UNIVERSITY OF LJUBLJANA

SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

THE CONCEPTUAL FRAMEWORK FOR SME'S STRATEGIC POSITIONING IN THE GLOBAL VALUE CHAIN IN INDUSTRY 4.0 ENVIRONMENT

Ljubljana, February 2020 MARK SØVANG PEDERSEN

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LIST OF ABBREVIATIONS

CEO - Chief Executive Officer

CFD - Computational Fluid Dynamics

CNC - Computer Numerical Control

CRM - Customer Relations Management System

ERP - Enterprise Resource Planning System

FMS - Flexible Manufacturing Systems

GVC - Global Value Chain

I4.0 - Industry 4.0

IoT - Internet of Things

KP - Korsør Propeller A/S

MNC - Multinational Corporation

PwC - PriceWaterHouse Coopers

R&D - Research and Development

RFID - Radio Frequency Identification

RM – Rapid Manufacturing

SCF - Supply Chain Flexibility

SCI - Supply Chain Integration

SME - Small to Medium sized Enterprises

SMP - Sustainability Management Practices

INTRODUCTION

Small and Medium sized Enterprises (hereinafter: SME) comprise 99% of the economic activities within the European Union (Falkner & Hiebl, 2015). The delivery of products and services has since the 1990'ies been improved by optimization projects within LEAN terminology and business improvement exercises, an area in which SMEs with the correct mindset of the management has been able to equally participate in on the line of Multinational Corporations[1] (hereinafter: MNC).

However, with the emergence of Industry 4.0 (term coined in 2011), new and exceedingly expensive technologies are required for businesses to continue maintaining the competitive advantage. This might not be of any considerable problem to the MNCs, who have large capital reserves or access to loans, issuing of bonds or shares, but what about the SMEs?

The essence of Industry 4.0 is machines being able to communicate without human inputs, or to let the human controller have extensive information about the process of the system, so optimization is possible. The ultimate scenario is a "I4.0 factory" where raw materials enter and exit as finished products, all planned and executed by the system itself. For the modern SME to follow suite and keep up with MNC's use of this I4.0 technology, this thesis will research methods the SME can use to both implement the right I4.0 technologies, but also how to join a Global Value Chain (hereinafter: GVC), controlled by MNCs.

The purpose of this paper is to provide the necessary knowledge for SMEs to understand the implications of Industry 4.0 (hereinafter: I4.0). The author means to provide ideas and methods useful for consideration when SMEs strategy is to join the Global Value Chain as an effort to grasp the advantage of I4.0 methodology. It is the goal to provide SMEs with a framework that will give the SME an easy to use model for implementing I4.0 technologies for whatever aim it is for the SMEs business strategy.

The aim of this thesis is to develop firstly an understanding of what the concept on I4.0 really means. What kind of implications will it have for the SMEs of tomorrow and how do they deal with these new technologies, which not only are complicated to understand on a theoretical level, but in many cases also incur large amount of financial investments. The viewpoint taken from this project is that the world in an increasing fashion will move towards GVCs, so how will SMEs use this to create competitive advantage for future survival?

Once the technological implications have been clarified and research will show how SMEs must deal with value chain integration, a more practical switch will be made. The final part

[1] Multinational Corporation in this context meaning a company operating in multiple countries and of a large-scale employment size of +1000 employees.

of this thesis will start by presenting a conceptual framework, which SMEs can use to understand their level of I4.0 integration so far, where to go next and what to do about it.

It will be proposed that via this framework, SMEs will be able to lead themselves into the era of I4.0. As a reality check, a case company has been included to work out any contradictory parts of the framework stemming from too literal use of theory. Understanding of I4.0, the GVC and SMEs role in the future of these shifts of paradigm in business will be the aim of this thesis.

The following research questions will be answered through this thesis:

- RQ1: What technologies and how will they impact SMEs future business viability in the context of Industry 4.0?
- RQ2: What are the specific characteristics of the SME in relation of business operation and mentality?
- RQ3: How can an SME be integrated into a Global Value Chain?
- RQ4: What real life challenges are laying ahead of SMEs in the era of Industry 4.0?
- RQ5: How can the SME practically work with integrating Industry 4.0 concepts into their daily processes?
- RQ6: What is the value proposition for SME to start work on Industry 4.0 and GVC integration?

The majority of the thesis has been researched via literature reviews in scientific journals, hence, the use of secondary data. To a lesser extent books on specific subjects has also been used in areas such as economical risk, production operations methods and business mentality change.

Interviews has been the main source of primary data collection. Structured interviews have been used in connection with the case company, in which questions were prepared beforehand and the interviews were recorded in audio format with the acceptance of the interviewees. Unstructured interviews were used at a seminar, thereby making interviews with persons of interest on the spot, these interviews were reconstructed from notes taken at the event.

Lastly, discussion groups and brainstorming event has been instrumental for initial research and later discovery of methods for dealing with analysis at the case company.

Throughout this thesis, research will first delve into what I4.0 actually requires, which technologies are here already and what is the point of each technological innovation in the production of services and products. After a baseline of I4.0 has been established, the SME structure and way of doing business will be analyzed to provide the knowledge of how integration into a Global Value Chain may be achieved.

A conceptual framework for SMEs integration will be presented in written detail and visually for greater ease of understanding for any management in an SME, being cross-referenced with the case company for coherency.

For practical application of the research, a Danish SME (Korsør Propeller A/S) has been selected to provide vital real-world information, by the use of both structured and unstructured interviews before, during and after the development of the conceptual framework for SME integration with Industry 4.0 and the GVC. Other organizations will also be used for gaining up-to-date information about the research subjects as Industry 4.0 is a fast-moving concept.

1. INDUSTRY 4.0 - ROLES, TECHNOLOGY AND IMPLEMENTATION

In order to provide a wider context of the technologies involved in creating an I4.0 environment, this section will introduce the various technologies of I4.0 and its historic development. This will build the required knowledge to comprehend the later conceptual modelling of SMEs integration into I4.0, a prerequisite for joining the modern version of the GVC. Concepts behind the technology will also be reviewed in order to better understand the implications of each technology and how relevant it will be for an SME. Where it has been deemed necessary for explanatory purposes, figures have been used to illustrate the technology.

1.1 Design principles and technologies of Industry 4.0

1.2.1 Historic development and context

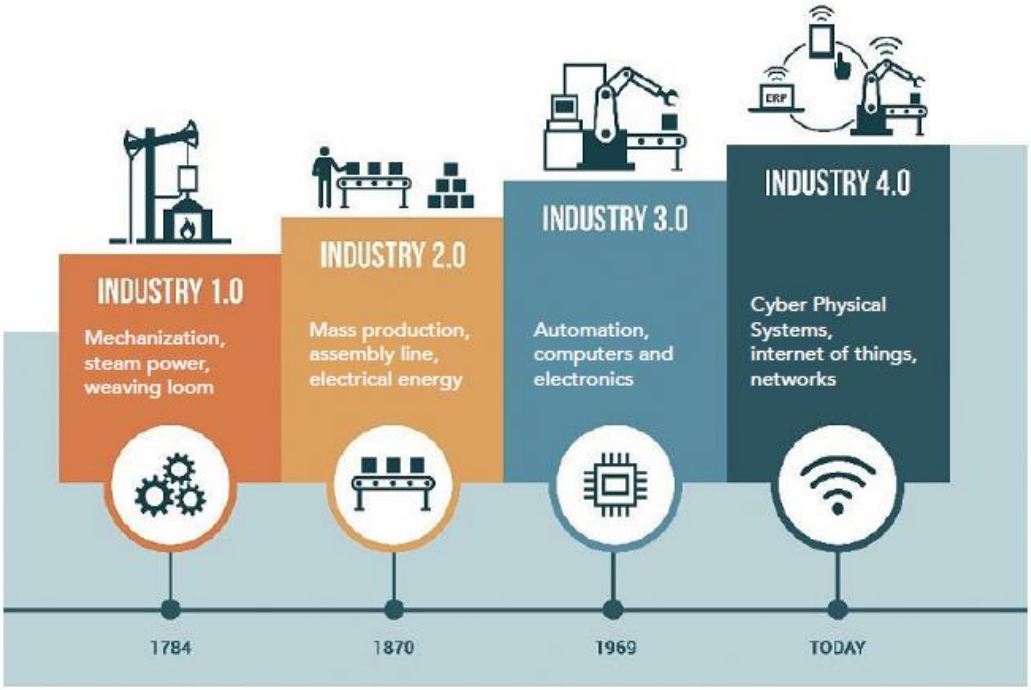
The first industrial revolution came about in the end of the 18th century in Britain with the invention of steam power. These first mechanized factories were the first major shift in human industrial evolution and not only meant cheaper and higher quality goods, but also instrumented the urban development of western society (Mathias, 1969).

The second industrial revolution started around 1870 with the invention of mass production and electric engines, no longer requiring the belt driven technology from “Industry 1.0”. The most classic example of how assembly line improved both competitive advantage but also bringing new technology to the middle class, is that of Henry Ford and the model-T. As production started in 1908, Ford manufactured approximately 10.000 cars annually, but by 1920 the number had increased to 933.720 cars (Vlaskovits, 2011).

During the 1970'ies and 1980'ies Toyota was paramount in developing the system of tools and ways of thinking later to be dobbed LEAN. This was the leading edge in innovation of processes in any production company and during the 1990'ies it became the trend for Western MNC and to some extent Medium sized enterprises to implement LEAN in their production, this can be argued to be the next step from the highly popular Business Process Re-engineering of processes of the 1980'ies in the West (Womack & Jones, 2003).

By 2011 the concept of Industry 4.0 was the main theme at the Hanover Messe in Germany, by this time those previous methodologies were described as being part of Industry 3.0 (LEAN possibly 3.5), before this I2.0 was the mass production of the 20th century and first iteration being the introduction of steam engines in the 19th century (See Figure 1) (Wilkesmann & Wilkesmann, 2018).

Figure 1: From industrial revolution to Industry 4.0



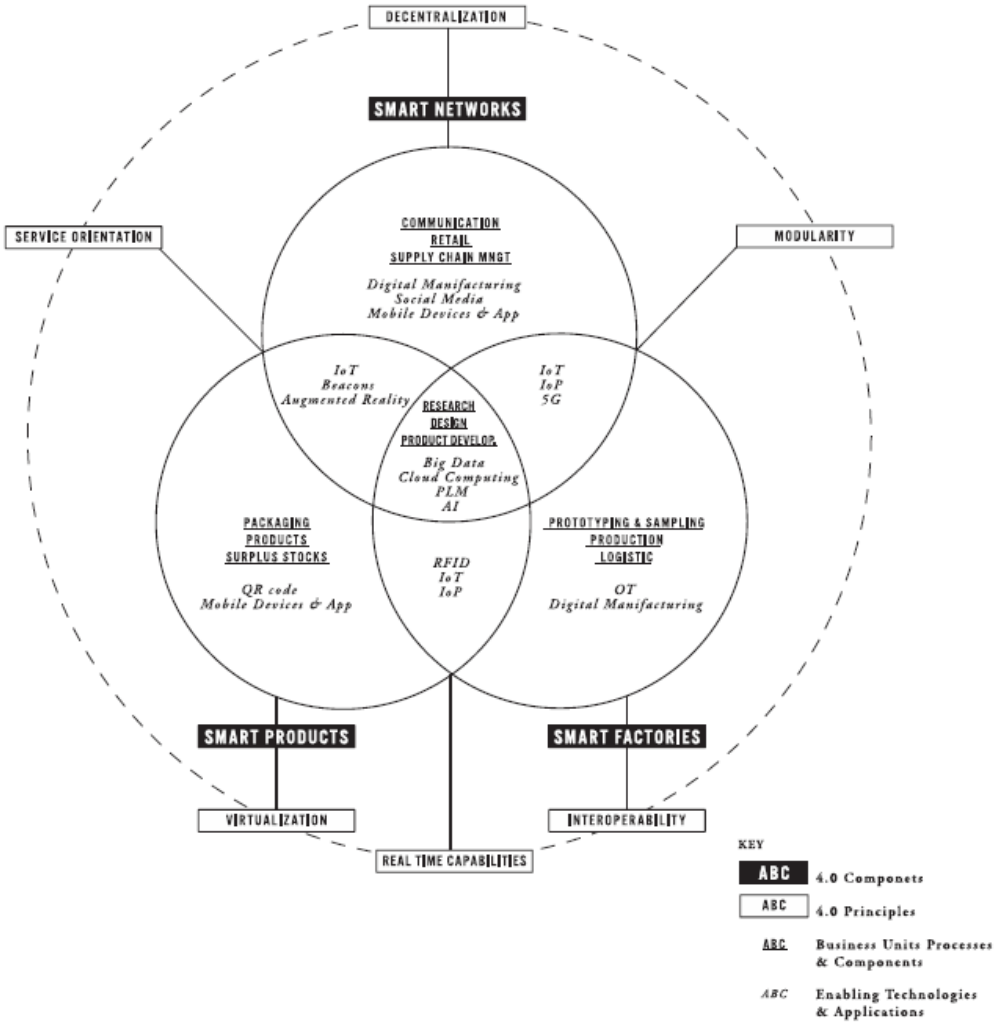
Source: Hammel Scale Company, Inc. (2019).

1.2.2 Context of Industry 4.0

I4.0 is the integration of many new technologies into one very effective and highly communicative system, in which Humans to Machines and Machine to Machine combine these technologies into Cyber-Physical Systems.

3 main elements of the combination from new technologies make up for this system; “smart factories” + “smart networks” + “smart products” = Industry 4.0 capable system (Bertola & Teunissen, 2018) which is illustrated in figure 2.

Figure 2: 3 main elements of Industry 4.0



Source: Bertola & Teunissen (2018).

The main technologies include; Internet of Things (hereinafter: IoT), Additive manufacturing (3D printing), Radio Frequency Identification (hereinafter: RFID), Blockchain and Augmented reality. Each technology will be investigated in the following sub-sections.

One of the main ideas, just as with LEAN, is a further optimized way for a company to bring products and services to the customer, the main focus of I4.0 is connectedness between companies, higher understanding of communication in conjunction with the most innovative technologies the human race has invented so far. A benefit for multinational corporations is the control and visibility this new paradigm can provide. For SMEs, there is a substantial benefit in streamlining the processes and create understanding on a deeper level of the

company. It was described as streamlining the company by use of new methods in technology, but just as important to understand underlying processes that goes into producing products and services of high enough quality to survive in an ever more competitive business environment (Lewis, 2000).

1.2.3 Internet of things, connecting the GVC through tech-solutions

Of all the individual technologies analyzed throughout this report, IoT is the one technology will most impact as this is the link making I4.0 and not 3.0. IoT link together all the high-tech solutions and making this into a network, which eventually will simulate artificial intelligence, as the system itself can learn and optimize the production for fastest cycle times (Mishra and others, 2016).

IoT makes it possible to "hook-up" any machine or "thing" to the Internet, making it possible to connect from anywhere on the planet (or off planet) to control or change parameters for production. What started as a gimmick, like being able to make the fridge in a house order food on its own, will come into its own right working in smart factories in the I4.0 era. Warehouses will run itself; production units already know the optimal processes for a particular product or service, but critically everybody in the value chain will know what is going on, streamlining the process from raw material to finished product at the customer (Strange & Zucchalla, 2017).

In traditional manufacturing it has been essential that research and development has been tightly connected with manufacturing. One case in point is Danish manufacturing and engineering company Grundfos, who has a research and development (hereinafter: R&D) department of 500 engineers and a "tier 1" production line. Once a product has been developed, it will be put into production in the building adjacent. Only when it has been running smoothly and mistakes has been eliminated, the whole interior of the production facility will be moved to a low-cost production country such as Vietnam. The whole unit is off shored to make room for the next product line, this of course being highly costly, yet necessary for the high quality which Grundfos's customers expect.

IoT will make it possible to make simulated factories in Denmark, that will emulate the facility in e.g. Vietnam, so production can start immediately in Vietnam and any problems can be fixed by the engineers in Denmark via connected production units, e.g. by use of augmented reality (see section 2.2.7 Augmented Reality).

1.2.4 Additive manufacturing/3D printing

Additive Manufacturing is a component of advanced production technologies and works as a part of these new systems. The technology has come far, though it is yet considered too

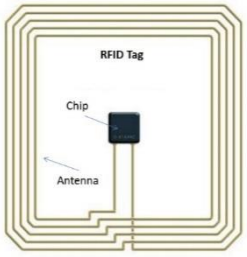
slow for mass production, it still has a potential for helping I4.0 reach the target 1-batch size, hence, making each product specifically for one customer at the amount the customer needs. Experiments has shown that industries like fast moving fashion can print elements of clothing, making the product where the customer require it, instead of producing and then shipping. Designs can simply be sent via the Internet and printed at point of sales (Bertola & Teunissen, 2018).

Limitations to 3D printing include the speed, or lack of, final finish and structural integrity of the components. Today more than 250 materials can be used for 3D printing, however, none of them has high strength capabilities, e.g. resistant for torsion or tensile forces (twisting and pulling forces) (Kalpakjian & Schmid, 2010).

1.2.5 Radio Frequency Identification

RFID chips has been extensively used for a long period, in the beginning mostly for convenience in security locks. However, this has changed to a level where every product today can be verified and found using RFID. The basis of the technology is that a small circuit activates when coming into contact with the transponder unit, this means that the chip itself do not need any power supply as the radio waves provide enough electrical current for the chip to send its 128-bit identification number (See Figure 3 the antenna also act as power generator for the chip). By linking an ID to products, machines will be able to identify the parts when needed, eliminating any human interaction in the process, this makes Machine to Machine communication possible in production lines (Barata, Cunha & Stal, 2018).

Figure 3: RFID internals



Source: Research Gate (2019).

1.2.6 Blockchain

Blockchain technology is the most resent of the new technologies which will be a part of the implementation and realization of I4.0. The in-corruptibility of this ledger technology will help in third part authentication removal. No intermediary will have to be utilized when signing a contract. Smart contracts will be able to figure out by itself if the terms and conditions has been met, once this happens the money or products will be released. Traditionally when doing business in a network, trust would have to be built over extended periods of time and transactions or a third party who both dealing parties trust will have to

be paid to act as intermediary. Now, trust can be achieved the very first time with blockchain technology. One caveat is that though it is considered impossible to “hack” or meddle with today, quantum computers might be able to do this, we might already see the first quantum computers in 2026 (Tapscott & Tapscott, 2018).

The development of blockchain is still in its infancy and how it will affect the industry is yet to be seen, however, the prospect of having ultimate trust is tantalizing for the future of doing business in large networks.

1.2.7 Augmented Reality

Augmented Reality uses 3D environment projected directly into a worker’s eye what information is relevant. Cases have been shown where glasses of warehouse workers show in real-time where to go and which Stock Keeping Unit to pick, everything calculated by an algorithm for optimal process time. Information will be more readily available in the future, and though it can be discussed for or against having a worker instead of robots in the first place, some transition period has already begun (Ghobakhloo, 2018).

1.3 The road map to Industry 4.0

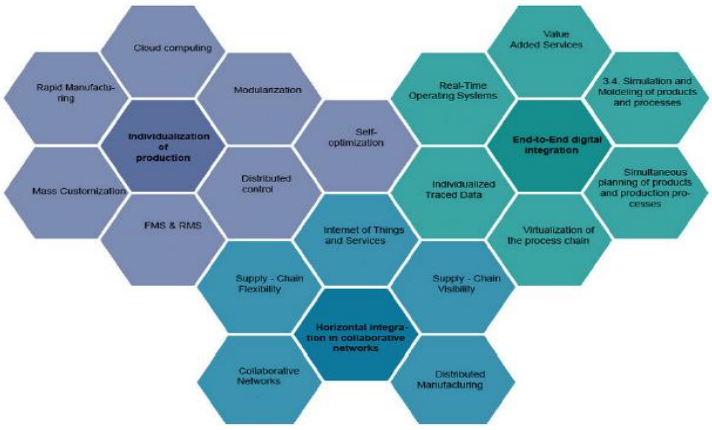
How I4.0 will be rolled out in individual companies will vary. However, research show 3 main areas of interest (Brettel, Friederichsen & Michael Keller, 2014):

- Individualization of production
- Horizontal integration in collaborative networks
- End-to-end digital integration

From these 3 main categories, the individual technologies required to reach the state of I4.0 will be investigated in order to produce the road map for companies to follow. Not all technologies will fit any company, this depends on size of the firm, product line and the state of development in the GVC, more on this in the conceptual framework section 3. Below in

Figure 4, all the technologies and their inter-relatedness has been visualized, notice the main objective of I4.0, Self-optimization, is the all-linking factor.

Figure 4: I4.0 related to research streams



Source: Adapted from Brettel, Friederichsen, & Michael Keller (2014).

1.3.1 Individualization of production

Modulization

Modulization of products make for more flexible product delivery to customers while keeping costs lower, while economy of scope utilizes cells of a production facility for more than one product. The modulization can help keep cost lower by subdividing products. One case; American computer company HP and their production line of printers, the power supply was designed in such a way that only the power cord had to be different for different markets (America getting the 110volt and European Union the 220volt power supply). Other areas include car production, a case in point is the German VAG group producing amongst other products; Audi, VW, Skoda and SEAT, many of their products has been modularized, reducing the Stock Keeping Units drastically, to such an extent that parts used for expensive models like the Audi A8 can be found in lesser expensive cars like a VW Golf, due to the cost savings of not having to produce 2 or more different parts for each model (Taleb, 2018).

Mass customization

To be able to mass customize means to develop a strategy that supports giving a customer anything they want, anytime and in any way, all by being profitable for the company. If this is scaled down to something more attainable, it can also be stated as providing superior customer value. This advantage will only be effective if the customers know what they want, hence, a thorough segmentation and understanding of the customers will be required. Customers can be split into 2 categories for judging whether or not mass customization will be profitable. Type 1 customers know what they want, they are well aware of the type of products they are looking for and will research who can provide the best. Type 2 despise too many options, examples are customers choosing McDonald's over Subway as they do not

have to choose fillings. On higher value items, sports cars usually have options of above normal choices in equipment, whereas standard family cars have packages so customers do not have an excess of choices (Buffington, 2011).

Rapid manufacturing/Additive/3D printing

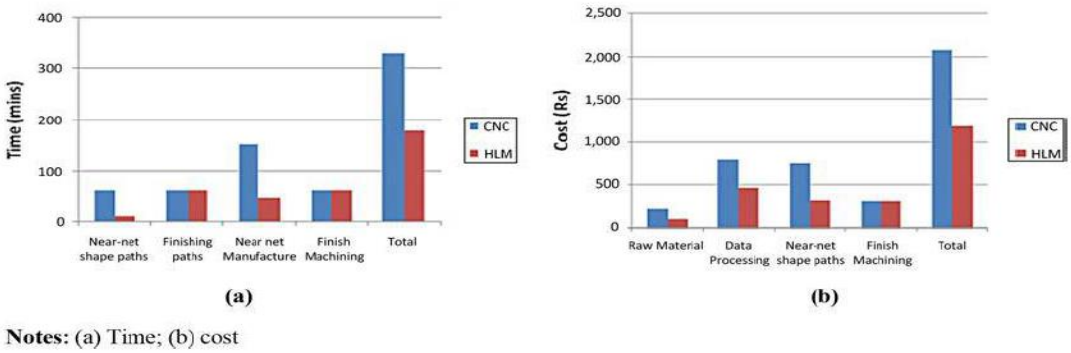
Rapid Manufacturing (hereinafter: RM) or 3D printing objects has become part of I4.0 as the technology has matured, amongst the most used technologies of RM are; Stereolithography, Multi-jet modeling, Fused-deposition, Ballistic-particle manufacturing, Selective laser sintering, Electron-beam melting and Laminated-object manufacturing.

RM has a huge advantage in the time and cost it can produce special products, that means it increase flexibility and the ability of rapid innovation as this technology also lend itself to rapid prototyping. Combining this with IoT it can increase mobility of production units, i.e. cells can produce anything required at the moment and not be stuck at producing one particular product before having to be re-tooled (Kalpakjian & Schmid, 2010).

Further, integration of existing technologies make the limitations of e.g. the finish of each product, much easier to automate as the next case example will demonstrate.

One study in this field of RM, was carried out using Hybrid Layered Manufacturing method in which deposition manufacturing first create an object, after which this machine automatically uses Computer Numerical Control (hereinafter: CNC) manufacturing elements to create the final finish of the product. As can be seen in Figure 5 cost reduction from traditional CNC machining was 43% whereas time spend producing the part was reduced by 47%. Not only will this benefit the profits of any company using RM technology, it will also benefit the environmental aspect of production as usage of raw material (in the case example aluminum) fell by 54% (Simhambhatla & Karunakaran, 2015).

Figure 5: Comparison of subtractive and Hybrid layered manufacturing routes for quad-copter blade

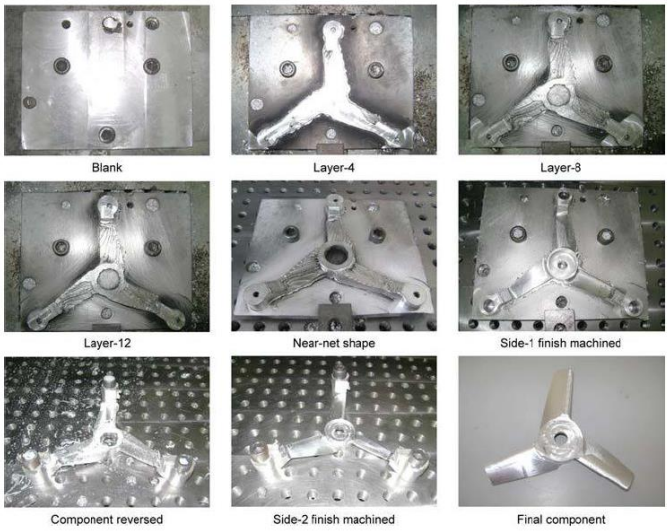


Notes: (a) Time; (b) cost

Source: Simhambhatla & Karunakaran (2015).

