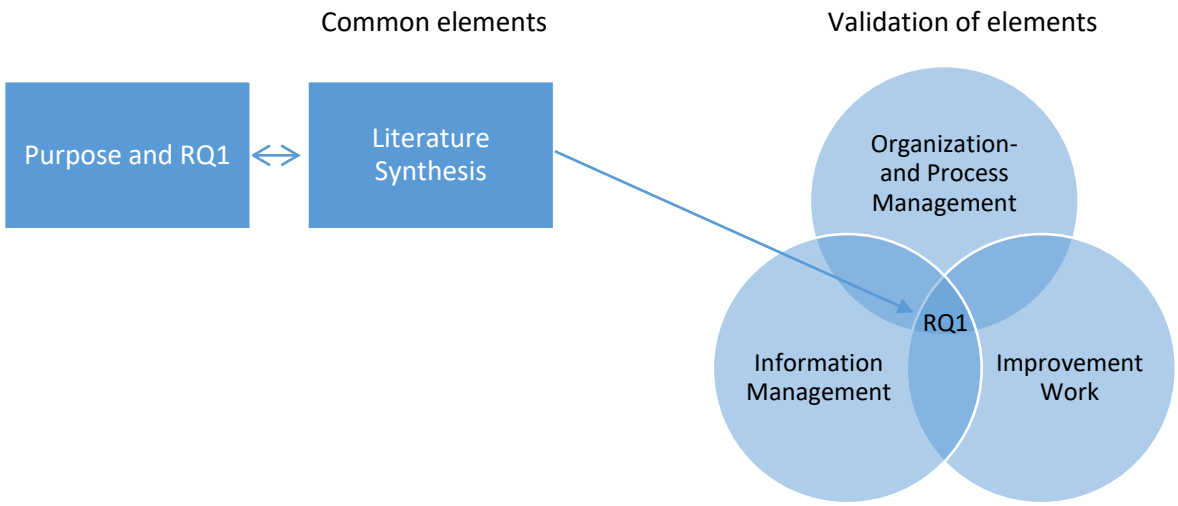

Figure 26 Illustration of the relation between the literature synthesis and established theory, which answers RQ 1 (Authors' image)

4.1 Findings from the Literature Synthesis Analysis

Below follows a brief presentation of the common elements, or elements of importance, found in the literature regarding the area of digitalization. However, interviews with two IT-consulting companies aided in developing the conceptual framework, the expertise of these parties were used in both the conceptual framework and the final framework. These elements, shown below, are composed of the common characteristics deemed relevant for identifying digital improvement opportunities.

4.1.1 Prerequisites When Working with Digitalization

Create an understanding regarding the subject

The initial step ensuring that all parties has the same understanding regarding digitalization, digitalization efforts and the solutions currently in existence. Thus, creating a sense of urgency and relevance for the client in the context of improvement efforts. (Parmar, et al., 2014) (Westerman, et al., 2011) (Kotter, 2007) (Bossen & Ingemansson, 2016) (Kagermann, et al., 2013) (Cybercom Sweden AB, 2018) (Supplementary IT Consultant, 2018)

Position the company and identify drivers

Positioning the company with respect to other companies in the same sector, as well as identifying the technological drivers for the sector. This step shares connection with the previous step, since the environment of the client's company, the position and the solutions currently in existence will affect the future path. (Parviainen, et al., 2017) (Westerman, et al., 2011) (Matt, et al., 2015) (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012)

Management's capability of leading change

Since improvements cannot exist without change, the capability of leading change and adapting to new concepts and innovations is of significance. This prerequisite is fundamental for the whole improvement efforts. Workshops could be utilized as a tool to increase the capability of leading change. (Kotter, 2007) (Parmar, et al., 2014) (Parviainen, et al., 2017) (Bergman & Klefsjö, 2001)

Create and communicate common objectives, strategies and a vision

To ensure that individuals involved are working towards the same objective and with the same action plan. Creates solidarity and increases commitment for the individuals affected by the change, to minimize conservative resistance. These objectives are on an organization wide basis. (Matt, et al., 2015) (Kotter, 2007) (Kagermann, et al., 2013) (Heberle, et al., 2017)

Involve external parties if necessary skills are missing

The technological skills or resources needed for a project can be found externally. (Parmar, et al., 2014) (Parviainen, et al., 2017) (Cybercom Sweden AB, 2018) (Supplementary IT Consultant, 2018)

4.1.2 Methods when Working with Digitalization

Define key areas, based on needs, drivers and position

The key areas where improvements efforts are to be focused involves concepts such as *production flexibility, productivity, speed* and *quality*. This area should be based on the client's needs, the position with respect to competitors and the market drivers. Furthermore, this step acts as an initial delimiter, as to narrow down the focus of the project. Concrete and quantifiable objective(s) are created to act as target values. (Rüßmann, et al., 2015) (Parviainen, et al., 2017) (Westerman, et al., 2011) (De Carolis, et al., 2017)

Identify the processes involved and create "*as is*" *model*
Identifying the key area and the process or processes influencing the area further narrows down the number of possible objects under investigation. The process in question and the relevant data should be mapped in an "*as is*" model to depict the current state. This current state serves as a reference point for future improvements, generates a common understanding of the process for all parties, and visualizes the system and its complexities. (Rüßmann, et al., 2015) (Parmar, et al., 2014) (Parviainen, et al., 2017) (Myndigheten för sammhällsskydd och beredskap & Riksarkivet, 2012) (De Carolis, et al., 2017) (Heberle, et al., 2017)

Create "*to be*"*, evaluate to as is and against the elements of digital transformation*
Create a desired state, which shares connections with the overall objectives of the improvement effort, based on the "*as is*" model. This step can incorporate the elements/patterns/pillars of digital transformation to explore different solution opportunities. The "*to be*" state must correspond to the concrete and quantifiable objectives/ target values previously stated. A GAP analysis assists in positioning the currents state to the preferred state, as to illustrate the distance. (Rüßmann, et al., 2015) (Parmar, et al., 2014) (Parviainen, et al., 2017) (De Carolis, et al., 2017)

Create and prioritize ideas based on feasibility and rationality
The desired state and the solution opportunities will enable the creation of improvement ideas. These ideas should enable the desired state and are also briefly prioritized by feasibility and rationality, i.e. are the ideas possible to implement and are they rational. Parameters of importance are time, resources and capabilities. (Parmar, et al., 2014) (De Carolis, et al., 2017) (Supplementary IT Consultant, 2018)

Analyze ideas for impact and identify important parameters
Here, an assessment of the organizational impact of the ideas, such as employee relocation, vocational training and recruitment needs to be performed. The parameters of importance, i.e. the parameters that can influence the implementation of the ideas needs to be identified. Such parameters can involve ongoing market trends, which the ideas must be validated against. (Parmar, et al., 2014) (Parviainen, et al., 2017) (Supplementary IT Consultant, 2018)

