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# TOWARDS AGILE MANUFACTURING

New Product Introduction

Technology and Communication  
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## TIIVISTELMÄ

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Globaalin pandemian vaikutukset yritysmaailmassa ovat olleet huomattavia. Pandemian vaikutukset on tutkittu olevan suurimmaksi osaksi negatiivisia yritystoiminnalle, mutta ketterien toimintatapojen on todettu lievittävän pandemian negatiivisia vaikutuksia.

Tämän opinnäytetyön tarkoituksena oli tutkia ketterää valmistusta ohjaavien tekijöiden ja mahdollistajien tärkeyttä uusien- ja kehitysohjelmien näkökulmasta. Tutkimus toteutettiin yhdistämällä strukturoitua haastattelua ja analyyttinen hierarkia prosessi (AHP). AHP on päätöksenteossa käytettävä työkalu, jota käytetään tässä työssä ohjaavien tekijöiden ja mahdollistajien tärkeysjärjestyksen selvittämiseen.

Tuloksien yhteenvedossa todettiin ketterän valmistuksen tärkeimmäksi ohjaavaksi tekijäksi kilpailullisuus ja tärkeimmiksi mahdollistajiksi tuotteen hinta, innovatiivinen valmistusympäristö sekä teknologiset jälkiasennukset ja päivitykset.

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Avainsanat    Ketterä,    valmistus,    analyyttinen,    prosessi,    lähestyminen

## ABSTRACT

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The impacts of global pandemic in corporate world have been huge. The impact of pandemic has been reported mostly as a negative impact on corporate operations, but an agile way of working has been discovered to mitigate the negative impacts of pandemic.

The purpose of this thesis was to study drivers and enablers of agile manufacturing and their importance from the perspective of new product development programs. This research was done by combining structured interviews and the analytical hierarchy process (AHP). The AHP is tool that is used in decision-making, and in this thesis, it was used to identify the importance of the drivers and enablers.

The conclusion of results states that the most important driver for agile manufacturing is competitiveness and most important enablers are product cost, innovative environment and technological retrofits and upgrades of products.

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Keywords                      Agile, new product introduction, and way of working

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# 1 INTRODUCTION

Industrial environment is changing, requirements of customers vary, and they demand faster time-to-market delivery. These factors make the environment more unpredictable and create pressure to change, be reformed and to reach agility both in management and manufacturing. Since the target organization operates in a global industrial field the agility could have a huge impact on efficiency in a new product introduction process and manufacturing of new products.

Manufacturing consists of a plenty of factors that affect the efficiency of a new product development process. Due to that fact it is not a simple project to choose what should be chosen as most important drivers and enablers to focus on. As a decision-making tool the analytical hierarchy process was chosen. The tool in this thesis was based on structured interviews of experts in different positions from the target organization.

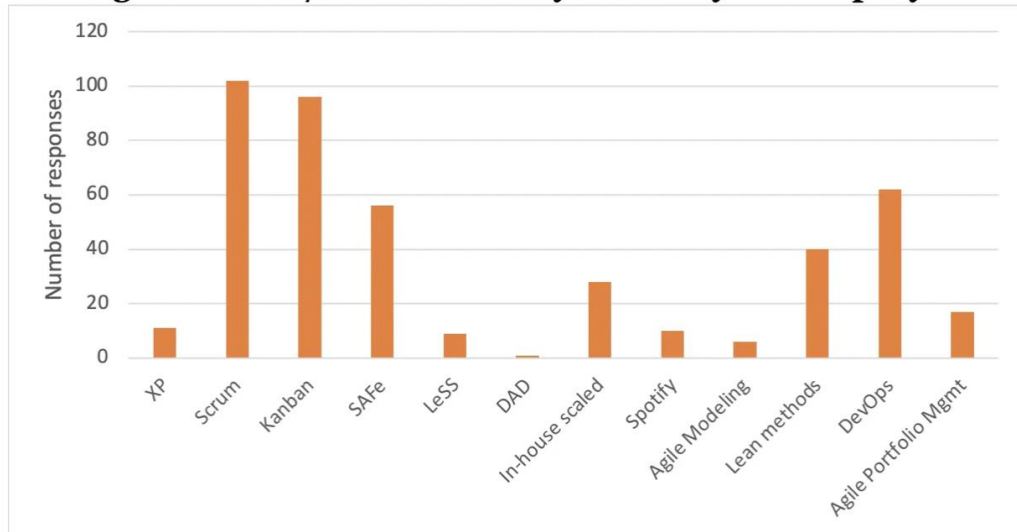
The thesis guides through how to use the analytical hierarchy process via an example that explains the process step by step, provides explanations for terminology, roles and methods that are generally in use in an agile way of working. Lastly in the thesis the results of interviews will be analysed, and the key performance indicators will be identified for most important enablers of agile manufacturing.