Figure 6 showcase the actual production of a complicated drone blade, this product is made by deposition aluminum RM method, after which it is finished by use of CNC method.

Figure 6: Various stages in the manufacturing of a quad-copter blade



Source: Simhambhatla & Karunakaran (2015).

1.3.2 Horizontal integration in collaborative networks

Cloud computing

Cloud computing makes for a highly flexible and resilient system, providing scalability and access to information throughout the value chain and can be defined as a technology by which disembodied services can be accessed anywhere in the world. Most businesses use cloud technology to some extent today, being that having a simple file storage system, Microsoft Office 365 or an Enterprise Resource Planning system[2] (hereinafter: ERP-system) based on cloud technology. One factor research has shown to affect the implementation of Cloud technology, is the size of the firm and the existing equipment in use. SMEs will by this definition be slower to implement cloud-based solutions as compared to larger organizations (Low, Chen & Wu, 2011).

The danger of having one site servers for e-mail, ERP-system, Customer Relations Management system (hereinafter: CRM-systems) etc. is the threat of cyber-attacks. For this reason, Sharif Tawfik (full interview in Appendix 3) argued that cloud-based solutions actually are safer as the data will be stored at specialized companies that has an intolerable risk size for cyber-attacks. In effect means that security will be at the highest level and not possible to match at company level, especially for SMEs due to their limited size, reducing the option to have sophisticated stand-alone security systems and IT-personnel.

[2] The ERP system is the main computerized system gathering data, account info, warehousing, etc. making controlling the company much more efficient and visible.

Distributed Control

For the I4.0 terminology, distributed control system combined with distribution of information is imperative for the successful implementation. This also require a flatter organizational structure as compared to the old hierarchies, more on this in the section on Flexible Manufacturing Systems (hereinafter: FMS) and Rapid Manufacturing Systems (Rodrígues-Díaz & Espino-Rodríguez, 2006).

How an actual distributed control system works can be broken into 4 categories:

- Sequencing
- Job bidding
- Negotiations
- Co-operation

Sequencing

Sequencing being the closest to old manufacturing techniques of line production, but still controlled for optimal usage of individual cells or agents in a production facility. A foreman will have the production schedule and manually walk to each cell with a job to be done.

Job bidding

Job bidding requires the cells to bid for jobs coming in, this is one better, in that, each cell know the capacity and capabilities so the optimal cell can be utilized for a particular process.

Negotiations

Negotiation can turn into deadlocks, however, the best cell should in theory win the bit for the job, computer algorithms are making this option more viable today than just a few years ago.

Co-operation

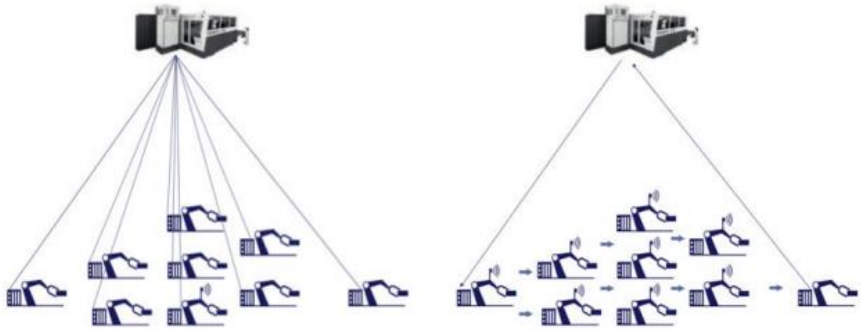
Co-operation driven by computers will autonomously select best option with possible inter-co-operation between cells for optimized production and utilization of capacity (Crowe & Stahlman, 1995).

Distributed control in I4.0

The cost of control systems is 75% installation cost. Not many MNC would run centralized systems anymore, however, SMEs with less access to economic means or from a lack of innovation will still run centralized control systems, the main disadvantage of centralized systems is; inflexibility, not taking advantage of new technology and high installation cost (Cables and connections running miles through the facility and lower worker involvement) (Mahalik & Moore, 1997).

A distributed control system rely on networks to which part of the processes are controlled down to the last components this include actuators, valves and sensors (see Figure 7). Central control can be maintained; however, the process units can work autonomously creating flexibility, lower cost and lower life-time installation costs. By utilizing wireless technology, it is easier to move part of the production around e.g. for testing new layouts in optimization projects. The link between machine are termed Machine to Machine communication.

Figure 7: Reduction of communication in distributed systems



Source: Brettel, Friederichsen, & Michael Keller (2014).

Flexible Manufacturing Systems

FMS was for a long time a great idea but hard to implement and for this reason has similar theoretical similarities with Industry 4.0 to which it has now become an integrate part of. The FMS incorporate automated materials handling, robots, automated inspection of quality, CNC and most important, the use of Wi-Fi technology in which more than just process control of the FMS will be used, but also transfer of files and more general information. In essence it is a cell within a cell in a production facility with the capabilities of flexibly change the output to specific customer needs. To illustrate, think of a car production facility where the assembly line is for "making cars" but each car is made individually for each customer; One is red and with leather interior, the one before was blue with cloth interior etc. (Miltenburg, 2005).

The organization of FMS was originally completely hierarchical however later developments has shown that a quasi-hierarchical organization in which wireless technology makes for independent fast decision making possible. In effect this means production is centrally controlled, with decision autonomy at the cells to come up with the best cell to use for maximized capacity and capability utilization (Crowe & Stahlman, 1995).

The main issues with FMS have been found to be implementation and development of the IT infrastructure around these systems, which in most cases has been created ad hoc. Specific problems have been identified to include; inadequate co-operation between designers, users and vendors and a lack of understanding the system (Canel, Mathieu & Das, 1997).

Self-optimizing systems

The final product of Industry 4.0 is the self-optimizing system. This bridge the subjects of End-to-end digital integration with the individualization of production. Processes, IT systems, Human to Machine and Machine to Machine technology will merge to be able to decide on the go how one product will be optimally produced, checked, expedited and even improved. I4.0 is still some years from this ultimate goal, however, the technology and most importantly, the humans designing the systems, are evolving at a high pace.

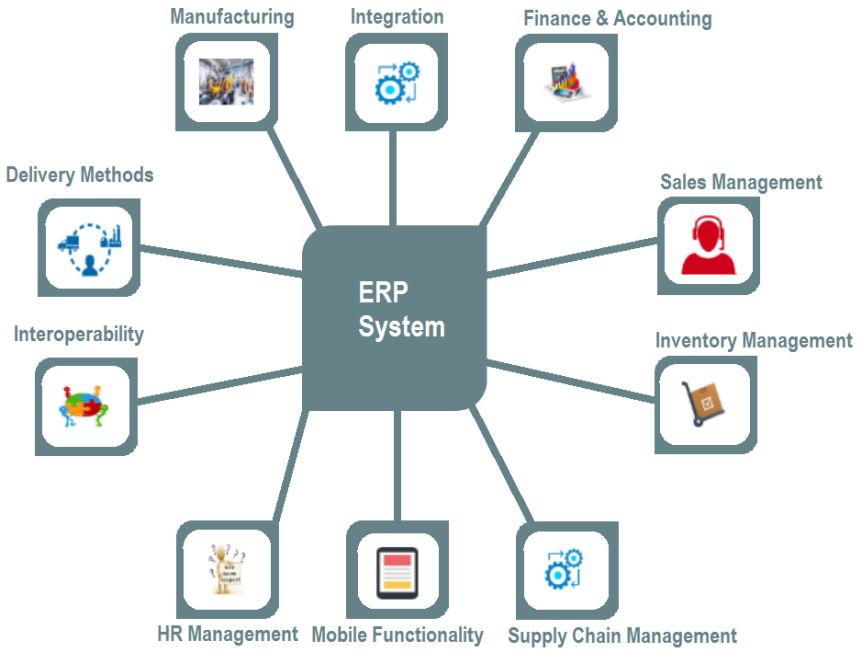
1.3.3 End-to-end digital integration

Real-time operating systems

The ERP-system of the company is the backbone of real-time, as it must handle not just recording of economic transactions and project management but also allow for sensors to send information about cells, machinery and other important factors of interest to the specific company.

Such factors as networked communication with other companies in the GVC will also be possible through the ERP-system. Figure 8 has been created to visualize the various areas in which such a system must be integrated in order to support I4.0 terminology. As with other technologies in I4.0, this ERP-system must be driven by data which makes it possible to then link work processes in a far more optimal way.

Figure 8: Impact of the ERP-system



Source: Own work.

Value added services

As SMEs usually have limited access to economic means, the low-cost production strategy for creation of a competitive advantage will not suffice, instead differentiation will be the correct choice for any given SME. For this reason, information technology can be used to analyze and keep track of customer data, which can be used to generate higher value for the end customers. In the past this method could have been through physical flow-mapping with value added processes, this must today be integrated in the IT systems of the SMEs, so any process that does not add any value to the product can be effectively eliminated and thereby create higher margins and add to the customer experience. As this usually also entitles faster cycle times and by having focus on the processes, it will also add to the quality of the product (Hilmola, Lorentz, Hilletotfh & Malmsten, 2015).

Another aspect of this process, as stated by Sharif Tawfik, will be the possibility to add higher levels of service to the customer, by being able to control the process on a higher level, any questions the customer might have or problems regarding quality or maintenance in the future, can be streamlined, this being part of adding a higher service value.

Simulation and modeling of products and processes

With the cost of computers and processing power falling, it has become possible even for SMEs to purchase simulation tools for computer modelling, there are two distinct areas of use for this technology; Products and processes (Rudall & Mann, 2009).

By using computers for designing the product, stress testing, quality levels, areas of possible failures etc. can now be designed out of products before they are being produced, this is of great advantage to SMEs as making prototypes are a costly affair and some products might still get through quality control with errors. Specifically, one such program is Computational Fluid Dynamics software (hereinafter: CFD), this program can calculate tensions e.g. under water, so problems like cavitation (super-heated air bubbles that erode metal from propellers on ships) does not happen to any end-product (Ferrantino & Koten, 2019).

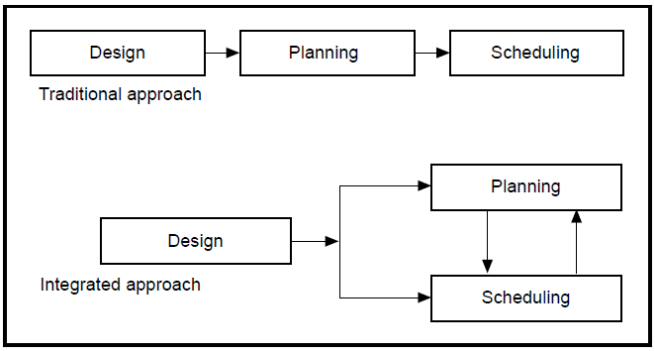
Processes can also be simulated, after the entire "as-is" process has been loaded into the program, industrial engineers can then simulate changes of machinery, production-cells, worker shifts etc. This is less expensive than actually experimenting by moving machines around, then measure to see results before getting a conclusion of efficiency as is the traditional LEAN methodology (Womack & Jones, 2003).

Simultaneous planning of products and production processes

Improvements in increased machine utilization, higher return on investments and reduction in inventories and flow times. These are all benefits of implementing simultaneous planning of products and processes. Also higher efficiency in deliveries on time, lower idle time on machinery, cycle time reduction can be managed by making sure their processes are not dealt with in 2 individual aspects but rather as a united production scheduling (Khoshnevis,

Bottlik, & Azmandian, 1994). Traditionally the approach to planning and scheduling in a straight line; Design, planning and scheduling, whereas the integrated simultaneous starts with design process but then iterate between planning and scheduling to maximize the utilization of free capacity, see Figure 9.

Figure 9: Simultaneous planning Vs. Traditional approach



Source: Khoshnevis, Bottlik, & Azmandian (1994).

Virtualization of the process chain

This important technology is producing results that used to be performed by "brown-paper" mapping, in which engineers (usually industrial engineers) would map the process flow chain from raw material to end product. Though still a powerful tool for showcasing the main idea, it is time consuming and require a lot of space. This will be made more efficient with virtualization of the whole process chain, by adding computational power and add-on programs for optimization, results might even beat "best practice" which used to be the aim of optimization strategies. This in part works toward the I4.0 main goal of self-optimization when the system will have enough data to calculate the optimal chain of processes trough the factory (Brettel, Friederichsen & Michael Keller, 2014).

Individualized traced data

Individualized traced data is important for I4.0 as it is the backbone of keeping track of core product data, quality, where the product is currently, and any other piece of information required to control the product during its lifecycle. The simplest tracking is known by most from package delivery e.g. UPS, GLS etc. the convenience of knowing where the package is and when to expect it has been a huge improvement for customers. However, for an MNC working with just-in-time, this information needs to be even more precise and could include GPS transponders on shipments. To showcase the tracing importance, pre-packaged food will be used as analysis example, noting that this industry is predicted to reach USD 3,03 trillion for the year 2020 (Li, Liu, Liu, Lai & Xu, 2017).

Individualized tracking, e.g. by the use of RFID chips, is an excellent option for making sure original and comprehensive data about the products will be kept during shipping, however,

at a certain point these RFIDs will become too expensive for the individual product. As the case of pre-packaged food industry, in which a product retailing for a few cents does not warrant the use of RFID technology, here only batches are of sufficient quantity e.g. whole pallets or containers. On the lower level, i.e. individual packaged food supply, the use of Quick Reference codes can simply be printed and linked to the RFID chip of the batch, this ensure that quality control can be maintained, while costs are kept at a minimum. As shown by example the Chinese alcohol producer Wuliangye Yibin Co. Ltd, individualized tracing of products via the use of RFID chips, can help mitigate counterfeiting alcohol products, which not only insure their market share, it also increase the public safety as the copy-cat products are not under regulation and might be dangerous to the public (Li, Liu, Liu, Lai & Xu, 2017).

A more recent and local event has created value for customers in Ljubljana, the pizzeria Dodo let customers make their own pizza, after which they can follow in detail where in the production line their pizza is located. They may even watch on video as the chef prepare their food. This might seem like a gimmick to some, but could become industry standard, not only is it interesting for the customer to know their food comes within an hour (not 30mins to 2,5 hours). Health issues can be traced fast if there are any problems with the food delivered, most important is that this technology has been implemented by a very small SME, a simple pizzeria, not a multinational corporation (Dodo is a Russian franchise, though individual restaurants pay their own equipment expenses) (Pizza, 2019).

Supply Chain Integration in collaborative networks

Supply Chain Integration (hereinafter: SCI) is not new to I4.0 and has as such been part of building competitive advantages for years. Nevertheless, this is important especially with regards to MNCs and SMEs collaborative networks. SCI refer to what degree the manufacturer collaborates with its suppliers both on intra and on inter organizational processes. One important area for MNCs is the Sustainability Management Practices (hereinafter: SMP), which govern the sustainability of the company and how the public perceive the company, this is important as case of Nike, Adidas and Uni Lever has shown lacking control of supply chain partners can lead to disastrous financial and public condemnation as a result of poor working conditions and environmental damages. These suppliers were not well integrated and as such resulted in low levels of SMP, despite the MNCs high internal standards. Due to these factors, SCI requires integration of data and information systems, collaboration and joint decision making, these not as a control mechanism, but as a strategic alignment protocol. In the case of the MNCs above, their suppliers might now have found their “standard” practices unethically by local standards, however, these where far from the SMP of the MNC purchasing their products. What needs to be conveyed in SCI is capabilities in; trust, national culture, logistics and technological integration. If MNCs has problems with SMEs in different cultural areas, they might need to invest in cross-functional liaisons who can increase the capabilities in advanced

environmental understanding, i.e. showing them how it must be done in order to be an integrated supply chain partner (Kang, Yang, Park & Huo, 2018).

On the other side of the supply chain is customer understanding. SMP and delivering the products the customers wants is of paramount for the company and in this regard MNCs will take on this responsibility of interacting with the customers. Whereas SMEs that is part of the supply chain will only get this information via collaboration with the MNC, which is why inter organizational communication is so important for SCI.

Collaborative networks

Collaborative networks involve the use of technology and the willingness to cooperate between companies in order to maximize the internal resources, this include capabilities and assets of each company.

It might not always be prudent for an MNC to integrate horizontally with SMEs who supply those MNCs, in those instances' collaboration is vital, by the use of e.g. Vendor Controlled Inventory, shared forecasting and instant recognition of issues in the production as any given level in the supply chain, thereby reducing bull-whip effect.

Not only will collaborative networks be of great benefit for both SMEs and MNCs, research show that the speed of which these collaborative networks are developed are of paramount for business success in the network. This also means that due to the investment both companies make into the Collaborative Network, ad hoc networks are less common and of less advantage for competitiveness (Francisco, Azevedo & Almeida, 2012).

Supply Chain Flexibility

Supply Chain Flexibility (hereinafter: SCF) is a trade-off between SC agility and SC efficiency, in order to increase competitiveness by supporting SCF, companies must also support Variety Management Strategies. The simpler a production or product, the easier it is to design a supply chain, the problem arise as todays customers want customized products delivered fast, this means higher complexity as more suppliers need sourcing and more processes are required internally. That is why variety management is important, this can be achieved through modularization, cell-manufacturing where cells can move to produce different components for each required product. For MNCs this can be done by having Flexible Manufacturing Systems, however, SMEs do not have access to adequate capital to make use of such technology, at the most it will be part of the supply chain and asked to adhere to set norms from the MNC. What can be done for the SME is to have multiple sources of suppliers, readily available alternative production e.g. out-sourcing options for emergency or when capacity has reached the limit on short term basis (Um, 2017).

Another aspect of SCF is to be connected in networks, a recurring theme through literature reviews. By using the digital technologies of I4.0, SMEs and MNCs will be able to connect to each other and organize the supply chain in a best practice method for increasing

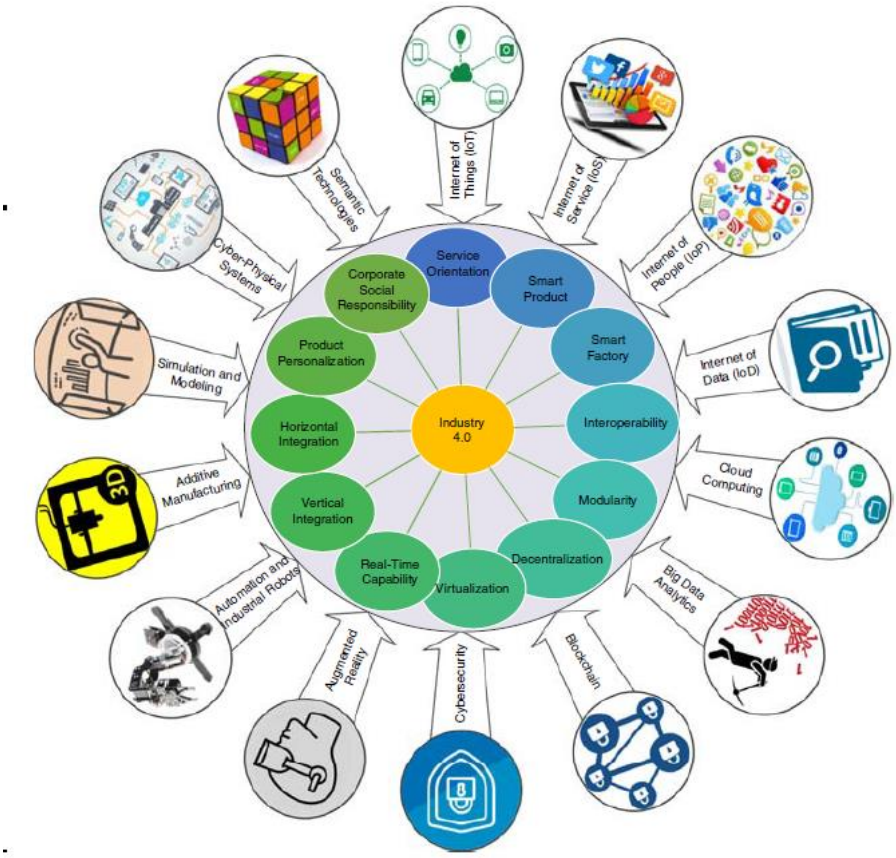
flexibility but also agility and better risk management (Brettel, Friederichsen & Michael Keller, 2014).

Internet of things and services

The Internet of Things makes the integration with ERP-systems possible to unite to a higher-level entity for the company, while the ERP-system keeps all the information and control/analyze the data, that data has to come from somewhere, enter the IoT.

As illustrated in Figure 10, everything from smart houses, to communications devices, machinery, phones, trucks and tools will eventually have its own IP address and be hooked up to the Internet, during an interview with Harald Toker (Full interview in appendix 3) revealed that more than 50 billion devices will be connected by the end of 2020. As overwhelming as this number might be, many more devices will be connected in the next decade.

Figure 10: Internet of Things



Source: Ghobakhloo (2018).

One example of the use of this technology today, is Danish shipping contractor DSV, a major operator of trucks within Europe. Every truck has been outfitted with connected devices, which means that at the headquarters in Denmark, there is a "command room" with a live map of Europe and every truck in service. At any given time, the data from one particular

truck can be accessed to check vital statistics, the computer system then use the data to calculate optimal routes with live traffic information and forecasting of "usual" conditions, to make sure that not only has the optimal route been selected. It also fits with the optimal shipment to be delivered or picked up and the amount of time the truck driver is allowed to be behind the wheel in comparison to laws on rest. This has hugely improved efficiency, quality of delivery and use of resources for DSV and subsequently the company has grown rapidly (König & Spinler, 2016).

On a smaller scale, sensors can be installed in the machine park, to give information about service interval or unusual frequencies in production. Combined with the ERP-system the operations manager can access this information anywhere in the world at will, the possibilities are seemingly endless for IoT, the main argument will be which technology create the highest value for the SME and the end customer.

Supply Chain Visibility

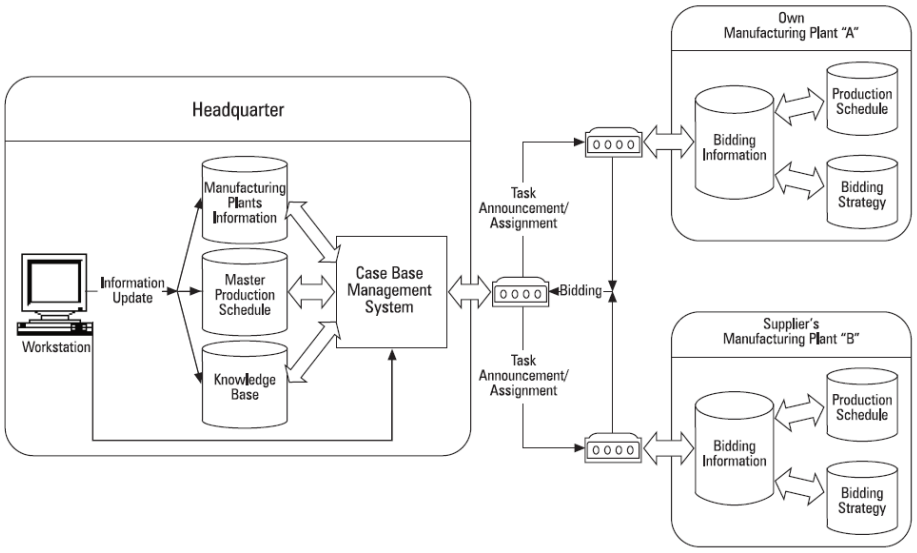
A large part of being in control of the GVC is to have visibility of the supply chain. This is one area in which all the new technologies of I4.0 will come into place, being able to not just track every part or raw material from source to facility but going further by having automated forecasting algorithms which works with the real-time operation systems.

This will drastically reduce both waste, which in normal LEAN terminology is called Muda (Japanese for waste), but it will also allow for more precise batch size, quality and delivery time. No longer will products "disappear" from the radar during transportation. One case in point is the use of GPS and RFID by Danish shipping company DSV from previous section, who can follow every truck, any problems will be visible at moment's notice and the problem can be solved as fast as possible, limiting the impact economically and disruption to the customer (PR RFID & Wireless IoT Global, 2016).

Distributed manufacturing

With an integrated system or sometimes termed Case Based Management System, the company's main goal long term is always profiting, hence, the system will distribute orders to be produced. These might go to the company's own plant A (see Figure 11). Or, if a supplier can make the same quality product at a lower price, the order will be filled through company B, which in the context of this report, would be a part system for a MNC, who can chose, based on order requirements and economic costs, whether to produce in-house or outsource to a SME. This SME might either be a randomly chosen company, but rather in a network with the MNC, so as the trustworthiness of the SME is known and hence, not part of the decision making process (Choy & Lee, 2000).

Figure 11: Distributed manufacturing in practical application



Source: Choy & Lee (2000).