Planning actions for implementation
If the ideas are deemed possible to implement, the work of creating a road map for implementation can be created. This road map contains the necessary specifics regarding hardware, software and infrastructure as well as a description of the whole improvement project and its steps. (Parmar, et al., 2014) (Parviainen, et al., 2017)

Implement the ideas deemed most important and follow up
The ideas, deemed possible from the previous steps, are implemented as described by the road map. This phase is self-explanatory. However, a follow up phase should be performed after implementation, to ensure that the improvement resulted in a desirable outcome. Here, the "*as is*" and "*to be*" state acts as reference points. (Parmar, et al., 2014) (Parviainen, et al., 2017) (Cybercom Sweden AB, 2018) (Supplementary IT Consultant, 2018)

4.1.3 Challenges Associated with Digitalization

Competing priorities, Inability to perform change
Any kind of implementation requires knowledge and understanding of the challenges that a change can result in. A common mistake is that companies often have too many focus areas and objectives, which result

in competing priorities. This leads to confusion regarding which objectives and areas to focus on, and ultimately harms the ability to perform change. (Kotter, 2007) (Parviainen, et al., 2017)

Growing demand for customized and complex products, increase level of flexibility and sustainability
In order to survive, stay competitive or gain market shares, companies need to be adaptable and innovative, especially in technological areas. Common for all industries is the increasing demand for customized and advanced products and services. This imposes on companies the ability to act flexible and involve a sustainable thinking throughout all processes. (Leitao, et al., 2016) (Ribeiro & Björkman, 2017) (Bossen & Ingemansson, 2016)

Security
This involves the individuals able to access the information, but also the event of a security breach. The security of a digital system must be maintained constantly to ensure stability and prevent information leaks. However, the degree of security in a digital system depends on the information being handled. (Parviainen, et al., 2017) (Bossen & Ingemansson, 2016) (Ribeiro & Björkman, 2017) (Leitao, et al., 2016)

4.2 Findings from the Analysis with Respect to Established Theory

By analyzing the elements with respect to theory regarding *Organization- and Process Management, Improvement Work* and *Information Management,* the following developments were made to the conceptual framework.

Developments in accordance to the frame of reference
When comparing the elements to existing theory regarding Process Management, and the improvement tool DMAIC, certain similarities could be identified. These similarities further developed the conceptual framework by relating the elements to existing and established frameworks, methods and theories. This led to an aggregation of the elements that resulted in a model, easier to illustrate and manage as to display the phases, elements and tools. However, the conceptual framework is not identical to the improvement tool DMAIC, but similarities exists. Furthermore, tools and methods from Information Management such as Enterprise Architecture, Process-oriented information mapping with the addition of a swim lane chart to identify the departments or individuals handling the information, where incorporated in the conceptual framework. The conceptual framework, *Figure 27,* and the tools or methods utilized in each phase are presented below.

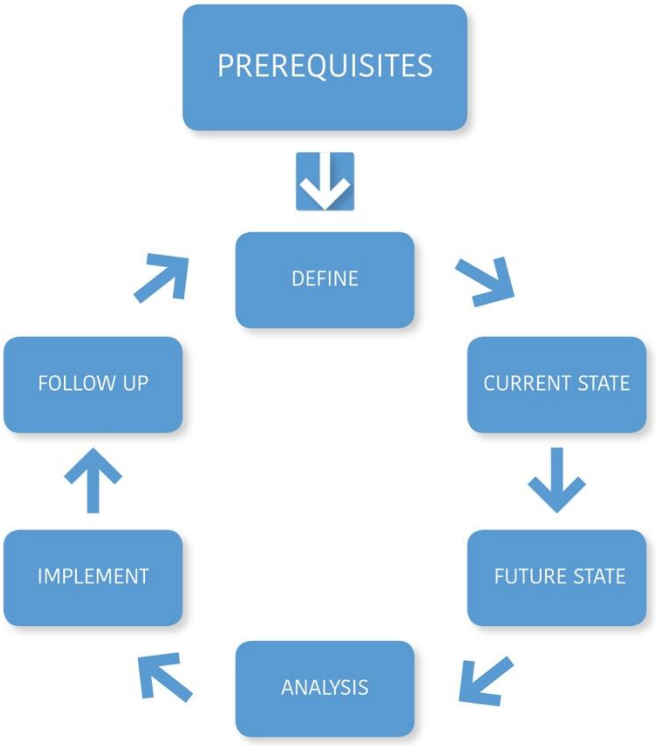

Figure 27 Illustration of the conceptual framework's main phases. (Authors' image)

The following paragraphs provides an explanation of the main categories, their elements and a suggestion of the tools utilized in each phase.

Challenges

The challenges associated with digital improvement work follows the conceptual framework throughout the whole project. These elements are dependent on the company and its data, where every case is regarded as unique. As an example, the organizational culture may impact the results of the project.

Prerequisites

- Create an understanding regarding the subject
- Position the company and identify drivers
- Ensure the management's capability of leading change
- Create and communicate common objectives, strategies and a vision
- Assess the necessary degree of security regarding the data handled by the company
    - Methods and tools: SWOT-Analysis and Benchmarking

Define

- Define key areas based on market position, market drivers and company needs
- Define the project scope, time span, available resources and roles
- Define the process(es) involved
- Define concrete and quantifiable objectives for the project

  - Methods and tools: Benchmarking, Gantt-chart, SMART-Objectives, Workshops and Brainstorming

Current State

- Map the current state of the process, involving the process(es), information flow(s), information set(s), information carrier(s) and information- user(s) and owner(s)
  - Methods and tools: Modified process-oriented information mapping

Future State

- Identify potentially valuable collected/uncollected and used/unused data
- Create a desired "*to be*" state
- Evaluate to "*as is*" / Current state
- Incorporate the elements/pillars/patterns of digital transformation to aid the idea creation process
- Create ideas, believed to enable "*to be*" state
- Evaluate ideas based on the preset limits, feasibility, ethicality, legislations, rationality etc.
  - Methods and tools: Modified process-oriented information mapping, GAP analysis, Simulations, Workshops and Brainstorming

Analysis

- Analyze organizational impact of ideas
- Analyze how the ideas can help improve the competitive advantage
- Analyze with respect to the required data, software and hardware
- Analyze scenarios where the ideas are successful or unsuccessful
- Identify parameters which can influence the ideas and scenarios
  - Methods and tools: Evaluation matrix and Enterprise Architecture Framework

Implement

- Create a road map for implementation for the remaining idea(s). The road map is a project planning report where the whole implementation phase is documented. (This phase can involve one or several ideas, depending on the individual ideas' scope and resource consumption)
- Perform the implementation according to the project plan.