1.4 Focal points for understanding the technology in I4.0

This section concludes the technology part of Industry 4.0. All the major technology found during research to be a possible part of I4.0 has been revised and its use established, though the possible use-cases are endless, and this section in itself warrants an in-depth study in itself. The macro level understanding of technologies and methodologies will help understand how later subsection connect the MNCs and SMEs in cooperative networks and how SMEs behavior towards integration in Industry 4.0 can be managed. Finally understanding the technology of I4.0 will be of importance in developing the framework for SME integration proposed later in this thesis.

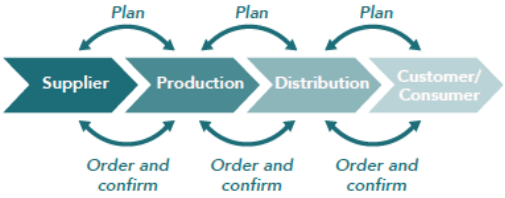
2. SMES INTEGRATION IN THE GLOBAL VALUE CHAIN

How will SMEs be able to integrate with GVCs in the future, is presented throughout this section. Important definitions will also be presented, as to give a rationale for the argumentation behind the benefits of joining the GVC. Certain factors need to be adhered to for any SME that wish to participate in the value chain of the future, this will be analyzed and presented in order to proceed to building the model for an actual action plan of integration in the next section (Conceptual framework model).

2.1 Defining the modern GVC

Traditionally the global value chain has consisted of straight-line nodes, moving products and services from supplier to producer to customers, this can be thought of as supply chain management 3.0 (in relation to Industry 3.0 of the 1990'ies). Figure 12 shows the relation from suppliers, production, distribution and customers.

Figure 12: Traditional supply chain model



Source: Ferrantino & Koten (2019).

Part of the "best-practice" of this era has been the Supply Chain Organization Reference model[3], the best way to operate in the value chain until recently. By moving into Industry 4.0, and by that also the underlaying Supply chain 4.0, information flow becomes omnipresent and will have to be dealt with differently. The old system had limitations as the producer of a certain product would lose sight of the production processes down the different tiers of the supply chain. E.g. French Renault, the automotive producer, might not see that a fire at a factory in Thailand, will disrupt production a month from now, as information flow is in a straight line (Ferrantino & Koten, 2019).

By using Supply chain towers and the technology provided by Industry 4.0, information of the complete value chain can be made visible to the actors in it. Figure 13 shows how this might be visualized.

Figure 13: Integrated supply chain ecosystem

Source: Ferrantino & Koten (2019).

[3] A model for grading and visualizing the processes inside a supply chain.

Instead of being in line, making visibility low, having complete overview of the GVC makes it much more efficient. Research at the same time shows bandwidth costs has fallen 40 times, while many of the IoT technologies has fallen 60times, making it viable to implement or participate in for both MNCs and SMEs. One main factor for SMEs to consider in this new paradigm is digitalization, as the MNCs will move towards I4.0 and the new GVC, SMEs will be required to be able to "connect", hence, providing the necessary information in order to make the GVC function effectively (Ferrantino & Koten, 2019).

2.2 Modes of Integration

For the purpose of integration into the global value chain by SMEs in this section, all types are potential opportunities, be it; Vertical integration, horizontal integration, joint-venture or a loose partnership agreement. Vertical integration for the SME would be to become part of a multi-link supply chain, e.g. a producer of tires will be bought by an MNC producing cars. Horizontal integration, taking the car manufacturer from previous example, would be to acquire other smaller car producers. One such example is the VAG group's latest purchase of Lamborghini (VAG also owns; Audi, VW, Porsche, SEAT and Skoda). Joint ventures might be appropriate form of integration, if the SME rely on special factors like innovation and flexibility to develop products, in this case an MNC and SME can make a joint venture, such a case would usually involve capital from the MNC and specialized knowledge from the SME. Finally, strategic partnership can be used to create trust between the MNC and the SME in the value chain. The advantage for the MNC is that they know what to expect in terms of quality, capabilities and delivery. The SME will have less risk as they can better forecast production, knowing in advance the orders coming from the MNC. Which type of integration is the right one will be dependent on each case (Volkswagen-AG, 2019).

For clarification the term MNC will not only be a reference to a company being multi-national, in this context even the smallest of SMEs might have export offices in a different country, thereby technically making this an MNC. The term LSE (Large Scale Enterprise) with +500 employees might be an interchangeable expression, however, MNC is used in this thesis as a reference to the participation of Global Value Chain. Hence, MNC is a reference to companies with +500 employees and business in multiple international markets, whereas SME refers to companies less than 500 employees, but who might also do business internationally.

2.3 Sources of competitive advantages of SMEs in the GVC

How will the SMEs be integrated in the GVC of the MNCs? Traditionally SMEs have been working in one of two ways, either completely independent of any network, simply producing niche market products or they have been part supplier for MNCs. This e.g. in the

way of Original Equipment Manufacturing for the car industry or similar industries, for the case study of this project, propulsion systems for shipping. This means that SMEs at best has been part of an out-sourcing effort from a MNC and as such could not rely completely upon this, which can be seen in profits swinging according with the requirements from MNCs. Expertly managed SMEs has been able to navigate this environment by use of flexibility and innovation; however, many companies of this size have entered bankruptcy in the 1980'ies and 1990'ies, the picture of the "family business" fading from the western world. Will Industry 4.0 mean the certain death to these companies or is it an opportunity for greater profits, efficiency and stability by officially becoming partners in the GVC? Research show that the most common way for SMEs to gain access to GVCs of the MNCs is through trade exhibitions, though the governance of the GVC creates asymmetric power relations between MNCs and SME, the exhibitions is at least a way into a networked existence (Measson & Campbell-Hunt, 2015).

2.3.1 Traditional competitive advantage

Traditionally a competitive advantage is what makes any company survive in the long term, three possible ways can be used to gain this overall competitive advantage; Cost, Differentiation or a combination to increase customer value. Cost advantage will in many cases be linked to economy of scale and be part of the strategy of MNCs who have access to capital and capabilities of mass production, whereas SMEs in most cases in the western world rely on differentiation strategies, or increased value at the same price as competitors e.g. in the east (Hilmola, Lorentz, Hilletotfh & Malmsten, 2015).

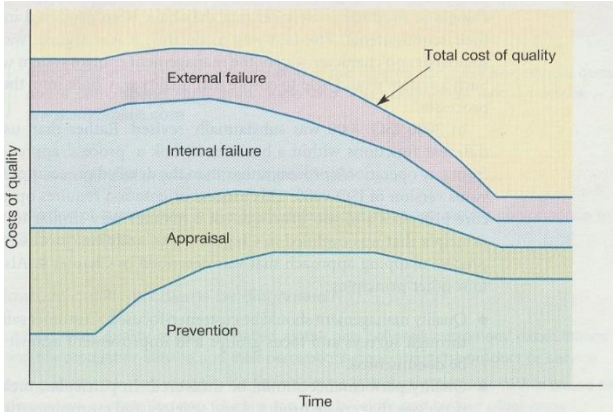
This creation of competitive advantage in SMEs comes as a result of having limited access to financial means, thereby relying on innovation and flexibility in order to compete. The next sub-sections will further describe in what ways SMEs can create competitive advantage for itself and MNCs by working in a network, instead of using off-shoring or out-sourcing (Off-shoring being moving production to a low wage country and out-sourcing being simply buying the required products from a different company with the intent of getting a better price or quality) (Bahrami, 2009). Also see Figure 11 for distributed manufacturing.

2.3.2 Quality control

Quality issues can be broken down into 4 categories (See Figure 14). Ranging from mitigating external failure, which is both very costly in terms of financial means and time it takes to mend the damage, it also lowers the trust in the product or service provided. Internal failure only means that the quality issue was found before shipping it to the end-user, whereas appraisal is locating issues before the product is finished and finally prevention, in which designing for excellence and quality management at the individual machines are taken

into consideration. This is the most prudent, yet sometimes missed, opportunity for lowering the total cost of quality control (Slack, Chambers & Johnston, 2010).

Figure 14: 4 Stages of quality costs



Source: Hollensen (2011).

By collaborating with SMEs, MNCs can save in quality control by insuring problems are either engineered out or found as they happen in the production, this factor is also important in regard to shipment from e.g. from China to the Netherlands, which can take up to 2 months, more on this in flexibility and speed section 2.3.5.

2.3.3 Cross-company knowledge sharing

Sharing of capabilities within companies across the network might create benefits for both SMEs and MNCs, Gorenje of Slovenia can be used as an example of capability building (though Gorenje under the normal definition cannot be called an SME). In 2015, after the acquisition of 10% of the company by Japanese Panasonic, Panasonic send a LEAN-team to Velenje to build capabilities within this facility, there by not only making Gorenje more productive, but also making sure standards were met to allow some of Panasonics products to be produced on site for the European market. It also served as a streamlining process of the 2 companies, in making both better understand the culture and processes of thinking within each company, easing cooperation (Novak, 2013).

2.3.4 Integration and understanding in the GVC

MNCs can save in both economical terms and in worker capacity by using Vendor Controlled Inventory, this require the SME to have gone through digital transformation and having an ERP-system that can manage this task. By utilizing the technology and being in a partnership, the SME will manage the inventory for the MNC thereby putting the control closer to the experts and making sure inventory is kept as low as possible, but within the

limit of safety. One example of this is again Slovenian Gorenje, who uses Vendor Controlled Inventory with SME suppliers, all Gorenje does is to state how much the production output will be for the next week and the SMEs deliver just-in-time, giving Gorenje the resources to perform other tasks and providing the SME with steady business sustainably. Vendor controlled inventory might also be an alternative to direct outsourcing, which ensure that risk is lowered as it can contribute in an in-sourcing way, thereby reducing risks of outsourcing for the sake of outsourcing (Gould, 1997).

2.3.5 Flexibility and speed in the supply chain

The major downside of offshoring is the delivery time, which can be accelerated by problems with quality. Should a shipment be defective, it might take months to receive a new production batch. By having integrated SMEs into the value chain, this increase flexibility as the SMEs can usually be located close to the MNC production facility, thereby lowering transportation time and by having lower time in transit, just-in-time principles can be better utilized reducing cost for MNCs (Lonsdale & Cox, 2000).

2.3.6 Value proposition of the GVC

Collaborative networks offer better access for SMEs to resources, which is an important element not only in internationalization but especially in Industry 4.0, as the size limits financial strength, becoming part of a network might grant much needed access to the benefit of both the MNC and the SME (Measson & Campbell-Hunt, 2015).

2.4 Mapping the SMEs niche in the GVCs

2.4.1 Resources of the SME

Financially, SMEs usually are limited in magnitude. The owners have put in some degree of capital or the company itself have retained a proportion of earnings, this dwindle in comparison with MNCs huge backing of capitalization either in liquid assets or options for loans in banks, investors or bond market.

Another aspect of the SME is the lack of business education or specialist expertise, contrary to MNCs the SMEs do not have access to major business disciplines like; business development, strategic positioning or international marketing experts, it is not unusual to see the owners directly involved in sales, distribution and price setting personally, as has been observed in the case company Korsør Propeller A/S (hereinafter: KP) (Barnes, 2000).

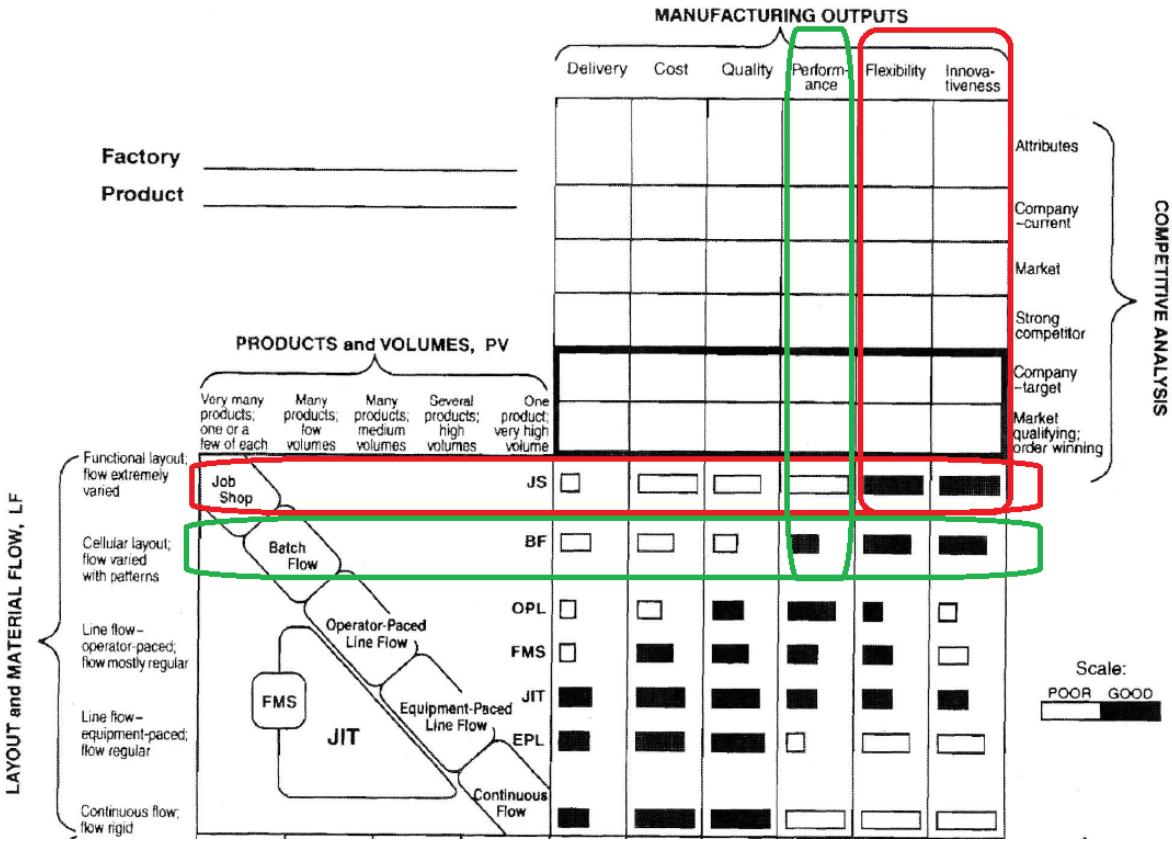
2.4.2 Manufacturing layout identification

According to the Miltenburg framework, an analysis should be made of the company in order to find the optimal production layout and methods (See Figure 15 below), generally SMEs tend to reside between job-shop and operator-paced line flow, anything above this level require substantial resources which makes it mostly the area of MNCs.

Red color marks the production method right for a job shop like environment, which is preferred for one-off engineering projects, it excels in flexibility and innovation. Green color indicates other potential SMEs, in which batch flow allow for higher performance, anything higher on the scale will start moving into international companies and MNCs in size.

Batch flow fits types of SMEs that deal in series of production runs e.g. +10 units (Miltenburg, 2005).

Figure 15: The Miltenburg framework show casing the case company's position



Source: Miltenburg (2005).

This finding corresponds to the research showing that innovation and knowledge are the most important factors in retaining a competitive advantage, though the strategic and tactical level also need to be in place for the day-to-day running of the business. That is especially

true for SMEs, as the financial backbone of an MNC cannot be relied upon for the SME to absorb large business venture failures (Wulf & Butel, 2017).

2.4.3 Sources of Information

Whereas MNCs can rely on their financial size to purchase marketing reports or hire consultancy firms to perform market analysis, SME more readily make use of face-to-face experience by which the manager creates a mental picture for him/herself, which may or may not be incomplete or lacking in detail. Sometimes this might result in a better-connected communication with the end customer, however, here it is a risk of misunderstanding in any form of communication. This direct connection with customers might come to the advantage of the SMEs when MNCs try to enter a market, integrating the SME in the GVC or partnering up can be an advantageous proposition for both parts (Bennett & Dekkers, 2005).

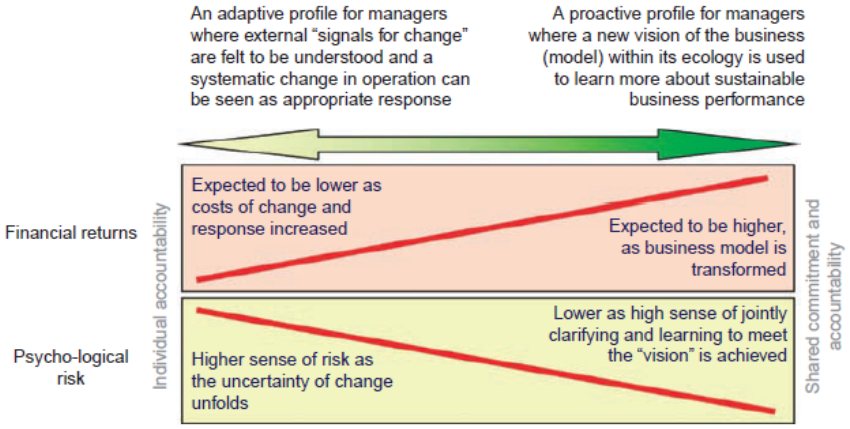
2.4.4 Growth in the SME vs. MNCs

Contrary to MNCs, it was found that the majority of SMEs did not see growth as a strategic goal, but rather as a risk to the company. The logic being that a larger organization need more resources and the risk of running out here would result in bankruptcy. This might explain the static size of many SMEs, unless an external event trigger growth, e.g. by a large order or partnership with an MNC. Further the study showed that SMEs with high levels of risk management also showed higher tendency to expand abroad (not only doing export from the home country) (Falkner & Hiebl, 2015).

2.4.5 SMEs management readiness for change

During the research it was found that SME's type of management can be divided into 2 types; Ownership leader and Managers, so either the SME is being family controlled or the SME has appointed a managing director. For the purpose of integrating a radical new paradigm like Industry 4.0, a study showed 2 distinct modes of reacting to change: Cost-based and Proactive reaction. The cost based way of thinking involves believing that change is only cost driven and will hence only happen with a severe economic threat to the company, this approach does not accelerate innovation and change within the company, the second is proactive and see the paradigm change as possibly an advantage, however, only under the condition that the management truly understand the implications of the change (Howarth & Fredericks, 2012). Figure 16 summarize the viewpoint.

Figure 16: Cost-based Vs. Proactive based management



Source: Howarth & Fredericks (2012).

Further, interviews with Heidi Svane from Lifestyle & Design cluster, showed that the understanding from employees will be crucial for a successful implementation of such a project as to move towards I4.0.

2.4.6 Benefits for both parts in maintaining the GVC

The benefit for an SME to become part of a value chain with the MNCs, is to lower risk in regard to long term survival, this either being better secured in financial areas or to have access to higher level capabilities within the MNC, that the SME could normally not have gained, this plus the advantage of long-term purchase orders (Thakkar, Kanda & Deshmukh, 2008). However, the MNC has the advantage of leveraging the size of the company to reach out to SMEs for development, even MNCs cannot be omnipresent in R&D (and most likely should not even try) and will have to reach out to the small SMEs that has specific knowledge in specific areas (O'Neill & Sackett, 1994).

2.5 Risks for SME's integration in GVC

What are the risks for an SME to integrate with the Global Value Chain and to what extend will this affect the company on an economical basis? These risks and financial areas will be analyzed throughout this section.

2.5.1. Macro environmental risks

To get a structed result a PESTEL analysis will create the basis for analysis of the macro environment. For the purpose of this project, the risk factors have been limited to include relevant factors for SMEs and not MNCs.

Political

The most prominent risk for a GVC is the government of the countries involved, e.g. the MNC has headquarters in the US but building the value chain with SMEs from Sweden, Netherlands and Slovenia, for this one value chain the political environment must be at the very least known to the parties involved. Just a few years ago, it seemed that GVC within western countries were stable and relatively low risk. However, event like the election of US president Donald Trump and the voting for Brexit, has shown that political risk is still very much a concern for collaborative networks on an international scale. What each SME must do will be specific to each case, however, mitigation plans for risk is a must for both parties as simply being good due diligence before entering any partnership (Abdulkareem, 2018).

It might be necessary to research the level of corruption and to what extent it will be required in order to conduct everyday business. Taking the most recent data, it shows the corruption level of Slovenia is on par with France at 70/100, while Sweden ranks 85/100, this may be compared to Russia with a low score of just 28/100. Where the links of the GVC is located has an important factor on the overall political risk any SME will face (Transparency International, 2019).

Though the local government can be seen as a risk, the opposite can also be true. In an interview with the major of the Danish city Odense, Peter Rahbæk Juel stated that he was spearheading technological development in the municipality by injecting approximately €6.67mio over the next 10 years to enhance the capabilities of the city becoming a technology hub in robotics. On a macro level governmental scale, it was found that several grants could be obtained for SMEs in developing their digital footprint, one such government body was Sprint: Digital, offering financial help to further develop technological capabilities in SMEs.

Economic

SMEs are highly reliant on external financing as internal resources are either small or utilized fully already, hence, loans are the main source of financing for SMEs, which due to the small size and higher systemic risk of an SME means higher rates on these loans (or sometimes rejection of applications for loans). Another factor is the managements/Chief Executive Office (hereinafter: CEO) appetite for risky ventures. Research showed that most SMEs prefer fixed-rate loans as variable loans require a high understanding of risk factors and is highly correlated with the knowledge of the CEO and as the research showed. SMEs in

general are less aware of risk management practices, would benefit from the less risk (yet, possibly more expensive) fixed-rate loans (Falkner & Hiebl, 2015).

A case from Finland shows an SME that went bankrupt in 2014. The company tried to survive solely based on research and development, not being backed by any MNC or being in any network. They themselves later released a press note that while profits had dropped by 60% from 2008 to 2014, spending on R&D had increased by 40% every year since 2008, which lead to the situation in 2013 when their first deficit lead to empty cash reserves and, hence, a bankruptcy (Hilmola, Lorentz, Hilletotfh & Malmsten, 2015).

This showcase clearly that the risk for SMEs being outside a network can be exponentially more dangerous than at a first glance. Research also showed that a more balanced level of R&D within companies in the US of around 10% of earnings, showed more growth and sustained competitive advantage in the long run (Strategic Direction, 2005).

SMEs that have exporting business or subsidiaries abroad, will need to understand the risk of exchange between currencies. Trading within the European zone can in most cases be disregarded on these issues, however, if the SME is located in the European Union but export to e.g. USA, the fluctuation in currency value might adversely (or positively) affect the profitability of goods sold.

On the supply side, this risk also occurs as the same SME located in the European Union might need materials from USA, and if the US dollar strengthen then the SME will have to pay more for the required goods. One possible solution to this problem is hedging, e.g. by buying forward contracts, this ensure the SME knows the cost/profit to be expected before hand and will make it less riskier in making business decisions into the future (Madura & Fox, 2016).

Social

A major contributor to risk when an SME is to join any kind of value chain, will be the cultural issues that might arise. It will be a problem of communication, in which people think they understand, yet, this might not be the case and is therefore a major factor in any cooperation between companies.

As MNCs include SMEs into their GVC, the risk is of adding too much value in one venture. In short, if the SME fail to live up to its contractual obligations, and the MNC has no alternatives, the expense of finding a new supplier can be substantial. This is not to say there might not be economic benefit in e.g. quality and delivery time as stated above, but a risk any MNC should consider to mitigate by having emergency suppliers, which can actually consist of other SMEs who will be on "stand-by" in case something happens to the tier one supplier. Here the I4.0 technologies will also be of help, as linked communication of internal ERP-systems can give early warning to other members of the GVC, if any disturbances happen within one company in the chain (Christopher, 1992).

Technology

The pretext of this project is I4.0 and why it is important to become part of this new era, it is exactly due to this new development in technology that SMEs need to keep up the pace of development. Even in slow moving industrial engineering manufacturing, technology is moving fast, perhaps not in the product itself, but in the processes of how products are produced. Therefore, it is exceedingly risky to not follow trends of development. Automation, sensor technology, internet and increased level of processing power, are all areas that even the smallest SME need to be at least aware of.

In the 80'ies LEAN process management started and later business process re-engineering came about, Internet came in force in the early 2000s. Research shows that lacking in R&D can directly lead to lowered competitive advantage, though as the example from previous section on the Finish company, R&D alone is not enough and have to be balanced (Holtzman, 2008).

A resent example of the overlapping between technology and legal areas, is the emergence of crypto currency, to which companies must decide whether or not to make use of. While having in mind that governments are debating the validity and legal usage of this new technology, just one area in which technology can be either a risk or value adding.

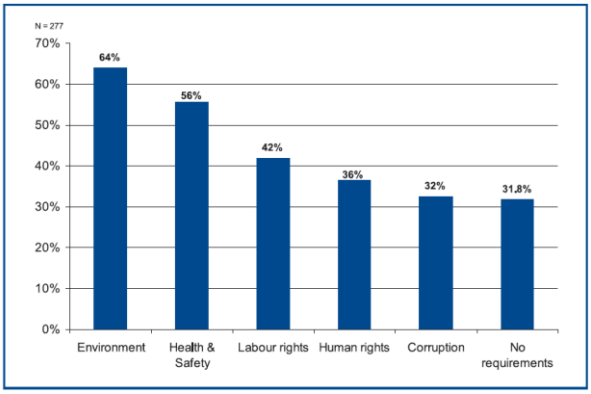
This also has implication for SMEs who are outsourcing parts of their manufacturing to countries like China, where intellectual property rights are not protected and hence, vulnerable to copy-cats and a lower competitive advantage (Chaudhury, Gerdemann & Kapoor, 2015).