Follow up

- Follow up to investigate if the result met the objectives, i.e. ensure stakeholder satisfaction
- Ensure that no problem shifting occurred
- Ensure sustainability (usage of the implemented improvement)

These phases, elements and tools were further evaluated in the case study, presented in the subsequent chapter *5 Findings and Analysis: Case Study.*

5 Findings and Analysis: Case Study

The following chapter provides the research procedure, findings and analysis of the case study. The case study involves the observations, interviews and workshops performed during the study, leading up to the final framework.

The case study and external innovation partners, utilized to validate the practical applicability of the framework, sought to answer *Research Question 2* and *3*. However, the opinion and expertise of the external innovation partners were also included in the construction of the conceptual framework. Below in *Figure 28*, follows an illustration of the framework development, from conceptual- to final framework.

> **RQ 2**: *How can digital improvement opportunities be prioritized and evaluated, to create value for an organization, whilst being practicable?*
>
> **RQ 3**: *Which information is necessary to retrieve, to successfully implement digital improvements?*

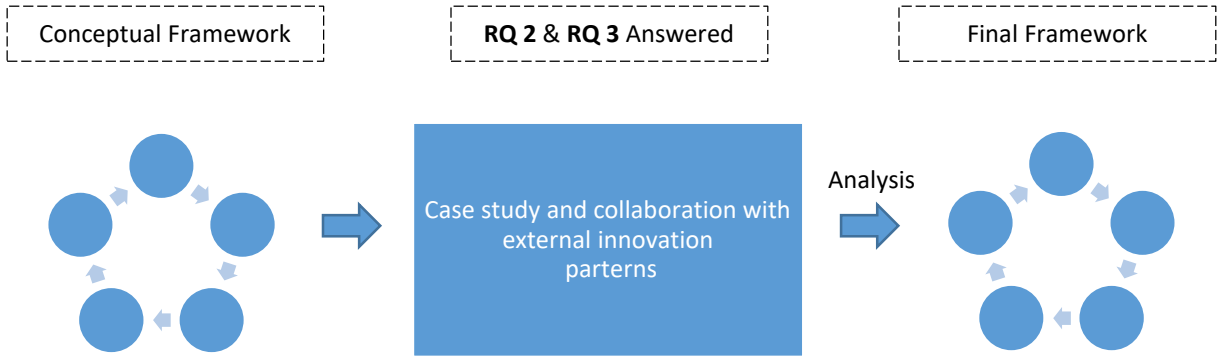

Figure 28 The development of the framework (Authors' image)

The preliminary framework was developed in collaboration with the case companies. The following chapters provides the results and findings from the case study. The procedure followed four phases, *Introduction, Observation and Interviews, Workshop* and *Development.* These are described further in the subsequent chapters. Interviews with external parties contributed with knowledge regarding their own methods when working with clients. These interviews focused on validating the conceptual framework's phases and elements, based on their expertise in the field.

5.1 Introduction

The introduction phase started with a simple presentation of the thesis, the authors and the involvement of the case companies. The participants were the CEOs of the case companies. The case companies' roles were defined as development partners and test subjects for the conceptual framework. To evaluate whether certain elements were valuable or not. Educational seminars were also held to increase the understanding regarding digital technologies, the technologies used by the company and technologies used in the same sector. The seminars served the purpose of establishing a shared view of digital improvement efforts as well as illustrating the impact of these efforts in other organizations.

Findings from the introduction

This phase primarily focused on the thesis, the CEOs current understanding and the involvement or role of the case companies. The findings, affecting the conceptual framework, were:

- The importance of knowing the sector or industry culture
- The importance of knowing the organizational structure and culture
- The importance of committed and motivated leadership

These findings provided the empirical foundation for the elements of the *Prerequisites* phase, since the behavioral barriers were seen as a factor, which can influence the outcome. Furthermore, the respondents were committed to the task and had a positive attitude towards change, understanding of the barriers of change and the importance of being able to change.

5.2 Observation and Interviews

In addition to the introduction and educational seminars, the CEOs also contributed with a description of the organization, its values, the core process flow and a fraction of the information flowing around the core process. The information flows of the core process were later used as the primarily investigation area for finding digital improvement opportunities.

5.2.1 Findings from the observation and interviews at the case companies

The process map was created by observations and interviews, where the core process from, input to output, was observed, to visualize and concretize the flow of products. The observations were supported by interviews to ensure a shared view from both the authors and the system experts. This resulted in a preliminary information map, where the current information, created, sent or received, by each sub process were described.

5.2.2 Findings from the interviews with external innovation partner Cybercom

The interview with Cybercom focused on their current way of working with clients, to receive input to the framework's structure, method and tools. The findings, and how these findings affected the framework, is presented below.

Working process with clients, in short

The process is initialized with a workshop, where representatives, from Cybercom and the client, are present. The objectives of the workshop are to increase the client's knowledge regarding existing technological advancements, as to broaden the client's perspective in the context of digitalization, as well as reaching a common understanding of the client's perceived improvement area(s). Further, a minimum viable product containing the core functions is created, to illustrate a possible solution. The whole process

builds on close collaboration with the client, in an iterative way, to ensure that the client's needs and requirements are fulfilled.

Impacts on the framework
Cybercom, as an innovation partner with experience in the field, brought the following notes to the framework:

- The importance of the client's knowledge regarding digitalization. This knowledge can increase during workshops with examples of technological advancements implemented by other companies.
- The importance of starting small, i.e. minimum viable product, as to spend resources efficiently.
- The importance of a close collaboration with the clients. Since the client's technological expertise might be limited (the reason for contacting an external innovation partner) and the innovation partner has limited knowledge regarding the client's organization, a close collaboration ensures that the right parameters, requirements and improvement areas are included.

5.2.3 Findings from the interviews with supplementary innovation partner

The first interview with the supplementary innovation partner focused on evaluating the conceptual framework's elements, to investigate if the elements are appropriate on broader scope. No deep analysis was performed but rather a brief discussion comparing the conceptual framework to their own methods.

The second interview focused on the information needed to fulfill the client's requirements. Hence, the interviews resulted in the specification that the supplementary innovation partner utilizes to deliver the final product. However, the work is performed over a period of several weeks, or longer, depending on the project's scope and the knowledge of all involved parties. Situations arise where the client already knows its needs, these projects are finalized earlier. Furthermore, important elements regarding the developing process of products involved close collaboration during the development phase, and efficient resource usage by prioritizing high yield efforts.

Evaluation of the conceptual framework

- It is important to create a shared understanding regarding the subject
- If the necessary skills or knowledge are missing, it is favorable to have a close collaboration with the client
- Complex ideas are often difficult to imagine, therefore, when first attempting an improvement, the ideas are evaluated on a basic level. Often, a minimum viable product is created to show core functionalities before an actual implementation of the finished product.
- The impact on the organization is important to assess, especially if the improvement concerns data that is regulated by laws. This can bring a new dimension of security to the organization.