Environment

Research has shown that though MNCs have requirements for environmental protection; use of child labor, corruption, health and safety etc. (See Figure 17 and 18 for comparison), they only apply this to tier 1 suppliers, from here on the SME need to apply the same rules of conduct to their suppliers, however, this turns out is not the case. Whereas 64% of MNC require contractual application and verification on questions of environmental issues, only 36,1% of the SMEs required this for their suppliers. Whether this is due to SMEs believing in "decent" conduct by their suppliers, does not make for a better case in regard to sustainability from the MNC level (Jorgensen & Knudsen, 2006).

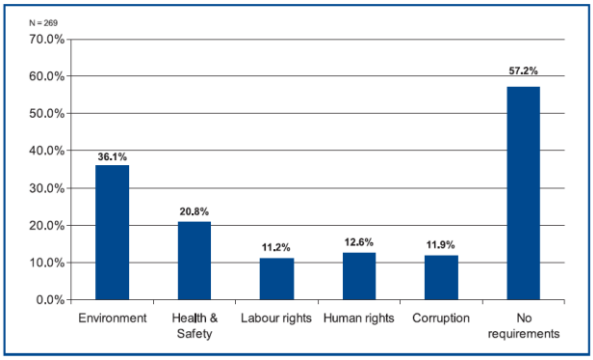
It could be argued that SMEs need to act as change agents on behalf of the MNC, if not for their own ideology, then for the goodwill (Not as much economically) this will provide towards the MNC and their position in the GVC. In interviews with Ole H. Pedersen (Full interview in Appendix 3), it was stated that it was rare if ever any questions were asked about environmental issues before accepting a project, more so it seemed that the MNCs just trust that those issues are taken care of in accordance with standards that are proficient.

Figure 17: Percentage of MNCs requiring various CSR practices



Source: Jorgensen & Knudsen (2006).

Figure 18: Percentage of SMEs requiring CSR practices



Source: Jorgensen & Knudsen (2006).

Legal

For the SME there will always be a risk of asymmetric power distribution in comparison with the MNC, even though it is a value "chain". The MNC will by definition have more power due to economic size, this also means that the governance of and access to these value chains are controlled by MNCs, hence, they can both be a helping hand but just as much impede the entrance of the SME (Measson & Campbell-Hunt, 2015).

For some companies e.g. located in Scandinavia, it was found that labor laws made it possible for companies to work in a flexible way (stated by Ole H. Pedersen during interviews), making it possible to hire employees for short amounts of time during high season or to simply let people work longer hours for a higher pay.

2.5.2 Micro risks

Having focused on the possible risks involved in the macro environment, this subsection will uncover some important internal risk factors found during research. It is important that both kind of risk factors are taken into consideration as they are to be dealt with in 2 different

ways, the macro environment being one sided, the company cannot do anything to affect the risk factor, other than to have mitigation plans for those events, however, micro environmental factors can be affected by the individual company and is therefore important to be aware of.

Supply chain risks

SMEs was shown in a research study to mostly have only one supplier in each product category, exposing them to risk if the one supplier for any reason cannot deliver as promised. This is quite opposite of the Supply Chain Management practice of MNCs in which redundancy suppliers are available, should a preferred supplier not be able to deliver. It might not be practical for an SME to have multiple suppliers standing by; however, it is suggested that the company at least know alternatives to the usual supplier in case it is needed, this is low cost risk mitigation (Thakkar, Kanda & Deshmukh, 2008).

Risks of joining a Global Value Chain

One of the major problems found during research of complex networks (or collaborative networks) within manufacturing is the decentralization of decision making. Traditionally there is a centralized decision-making body, controlling the strategic and tactical direction.

However, in GVCs where networks are more loosely founded by cooperation between different entities, a change toward decentralized decision making must be anticipated. Another factor which must be taken into consideration is the resources and capabilities for either horizontal or vertical integration, in which under normal circumstances the MNC can deliver resources and capabilities (Assuming an integration process has been done before in the history of the MNC), while the SME mostly must work on capabilities and then hope for resource support externally (this either by financing in traditional banks, MNCs providing resources or government programs for support). Amongst other areas of importance was multi-agent theory, inter-organizational integration (interface between the companies governance) and changeability (to what extent are the companies prepared for the change of decision making and cooperation) (Dekkers & Kühnle, 2012).

Management and employee risk

The loss of a long-term employee with deep knowledge will invariably hit harder in a small company, as there might not be any other employees with this specific knowledge. Also, the lack of awareness of risk management can lead to not understanding e.g. loss of intellectual rights or simply protecting this knowledge legally. It is suggested that SMEs management must invest in the employee's development personally to an extent where they feel less inclined to leave the company with valuable knowledge lost. If this cannot be done, the next level of mitigation will be to make the processes and knowledge more tangible and codifiable, so that a new employee will spend less time learning the process (Dalio, 2017).

2.5.3 Managing risks when integrating with the GVC

Having identified major sources of risks, the following steps of risk management has been identified according to (Falkner & Hiebl, 2015):

- Risk Identification
- Risk analysis
- Selection of techniques
- Implementation strategy
- Control

In the following sections, mitigation of risks has been described in an, easy to use, strategy for SMEs. Risk management is an important step for streamlining of the SME, if it is to join a GVC.

Risk identification

First step in risk mitigation is to identify the possible areas of gains or loss, this can be done by analyzing the business data in the form of staff, activities and assets, or to use the PESTEL framework as per this section, alternatively to this approach, Porter's 5 Forces framework can be used for identification of micro environmental risks.

Next, the financial statement can be used to locate potential financial losses/gains, finally flow charting the processes of the company will give a holistic picture of potential danger areas. The employees might not be accustomed to these processes, so the SME might have to invest in educating the personnel in their capacity for risk management. It might also be prudent to brainstorm what kind of highly unlikely events that could have a huge impact (Falkner & Hiebl, 2015).

Risk analysis

After having identified risks, it is important to analyze potential frequency of risk occurring and the potential impact, these two factors will ensure that the highest risk areas can be addressed first and most effective, it should provide a plan of action and sorting of importance of risk areas. In the frequency topic, words like "unlikely" and "highly likely" can be used for employees to understand the concept of analysis, while for impact, words like "Significant" and "Catastrophic" will make it easy to understand the effects if one process has the combine risk factor of "highly likely" + "catastrophic", this is a priority task to mitigate (Elahi, 2013).

Selection of techniques

According to which area has been analyzed to be the most important, individual response strategies must be implemented. A highly used technique used by SMEs is insurance, e.g. insuring the cargo in transport in accordance with Incoterms, insurance in case of fire in the

production etc. However, under this category, also redundancy of suppliers can mitigate the risk of losing valuable raw materials when needed.

An important area is capacity in production. How to balance having enough capacity to meet the needs of customers, but not having so much overcapacity that the business becomes unprofitable, this include both manpower for the job and materials in the warehouse ready for instant use (Falkner & Hiebl, 2015).

Implementation strategy

After the previous steps has been completed, everything must be implemented, this include informing the relevant personnel of the new risk management, but more importantly to make sure responsibility has been delegated to specific employees/managers, everybody will have an area of responsibility, which cannot be shared in any way, this insure the highest possibility of successful implementation.

Control

Regular reviews of the techniques for risk responses must be carried out. Performance standards have to be in place, e.g. key performance indicators to measure that all responsible parties are performing in accordance with the plan.

Should the SME want to join into a GVC by which several countries are involved, or the reverse, should the MNC be looking for SMEs to join into the value chain. Specific country factors can be evaluated by the use of a weighted average matrix, this decision-making tool is especially useful if there are no obvious choice by normal judgement from management, or if the options are appearing to be equally advantageous.

Simply by weighting in the most important factors for the company in regard to risk, a clearer picture of the risks and value of each chain link will become apparent.

2.5.4 Suggested sources for SME

When the SME has to perform its risk assessment, it might not always be obvious to the management where to find this information. As described earlier management in SMEs are less likely to have access to specialized personnel with business degrees, hence, sources from this research has been included below for future risk information usage:

- OECD’s data lookup on data.oecd.org
- Tradingeconomics.com
- Data.worldbank.org
- Theglobaleconomy.com

This has been provided as a theoretical add-on to the conceptual framework, in which risk factors will be analyzed during the procedure of analyzing the company's readiness for future participation in the global value chain.

2.6 Risk awareness for management of the SME

Suggestions for implementing risk management in SMEs has been put forward as this will help streamline the SME and make it easier for an MNC to assess the level of professionalism within the SME, point being in making it easier to either join the value chain of the MNC in the form of partnership or some other integration method e.g. joint-venture or outright horizontal integration with the MNC.

SMEs main limitations is within its limited resources both financially and capability wise in relation to employees with university degrees. It was also discovered that growth many times are seen as a risk for SMEs and not an opportunity like in MNCs.

Much comes down to the management in each SME to which degree the SME will be willing to integrate in a value chain, however, the advantages are great if done successfully.

For MNCs it will be important that integrations with SMEs will be of the nature of understanding each other, making communication paramount for success, this means a streamlining of the SME, which will be dealt with in greater details in the conceptual modelling section of the report.

3. CONCEPTUAL MODEL DEVELOPMENT FOR A SME STRATEGY IN THE CONTEXT OF INDUSTRY 4.0

In order for an SME to be firstly integrated in the GVC, and secondly to grasp the benefits of diving into the whole I4.0 universe, a model will prove highly effective.

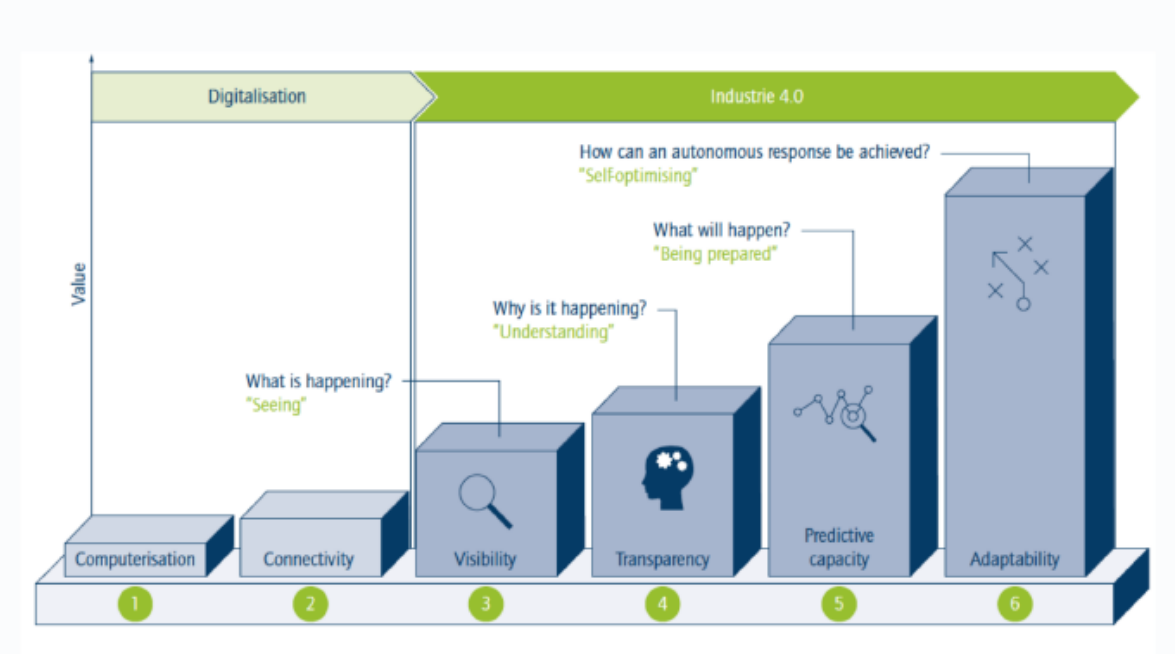
A framework will be developed through comprehensive research, analyzing logical needs based on available theories ranging from organizational behavior to change management and disciplines in industrial engineering. Finally, after the framework is developed, interviews have been arranged for a "reality check" on the proposed framework. The following section include the framework and logic behind, which in section 4 will provide the final value proposition for a case study.

3.1 Framework development

Research into best-practice application of I4.0 show that most SMEs need to do a digital footprint analysis before starting the journey down the I4.0 road.

In Figure 19 it can be seen how computerization and connectivity (Step 1 and 2) has to be established before attempting to move further, this is part of the terminology of digital transformation.

Figure 19: Stages in the I4.0 development path



Source: Hoppe (2018).

The next step is to visualize how the production is actually performing. The processes and layouts have to be digitalized before step 4 can take effect, which is to understand the production as a whole, this is usually a problem as employees, even the management/CEO only know half of the picture.

Consolidation has to happen before trying to implement any new technology, as its effect might cause unwanted ripples down the line. Step 5 prepare for the correct use of facilities, cells and production equipment, whereas the last step is the most difficult and the “holy grail” of industry 4.0, self-optimizing systems that learn from itself, machine learning or Machine to Machine.

As mentioned in under section 1.3.3 (Simulation and modeling of products and processes) hardware has fallen in price and is still becoming more affordable, making it possible for SMEs to actually invest in some of the technologies previously only thought to be for MNCs.

Moving from industry 3.0 to 4.0 can be split into 2 main sub-section, Efficiency and business model changes. See Table 1 for improvement areas in each section.

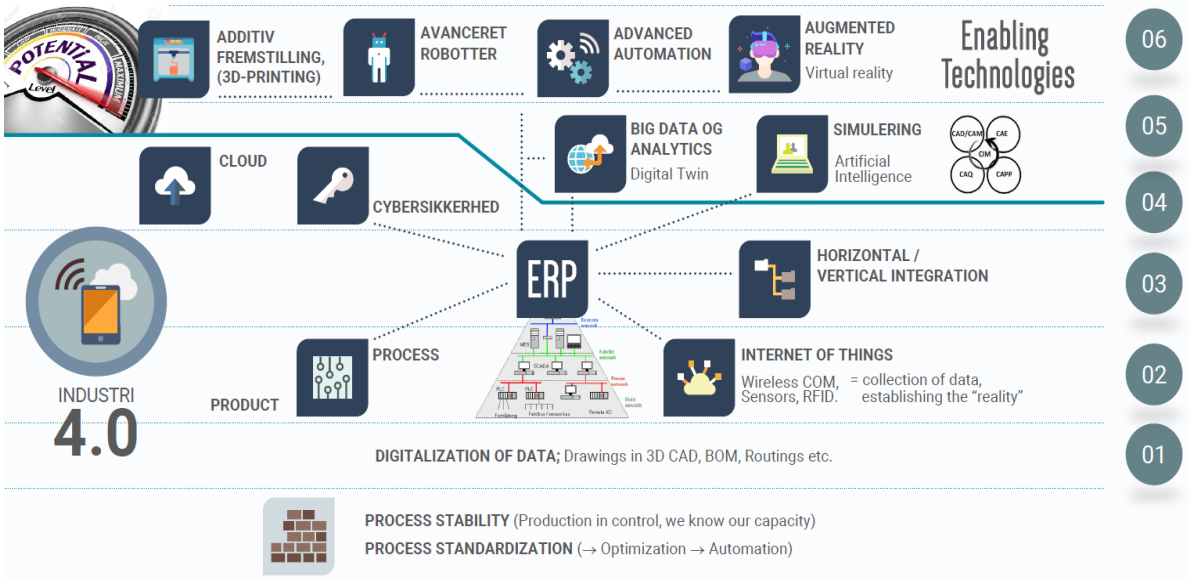
Table 1: Efficiency and competitive advantage of I4.0

Efficiency (Better and cheaper products)	**Business model (higher competitive advantage)**
Reduction in labor costs by implementing robots	Improved quality by using sensor technology
Reduction of logistical costs by optimizing supplier logistical systems	Possible to offer customer customized products
Reduce operational costs from lover set-up costs from production optimization projects	Higher speed in delivery from ordering to delivery
Reduction of waste (Muda) by more efficient use of raw materials	Faster production development from idea to products
Reduction of errors by simplifying information flow and fewer people involved	Employees has more mental capacity to focus on value creation and innovation

Source: Own work.

In order to make a more visualized and comprehensive case, Figure 20 has been created to showcase the proposed 6 levels of progress towards Industry 4.0.

Figure 20: Holistic view of the levels involved reaching I4.0



Source: Tawfik (2019).

Step 1 and 2 as mentioned earlier in this section, is part of the digital transformation and an absolute requirement in order to reach I4.0. Several important points can be understood from

this point of view, taking one example of the ERP-system, during the interview with Sharif Tawfik (Full interview in appendix 3), it came about that many SMEs in Denmark right now are forced to change their old Microsoft Navision C5 ERP system to a new, as C5 is being discontinued. Many of these are considering software such as E-Conomics, which is an adequate program for sending out an invoice, but completely lack the capability of integration for Industry 4.0 technologies.

3.2 Maturity of the SME

The macro picture of I4.0 for SMEs will eventually be integrated in the I4.0 era, however, before starting the journey, the company must be evaluated on the scale of readiness and most importantly, where the company needs to pay most attention in the implementation. It can be a daunting task standing with a 25-employee company and simply stating this company will now be part of I4.0. To this extent, a framework has been developed to scale the company's readiness and to get a more complete understanding of the processes in the company. 2 axes of readiness have been combined into Figure 21, in which 36 individual categories pinpoint areas of interest to ask companies before starting the I4.0 journey. This gives president as to which questions need to be asked at the discovery process (As-Is).

Figure 21: Maturity model for SMEs

Source: Tawfik (2019).

Figure 22 show what will become the Y-axis, the level measurement of I4.0 improvements.

Figure 22: Y-axis of the maturity model

Source: Tawfik (2019).

3.2.1 Reactive decision making

Things are handled when it arrives on the table, commonly known as “fire-fighting” it is an old type of work process that does not take the future or strategy into consideration. These are the essential decisions on an everyday basis, like controlling economics, talking across tables for information, detached process flows.

3.2.2 Creation of transparency

Essential part of Industry 4.0, this create flow of information not only inside the company but also outside, this might be in vendor-controlled inventory systems in which the supplier can gain access to information in the ERP system of the company, it might also help customer relations with CRM systems integration.

3.2.3 Increased understanding

This is an important part of the innovation process and will be part of the higher competitive advantage from high-tech companies, it utilizes business intelligence tools, synchronize information and makes products intelligent through sensors and Cyber Physical Systems.

3.2.4 Improved decision-making process

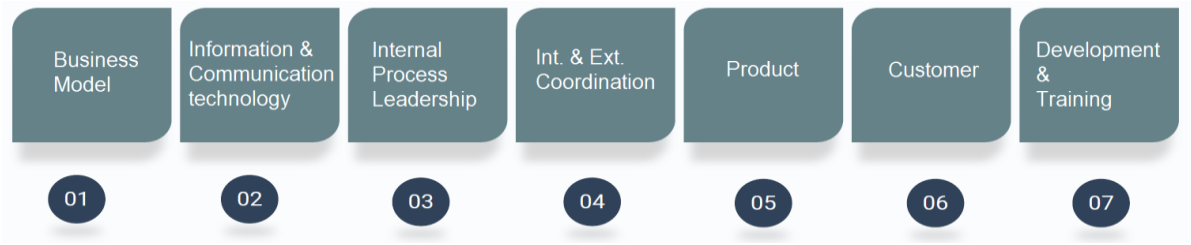
Personalize the business model by external integration, this might be via supplier communication or coordination with customers, this area will also include innovation of products and look at the product life cycle.

3.2.5 Self-optimization

The top level of I4.0 integration, when processes and strategies are able to self-optimize, there will still be a need for employees to oversee this process, however, a lot less energy and resources will be used during the production.

On the X-axis the following categories has been found to represent the structural foundation in the company, these categories describe systems and products produced by the company, see Figure 23.

Figure 23: X-axis of the maturity model



Source: Tawfik (2019).

3.2.6 Business model

Has the business model been updated to include the changes of moving towards I4.0? The business model does work as is currently, however, will there be any conflicts with the current model when trying to integrate new process models and technology, all has to be evaluated. Here it is important to understand what the digital transformation will mean to each business sector (Berman, 2012).

3.2.7 Information and Communication technology

This is the foundation of which I4.0 should be build and an important factor in how mature the company is towards I4.0 integration, the most basic being internet connection and control of the economic systems, by the end of I4.0 this should support the complete supply line and employees should be able to extract important data for analysis.

3.2.8 Internal process leadership

Each project leading toward this change must have leadership, therefor todays capabilities in leadership and delegation of responsibility will be an important part of judging the

readiness of the company. If any aspect is lacking in this area, additional resources in training and capability building must be part of the investment.

3.2.9 Internal and external coordination

How well does the company coordinate internally all its processes and just as important, how does it manage the interaction with suppliers and customers, are there systems for this or is it simply done ad hoc or in a reactive manner?

3.2.10 Product

How intelligent are the products produced? Is it a one-time project, specific for each customer or can modularization be integrated in the process? Are there coordinated Product Life cycle analysis going on already or will this need to be improved in the I4.0 journey.

3.2.11 Customer

How well are the customers handled currently? Does the company have effective CRM systems management, and does it utilize the data from these systems? Will customers be calling and treated as a one-time event or does the company employ segmentation and innovation judged from the customer's needs and requirements.

3.2.12 Development and training

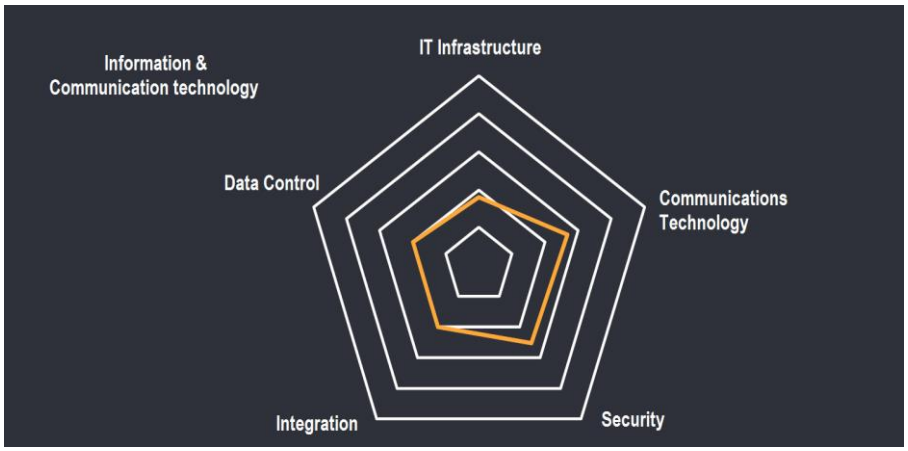
How does the company handle training and further retainment of knowledge within the company? Is there a dedicated Human Resources department that handle hiring and firing plus education and courses for the employees or is this handled by managers as extra tasks in their everyday running of the production?

3.2.13 Measuring the results of analysis

By using radar diagrams, each section of the SME can be mapped and evaluated. In Figure 24, an example has been made for the information and communication technology of a company. This case being a seriously lacking company, who would have to upgrade the infrastructure of the digital technology before attempting I4.0 integration. This will be a long process, but quite essential for the project to succeed in the long run, this will create a solid foundation unto which the I4.0 terminology will be built upon.

This example has been taken from section (3.2.7) Information and Communication technology. It separates a major headline into specific areas of interest, so here information and communication technology split into, IT infrastructure, Communications technology, Security, Integration and Data control. By giving scores between 0-5, the company may visualize better where there are areas that needs improvements in order to move towards I4.0.

Figure 24: Example of radar diagram for Information and Communication technology



Source: Own work.