Impacts on the framework

- What or which kind of data that is necessary to gather, analyze and present.
- Where the data source exists, i.e. on a server, in a machine or a physical location.
- When the data is created, if it is created, otherwise a creation or gathering method must first be in place. In addition, when the data should be available or for how long the data is relevant for the involved parties.
- To whom the data is important, i.e. who will receive the analyzed data and on which form.

- Why the data is important, sets the prerequisites for the work such as security, analysis method and presentation form.
- Working closely with the client to ensure customer satisfaction
- Creating a minimum viable product to display core functionality

5.3 Workshop

To further evaluate the conceptual framework, now consisting of the theoretical findings and a part of the empirical findings, a workshop was held with the case companies. Discussions with the parties involved were held during the workshop to promote an open dialogue, with the purpose of reaching a conclusion through collaboration. The workshop was divided into three main phases further described below.

Presentation
The conceptual framework, illustrated in *Figure 27,* was presented to the case companies along with the theoretical foundation, which the conceptual framework relies on. Further on, a description of the phases was held to provide the participants with an overview of the conceptual framework. This was followed by a detailed description of the elements in each phase and related tools used in each phase. Lastly, the procedure when working with the conceptual framework were explained, in order to evaluate the practical applicability.

Implementation with a test case
To investigate whether the conceptual framework's phases are relevant and applicable, a test case was constructed. The purpose of the test case was to create a discussion regarding the conceptual framework and its practical applicability, I.E how it is used in a real-world scenario. Furthermore, the test case was constructed with respect to the actual information flows in the organization, as to depict the reality as close as possible. However, a real implementation requires more time and resources, to reach a successful conclusion. Below follows a description of the test case procedure.

Initially, the *Prerequisites* phase was constructed by the authors, based on the previous steps in the case study. Here, the understanding regarding the subject was constructed earlier and a common improvement area, for both companies, were identified during the observation and interview steps. The *Prerequisites* phase would usually be performed over a longer period; however, an adequate scenario was picked for the test case due to time limitations. The evaluation of the phases and their feasibility was more relevant than the resulting solutions.

The *Define* phase managed to delimit the improvement area based on the companies' needs, market drivers and market position. The project scope, time span etc. assumed arbitrary but realistic values for the test scenario, as to enable creativity under realistic circumstances. The processes involved were identified and a single quantifiable objective were constructed.

Based on the information gathered in the previous steps, the creation of a *Current State* was performed in collaboration with the participants. The method used was a modified process-oriented information map containing the processes, information- flows, sets, carriers, owners and users. An example of the map is provided in *APPENDIX B.*

The *Future State,* where a desirable state should be specified, had the *Current State* as its starting point. The process began with a discussion regarding the collected or uncollected data, which are either used or unused, and could provide value for internal or external customers. The modified process-oriented information map, created in *Current State*, therefore assisted in visualizing:

- Gaps in the information flow
- Unnecessary information flows
- Inadequate information flows
- Time delays
- Missing information flows etc.

By visualizing the current information- and process flow and allowing an open discussion with the stakeholders and system experts, a *Future State* could be developed. This *Future State* were evaluated against the *Current State*, where the gap provided the missing, inadequate or unnecessary information flows etc. Further on, ideas were created capable of reaching the *Future State*, based on the gap visualized in the process-oriented information map. These ideas underwent a brief evaluation based on feasibility, the preset limits of the project, ethicality, legislations, rationality etc.

The ideas, now proven at least feasible, had to be analyzed further, in the *Analysis* phase, to assess the organizational impact and the potential direct or indirect benefits. However, the current capabilities regarding software, hardware and technological competence hade to be considered in order to evaluate the ideas' compatibility. This highlighted the necessary components required to realize the ideas. Later on, scenarios where the ideas were successful or not were created based on the organizational impact, to enable the identification of important parameters. As an example, the employees affected by the change, must be able to adapt to the change.

The *Implement* and *Follow up* phases were discussed, not performed, since the workshop only involved a test case. Therefore, no actual implementation of any ideas was executed, thus, no follow up was necessary.

Feedback and findings from the workshop
Evaluation of the framework was conducted through the whole workshop and feedback was received continuously. The discussed subjects are presented below:

- The importance of collaboration and communication between involved parties
- Clearly declaring the purpose of the improvement work for the involved individuals.
- The responsibility of the top management, to motivate and lead the organization towards its desirable state.
- The modified process-oriented information map was seen as a good tool to visualize the information flows, its users and the process flow, giving a holistic and comprehensible perspective.
- Behavioral and cultural barriers were believed to have a major impact on the improvement work and its result. Where, as an example, an improvement incorporated but not accepted or utilized by the individuals involved brings no value.
- By visualizing the information flows with the modified process-oriented information map, the departments, and thus, the individuals directly affected by the change are identified. Therefore, aiding in analyzing the organizational impact and indicating where resources and effort should be focused.
- The analysis phase, where ideas or digital improvement opportunities are evaluated, can benefit from an evaluation matrix, to further evaluate and possibly prioritize ideas. However, the evaluation matrix's criteria should be organization specific.

5.4 Analysis and Framework Development

The interviews with the external and supplementary innovation partners focused on the validity of the phases and elements, to assess whether the approach was rational from a system expert's perspective.

Therefore, the input from these individuals was seen as trustworthy, based on their expertise and experience when working with digital improvements.

The case study utilized to validate the framework's practical applicability underwent a brief analysis, since the conceptual framework could be applied in a real-world environment. However, some factors could impact the results from the case study, negatively affecting the conceptual framework's practical applicability, these factors are described below.

- The respondents had an open mind and a positive approach against technological development, which resulted in a case study that met minimal resistance. In contrast, if the respondents were conservative or unmotivated to change, the conceptual framework could have been developed differently.
- The case study was limited to the Swedish forest sector, which could affect the generalizability of the study, and ultimately the conceptual framework. However, the conceptual framework relies on the three theoretical main areas of the study, and the generalizability is discussed in *2.5 Expected Generalizability*.
- The case study was limited to two case companies. This can be considered as negative for the evaluation of the conceptual framework where a larger number of companies involved could lead to a different conceptual framework. However, the time and resources available limited the study to two case companies.
- One representative from each company acted as respondents, this could harm the conceptual framework where more representatives from each department could mitigate possible biases or lack of expertise. However, the CEOs from each company had a good understanding and holistic perspective of their organization, in combination with the authority to make decisions. This direct contact reduced the range of communication and enabled the conceptual framework to be constructed from a CEOs' perspective.

Impact on the conceptual framework

- More weight on the modified process-oriented information map, where the level of detail should be on an understandable level. An unnecessary complex and detailed map can result in confusion, which reduces the visualization of potential improvement areas. Several smaller maps were considered superior to one larger and complex map.
- The behavioral and cultural barriers, based on the respondents' previous experience, were considered to have a major impact when implementing digital improvements. Therefore, more focus should be directed to the organizational analysis.
- When working with the conceptual framework, it is of importance to involve the right stakeholders. These stakeholders can be employees, internal- and external customers. The process-oriented information map might identify stakeholders affected by changes in the information flow. This enables organizations to focus resources effectively.
- The conceptual framework is capable of filtering different digital improvement opportunities, based on an organization's objectives, strategies and vision, and going through the framework, down to the analysis phase where these opportunities are evaluated and prioritized. Therefore, a consistent line between the phases must exist.

- The conceptual framework is capable of identifying the information necessary for realizing the digital improvement opportunities. Which puts emphasis on the *Current-* and *Future State*, where the information flows need to be explicitly described.

6 FINAL FRAMEWORK

This chapter presents the final framework, which consists of the theoretical and empirical findings gathered and analyzed throughout the study, as well as an explanation to the phases and elements involved in the final framework.

The final framework its phases and elements are explained in the subsequent chapters. Below, in *Figure 29* follows an illustration of the final framework. The phases are the components visible in the figure, whilst the elements are the subcomponents described in each phase.

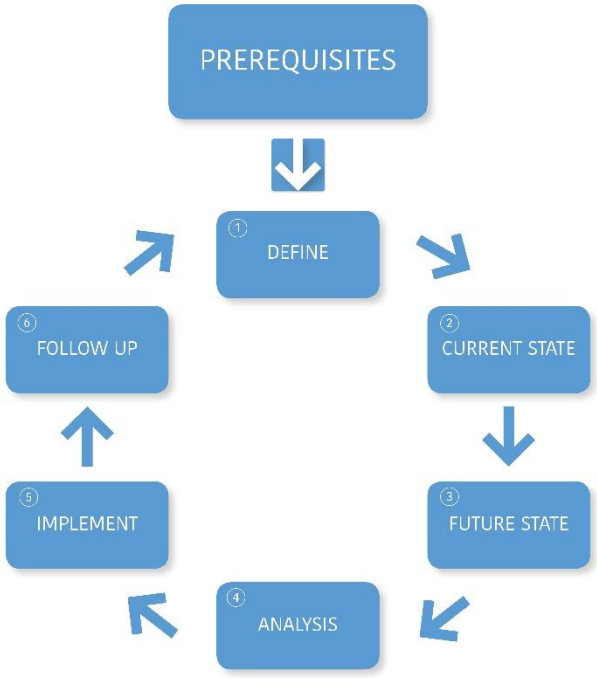

Figure 29 The final framework (Authors' image)

6.1 Prerequisites

The *Prerequisites Phase* has its focus on the organization and the management, therefore excluded from the improvement cycle. Here, a common understanding regarding the subject is created to ensure that the involved parties has the same point of view. Different concepts, terms, efforts and related topics of interest are discussed and explained. This should create a sense of urgency by highlighting the potential benefits and risks of neglecting development.

The position of the company in relation to other competitors on the same market has to be evaluated, to investigate the strengths, weaknesses, opportunities and threats in the industry. This is preferably performed with the assistance of a SWOT-analysis, or alternatively external benchmarking. In addition, the market drivers and/or order winners currently in existence depicts the customers' needs. However, considerations

regarding market driver fluctuations and customer demand variations are of importance. Miltenburg's Framework can be utilized in this phase.

The management's capability of leading change is crucial for the whole development/improvement process. The understanding of how individual behavior and organization culture affects, or is affected, by change is vital for improvement work. This is coupled with the ability to create and communicate shared and organization wide objectives, strategies and a vision of the organization future position. To ensure that the organization strives in the same direction by creating commitment and a sense of solidarity. Education, such as workshops, for management positions can increase the capability of leading change.

The necessary degree of confidentiality or transparency must be established when handling an organization's data. An assessment of the laws regulating the data as well as data that, for other purposes, should be confidential or accessible, will impact the degree of security.

6.2 Phase 1: Define

The process continues by combining the company needs with the previously identified market- position and drivers. This will assist in defining the key area for further investigation, such as production flexibility, productivity, quality etc. as to delimit the focus area of the digital improvement work. Workshops/brainstorming and benchmarking could be utilized as tools for identifying the key area.

Further on, the project scope, available resources, responsibilities and processes involved are defined, to effectively and successfully manage the project. The roles of the project are based on the key area and processes, where an individual with decision-making authority should govern the project in collaboration with system experts. By establishing concrete and quantifiable objectives for the defined project, involving the key area and processes, a measurable target to reach is created. The project could follow basic project management principles, utilizing SMART-Objectives and Gantt-chart etc. as tools.

6.3 Phase 2: Current State

When the appropriate process has been defined, the procedure continues by mapping the current state. This was performed, in this study, with a modified process-oriented information map. The map visualizes the information- flows, sets, carriers, owners and users, to give a holistic and comprehensible perspective. Here, it is appropriate to use several small and understandable maps, in contrast to one large and complex map. An example of a modified process-oriented information map can be found in *APPENDIX B.*

6.4 Phase 3: Future State

With the *Current State* mapped, the next step in the procedure is to create a desirable condition, called *Future State*. By visualizing the information flows with respect to the process, it is easier for involved stakeholders to assess the current situation and find improvement areas. Here, the information- flows, sets, carriers, owners and users are evaluated in an attempt to find unnecessary, inadequate and missing information flows, as well as gaps and time delays in the information flows. Different strategies can be utilized to find these potential improvement areas, but one aspect of importance is the quality of information. The dimensions of information quality must be taken into consideration, as an example, too accurate or redundant information will not necessarily improve the process, i.e. the information quality must match the purpose. The work with creating a *Future State* is preferably performed within a workshop using the modified process-oriented information map, involving the stakeholders. These stakeholders are identified by the information flows, i.e. the information owners and users.

By visualizing the *Future State* and comparing it to the *Current State*, the differences are illustrated and concretized. These differences depict the *Current State's* deficiencies, as to clearly show the information flow that needs to be investigated further. As an example, a GAP analysis can be used as a tool for comparing the differences between the states.

When the improvement area is identified, the procedure continues with the idea creation process. This process attempts to close the gap between the *Current State* and the *Future State*. The elements, pillars or patterns of digital transformation can be used as inspiration for the idea creation process. These ideas, now believed to enable the *Future State* should be evaluated based on the previously stated limits of the project involving areas such as feasibility, ethicality, legislation, rationality and environmental aspects. To enable out of the box thinking a brief evaluation is preferred in contrast to a resource consuming investigation of all the possible ideas. A deeper analysis will be performed in the subsequent phase. Again, a workshop or brainstorming session or simulations can be used to create or evaluate ideas. This is the first filtering phase for the ideas.