3.3 Action plan

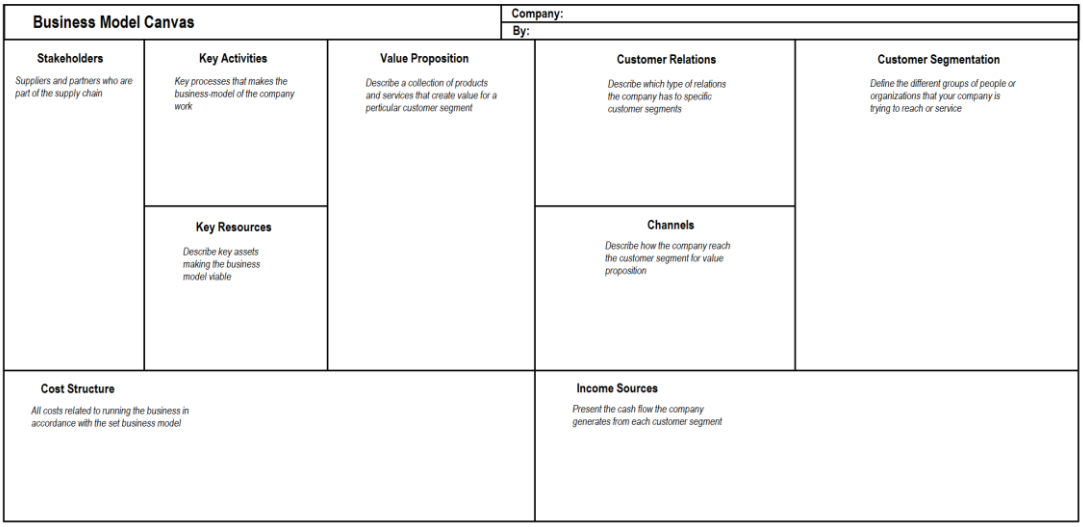
3.3.1 Initiation of analysis

In order to break down the process, and by such making the scope of the project easier to comprehend and actually implement. 3 phases are found to be best practice to give the best holistic point of view. These 3 steps are from my own experience working as a process engineer:

- Phase 1: Identify and evaluation of the “As-is” state
- Phase 2: Mapping of resources and possible risks
- Phase 3: Implementation using e.g. GANTT chart

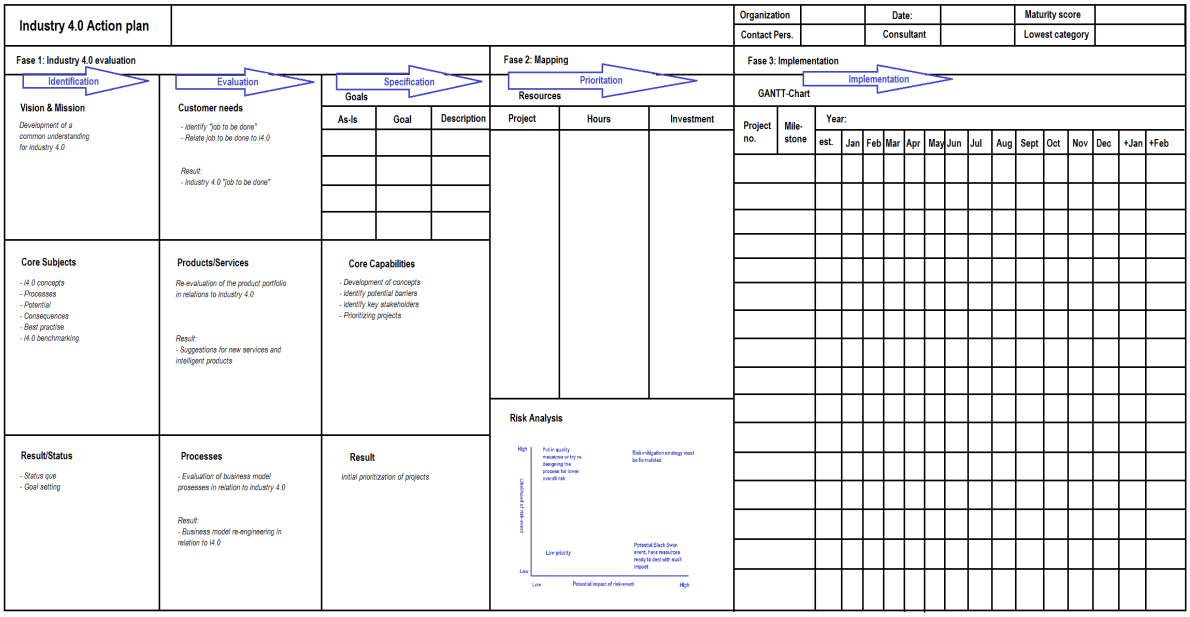
A visual worksheet has been developed for SMEs to easily map the flow and schedule the project; this can be seen in full in appendix 2 and an illustration on Figure 25 and 26.

Figure 25: Business Model Canvas



Source: Own work.

Figure 26: Industry 4.0 Action plan



Source: Own work.

The Business Model Canvas helps to identify stakeholders and get an overview of the business from a holistic perspective, it maps processes and resources in relation to responsible parts. The I4.0 action plan makes it easy to scope out the process of implementing I4.0, starting from identification of potential areas, through prioritization stages all the way to a specific GANTT-chart in which the decided upon projects can be managed in detail.

3.3.2 Phase 1: ID and evaluate the As-Is state

Identify processes

The very first item on the agenda is to create a vision and mission for the project, this will make sure that not only the management know the details and vision of the project, but also the employees and lower level managers who will be working on implementation are all in complete comprehension of the project.

This will also serve as motivation for the employees, as it gives them a sense of ownership of the project, it was found that most large change projects failed due to lack of understanding and ownership from employees and lower management as it felt like a top-down push, not a collaboration process (Kotter, 1996).

Next sub-step is to list the areas in which I4.0 projects will take place, examples of this is: I4.0 concepts, Processes, various potential, consequences of change, best practice and benchmarking to insure actual improvement from I4.0 integration.

Finally, in this step the status que has been mapped, information gathered and analyzed, this information will be part of the goal setting for the whole project.

Customer, products and processes

The demand of the customer must be identified and made tangible, here the "job to be done" must be related to the I4.0 possibilities. This will result in a direct line between the projects of I4.0 and what gives value to the customer in the end, thereby eliminating none-value adding projects and processes.

In this phase the products themselves also have to be evaluated, are there possibilities for integrating smart-devices, IoT solutions or connect products with the ERP system, brainstorm the possible areas where technology can assist the old products, or redesign the products. It might take complete re-engineering of some processes to fit it to new technology, this is a highly innovative step and an open mind should be kept.

Goal setting

After all the information has been gathered, specific goals for the implementation must be made. Core concepts must be defined with As-Is turning into To-Be.

Prioritization of the projects should also be made, as not all sub-projects can be started before others and some projects will provide greater benefit faster and hence, must be implemented first e.g. high-speed internet connection must come before integrated IoT solutions.

3.3.3 Phase 2: Mapping resources and risk analysis

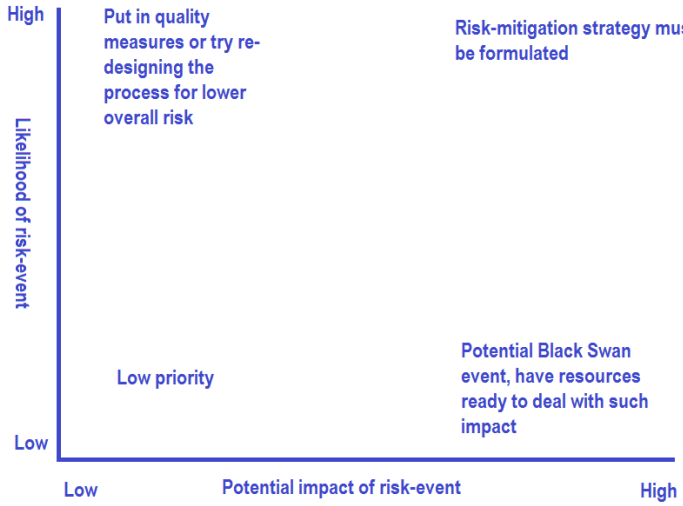
Resources available to the project

Each project will in this stage be allocated resources, this will both include, materials, funds and personnel required to complete the project. Time must be assessed for each project and allocated as deemed feasible both in terms of finances and company capabilities.

Risk analysis

A simple two dimensional graph is suggested to show the degree of risk involved in each project, on the Y-axis is the likelihood of the risk event happening, on the X-axis is the impact of the risk should it happen, a simply tool that will quickly give the project owners an idea about the project in most need of supervision in regard to risk (See Figure 27).

Figure 27: Combined focus of attention related to risk-impact



Source: Own work.

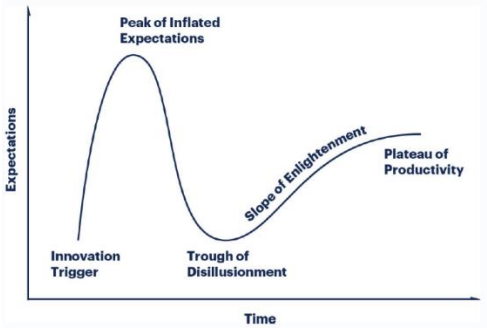
3.3.4 Phase 3: Implementing and planning

The final step is to create a GANTT chart for each project in the I4.0 implementation, this will include project number, milestones and the anticipated amount of time for completion of the project. At this point the project leaders can start the I4.0 implementation, knowing that all available information has been found and analyzed and that none of the project (theoretically) will clash during implementation.

3.4 Appropriate technologies for SMEs

At the point where the analysis of the As-Is state have been uncovered, it is important for SMEs to understand which technologies are available, but also which technologies are appropriate for smaller companies. An important factor here is the economic cost and the actual productivity level such a technology can deliver. In order to evaluate the various technologies available right now, the graph in Figure 28 has been used to illustrate the readiness of the technologies.

Figure 28: Readiness of new technologies



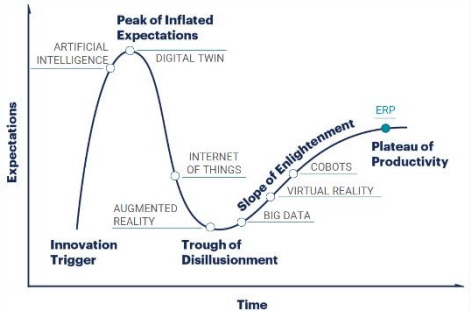
Source: Tawfik (2019).

At first the new technology is at innovation stage, experimental and in prototype stage, this might at best be part of experimentation at the largest MNCs or research institutions/universities, not something to be considered for any SME.

The danger comes at stage 2, inflated expectations, an SME with a tech-savvy CEO might be enthusiastic about new technology and will try to implement a piece of technology not yet proved to be productive.

At the current moment it is believed to be Artificial Intelligent which has the spotlight, quite interesting for the future if proven to work, however, not a technology ready for use in SMEs (See Figure 29).

Figure 29: Readiness of Artificial Intelligence for SME integration



Source: Tawfik (2019).

Only after the hype has vanished and MNCs slowly develop the technology, will the new tech move towards the plateau of productivity, SMEs should not engage in I4.0 projects using any other technology, unless this is a project in corporation with an MNC.

As a rough guide to be used by the SMEs in choosing technology to implement, various technologies have been added to the graph in accordance with maturity of the technology, figure 29 also represent these findings. These findings have been found by way of discussion with Sharif Tarwik and his experience working with 10 different SMEs in implementing I4.0 technology.

Technology such as Artificial Intelligence, creation of digital twins, IoT, Augmented Reality and Big data, are of little interest for SMEs as of writing, only substantially large MNCs can afford experimenting with these technologies. SMEs should concentrate the energy and resources on integration of e.g. ERP-systems (which can be a daunting task in itself) and the introduction of cobots, robots installed for helping employees with repetitive tasks or heavy lifting. These technologies have become affordable and has matured enough to prove their capability in creating value for the company from the get-go. Another factor being this technology has sufficient grounds in consulting, which means the capabilities can be bought and learned faster than break-through new technology.

3.5 Management action steps

The road map for SMEs integration of I4.0 technologies has been summarized in the work tool in appendix 2. The main course for the conceptual model is to identify processes and to learn how the company is actually working right now, after which a screening process of technology projects and improvements must be agreed upon.

Finally, a GANTT-chart for each project should set the phase for successful implementation of I4.0 for the SME. Areas of potential risk has also been identified, which puts an emphasis on involvement of all parties and to be careful of trying to use too new technologies for the SME.

4. APPLICATION OF CONCEPTUAL MODEL TO THE CASE OF KORSØR PROPELLER A/S

The purpose of this thesis is to develop the conceptual framework and underlaying understanding of the complications for SMEs. In order to make sure this being as usable as possible, if was found prudent to connect with a real-life SME to exchange ideas during the developmental phase and for later practical testing. In this section the collaboration with Korsør Propeller A/S will be presented, first with a brief history, followed by the project as

it has progressed from idea to an actual project being implemented at the time of writing (November 2019).

4.1 Company introduction

Korsør Propeller A/S, was founded in Korsør, Denmark in 1947 and has since that time been producing and whole selling custom propulsion systems for ships, with an engine producing business unit working up till the 1990'ies before being unprofitable and sold to another Danish manufacturer. Today the company employ between 10-12 full time employees with auxiliary personnel for ad hoc project and tasks (flexibility). The company is divided into 2 sections; wholesale of smaller propellers, axels, sealing and spare parts, and the engineering department producing larger systems specific for each vessel, this ranges from 1.5 to 4.0 meters in diameter and the project cycle time is usually 2-3 months (See figure 30).

The company has an annual turnover of roughly €2 million and for the last 4 years has produced consistent profits, after tough years following the 2008 financial crisis. The customer reach is global; however, the retail is mostly within Scandinavia. A joint venture with XMH in Singapore was proposed and almost materialized, this was in 2007/8 and ended up being unsuccessful. For the purpose of this project, the company will be scrutinized as to how it will survive in the future of Industry 4.0, how the framework can help KPs development in the future and how such a small production company, located in a high-wage country, can fit into the GVC of much larger companies.

Figure 30: Managing Director Ole H. Pedersen with a CP24 propeller

Source: PR materials at KP.

4.2 Interviews

Interviews may be read in full in appendix 3. Following are the details of credentials for the persons interviews in connection with the research of this thesis. First markings will be used to note whether the person was instrumental in the initial research, participating in the development of the conceptual framework or both. Only information that can be verified has been added to the information about each interviewee, if information has not been verified or located it will be market "N/A" (Not Available).

Table 2: Interview with Sharif Tawfik

Sharif Tawfik	
Involvement	Brain storming of directional ideas, later consultant on the case project
Occupation	Senior Associate, Operations Consulting at PriceWaterHouse Coopers
Education	- Master's in Operations management at University of Southern Denmark - Bachelor's in Global Management and Manufacturing Engineering at University of Southern Denmark
Age	27
Previous occupation	- Member of the board at Airtech A/S - Teaching assistant at University of Southern Denmark - Management consultant at Dansk Produktions Univers
Language spoken	- Danish - Arab - English
Implementation	Location: Sprint: Digital event, Odense, Denmark + on location at KP, Korsør, Denmark Date: 10/4-19, 13/5-19, 16/7-19 Method: Unstructured interview, Structured interviews on phone calls How: Sprint: Digital was found via Linkedin.com, made aware as Mr. Tawfik is an old acquaintance of me.

Source: Appendix 3.

Table 3: Interview with Peter Rahbæk Juel

Peter Rahbæk Juel	
Involvement	Initial research, inspiration for governmental involvement in Industry 4.0
Occupation	Major of Odense city, Denmark as of 1st of January 2014 (Social Democrats)
Education	- Senior Executive in State and Local Government, Executive Education at Harvard University, John F. Kennedy School of Government - Bachelor's in history and public administration at University of Southern Denmark
Age	42
Previous occupation	- Member of the board at Beredskab Fyn - Member of the board at Danish commercial improvement agency - Vice president at Lindø port of Odense - Member of the board at HCA Airport
Language spoken	- Danish - English
Implementation	Location: Sprint: Digital event, Odense, Denmark Date: 10/4-2019 Method: Event speaker, unstructured interview How: Part of event speakers, had opportunity to talk during the breaks

Source: Appendix 3.

Table 4: Interview with Ole Hans Pedersen

Ole Hans Pedersen	
Involvement	Direct contact for case company Korsør Propeller A/S
Occupation	Managing Director of Korsør Propeller A/S since 1989
Education	- Bachelor's in industrial design - Automotive mechanic
Age	60
Previous occupation	- Chief technical designer at Korsør Motor og Propeller Fabrik A/S (former name of Korsør Propeller A/S) - Technical designer at Wilhelm Pedersen A/S
Language spoken	- Danish - English - German
Implementation	Location: At KP, Korsør Denmark

	Date: Multiple ranging from 22/4-2019 to November 2019 Method: Unstructured interview, Structured interviews, meetings for brainstorming, phone calls + e-mail How: My old place of work

Source: Appendix 3.

Table 5: Interview with Heidi Svane

Heidi Svane	
Involvement	Speaker at Sprint: Digital, initial research of digital transformation in SMEs
Occupation	Head of Digital at Lifestyle & Design Cluster
Education	- Master's in Strategic Organization at Aarhus University - Bachelor's in International Economics and Business Administration at Aarhus University
Age	N/A
Previous occupation	- Creative concept developer at HARMAN International - Creative concept developer at Martin Professional
Language spoken	- Danish - English
Implementation	Location: Digital event, Odense, Denmark Date: 10/4-2019 Method: Unstructured interview How: Part of event speakers, had opportunity to talk during the breaks

Source: Appendix 3.

Table 6: Interview with Sofie Wessberg

Sofie Wessberg	
Involvement	Works on daily level with the ERP-system and the SC of Korsør Propeller A/S. Given information regarding practical application of a new system vs. the old Navision C5
Occupation	Senior accountant at Korsør Propeller A/S
Education	Market Accounting from Selandia-CEU
Age	N/A
Previous occupation	- Junior accountant at CLK Byg ApS - Personal assistant for the CEO of CLK Byg ApS
Language spoken	- Danish - English - German
Implementation	Location: KP, Korsør, Denmark

	Date: 22/4-2019 Method: Structured interview, recorded then transcribed from Danish to English on paper. How: Old colleague and part of staff at KP

Source: Appendix 3.

Table 7: Interview with Martin Dyrlund Jacobsen

Martin Dyrlund Jacobsen	
Involvement	Work daily with the ERP-system in a project management capacity. Providing information regarding the needs from the production operations point of view.
Occupation	Chief Mechanical Engineer at Korsør Propeller A/S
Education	Bachelor's in mechanical engineering at Technical University of Denmark (DTU)
Age	32
Previous occupation	Started at Korsør Propeller A/S in 2010
Language spoken	- Danish - English
Implementation	Location: KP, Korsør, Denmark Date: 22/4-2019 Method: Structured interview, recorded then transcribed from Danish to English on paper. How: Through Ole H. Pedersen, part of the management (10% ownership of stocks in KP)

Source: Appendix 3.

Table 8: Interview with Harald Reedtz Tokerød

Harald Reedtz Tokerød	
Involvement	Speaker at Spring: Digital and initial research
Occupation	Digital Transformation advisor at Tokerød Plus Consulting
Education	- Master's in Strategy and Organization at University of Southern Denmark - Bachelor's in International Management at Aarhus University
Age	N/A
Previous occupation	- Director of Tokerød Plus - Partner and investor at X-media - Founder and investor of OTOWN - Founder and investor in Tokerød X – Innovation hub - Founder and facilitator of Tænketank+

Language spoken	- Danish - English - German - Norwegian
Implementation	Location: Spring: Digital, Odense, Denmark Date: 10/4-2019 Method: Unstructured interview, hand-written notes during interview How: Part of event speakers, had opportunity to talk during the breaks

Source: Appendix 3.

Table 9: Interview with Michael Larsen

Michael Larsen	
Involvement	Getting the human perspective of the workers in the production area
Occupation	Foreman and machinist at Korsør Propeller A/S
Education	4 years practical college in machining
Age	50
Previous occupation	Started at Korsør Propeller A/S
Language spoken	- Danish - German
Implementation	Location: KP, Korsør, Denmark Date: 22/4-2019 Method: Structured interview, hand-written notes as recording was not permitted How: Foreman at KP, access through Ole H. Pedersen

Source: Appendix 3.

4.3 Conceptual model application

4.3.1 Analysis of Korsør Propeller A/S – Maturity level

Korsør Propeller A/S on strategic level

On the strategic level SMEs has their strength in being flexible/agile, being able to make quick decisions as the hierarchy of command is usually shallow, the lack of this making inter-personnel corporation fast and efficient, specific areas of technical know-how are also

amongst the strengths of the SME. Contrary, the weakness of SMEs lay in lacking the newest technology, a vital part of the Industry 4.0 paradigm, but also infrastructure and financial capacity can be a hindrance for the strategic development of the SME (Thakkar, Kanda, & Deshmukh, 2008). Further it was found that flexibility of being able to take on orders very fast, many times lead KP to take orders from larger competing companies, it was described as being dynamic in regard to capacity management, e.g. by the use of flexible personnel, multiple suppliers and out-sourcing locally.

Resent macro environment effect on KP

Resent world event, regarding President Trump and Brexit, has highlighted the need for awareness within raw material risks. The case company use primarily high-grade stainless steel and bronze-alloys for the engineering department, while many of the retail products are sourced in the USA or UK, both countries now facing tariffs and the threat of Brexit. One possible solution in this area is the redundancy principle, sourcing new suppliers in case of price hikes that the end customer is not willing to absorb. This might be tough as one specific supplier from England had been supplying KP since the 1970ies and hence has a high level of trust and intangible understanding of the needs and specifications.

So far, in order to mitigate some of the risks, KP has been doubling the usual stock in the warehouse, going from having 4-6 months of supply, to now covering about 12months of usage. This has only been possible due to earlier optimization projects in which the warehouse stock was reduced from EUR 700.000 to about EUR 300.000, as part of LEAN methodology. Old suppliers from Italy and China has been contacted and deals have been made to take deliveries again, should tariffs or legal complications arrive.

E-business and technological risks

SMEs are exposed to a higher degree of cyber-attacks than MNCs, as the whole business unit is at risk at any given time, this include areas like; e-mail phishing, hacking of servers, identity theft and ransom holding to mention some. During the work at KP, it was revealed that several cyber-attacks had been experienced, yet by a combination of luck and a good IT supervisor nothing serious had happened so far. As mentioned in the technology section, outsourcing servers in the form of cloud solutions is one practical way of mitigating this type of risk, as the large MNCs providing the service has vastly better security resources than any one SME can be expected to possess. To this extent the ERP-system upgrade, explained in the next section, together with local cyber security updates, should insure a much higher reduction in these attacks in the future.

Finance risk

Korsør Propeller A/S, accepted in 2007 the largest order in the company's history, a delivery worth EUR 1.8mio from American MNC Exxon Mobil, the order was fixed, however, the bank supporting Korsør Propeller did not want to risk the initial EUR 400.000 it would cost to start the project. The bank at the same time doubted whether or not KP could handle a

single order representing almost 1 whole year revenue. The situation was saved only by switching to another bank, which in itself required huge resources from the company. It would have been a lot less risk involved had Exxon Mobil and Korsør Propeller negotiated a network profile in which Exxon had fronted the initial capital for a later discount on the final product. One mitigation option the company has been using after this incident is the use of 30% upfront cash on signing the order, thereby providing the necessary cash for starting projects.

Case example of strategic development towards GVC integration

During the course of this project, a coincident of fortune occurred, research into I4.0 lead to a trip to Odense in Denmark, in which I attended a seminar on the subject. At this seminar an old student colleague was making a presentation on I4.0, this led to a collaboration between PriceWaterhouse Coopers[4] (hereinafter: PwC) and Korsør Propeller A/S, semi-government sponsored project of exchanging current ERP system to a new system capable of integrating modern technology solutions and potentially integration in I4.0. This way of strategic development was found to be common, though theory suggest that a top-down strategic planning process should provide best results, SMEs usually develop via hybrid, some from the management and others either button-up or externally incurred (Barnes, 2000).

As a result, from using the conceptual framework developed in this thesis (In full in Appendix 4), a decision was made from the managing director to analyze the first step needed for KP to become integrated in a GVC, this is a long-term strategy for expanding the company beyond current production levels. By 2018 the steps had already been taken to upgrade the internet connection, which according to the framework is an absolute must and first step for I4.0 integration (Digital Transformation, step 1 and 2 on figure 19).

Many other areas of technology were discussed during this project case, including Digitalized time scheduling for the workers, Kanban card systems for warehousing, various apps for the phones. Ultimately the combination of lacking support for the current ERP system (Microsoft Navision C5), governmental support for digitalization and a wish for greater efficiency within the management of the company, lead to the decision to change the ERP system.

This would ensure a complete breakdown and analysis of the processes within the company, creating greater holistic understanding of the dynamics of the company, but more importantly, it will streamline the processes so integration with an MNC will be much easier. As of today, such integration has only failed in the past with an MNC from Singapore, XMH, which due to lack of cultural and process understanding was cancelled.

As described in previous section on the risks of joining a Global Value Chain, KP had to find both capabilities and resources externally. Capabilities was found through a specialist

[4] One of the "Big 4" accounting houses, who also deals in major consulting business.

consultant with PwC (Sharif Tawfik) and resources was partly found through a government program for digital integration (DKK 100.000 or approx. EUR13.000). As of writing (August 2019) this project has been given the "go-ahead" by the management of KP and will lead the strategic development for years to come in integration with I4.0 technologies, with the goal of becoming part of a GVC through either merger or cooperation with an MNC.

Types of GVC Membership

There are many types of which an SME can join the GVC, one was even tried during the period 2007-8, which was a proposed joint venture between KP and XMH of Singapore, though this never materialized, other types of integration are available. MNCs and SME can reap competitive benefits by maintaining inter-organizational networks one being joint venture, others being co-development between suppliers or strategic alliances (Bennett & Dekkers, 2005).

A case in point for KP becoming a part of the value chain in a strategic alliance, could be in the development of new products. As propulsion systems already require considerable engineering work to complete, new product development could be required by an MNC, e.g. this could be use of a new material. KP by itself does not have resources to complete such a major R&D project, but having the resources from an MNC, could utilize the knowhow of KP to develop superior products in partnership to the advantage of both partners in building capabilities.

This being an actual event, as KP does have ideas for product development, but lack the time to actually start and finish such a project. Korsør Propeller can leverage the decades of knowledge in propeller design to make optimal solutions for larger shipyards. Yet, as interviews with Ole H. Pedersen indicated, it is rare that MNCs are interested in partnership within this business sector as they shop around for the least expensive option and then use classification companies like Lloyd's Register to ensure quality of the work.

4.3.2 Action plan – Case study KP

The project started out making a collaboration with KP in order to gain practical knowledge and feedback on the development of a conceptual framework for integrating SMEs into a GVC. Interviews at first gave a strategic direction, but after a seminar in Denmark, the project turned into a real-life project, using the framework as a basis for the strategic step into I4.0 by KP.

Phase 1, 2 and 3: As-Is, Mapping and Planning

The strategy for KP was discussed extensively in the first phase of the project. It was clear that the company was running well as an isolated production unit, however, it was the wish to be integrated with a larger MNC. As can be seen in Appendix 4, it was an extensive

process of finding the right direction for technology, but as the old ERP-system were to be changed anyway in 2019, the focus fell on the IT structure.