6.5 Phase 4: Analysis

The *Analysis* phase serves to examine the ideas through different perspectives. The organizational impact such as changes in working conditions or employee repositioning etc. should be evaluated to assess the necessary counteractions. Vocational education depending on skills and competence within the organization and other actions can be included in this step. However, the human behavioral is an important factor, and the resistance to change can alter the outcome of any project. Therefore, a thorough investigation of the individuals affected by the change, identified by the modified process-oriented information map, must be performed. An analysis of the required data, software and hardware necessary to realize the idea will evaluate its compatibility with other components of the organization. These evaluations can be performed with tools such as Root Cause Analysis, Enterprise Architecture Framework and Failure Mode and Effects Analysis, to assess the risk regarding the changes.

Further on, the ideas' ability to improve the organization's competitive advantage, with respect to external factors such as customer values etc. should be analyzed to prevent the scenario of implementing an improvement which improves a process but harms other areas. Here, customer or market analysis and other tools to evaluate external factors can be utilized, this analysis shares connection to the *Prerequisites* phase, but is performed on a more detailed and idea specific level.

The next step in the *Analysis* phase is to create scenarios where the ideas are successful or unsuccessful and attempt to identify the parameters or factors that can influence the outcome. Here, the changes or alterations necessary are put into a broader context to predict the outcome. Such a scenario can be the event of individuals' resistance to change to a new software, where the parameters of importance are the competence level, and the actions to prevent failure is to educate and increase the understanding of the new software. Other factors can be political agendas, laws and regulations, and drastic changes to the market. By identifying these factors or parameters, countermeasures, if possible, can be created to ensure the ideas' survival after implementation. Tools to work with these scenarios are workshops or brainstorming.

The ideas remaining are now ensured to be able to improve the organization, unable to harm other areas and the parameters, which can influence the outcome, are identified. The last step will attempt to prioritize or rank the ideas based on parameters set by the organization. As an example, these parameters can include risk of failure, cost, time to complete etc. and can be investigated by an evaluation matrix. Furthermore, the

Current State, *Future State* and *Analysis* phase, collects and indicates the information necessary to realize the definitive idea. The information regarding *which* data, *receiver*, *owner*, *transmitter*, *origin place* and *point in time* and *relevancy* can be gathered throughout the framework.

6.6 Phase 5: Implement

The idea(s) deemed most appropriate for implementation are now identified and filtered through the whole procedure. The following phase will take the ideas and create a new project for implementation. This project can follow standard project procedures. However, it is necessary to evaluate if the required skills and knowledge for implementation exists in the organization, or if the implementation phase should involve external partners. A decision whether to implement the idea(s), now considered a digital improvement opportunity, as a pilot project or on full scale is also considered in the *Implement* phase. Project management tools can assist in the implementation of the ideas.

6.7 Phase 6: Follow up and repeat

The *Follow up* phase investigate if the project succeeded in reaching the target objectives. This phase should evaluate the stakeholder satisfaction, outcome and sustainability, to ensure that no problem shifting occurred. Following up and controlling the improved areas can unveil valuable learnings for future improvement work.

7 CONCLUSION

The following chapter concludes the study by answering the research questions as well as providing a motivation of the prioritization process, answering Research question 2 and 3.

This chapter concludes the study by describing how the purpose and research questions were answered, leading to the final framework. In the subsequent chapter *7.1 Answering the Research Questions*, follows motivation and reasoning regarding how the study answers the research questions.

This chapter provides the reader with the conclusion of the study. The subsequent chapter *7.1 Answering the Research Questions*, attempts to illustrate how the purpose of the study and the research questions were answered with the qualitative methods of a literature synthesis and a case study. Where, the literature synthesis resulted in a conceptual framework and the case study attempted to evaluate the practical applicability, leading to a final framework. The final framework is therefore theoretically based and evaluated in collaboration with the companies involved in the case study, illustrating applicability. The path towards the final framework is illustrated in *Figure 30*

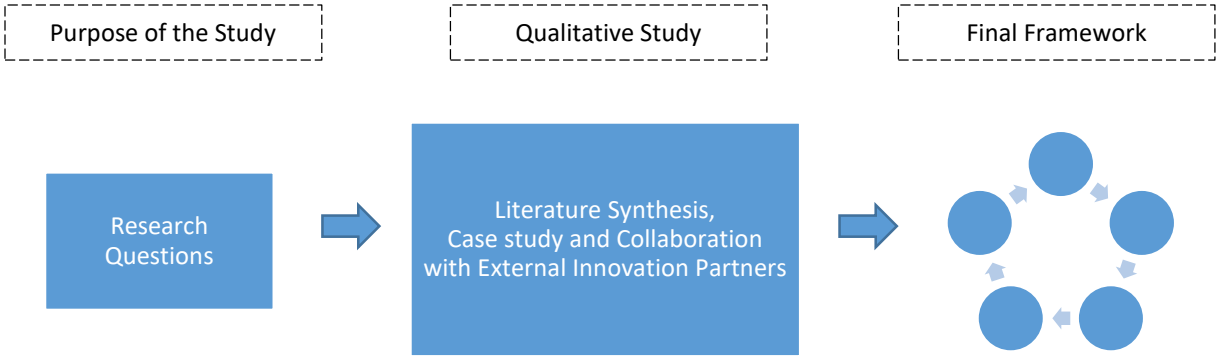

Figure 30 The path towards the final framework (Authors' image)

7.1 Answering the Research Questions

To sufficiently answer the stated research questions, theory regarding *Organization- and Process Management, Improvement Work* and *Information Management* were combined with a literature synthesis concerning digital improvement efforts, and a case study involving two Swedish companies in the forest sector. This resulted in the following conclusion regarding the research questions:

RQ 1: *How would a framework capable of identifying digital improvement opportunities, based on common characteristics found in literature, be presented?*

RQ 2*: How can digital improvement opportunities be prioritized and evaluated, to create value for an organization, whilst being practicable?*

RQ 3: *Which information is necessary to retrieve, to successfully implement digital improvements?*

The framework capable of identifying digital improvement opportunities, which answers *Research question 1* is presented in the previous chapter *6 Final Framework.* The elements of the framework are composed of the common characteristics found in the literature synthesis and further evaluated by established theory and methods. The literature synthesis, triangulating common characteristics, is believed to increase the internal validity of the elements involved in the framework. Whilst the evaluation and comparison to the established theory and methods is believed to increase the external validity or generalizability.

To answer *Research question 2*, a demonstration of the framework's capability to narrow down focus areas and prioritize ideas based on the organization's criteria, market factors or needs is presented below. A motivation for the answer to *Research Question 3* is also provided in the end of this chapter.

The P*rerequisites* phase investigates external factors such as the organization's position on the market, the market drivers, and thus, the customer values and needs, to initiate the improvement process. Further on, the *Define* phase continues by combining the position and market drivers with the needs of the organization to identify the key area. This key area, which could involve production flexibility, productivity and quality, should share correlation with the market drivers, organization position and the needs of the organization. As to ensure the key area's positive impact on the organization's competitiveness. By defining the key area, the processes capable of directly influencing the key area can be identified, which further narrows down the focus area by involving internal factors.

The *Future State*, which now handles ideas capable of realizing the desired state, filters the ideas based on the preset limits of the project. Here, a brief evaluation attempts to sort out the ideas that are strictly unfeasible or irrational. In short, the ideas are allowed to be ambitious but not illegal, as to encourage out of the box thinking.

Further on when entering the Analysis phase, a deeper evaluation and analysis is performed on the ideas. Here, the organizational impact is analyzed, changes such as reallocation of staff or equipment, vocational training, restructuring of the organization and departments etc. are accounted for to assess the resulting alterations to the organization. The existing or missing technological capabilities of the organization are also evaluated in the *Analysis* phase. These technological capabilities can involve hardware, software and data necessary for realizing the *Future State.* The final evaluation, which can be performed by an evaluation matrix, now incorporates the outcome of the ideas and attempts to prioritize by the organization's own parameters of importance.

The framework's procedure ensures that the ideas, now considered a digital improvement opportunity, are connected to the organization's objectives, strategy and vision, as well as external factors involved in the *Prerequisites* phase and lastly evaluated and prioritized in the *Analysis* Phase. Furthermore, the information necessary to realize the ideas is provided in the *Current state*, *Future State* and *Analysis* phase, as described in chapter *6.5 Phase 4: Analysis*. This reasoning and explanation serves to answer *Research Question 2* and 3. A figure of the "*filtering process*" is illustrated below, in *Figure 31*.

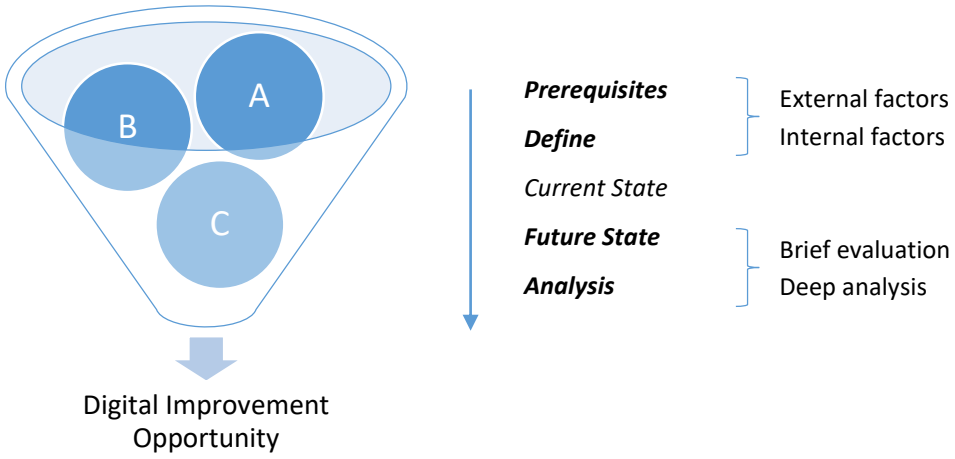

Figure 31 An illustration of the framework's "filtering process" (Authors' image)

8 DISCUSSION

This chapter contains a discussion and the opinion of the authors regarding the study, its ethical aspects, limitations and research contribution, as well as the future work.

This study was a collaboration involving Linköping University, the consulting firm Propia AB, the business cluster Paper Province, the case companies Nykvist Skogs AB and Bäckebrons Sågverk AB and the IT consultant company Cybercom Sweden AB. The involvement of several parties and stakeholders provides robustness to the study by including competence and experience from different areas. Furthermore, the individuals involved were positive and committed to contribute time and resources to the study, which resulted in a study with good initial conditions. The framework creation process was time and resource consuming, due to the size and relatively undefined research area. In addition, the number of stakeholders and their geographical dispersion resulted in the situation where time and resources were limited. Therefore, investing more time and resources in the framework would benefit the development by enabling more input from other parties. However, the framework's theoretical foundation is believed to be solid and is an appropriate starting point for further empirical testing and development.

During the case study with the involved companies, a certain barrier to change were mentioned more often compared to others. The most concerning barrier was the individual's resistance to change when using new technologies or working methods. These concerns were based on years of experience as managers and CEOs, managing different departments and individuals. Therefore, the organizational impact regarding changes in working methods, reallocation of staff, reorganization etc. must be analyzed thoroughly and in detail. Otherwise, the risk of implementing an improvement, which is not accepted nor understood by the employees, might harm the outcome of the improvement.

8.1 Ethics

Since the study involved interviews and personal contact where information was exchanged between several parties, the basic principles of informed consent, anonymity and confidentiality were applied. The involved individuals were all supplied with the information of their involvement beforehand, as to ensure their awareness. Furthermore, their anonymity was honored, whilst confidentiality of the information provided was respected to the degree agreed upon. Therefore, the report will not provide any transcript or documentation of the interviews, workshops or other sensitive information, only summaries of the events or arbitrary illustrations.

The framework, on the other hand, might lead to other ethical complications. Since the framework can handle information of different degrees of sensitivity, the ethical aspects must be ensured by its user. Moreover, improved information management can lead to increased traceability, which might impose problems for individuals where their integrity is exposed. As an example, by tracing a faulty product back to its origin, the individuals handling the faulty product are exposed. Thus, depending on the level of detail, the integrity of the individuals is compromised. The same arguments can be applied to confidential information, where the user of the framework might be an individual who is not eligible to access certain information.

8.2 Limitations

All studies have its limitations regarding time and resources. This study was performed over a period of approximately 20 weeks with the participation of two authors, two representatives from two case companies, one supervisor from the Linköping University, one supervisor from Propia AB, one supervisor from Paper Province and two external IT consultants.

It is understood that additional time would benefit the study, since it would enable a deeper investigation of the elements constructing the framework. A larger set of case companies, preferably from different industries or even countries would also contribute to the generalizability and robustness of the study and its framework. The same applies to the amount of system experts involved, where additional expertise and experience would benefit the framework.

8.3 Research Contribution

The concept Industrie 4.0 is nowadays an often-discussed topic; however, the path towards Industrie 4.0 is not as clearly defined as the concept itself. The idea relies on a highly digital and connected organization, which is capable of handling vast amounts of data and information. Previous studies regarding digitalization efforts are mainly performed at a single company and the methods described were often company specific or untested on other companies or sectors. Therefore, a research gap exists concerning a general framework for identifying digital improvement opportunities.