The conceptual framework was extensively used to structure the process of the project. Starting with analyzing the entire company and charting the business on the Miltenburg framework. This showed the right strategy in use, a functional layout or "job-shop", by making sure the underlying foundation of processes are correct, the various possible technologies could be discussed. As described, the company were to change the current ERP-system, so this provided a guideline of thought towards IT.

Seeing that ERP-systems are on the mature side of modern I4.0 technology, this allowed the project to continue in this direction. A plan was then created as a first step, to start the project researching the right ERP-system, as there are many to choose from and KP had issues in the past with providers of ERP-system (Mainly lacking support and illogical system setup).

This turned into a project of changing the ERP-system with the help of PwC and part government sponsored via Sprint: Digital. The framework was altered slightly during this process of feedback to its current state, which has been presented in section 3 with further details in appendix 2 and 4.

It is expected that this first step towards I4.0 will be the foundation for further projects in the future. One possible option is to implement Total Quality Management as the machines in the production now can communicate with the ERP-system, thereby informing about scheduled maintenance before the machine breaks down.

As of editing this thesis, the project is delayed due to providers of ERP-systems has been slower than expected to come up with offers for implementation (20-01-2020).

4.3.3 **Theoretical premises vs. case study - Discussion**

At the outset of the project, Korsør Propeller A/S agreed to participate as a case study for the theories found and to help understand how SMEs can work toward integration with MNCs in a GVC and what technological development would be optimal for implementation.

During this period of time the scope was altered to be closer to the development of the I4.0 framework for SMEs and how they utilize this new paradigm, in this process KP actually needed help in switching from an old ERP system to a new one and as this being part of I4.0, it was decided to make good use of the project to help KP understand what the future requires, so that the right system could be found, this being instead of the old way of choosing a system from a known supplier, even if this system did not fit the requirements.

4.4 Financials of the ERP-integration project

3 parties are involved in the financials of the case project, including Korsør Propeller A/S, PriceWaterHouse and the government body for digitalization of SMEs (Sprint: Digital).

Due to the self-financing requirement from the government, every DKK 1,00 financed by the Digital fund, must be matched with DKK 1,00 spend from KP. The grant approved was a potential maximum of DKK 100.000 (Approx. EUR 13.000) for the analysis part of the project, hence, consultant work in mapping the company and finding the correct ERP system for implementation.

A further DKK 100.000 may be granted if the first part of the project is a success, which for the purpose of this project will be assumed to be. This second sum may be used for implementation of the ERP-system (Though not directly payment for the software itself). PwC was chosen as consultant for the project, one reason being that KP already use PwC for auditing of the company financials and second as the specific consultant Sharif Tarwik has personal connections to the author from earlier studies, hence, the integrity of performance is known to be very high.

4.4.1 Estimated costs of project

Table 10 shows the breakdown of cost regarding the Enterprise Resource Planning project, part 1. Part one includes the mapping of the company in conjunction with PwC consultants, getting quotations for possible systems and consulting in gaining the next level of government sponsorship for the actual implementation of the ERP system.

Table 10: Cost breakdown of part 1, ERP-system

Organization	**Estimated cost (EUR)**
PriceWaterHouse Coopers	€ 18-20.000
Korsør Propeller A/S (management time)	€ 2.750
Total	€ 20.750-22.750

Source: Own work.

After the first part of the project has been completed successfully, the second part will consist of the actual purchase of the system that has been found to be the optimal via project part 1. Good chances have been stated from PwC in their ability to obtain a second grant from the Danish government, hence, this will be included in the reduction of the second part. The cost structure can be seen in Table 11.

Table 11: Cost breakdown of part 2, ERP-system

Organization	**Estimated cost (EUR)**
PriceWaterHouse Coopers	€ 1.500
Korsør Propeller A/S (employee time)	€ 10.000
Purchase of ERP-system	€ 14.500
Consulting for implementation	€ 5.000
Total	€ 31.000

Source: Own work.

Adding these 2 total estimated costs and the complete cost of this ERP-system project will be between €51.750-€53.750. However, the governmental grant from Sprint: Digital of DKK100.000 for each stage will deduct roughly €26.600 from the cost, making to total cost for KP €25.150-27.150. This number falls within the marginal utility of Korsør Propeller A/S, who in the very beginning of the project revealed that is was estimated such a project would cost in the vicinity of DKK250.000 (€ 33.300).

4.4.2 Value proposition for KP

The baseline for the project is the estimated cost of roughly €26.000, which comes in below the marginal utility of KP, more importantly is that a doubling of the price could have been the case, if not for the seminar attended in Odense, Denmark, prior to starting the use of the conceptual framework. Further is has been estimated, in conjunction with the managing director Ole H. Pedersen, that the hourly cost on average for any of the management within the company is €200, which means a total of 130 hours will be required "saved" in time and value adding services to customers in order to justify the project. 130 hours is judged to be a small number, especially in comparison with the increased flexibility the management will have for the future.

Another aspect of value comes in the form of streamlining the company, as this correlates with the plan of having the company integrated with an MNC within 5-7 years, processes that today remain implicit can now be codified, thereby making it easier for an MNC to integrate communication and process control into their own systems. The framework has been used to start one project for the case company, however, after completion of this project, it may once again be used to go one step up towards Industry 4.0, though time and financial means are not abundant. One project a year will be more than a lot of SMEs are currently doing and will add to the competitive advantage of Korsør Propeller A/S.

4.5 Results and interpretations

In earlier sections, research theory has been analyzed and possible entries both into the GVC and I4.0 for SMEs was found. Yet, through the close cooperation with the case company, it was found that many individual parts of the theory will far from fit every company. In the case of KP there was not a lot of possible partnerships available with MNCs, it was a mere question of being bought (integrated) by the MNC or to continue the ad-hoc projects as always.

It was found by the author that the management, though being open minded, did not fully understand the usage of the new technologies. Which is why emphasis has been put into the framework that the first and most important part in entering I4.0 era, will be for the top management to fully understand its implications before starting. This issue might reverse in the case of e.g. the ERP system upgrade for the case company, during interviews it was clear that everybody involved had an idea of what they wanted and expected from a new system. There even seemed to be an emphasis on the psychological problems of change management, as in everybody had been involved and everybody was allowed to express their opinions, giving the employees a sense of ownership in the project.

The aspect of time also became an important factor, while researching the theory, it seemed that the move to I4.0 might be done relatively expedient. The fact that the ERP system change has been running for 5 months by the time of writing (September 2019) and the onlook for completion seems to be by the end of the year 2019, time constraints might be a larger factor in the risk of changing technology within SMEs. The main problem here was found to be lacking time from all involved parties, as the business had to be running as usual during this project. Here seasonality also plays a role, as KP has comparatively much more work in the spring, than in the autumn and hence, only really have time for projects like this during the autumn part of the year. In discussing with Ole H. Pedersen, the framework received positive critique for being easy to understand and visually pleasing to work with. A point of notice is that the financial burden of these technologies did seem to be quite high, especially as KP does not have a partner MNC to finance the transition. It was however stated that projects can be taken one by one, e.g. once a year a next step can be taken. The highest limiting factor was found to be time as all employees today are running on full capacity, Ole H. Pedersen did express his hope for releasing more time via the use of technology such as a modern ERP system, this project will the test to see whether or not it is the case.

4.6 Value proposition for SMEs

The basis of value proposition is that the company is able to offer a differentiated product which provide value that the end-customer actually value, all this at a cost the customer is

willing to pay, in essence it is a trade-off between price/quality of a product and what the customer perceive as its worth in economic terms (Lindic & Silva, 2011).

For KP this was clearly found to be flexibility of production, quality and price could in most cased be matched by competitors. Yet, KP has the ability to act fast and make sure delivery date is much faster than the larger competitors, after completion of the project it is believed that this flexibility will increase in the form of better transparency of data, organization in managing the production and be more precise on the margins of each project, thereby making more precise offerings to potential customers.

5. LIMITATIONS AND DISCUSSION

This thesis has been based around a single Danish manufacturing company and might have yielded a more in-depth insight into what SMEs need to integrate and become part of Industry 4.0. It might also be argued that the span in employees simply is too great, the case company having 10 employees, while other SMEs might have +200, the access to capital in these cases might differ greatly, plus there can be arguments for the chance of horizontal integration being more plausible for smaller companies, though with higher tail risk.

Interviews has been made in 2 larger rounds and then further inquiries during the development of the framework phase, it can be argued that more interviews would have gain better understanding from a wider spectrum of SMEs, this being only metal production for one-off projects. Attempts has been made to be granted interviews at MNCs (e.g. Danfoss and Grundfos, 2 Danish MNCs), however, no respond was received.

The majority of journals used for the secondary data research comes from the Emerald database, some via Google Scholar and some books on various subjects befitting the theory, however, for simply data disparity it might have been prudent to obtain research data from more sources, mostly this limitation came from lack of access to pay-per-journal databases or none-access errors on the available database systems.

The risk section was limited to include only subjects of interest to SMEs, only when there were links between SMEs and MNCs, were it part of the risk theory. The simple reason for this was the scope of this project, risk is important in any major strategic shift within a company, especially a small company, so it was deemed that risk was important, however, had MNCs and the entire eco-system been included, it would have been an academic research project by itself. Though excellent information has been gained from interviews, it would have helped the project to be able to have the unstructured interviews in a more structured way. This was, however, not possible at the time as the expectations for the seminar were extremely low compared to the actual value of information.

CONCLUSION

The major technologies of Industry 4.0 were found through research and interviews in first part, some of which include Internet of Things, Cyber-Physical Systems, RFID tracking and interconnected collaborative systems all in the pursuit of self-optimizing systems. Which systems SMEs are to implement depends on the situation, from this exhaustive list, the conceptual model developed will help determine just that for the SMEs.

The difference between SMEs and MNCs was determined to be access to capital and the style in which the management strategize and run the everyday processes, while SMEs have less access to resources, they have an advantage in being flexible and innovative, plus in many instances they are close to the customer, thereby knowing the needs to a higher degree than MNCs. Though the industry the case company, Korsør Propeller A/S, is in was found less apt for integration in a global value chain, methods such as trade exhibitions was found to have the largest chance of successful contact with MNCs and possible joint partnership or outright integrating into the MNC. A position in a GVC will give the advantage of access to resources for SME, thereby creating stability, while the main advantage by the MNC is gaining highly specialized know-how, R&D and connectedness with customer needs.

Risk was analyzed through the use of PESTEL and on a micro-environmental scale and include ways of measurement for impact of risk and mitigation strategies, one important part in any change of processes is the management of employees and the understanding of the technology by the top management.

The conceptual framework was developed so that SMEs has a place to start any Industry 4.0 project, with the intent of becoming better integrated with international business opportunities, this framework takes the SME from discovery stage, to analysis of the "as-is" situation, to decision on a way to proceed, all the way to actual project management of the best-suited project chosen.

The value proposition finally shows that Industry 4.0 in itself will help optimized the time and efficiency of any company, being it SME or an MNC, where the two cross paths, are in the streamline process SMEs obtain from introducing connected systems, these systems will better integrate with MNCs Machine to machine production units, using tracing like RFID chips and Vendor controlled Inventory.

Industry 4.0 has the potential to help both SMEs and MNCs in becoming more efficient in delivering the right amounts of products in the right quality at the exact time for the customers. It is a paradigm of connectedness between business entities and even in the event of an SME not having strong connection like the case company, an investment toward I4.0 will either lead to optimized production or partnership/integration with MNCs, either case will be an advantage for the SME. Any SME trying to ignore this change of paradigm, stand the chance of ending like so many SMEs in the west during the 1980'ies and 1990'ies.

REFERENCE LIST

1. Abdulkareem, Y. A. (2018). Confligt, international trade and President Trump's isolationist policies. *Journal of International Trade Law and Policy, 17*(1/2), 34-45.

2. Bahrami, B. (2009). A look at outsourcing offshore. *Competitive review: And International Business Journal, 19*(3), 212-223.

3. Barata, J., Cunha, P. R. & Stal, J. (2018). Mobile supply chain management in the industry 4.0 era: An annotated bibliography and guide for future research. *Journal of Enterprise information management, 31*(1), 173-192.

4. Barnes, D. (2000). In search of the source of the stream: The process of information on manufacturing strategy in SMEs. *Journal of Small business and Interprise development, 7*(3), 261-271.

5. Bennett, D. & Dekkers, R. (2005). Industrial networks of the future- a critical commentary on research and practice. *International Operations Management*, 677-686.

6. Berman, S. J. (2012). Digital transformation: Opportunities to create new business models. *Strategy & Leadership, 40*(2), 16-24.

7. Bertola, P. & Teunissen, J. (2018). Fashion 4.0. Innovating fashion industry through digital transformation. *Research journal of textile and apparel, 22*(4), 352-369.

8. Brettel, M., Friederichsen, N. & Michael Keller, M. R. (2014). How virtualization, decentralization and network building change the manufacturing landscape: In Industry 4.0 perspective. *International Journal of Information and Communication Engineering, 8*(1), 37-44.

9. Buffington, J. (2011). Comparison of mass customization and generative customization in mass markets. *Industrial Management & Data Systems, 111*(1), 41-62.

10. Canel, C., Mathieu, R. G. & Das, S. R. (1997). The successful development of information systems for FMS: Some useful lessons. *Industrial Management & Data Systems, 97*(8), 316-319.

11. Chaudhury, R., Gerdemann, D. & Kapoor, B. (2015). Innovation advantage: Insourcing engineering. *Strategy & Leadership, 43*(6), 3-9.

12. Choy, K. & Lee, W. (2000). Task allocation using case-based reasoning for distributed manufacturing systems. *Logistics Information Management, 13*(3), 167-176.

13. Christopher, M. (1992). *Logistics & Supply Chain Management.* Harlow: Financial Times Prentice Hall.

14. Crowe, T. J. & Stahlman, E. J. (1995). A proposed structure for distributed shopfloor control. *Integrated Manufacturing Systems, 6*(6), 31-36.

15. Dalio, R. (2017). *Principles.* New York: Simon & Schuster.

16. Dekkers, R. & Kühnle, H. (2012). Appraising interdisciplinary contributions to theory for collaborative (manufacturing) networks. *Journal of manufacturing technology, 23*(8), 1090-1128.

17. Elahi, E. (2013). Risk management: the next source of competitive advantage. *Foresight, 15*(2), 117-131.

18. Falkner, E. M. & Hiebl, M. R. (2015). Risk management in SMEs: a systematic review of available evidence. *The journal of risk finance, 16*(2), 122-144.

19. Ferrantino, M. J. & Koten, E. E. (2019). Understanding the supply chain 4.0 and its potential impact on global value chains. *World Trade Organization, 5*, 103-119.

20. Francisco, R. d., Azevedo, A. & Almeida, A. (2012). Alignment prediction in collaborative networks. *Journal of Manufacturing Technology Management, 23*(8), 1038-1056.

21. Ghobakhloo, M. (2018). The future of manufacturing industry: a strategic roadmap toward Industry 4.0. *Journal of Manufacturing Technology Management, 29*(6), 910-936.

22. Gould, B. (1997). Incompetence and outsourcing: running backwards in the race to learn. *The Antidote, 2*(6), 26-27.

23. Hammel Scale Company, Inc. (2019, November 2). *Hammelscale.com*. Obtained from: http://www.hammelscale.com/industry-4-0/

24. Hilmola, O.-P., Lorentz, H., Hilletotfh, P. & Malmsten, J. (2015). Manufacturing strategy in SMEs and its performance implications. *Industrial Management & Data Systems, 115*(6), 1004-1021.

25. Hollensen, S. (2011). *Global Marketing.* Harlow, Essex: Pearson Education Limited.

26. Holtzman, Y. (2008). Innovation in research and development: Tool of strategic growth. *Journal of management development, 27*(10), 1037-1052.

27. Hoppe, S. (2018, March 30). The Industrial IoT Maturity Model. *Maint World.* Obtained from: https://www.maintworld.com/Applications/The-Industrial-IoT-Maturity-Model

28. Howarth, R. & Fredericks, J. (2012). Sustainable SME practice. *Management of Environmental Quality, 23*(6), 673-685.

29. Jorgensen, A. L. & Knudsen, J. S. (2006). Sustainable competitiveness in global value chains: How small Danish firms behave. *Corporate governance: The international journal of business in society, 6*(4), 449-462.

30. Kalpakjian, S. & Schmid, S. R. (2010). *Manufacturing Engineering and Technology*. Singapore: Prentice Hall.

31. Kang, M., Yang, M. G., Park, Y. & Huo, B. (2018). Supply chain integration and its impact on sustainability. *Industrial Management & Data Systems, 118*(9), 1749-1765.

32. Khoshnevis, B., Bottlik, G. & Azmandian, A. R. (1994). Simultaneous generation of assembly plans and schedules in electronics assembly operations. *Integrated Manufacturing Systems, 5*(4/5), 30-40.

33. König, A. & Spinler, S. (2016). The effect of logistics outsourcing on the supply chain vulnerability of shippers: Development of a conceptual risk management framework. *The International Journal of Logistics Management, 27*(1), 122-141.

34. Kotter, J. P. (1996). *Leading Change.* USA: Harvard Business Review Press.

35. Lewis, M. A. (2000). Lean production and sustainable competitive advantage. *International Journal of Operations & Production Management, 20*(8), 959-978.

36. Li, Z., Liu, G., Liu, L., Lai, X. & Xu, G. (2017). IoT-based tracking and tracing platform for prepackaged food supply chain. *Industrial Management & Data systems, 117*(9), 1906-1916.

37. Lindic, J. & Silva, C. M. (2011). Value proposition as a catalyst for a customer focused innovation. *Management Decision, 49*(10), 1694-1708.

38. Lonsdale, C. & Cox, A. (2000). The historical development of outsourcing: the latest fad? *Industrial Management & Data Systems, 100*(9), 444-450.

39. Low, C., Chen, Y. & Wu, M. (2011). Understanding the determinants of cloud computing adoption. *Industrial Management & Data Systems, 111*(7), 1006-1023.

40. Madura, J. & Fox, R. (2016). *International Financial Management.* Hampshire: Cengage Learning.

41. Mahalik, N. & Moore, P. (1997). Fieldbus technology based, distribution control in process industries: a case study with LonWorks Technology. *Integrated Manufacturing Systems, 8*(4), 231-243.

42. Mathias, P. (1969). *The first industrial nation - The economic history of Britain 1700-1914.* New York: Taylor & Francis Group.

43. Measson, N. & Campbell-Hunt, C. (2015). How SMEs use trade shows to enter global value chains. *Journal of Small Business and Enterprise Development, 22*(1), 99-126.

44. Miltenburg, J. (2005). *Manufacturing Strategy.* New York: Productivity Press.

45. Mishra, D., Gunasekaran, A., Childe, S. J., Papadopoulos, T., Dubey, R. & Wamba, S. (2016). Vision, application and future of challenges of internet of things: A biliometric study of the recent literature. *Industrial Management & Data Systems, 116*(7), 1331-1355.

46. Novak, M. (2013, July 5). Panasonic buy stake in Slovenia's Gorenje. *Reuters.com*. Obtained October 13, 2019, from: https://www.reuters.com/article/us-panasonic-gorenje/panasonic-to-buy-stake-in-slovenias-gorenje-idUSBRE9640E320130705

47. O'Neill, H. & Sackett, P. (1994). The Extended Manufacturing Enterprise Paradigm. *Management Decision, 32*(8), 42-49.

48. Pizza, D. (2019, September 4). DODO Pizza Franchise concept. *DODO Pizza*. Obtained from https://dodofranchise.com/

49. PR RFID & Wireless IoT Global. (2016, February 1). RFID & Wireless IoT Global. Obtained from: https://www.rfid-im-blick.de/en/201602013106/logistics-service-provider-dsv-rfid-would-be-our-method-of-choice-for-effective-cross-docking.html

50. Research Gate. (2019, May 13). Obtained from researchgate.net: http://www.researchgate.net/

51. Rodrígues-Díaz, M. & Espino-Rodríguez, T. F. (2006). Redesigning the supply chain: Reengineering, outsourcing, and relational capabilities. *Business Process Management Journal, 12*(4), 483-502.

52. Rudall, B. & Mann, C. (2009). Global research and development: Some new initiatives. *Kybernetes, 38*(6), 853-859.

53. Simhambhatla, S. & Karunakaran, K. (2015). Build strategies for rapid manufacturing of components of varying complexity. *Rapid Manufacturing Journal, 21*(3), 340-350.

54. Slack, N., Chambers, S. & Johnston, R. (2010). *Operations Management (6th Edition).* Edinburgh Gate: Pearson Education Limited.

55. Strange, R. & Zucchalla, A. (2017). Industry 4.0, global value chains and international business. *Multinational Business Review, 25*(3), 174-184.

56. Strategic Direction. (2005). Investing in research and development: Competitive benchmarking. *Strategic Direction, 21*(2), 35-37.

57. Taleb, N. N. (2018). *Skin in the game.* Penguin Random House UK.

58. Tapscott, D. & Tapscott, A. (2018). *Blockchain Revolution.* St Ives: Penguin Random House UK.

59. Tawfik, S. (2019, April 10). Senior Associate Operations Consulting. (M. S. Pedersen, Interviewer)

60. Thakkar, J., Kanda, A. & Deshmukh, S. (2008). Supply chain management in SMEs: development of constructs and propositions. *Asia Pacific Journal of Marketing and Logistics, 20*(1), 97-131.

61. Transparency International. (2019, October 21). *transparency.org*. Obtained from: https://www.transparency.org/cpi2018?gclid=Cj0KCQjwrrXtBRCKARIsAMbU6bEpTqvVIWkQA6Jk5QJ7BPoO9NtRD19pkePSfcSO9H0KuPvQ7V4s5mMaAr_1EALw_wcB

62. Um, J. (2017). Improving supply chain flexibility and agility through variety management. *The International Journal of Logistics Management, 28*(2), 464-487.

63. Vlaskovits, P. (2011, August 29). Henry Ford, Innovation, and that "Faster horse" quote. *Squarespace.com* Obtained from https://static1.squarespace.com/static/5ba7b499755be22c410b1cae/t/5d61989954372300015ecec5/1566677145851/Henry+Ford%2C+Innovation%2C+and+That+%E2%80%9CFaster+Horse%E2%80%9D+Quote.pdf

64. Volkswagen-AG. (2019, December 2). The brands and models of VAG group. *VAG Group*. Obtained from: Brands & Models: https://www.volkswagenag.com/en/brands-and-models.html

65. Wilkesmann, M. & Wilkesmann, U. (2018). Industry 4.0 - organizing routines or innovations? *VINE Journal of information and knowledge management systems, 48*(2), 238-254.

66. Womack, J. P. & Jones, D. T. (2003). *LEAN Thinking.* London: Simon & Schuster UK Ltd.

67. Wulf, A. & Butel, L. (2017). Knowledge sharing and collaborative relationships in business ecosystems and networks. *Industril Management & Data Systems, 117*(7), 1407-1425.

APPENDICES

APPENDIX 1: SLOVENE SUMMARY

Osnovni cilj magistrskega dela je identificirati in ovrednotiti položaj malih in srednje velikih podjetij (MSP) v globalnih verigah vrednosti (GVV) v okolju industrije 4.0 (I4.0). Magistrsko delo je razdeljeno v tri glavne dele. Prvi del predstavlja opredelitev tehnologij, ki igrajo ključno vlogo v I4.0, njihove povezave z organizacijo globalnih verig vrednosti ter pregled literature na tem področju. V drugem delu je razdelan razvoj konceptualnega modela za proces vključevanja MSP v GVV v okolju I4.0. V zadnjem delu pa se konceptualni model aplicira na primer izbranega danskega MSP s praktičnimi napotki za izbrano podjetje.