In addition, organizations surrounded by technology are having a hard time to adapt to the technological advancements (Brinker, 2016). This is due to the exponential development pace of technology, illustrated by Moore's Law (Salem Press Encyclopedia of Science, 2017). When comparing the adaptability of organizations with respect to technology, a wide and growing gap is visible. To close this gap, a digital transformation or digital improvement is necessary, as shown in *Figure 32*.

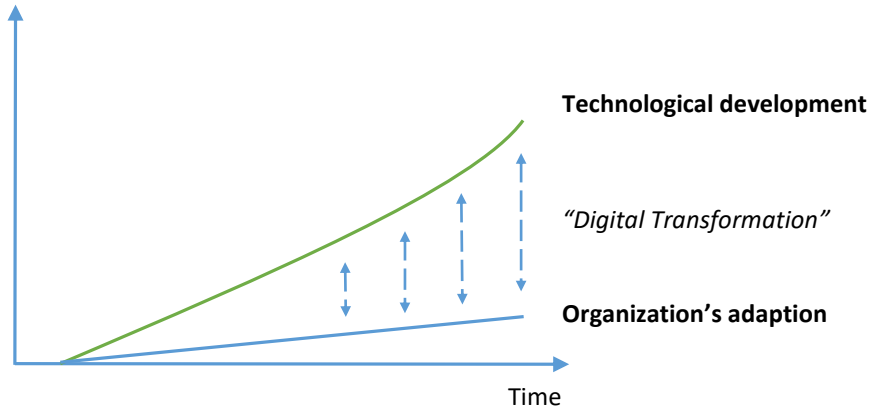

Figure 32 The gap between organization's technological adapation and technological development (Brinker, 2016)

According to McKinsey & Company (2015, p.7) "*the value lies in end-to-end optimization of the* "*digital thread*," *(i.e., making better use of information not captured/made available/used today) and in eliminating inefficiencies caused by information losses at the interfaces of functions, sites, and companies*". With this perspective, the master thesis attempts to close the perceived research gap, which also affects an organization's ability to adapt to new technologies.

8.4 Future Work

The following actions could be of interest for future work:

- Further analysis of the elements involved in the framework
- Further development and evaluation of the framework by implementation at an organization during a longer period to assess its applicability from start to finish
- Development of the tools and methods incorporated in the framework
- Test the framework's generalizability by implementation at a vast amount of different organizations and industries

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APPENDIX A: Search terms

Search terms:

1. Frameworks for digital improvement implementations
2. Prerequisites for digital improvement efforts
3. Challenges of digital improvement implementations
4. Benefits of digital improvement efforts
5. Definitions and theoretical background

Keywords:

- Digitalization frameworks
- Digital transformation
- Digitalization efforts
- Digitalization methods
- Towards digitalization
- Digitization
- Digital solutions
- Digital information flows
- Management of information flows

Databases:

- Linköping University library

APPENDIX B: Modified process-oriented information map

An example of the modified process-oriented information map, where the current and future state as well as the differences are visible. The red arrows depict the desirable path of the information flow. This is an illustration without connection to the case companies or the workshop.

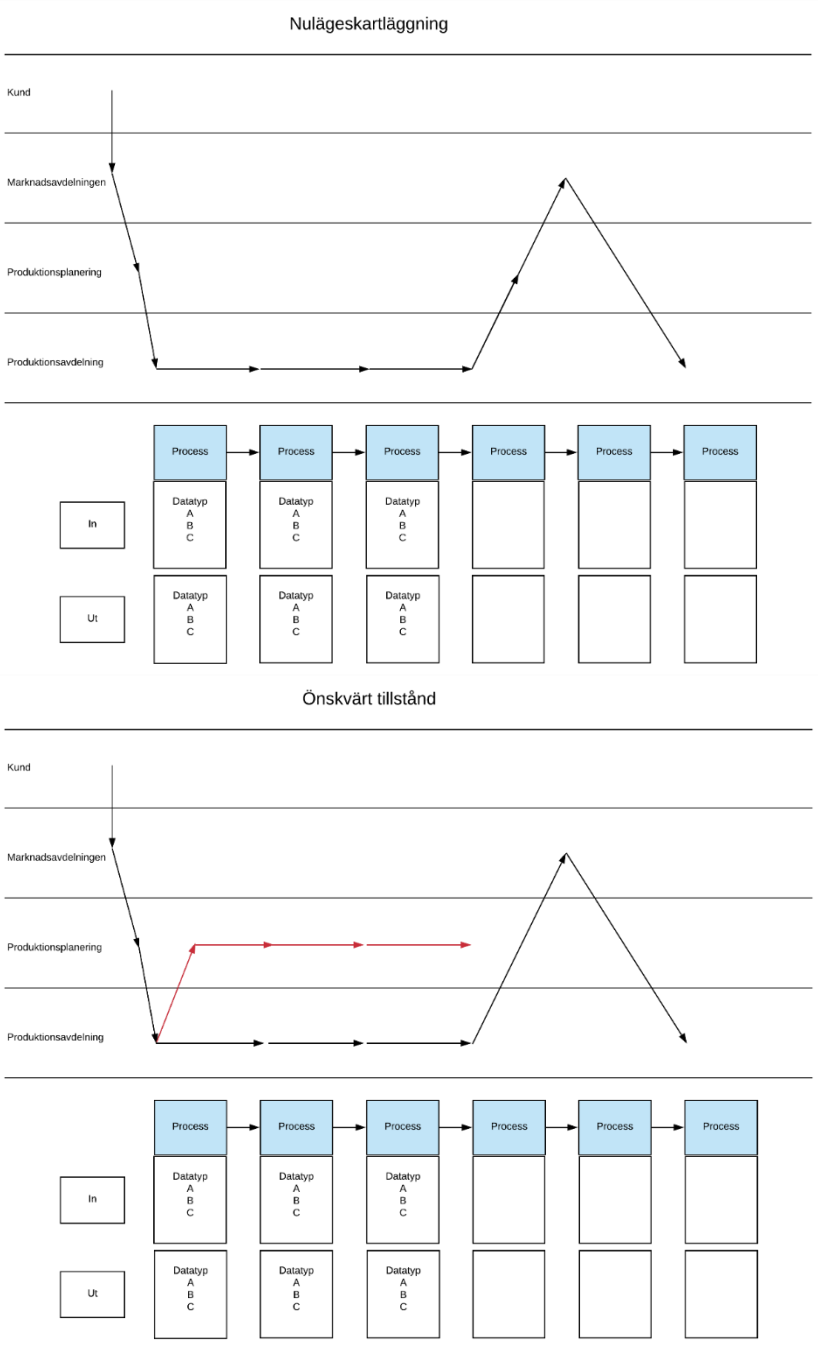

Figure 33 Illustration of the modified process-oriented information map. Current state (above) and future state (below). (Authors' image)