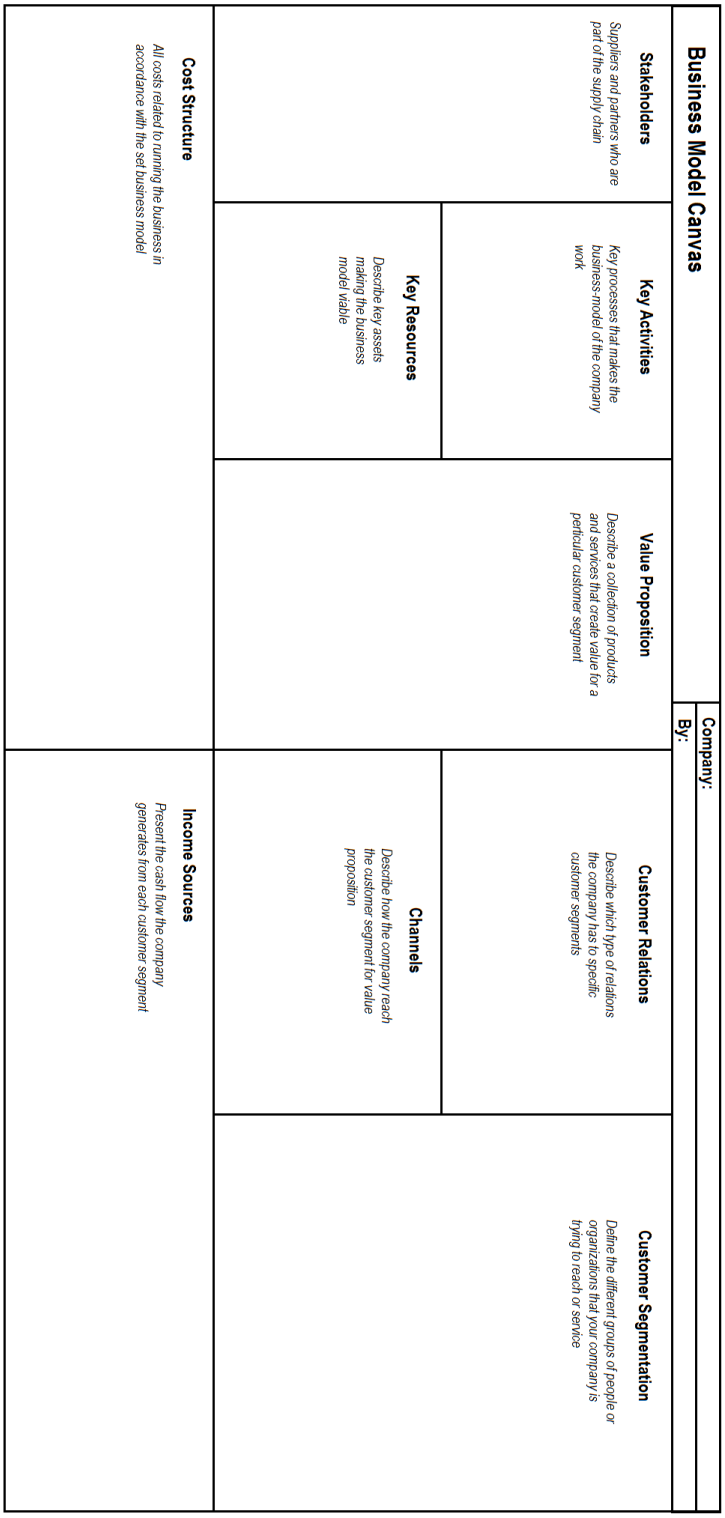
Magistrsko delo črpa teoretične osnove in vire iz znanstvene in strokovne literature o tehnologijah I4.0, organizaciji in razvoju GVV in vlogi MSP v teh procesih, ter o obvladovanju tveganj na globalnih trgih. V magistrskem delu so uporabljeni tako sekundarni kot primarni podatki, pridobljeni na osnovi poglobljenih intervjujev in uporabljeni pri razvoju konceptualnega modela in njegove aplikacije na izbranem podjetju.

Glavni prispevek magistrskega dela je razvoj konceptualnega modela za strateško pozicioniranje MSP v GVV v okolju I4.0. V magistrskem delu avtor ugotavlja, da je ključen dejavnik uspešne integracije MSP izbor in časovnica uvajanja tehnologij I4.0. Konceptualni model pomaga malim in srednjim podjetjem, da bolje razumejo svoje procese in pomen uvajanja I4.0 tehnologij. Gradi na postopnem pristopu, korak za korakom, ter izboru najprimernejših tehnologij za začetek njihove transformacije.

Konceptualni model je bil preizkušen na primeru izbranega danskega MSP, ki je že začelo z implementacijo »Enterprise Resource Planning" sistema z začetno investicijo 26.000 EUR, s ciljem uporabe novih I4.0 tehnologij, ki bodo izbranemu podjetju omogočale integracijo v dobaviteljske verige večjih multinacionalnih podjetij.

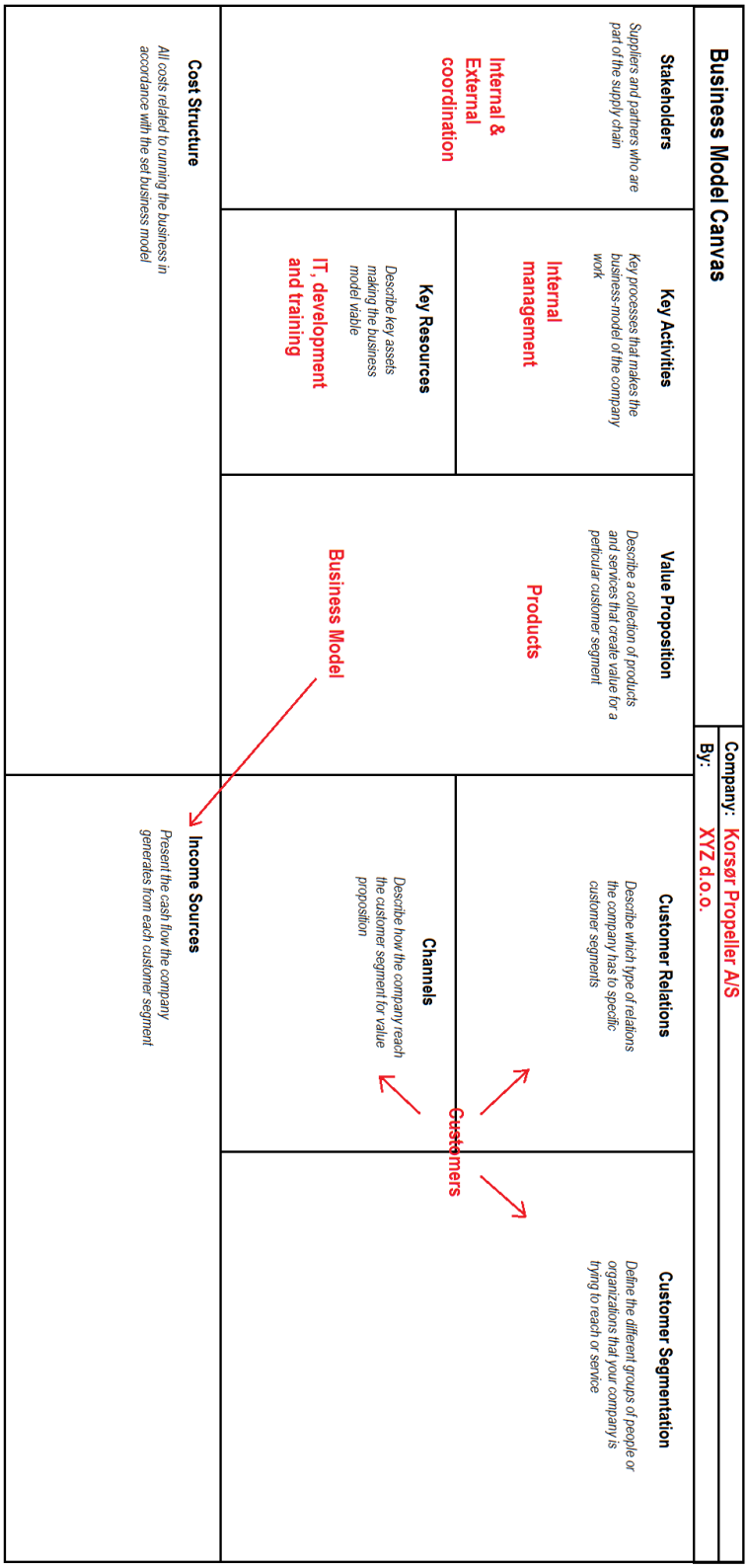
APPENDIX 2: INDUSTRY 4.0 PRACTICAL IMPLEMENTATION

Figure 25: Business Model Canvas



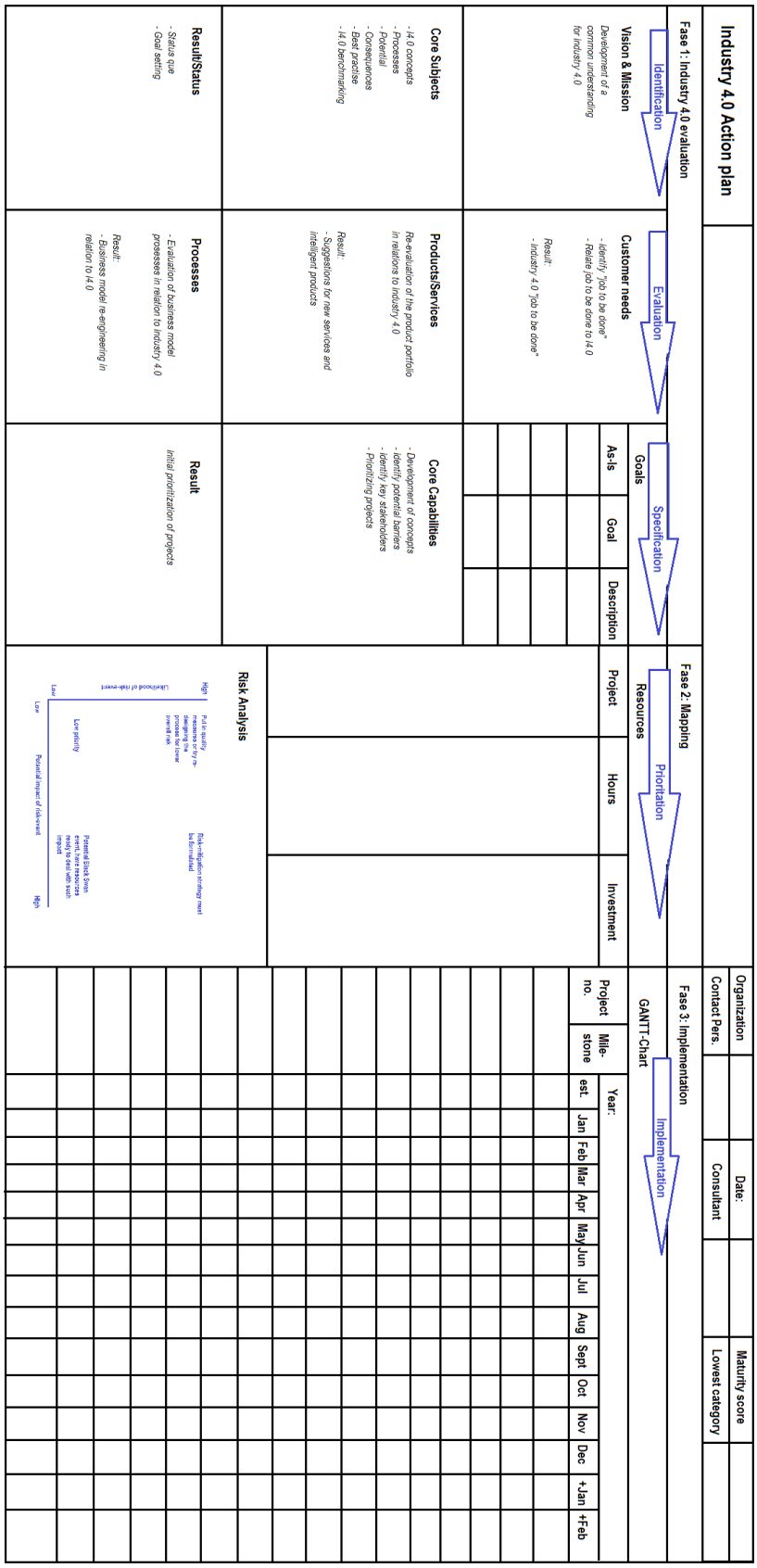
Source: Own work.

Figure 26: Explanation of stakeholder responsibility



Source: Own work.

Figure 27: Action Plan - Practical application for I4.0 project selection



Source: Own work.

APPENDIX 3: INTERVIEWS

Interviews at Sprint: Digital [10-04-2019]

Further to the interview at Korsør Propeller A/S, a seminar was attended in Odense, Denmark with the subject headline being how SMEs intergrade into the concept of Industry 4.0. This was a collaboration with University of Southern Denmark, Design to innovate (D2I), Dansk Design Center (DCC) and Sprint: Digital (a government funded program for digitalization of SMEs), held at the 10th of April 2019. Interviews were after the event arranged under non-formal conditions with speakers and event managers, the following has been restructured using handwritten notes from the event:

Sharif Tawfik [Senior Associate, Operations Consulting – PwC]

How must a SME start the process of becoming part of Industry 4.0?

As with any process optimization procedure, the first step will be to understand the processes of the company, this would usually be done by making "As-is" flow maps of the processes, it is extremely important that all parts involved in implementing I4.0 understand the structure of the company, next is to use a road map that has been customized to each specific company according to where in the integration process they are currently and finally a "To-be" map must be created as a sort of battle plan for the company, this will also function as a mile-stone map to keep track of the process from the very beginning.

Do you see the great cost of high-tech solutions as a main problem for SME?

Yes and no, it depends on the level of required tech solutions, lucky for SMEs the development of hardware not only means more high-tech solutions, but also incur falling prices on the technology itself making it more affordable, to the same extent computers used to be extremely expensive, today nobody is in a situation of not being able to afford this technology.

Do you see any pre-requisites for SMEs to implement I4.0 technology?

Yes, the baseline of the technology must be in order before I4.0 can be implemented, this means basic digitalization of the company, so if companies are struggling on this level, it is suggested to go through a digital transformation first, this can include basic hardware upgrades, upgrading the internet connection to fiber optic, switching the phone systems to IP-phones, installing a true ERP system etc. Only when the infrastructure is in place can the I4.0 process begin.

Do you think blue-collar workers are in danger due to I4.0?

No, I do not believe this to be true. Here in Odense we have many robotic producing companies, with accompanying training facilities for workers, who's jobs have been "upgraded" to include the use of robots, the new systems are so easy to learn, that usually a course of 90mins is enough for a worker to start operating robots.

Do you have any inputs as to the usability of high-tech for SMEs?

After the flow mapping of a company or the production area of this company, VR (Virtual Reality) can now be used to create a digital copy of the factory, this can then with the help of computers be used to visualize and calculate optimal flow solutions in the production, no longer will companies have to experiment and use time and money to move production cells around, this will be handled in a 3D environment on the computer, this in part is the Cyber Physical systems, as it represents the physical system yet in a digital environment. Another important aspect is the digitalization of warehouses in networked companies, Vendor Controlled Inventory has come a long way, so that the SME actually does not control its own inventory, an outside supplier has direct access and will manage the inventory to fit production, this gives better control of the part who know most about the product.

Do you see any differences between SMEs and MNC regarding I4.0 implementation?

My challenge with SMEs usually involves 5 different areas in which they are lacking behind, this especially compared to MNC. They have weak master data, as they usually do not have any comprehensive ERP system, data can be hard to get by, it might even only exist in hard-copy version. Many also lack a digital foundation to start implementing I4.0 technologies, this might be poor internet connections or simply old IT equipment not geared to handle the information flow. This usually goes hand in hand with lacking competences within the company regarding IT and an extremely process oriented management, spending most time "running the show" but never halting to ask questions. Finally, also in relation to management, they do not have a resolute idea about the strategy and future of the company, most do not have plans further than 6 months, which makes it harder to implement I4.0 as this will usually take years.

The MNCs do however also have problems, but this is usually complexity and the technological ecosystem, which has already been organically developed and by such making it hard to implement new systems, one example is robotic cells that already run on plans and programs, it is easier to set up a new system than to modify the old ones.

Peter Rahbæk Juel [Major of Odense since 2017]

How do you think the local government should involve itself with technology in SMEs?

Odense which I represents has a wish to become the world hub for robotics and high-tech solutions of the future, however, this is not something that one municipality can fully support financially, we have made investments of 50million DKK (6,67mill Euro) over the next 10

year for the elementary schools to develop technology, this will make sure that the mentality of this area are within high-tech solutions and will create the knowledge workers that the SMEs will need for further development.

When do you see Odense becoming this high-tech center?

As a city with only 203.000 inhabitants, it is extremely important to be on the forefront of development, lucky for us there are already a robotic cluster in connection with the university (University of Southern Denmark) and by 2020 Odense will be the no. 1 in robotics.

Heidi Svane [Head of Digital – Lifestyle & Design Cluster]

How do you see the I4.0 and Digital Transformation working right now for SMEs?

In my work management of the SMEs can be hard to convince that digital solutions and I4.0 will be the future, they are deep into the daily running of the company and are highly focused on the profit margins at the end of the year, so we suggest making digital business cases for each project, simply to see what is the projected result of this new technology, this also makes it easier to locate the most efficient use of funds. This will usually be helped along with a Net Present Value analysis, to show the real value proposition.

What kind of problems have you encountered with digital implementation?

The most common problem is for all parts of a digitalization project to feel ownership, if the solution is simply coming from top down, it is a formula for failure before even starting, this means that once a project has the get-go from the management, all people who will be touched by this project will have to be included, interviewed, talked to and shown exactly why it is prudent and how it may help themselves in their job function.

Do you have any inputs on what is important for this new era of I4.0?

Everything the company does must be customer orientated, no matter if the end customer is in retail or if it is business to business, so you must ask for each project "What value proposition is this for the customer" e.g. where is the value created, if any.

Harald Tokerød [Digital Transformation advisor – Tokerød Plus]

How do you see the integration of I4.0 in SMEs?

The digital foundation of the company is a must, todays customers are more used to technology than before, so technology like EPR, Customer Relations Management systems, must be utilized. Further it should be noted that agile manufacturing and customization will be required, everything is "on-demand" today and though larger engineering projects cannot be on demand, it should always strive towards faster cycle time.

Where do you see problems on the digital level in SMEs?

Basically we are talking about small problems, which have huge effect, it can be webpages of the company still using Flash technology, which makes it impossible for Apple devices to load the content as technology has moved to HTML5, we also see companies still using slow sub 10Mbit internet and not being aware of their digital foot print, that can include negative reviews on the internet which the company is not aware of.

In what context would you suggest SMEs to digitalize?

It is extremely important for SMEs to follow up on technology today, else their competitive advantage will simply slip away with time, however, it is important not to press on for high-tech solution on the cost of the people that have to work with it, everybody must be included and people are first over the digital transformation, else implementation will falter due to either intended or unintended sabotage from the very people who were supposed to gain from this technology.

Interviews at Korsør Propeller A/S

All interview was conducted in Danish and has been recorded during interviews, it was later transcribed into text and translated into English.

Interviews Korsør Propeller A/S: 22-04-2019

Ole H. Pedersen [Managing Director]

Overall where do you see the potential in a new ERP system?

"Well first of all I have the sensation that Navision C5 is out of date, it cannot work together with the Microsoft Office pack, so back functions like [Ctrl + C] doesn't work within the system. Then I expect the new system to automate a lot more processes. As of today, we cannot design receipts and other correspondence, we have to get in a specialist, I would want this to be easy for myself to do".

Do you make use of cloud technology at the company?

"Not really, we have the current ERP system on a server and old versions of Microsoft Office, if we need access to files or systems outside the company, we use Team Viewer and let a computer be switched on at all times."

In regard to your work with MNCs, do they require you to follow certain quality procedures?

"Not directly, they trust us and our capabilities as industry experts, once we started to implement ISO9000, however, it was deemed too expensive for the benefits it would provide. Materials are certified my bureaus and documents referred to the MNCs".

Do you think you'll start implementing some of the proposed new technology?

"We have no plans to start investing heavily in technology, our strategy is to outsource what requires special high technology intensive methods".

Do you have any cooperation with MNCs?

"We work closely together during projects; however, we have no direct deal that any MNC would only use us, every project will be put into elicitation and we bit on the order".

How do see the role of KP in the market today and in 10 years of from now?

"KP is in a niche market, we make propulsion systems ranging from 30cm to 4m diameter propellers and axels up to 12m in length, it requires a lot of skill and technical know-how. Today we're standing alone, 100% family owned, however, it is the strategy for the company to be bought within the next 5-7 years, to become part of the value chain of a larger corporation".

How has your dealings with MNCs previously turned out?

"Usually very well, of course there will always be a bad case amongst the good ones, but usually there can be years in between bad cooperation. Only problems have occurred while giving the responsibility to outside agents, who has let us down in quality and direct flaws of design, ultimately, we have the responsibility. We try every time to deliver best in class, so the MNCs will remember us next time they need a project done".

Was there any attempt to make a long-lasting cooperation with these companies?

"Yes in 2007 we were close to making a joint venture with an MNC from Singapore, with their company buying 30% of KP and we were then to provide the know-how for a brand-new factory in Malaysia, unfortunately finances and the 2008 crisis ended the relationship between us. Today we have a long-term cooperation with a medium sized enterprise here in Denmark, but other than that, we bit on projects from large shipyards and engineer to order when accepted".

Do you believe it is important for KP to be integrated in the supply chain of an MNC to survive?

"Yes and no, it would surely be nice to be part of a value chain, it would provide better usage of our capacity and being able to predict future orders, however, we have such technical know-how in a niche industry, so we can survive also in the long-term".

In which areas do you see KP use more technology in the future?

"As such we do not have a lot of capital for technology upgrades, as I stated before, if we need high tech solutions, we outsource that part of the production. Perhaps we will slowly see this new technology "seep" into our facility, the same way computers, internet and servers did in the 1980ies".

How protective are you about knowledge and information when working on projects with "partners"?

"We usually do not have to worry about information leakage, every project needs to be engineered and is highly specific to each project, only protection is that down payment of usually 30% has to be paid before we give any technical specifications, this in order for the buyer not to go elsewhere and have it made at a lesser cost now that the engineering has been done".

Do KP make any effort into researching or have standards for sub-contractor´s environmental behavior? (e.g. labor conditions, pollution, bribery, freedom of association) Does MNCs ask you this information from you?

"No and no, we keep to our own rigorous standards provided by the Danish labor law and we expect any subcontractor to be doing the same, we have never been asked by an MNC to provide any additional information about environmental issues".

Sofie Wessberg [Accountant]

What would worry you about new technology and a new ERP system

"I'm aware that there will be a roll-in period in which things might not go according to plan on a daily level. I do of course hope we will get a good introduction to the system, particular to get a consultant that can teach us the system and doesn't just rant off the information and leave us to figure it out by ourselves. Talking our language."

What expectations do you have for this new system?

"It can only become better! I was basically happy enough with the old system; however, some parts really take too long time. Creation of late payment statements is a manual task today, which I hope will become automatic in the new system, today we send individual

emails to customers. I hope for the new system to automate a lot more of the processes than is the case today. Another area is in project management, today I manually type in a lot of information, which my experience from other ERP systems, tells me can be automated".

What worries you about implementing a real ERP-system?

"I worry about the system being put on us from the top, that there will not be any inputs from me personally and that there must be a support line, so I can get help when I need it, a "good hotline" is essential."

How will you grabble this task in your position?

"The best way of learning for me is to just dive right into the system and play with it, see how it works and then, as I said before, have a good hotline for help when I cannot figure something out by myself. Practical working with the system after a good introduction is how I hope it will work out."

Do you have experience with such a change earlier?

"Yes, I used to work for an MNC in which the system was huge, I hope the system chosen for KP will be scaled to the needs we have and not having too many resources demanding applications that we actually do not need".

What kind of issues do you have with the current system?

"Financially we cannot know for sure how precise the numbers are, we get a balance of the accounts once a month, but just this July showed that all basic numbers were alright, however, the final result showed DKK900.000 (EUR 120.000) missing from the system. This makes it very hard to use as a management tool."

Follow up question: Why do you think this happens?

"I suspect that a project hasn't been properly booked in the system, it could either be missing or some payment of the project hasn't been properly registered. Usually it registers the expenses of a project first, but then it can miss the incoming payment, leaving the whole project registered as a loss".

Follow up question: What other issues have you personally experienced?

"Sometimes project costs are being randomly attached to a different project. This happens if I'm writing in data of the project in the system and then a warning pops up that the system cannot find the creditor accounts and then randomly drop the information to a different account, this mistake is very hard to mitigate as you then have to dig into the system to find the mistake. The result from this is suppliers calling to ask where the payment for material is, only then to discover this mistake has happened. Happened 3 times this year so far".

What kind of issues do you expect the new system will bring?

"Well, I hope it will have no programming errors and that the system will work as intended, so that the only errors will be from the person sitting at the computer aka human error. It might turn out to be cumbersome to transfer the old data to the new system, as we have a lot of old redundant data in the previous system that we do not wish to get transferred to the new, there might be a lot of manual work in the beginning".

What can you conclude on the old system?

"It is too manual and labor intensive, not enough automation, it makes weird unexpected errors, finally it requires you to sit at a specific computer or use Team-viewer to have remote access. Finally, I hope a system will be chosen that isn't a "program it yourself" system, I hope it will have the modules we need and that it works, no tinkering by ourselves to make it work".

Martin D. Jacobsen [Chief Mechanical Engineer/Project leader]

What are your expectations toward getting a new ERP system?

"Well I actually do not use the ERP system that much, I'm more in the periphery of the usage of the system, I use the materials purchase module and the order creation module. Further I add item numbers to the bill of material lists for projects ".

Do you think such a new system will help in your area of work?

"In some area it might be easier as some areas in C5 right now doesn't make a lot of sense to my work, it is very illogical".

What improvements are you hoping for with the new system?

"I hope for there to be a better graphical interface, making navigation easier and faster to use, right now I have 30 buttons on my screen and I only need 3-4 of them, making it confusing and slow. Today I also have to manually design and add every piece of material in the Bill of Material, I would which for the new system to have this process automated and easy to print. I guess I would like the new system to streamline the project management process".

Will it help you in project management?

"For now, I do not believe it will, I run every project in a very simple manner in which I use Excel and physical paper to plan ahead, I don't see any improvements in this area".

Switching from the new system to the projects, do you make use of multiple suppliers?

"Mostly we use only 1 supplier, most is in steel as we have 3 different. We do not shop around as it is too time consuming. In that regard C5 is very manual as every piece of material must be typed in, I hope a new system could help here, C5 is very old!".

Could you use the ERP system e.g. in regard to certification of the projects?

"Most certifiers have their own formulas that need to be filled for every project, so I find it hard to think such a system can handle all the information for each project by itself, further it is important that nothing goes wrong in this process, so I would prefer to keep this task manual".

You have quite some physical manuals standing around, will you digitalize this with the new system?

"First problem with this is that perhaps half of the projects with have records of might have been scrapped over time, so if we digitalize this information it might be wasted efforts. Fact is we don't know which ones are active anymore. What we could do is to make a date in time where everything will be digital, e.g. 2008 and onwards everything will only be in digital version, but then keeping paper records of everything before this".

How would you perceive getting an iPad instead of using paper in your work?

"For sure I prefer printed paper, especially for the manufacturing facility, if I need to make a correction I can just do it with my pencil instead of using an app, plus if you spill coffee on it, it can still be used for the intended purpose. At the office I might be inclined to try and use digital solutions in the future."

Do you have any suggestions from your personal experience where digital solutions would improve efficiency?

"If I had 2 computer monitors, then I would be able to read drawings and specifications on one screen, while working in the system on the other, then I wouldn't have to print all project drawings as I'm doing today, it's simple but would help."

How do you see the technology evolving in your area of daily work?

"The most important development I have experienced in my time here at KP, is the introduction of CFD calculations, being able to calculate propeller blades as not to have cavitation was a major advancement in quality. In my daily work I mostly work with 3D drawings and project management, plus I engage with the shop floor, things like automated time keeping cards for the works might enhance the precision of cost allocation for project, I hope a new ERP system might integrate this part".

Do you believe technologies like IoT, RFID and 3D printing will be of any significant advantage to your work?

"As of now I don't think we need a lot of technology, this is a small company and most stuff I deal with personally. Of course, it would be nice to monitor machines from my computer, it would for sure save some walking every day, but as production numbers are low, I do not have any problems with locating parts for each project and don't see the point in heavy investments".

Do you see any potential problems regarding loss of intellectual property?

"No each of the products we design here are specific to the project, you can say that all information about design is available to any company that has the right engineers, what sets us apart is the holistic knowledge build within the company making us very flexible, besides that we do not have financial capacity to do a lot of R&D which we would then have to protect".

Do you believe that innovation is a competitive advantage of your department?

"Honestly no, what we do here is a very slowly moving industry, we had innovation in the late 90ies by introduction of "highly-screw" blade design and now we do see the introduction of electric propulsion, but we know as a small company we can chose to make our advantage by either innovation or flexibility and we have for sure gone for flexibility, we can design, make and produce any project fast, which gives us an edge over many of our larger competitors".

I know you have been using CFD in your work, how has that changed your methods?

"Yes, Computational Fluid Dynamics has helped immensely by providing quality upgrades and lowering cost of mending those issues, even the best "manual" calculations in the past could produce cavitation forces and thereby destroying the propeller blades, now we do not experience this as the computer will let me know if there will be those problems."

Michael Larsen [Machinist/Foreman]

Are you aware of the emergence of Industry 4.0?

"I don't know what you mean by industry 4.0, but assuming it is technology I welcome it. This is a small company and we're always aware that it is a bit special that KP has survived where many others failed in the 80ies and 90ies, if technology will help us survive, then bring it on".

How do you see this new technology changing the work environment?

"We don't see much change in the manufacturing, we still use machines as in the 80ies and have a lot of paper drawings laying around. Perhaps we can get faster in touch with Martin if we have questions regarding specific materials in production or the warehouse might get upgraded, else I don't see it".

Do people in the production welcome new technology?

"Sure, as I said we're ready for new tech, but again, where to use this? Our jobs are turning metal lumps into mechanical parts, only administration might be done easier with use of technology".

What is your take on integrating with larger companies?

"I hope we will not lose the feeling of our small community; I like how it is like one big family here in the company. But, if the survival of our workplace is dependent on becoming part of a larger company, then I just hope they do not steamroll us with "new procedures"."

Where do you see challenges arise in the future for you personally?

"The boss has turned 60 this year and he can't stay on forever, who will take over when he goes on pension? This is my main concern. Will another company buy us, or will we the employees take over ourselves? I see many options; some are private to me".

Interview at Korsør Propeller A/S: 07-08-2019

Ole H. Pedersen [Managing Director]

Having seen the proposed framework, what are your thoughts for improvement?

"I can see the benefits of upgrading technology and how everything would be easier when talking together, however, it seems to me that the costs are still very high and as long as we're not required by a MNC to provide "linkage" with our production, it will be hard to justify the expenditure. That being said, as we're looking for possible buyers for the company within the next 5 years, we might want to use the framework to streamline the company, one might say to make it more appetizing for a MNC to integrate us, if the technology will make this easier, then it might be a good investment".

Do you believe I4.0 technologies will become part of your company?

"Eventually, but I don't think it will happen while I'm running the company, it will have to be someone who are more familiar with the possibilities of this new technology. Presently,

our focus is on getting a new ERP system that is modern and can help automate a lot of the office work, then we might follow the framework by adding new technology bit by bit."

How do you see the value proposition of this solution that has been found?

"The cost came in under our estimated budget and I'm quite pleased with this, however, I find it more important that I now have a more professional tool for the management, it will save immensely on time and frustrations that we had with the old system. Further, I like that this will streamline the company and the processes, we would very much like to see a takeover of the company within 5-7 years and this seems to accelerate those plans."

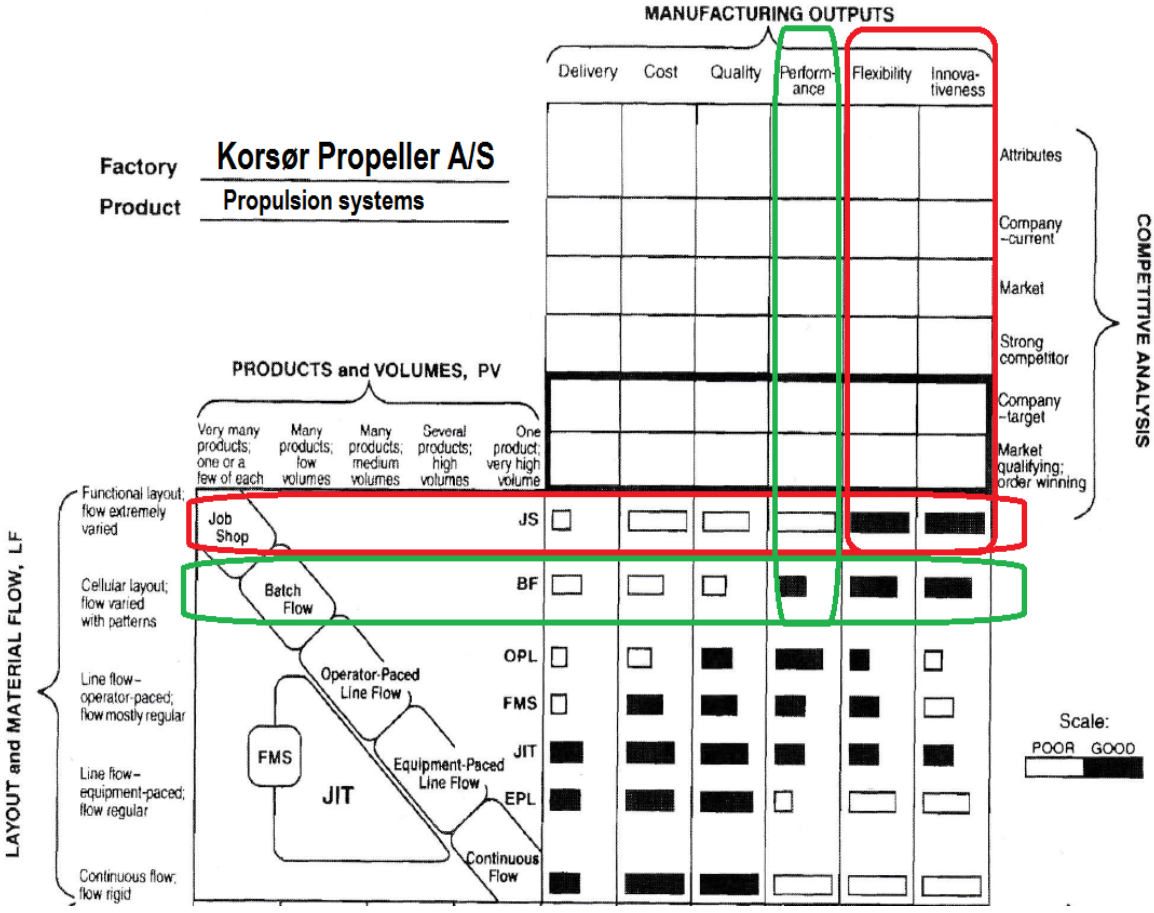
APPENDIX 4: CONCEPTUAL MODEL, CASE STUDY

To showcase the conceptual model in a real-life application, the methods used in cooperation with Korsør Propeller A/S (Henceforth "KP") will be shown in full in this appendix. From start to end it has not been a straight-line flow, but rather iterations much like the theory of the modern global value chain. Hence, the model is shown in a logical flow from start to finish, but the reader ought to know that the process for any given company might need going back and changing factors as required. The reason being new information might turn up as the research and analysis are being conducted.

Step 1: Analysis and charting

Using the Miltenburg framework for making sure that the underlaying processes are being utilized optimally for KP, this is a 2-step process in which observation firstly will give the primary data required and secondly this data can be compared with the framework theory. Figure 30 shows what KP ought to be working like in red.

Figure 28: KP's factory layout

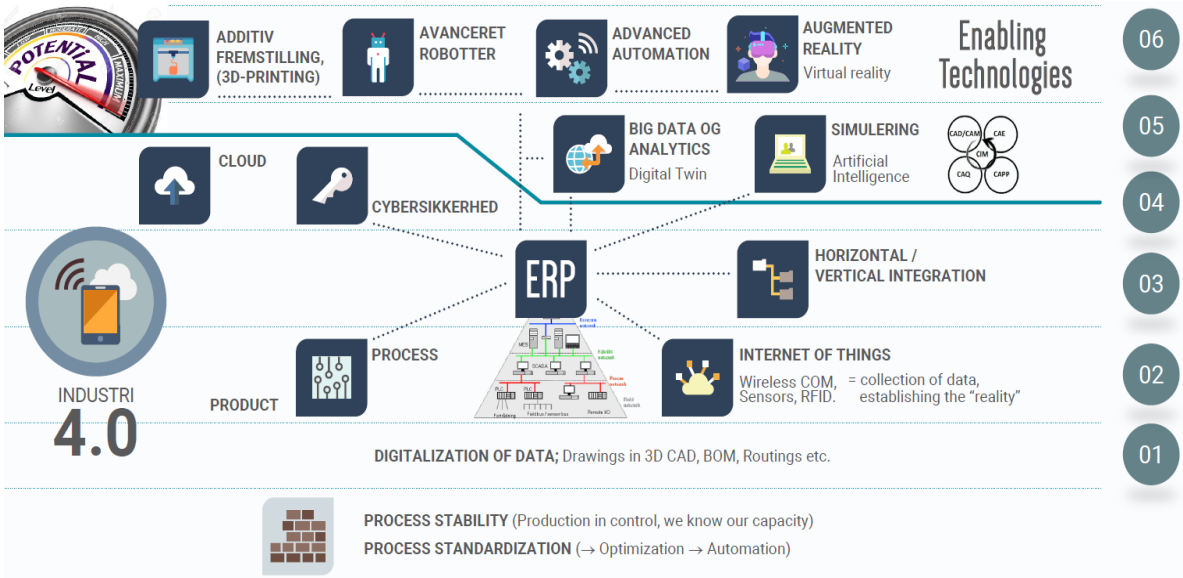


Source: Miltenburg (2005).

The emphasis in accordance with the framework is to enhance Flexibility and innovation in a Job shop environment. This is consistent with what was found at the facility during the investigation. The green line shows a one-time case KP had, in which a customer ordered 10 identical units, and KP had to rearrange the production process to Batch flow. As an interesting side note, cost was reduced by 30% directly compared to normal production processes for 1 or 2 units in the Job shop situation.

During the discovery phase, the digital footprint of KP was also analyzed. As the company had already been on a digital transformation earlier, all the basics were found to be supported, from the framework, KP was found to be at level 2, see Figure 31.

Figure 29: Levels of I4.0



Source: Tawfik (2019).

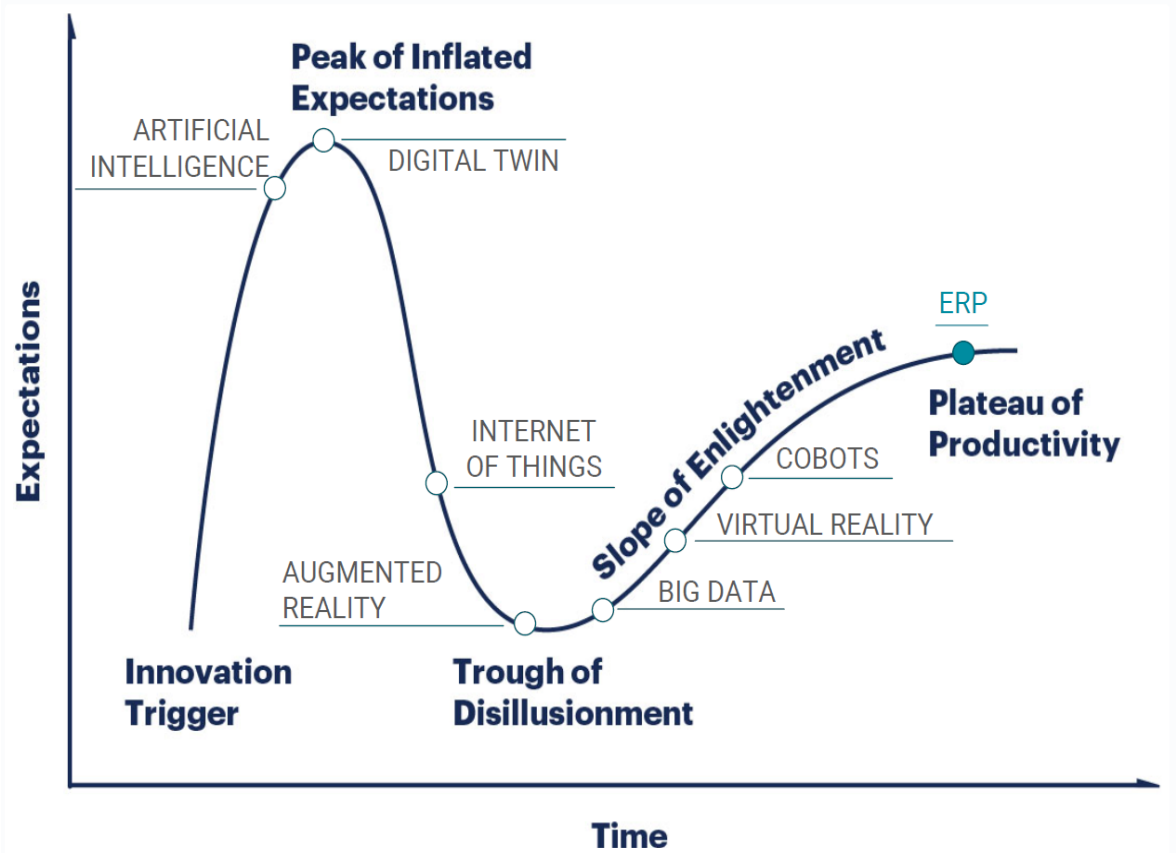
KP has modern computers, fiberoptic internet connection, people who can operate the IT system and the current systems are well known by the employees.

This is the stage where discussion took place of what options of technology could be integrated for KP. Using the maturity model, it was found that even though KP could benefit from many of the I4.0 technologies, the biggest impact would be a new ERP-system.

This also coincided with the fact that their old system (Microsoft Navision C5) would run out of support by 2020, so a new system would have to be found in any case. KP's management had been looking at purchasing the E-conomics system but was quickly persuaded to look into a more progressive system, ready for I4.0 integration.

Figure 32 shows that ERP-system upgrade is one of the more mature technologies within I4.0. Hence, it is a less risky solution for KP than other newer technologies.

Figure 30: Example of technology maturity



Source: Tawfik (2019).

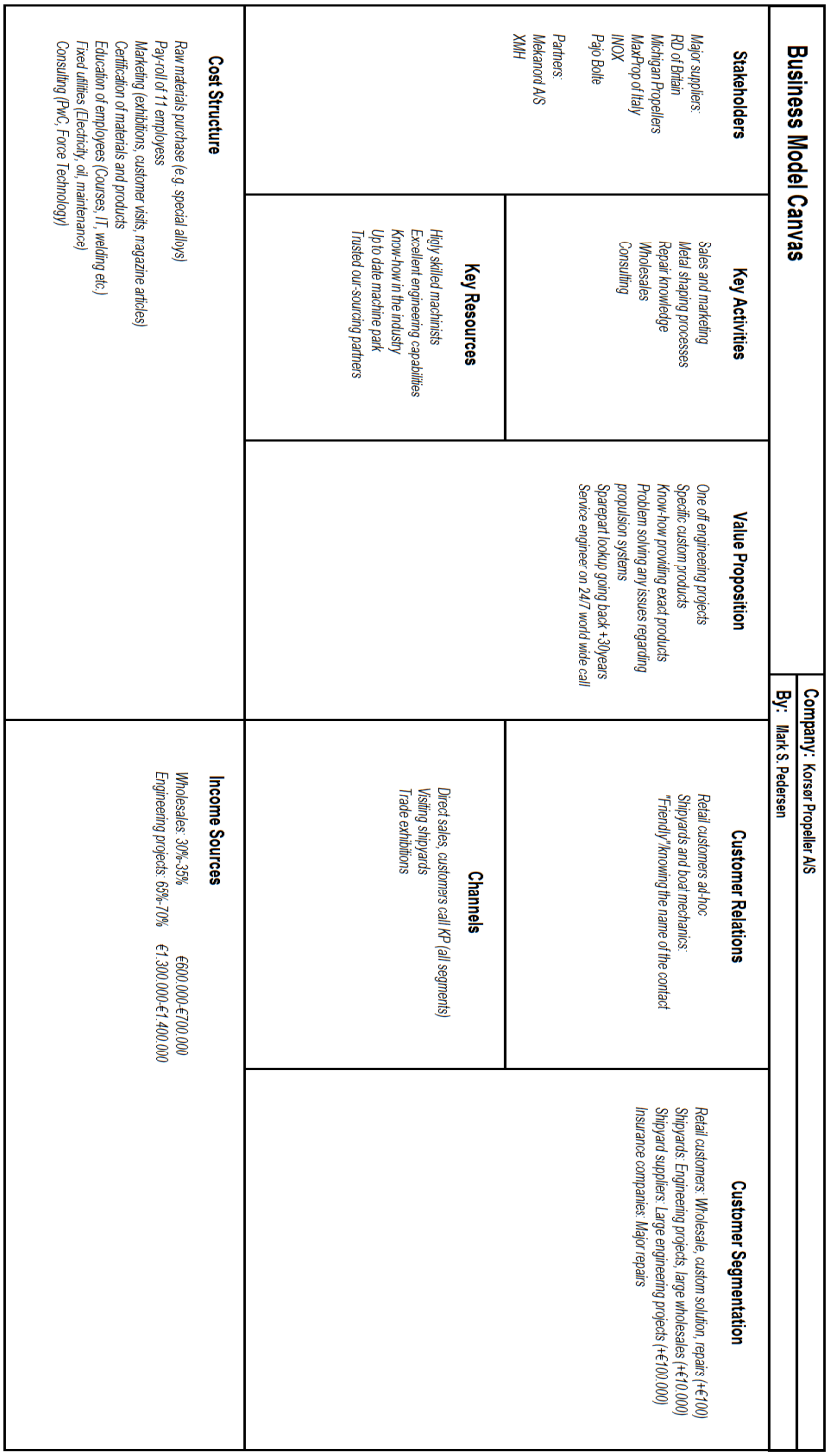
Once a new ERP-system has been integrated, KP will be ready in the future when other I4.0 technologies will reach maturity stage.

At this stage it was decided that the ERP-system change would be the best use of capital for KP. Next stage would be to find what kind of system will be the right for KP. To meet this requirement, PwC's Sharif Tawfik was asked to take on the role of consultant as neither KP nor the author felt competent enough (or time bound) to perform this task. As of writing, the result from PwC is underway, but no final recommendation has been presented yet.

Next part will describe the usage of the Business model canvas and the proposed action plan from the conceptual model.

Step 2: Creating an action plan

Figure 31: Business Canvas of KP

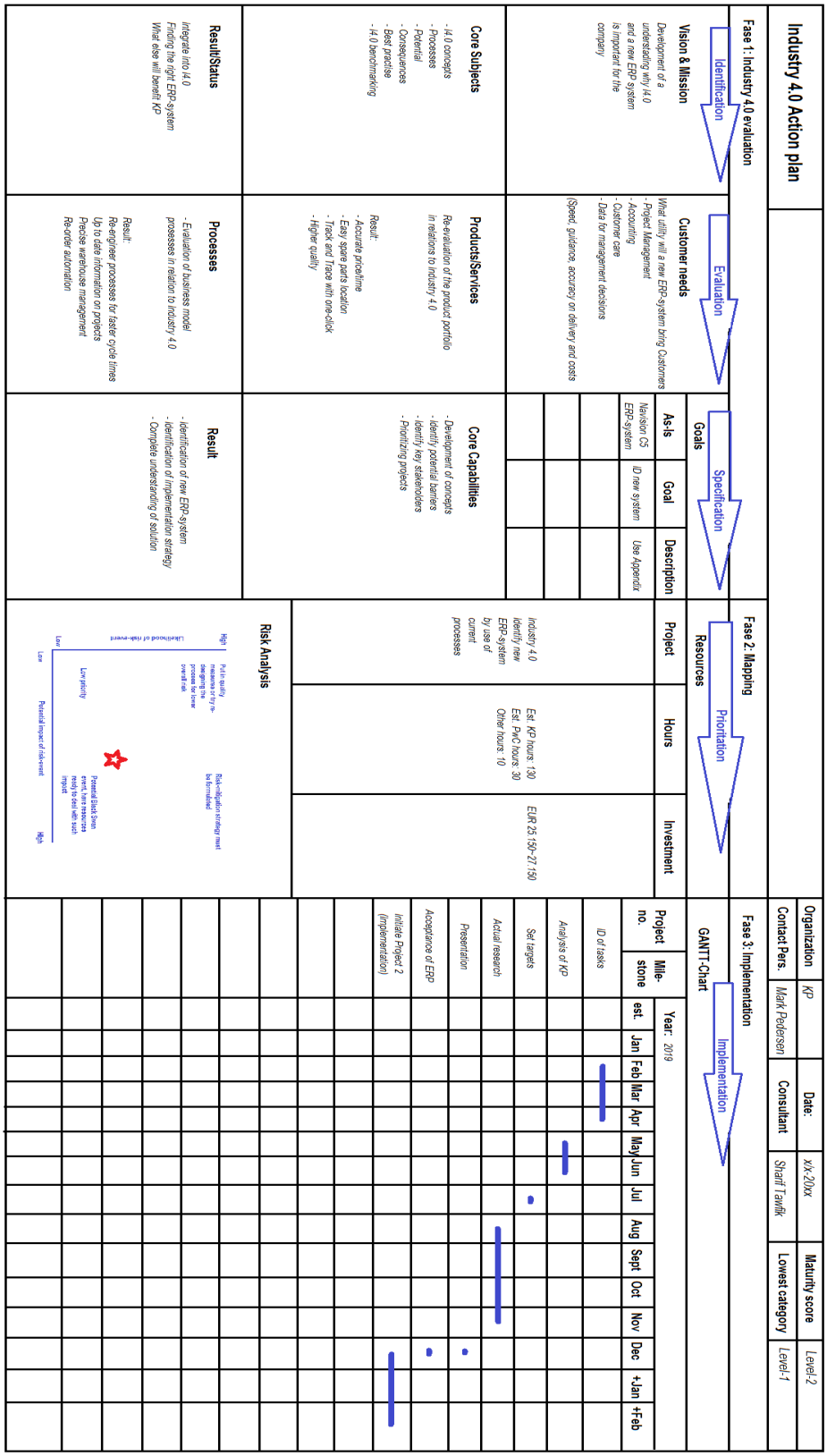


Source: Own work.

In Figure 33, the business model canvas has been used to gain an overview of KP's business model. It is important to know the business in detail before starting an I4.0 project. Even though it might be a small company, it helps when both the management and people involved, know the processes and why the company operates as it does. Using the canvas will also make it clearer in the future where KP can start joining value chains via I4.0 technology, e.g. by using vendor-controlled inventory in relation to the supply chain.

Final stage of applying the framework is to create the action plan for the project, this is a collection of best practice project management styles made simple to use. Figure 34 showcase one suggestion for the ERP-system project for KP. By this stage enough information has been gathered to plan out the event and this can be printed and used for both clarification but also inspiration during the project.

Figure 32: Action Plan detailing project run



Source: Own work.

This last stage will ensure maximum chance of success for KP to identify the new ERP-system, while making sure everybody involved are aware of the progression and expectations of the project, both from the viewpoint of the employees but also to keep the customers in mind.

Having a detail overview of the project will make it more effective in taking appropriate action. As there are stages of the project in which long time span follow in between action steps, it will also allow management to quickly realize where they stand and how to take action. One such example is the time period in which PwC used to analyze the correct ERP-system, being several months. However, as there is a detailed plan visually present, it was easy to resume the project once PwC had conducted their analysis.

Having used the framework for this first project, it seems obvious to use it for the next projects once this particular one has been finalized. Total quality management is one such area, to make sure all machinery is running perfectly when KP has its high season in the spring.