## 1.1 Background

According research of Nitor (2020) considering global pandemic in Finland and Sweden, the pandemic has had different effects on companies, 45% of companies reported a negative impact, 19% reported that the impact has been positive and 36% reported a mixed impact. The results show that regardless the impact being positive or negative, the agility has helped in responding to the situation. (Nitor, 2020.) The global pandemic is still on-going and must be considered as potential solution to respond to this situation and also it is a good way to be prepared for

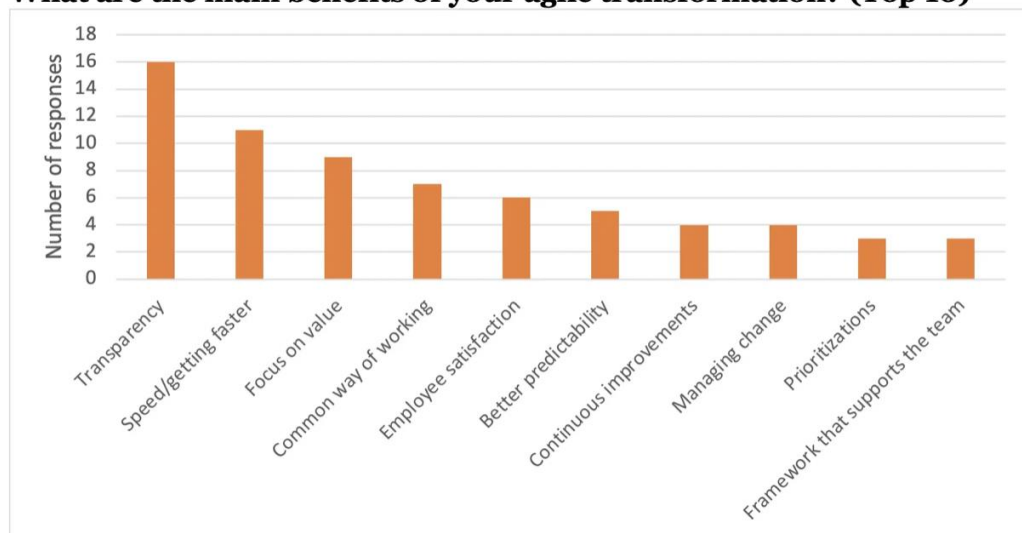
any upcoming issues in future. The survey from Nitor shows the mostly used methods in companies (Figure 1) and the main benefits of agile transformation (Figure 2).

### What agile methods/frameworks do you use in your company?



**Figure 1.** Most used agile methods (Nitor, 2020).

### What are the main benefits of your agile transformation? (Top 10)



**Figure 2.** Main benefits of agile transformation. (Nitor, 2020).

For the target company a Master thesis was completed during the year 2019. That Master thesis covered the topic of what is an agile way of working and how to

reach it in an industrial company. The Master thesis works as a base for this thesis and sets a framework. As Neil and Siegel (2019) point in their book, the large project that will benefit from frequent updates is suitable for agile management. This product development program has started several years ago and are still on-going. The updates varying from different prototypes is a sign that this product development program has a need for frequent updates, in order to follow the trends on the market and satisfying the needs of customers; therefore, this program is suitable for the agile way of working.

This thesis is a research of how to apply the agile way of working in manufacturing phase of new product development. The development program has reached a certain level of agility in the way of working inside the program, but it is still work in progress and has not been tested in manufacturing process yet.

## **1.2 Targets, Research Questions and Main Concept**

The main target of this research is to understand the current state of manufacturing process in a new product development, how to develop it to the agile manufacturing process and understand the requirements of agile from the manufacturing point of view. The research questions are as follows:

What are the reasons to leading to adopting agile manufacturing? Drivers of agile manufacturing

What are the key enablers of implementing agile manufacturing practices for a new product development?

What are key performance indicators that should be developed as a result of adopting agile manufacturing practices?

The development of the hybrid agile way of working framework for the case program began already some years ago, and after the previous research (Torkkola 2019) it has been developing further within the program. The previous research

(Torkkola 2019) focused more on the product development phase, but now when the program is reaching the manufacturing phase, it is important to further investigate how the agile values and principles could be better implemented also there. Continuous improvement is a crucial part of the program and lots of development actions have been already taken, but there is still room to improve, and that is why this thesis will focus on the agile values implementation in the manufacturing phase of the case program.

### **1.3 Research Methods and Structure**

This was done as a qualitative case study research for the new product introduction department. The new product introduction department is a part of several new product programs, but this thesis focused only for the one product development program.

The method for interviews was to combine the analytical hierarchy process and structured survey interviews. The interviews were completed as mentioned utilizing survey. In the survey the order and shape of the questions was fixed. (Hirsijärvi, Remes and Sajavaara 2009, 208.) The interviewer was there during the whole interview in order to secure the maximum understanding of the interviewee and secure the best possible consistency ratio. The consistency ratio will be explained in more detail in the chapter considering analytical hierarchy process.

The agile part of non-IT lines of business and part of manufacturing process is a relatively new topic. The growth in non-IT of business lines from 2020 to 2021 adoption has doubled according to research of CollabNet (2021).

The first chapter of this thesis will create a base frame and explain the topic and background. The second chapter will introduce traditional project management tools, new product development process, agile way of working and agile manufacturing. The third chapter is about the data collection method for analytical hierar-

chy process and how the AHP tool is used properly. In the fourth chapter the empirical findings will be covered and identified the results of the thesis. In the fifth chapter the thesis will be concluded and the proposal for further study is given.

#### **1.4 Target Organisation**

The target organisation operates worldwide in technology industry, hardware business. The fact that the target company operates in industrial environment with hardware sets challenges and opportunities for the implementation of the agile way of working. The target organisation has passionate targets to decrease lead times, ensure the quality of product, increase the amount of collaboration with customers and release new products and new product variants more often. In order to reach the listed targets, the agile way of working will be one of enabling management tool for it.

This research was done only for the one new product introduction program inside the company and that project takes place in Finland and Italy.

## **2 LITERATURE REVIEW**

The purpose of the literature review is to present the relevant information that is gathered from the different studies concerning project management methods used in new product development process. In this thesis New Product Development (NPD) and New Product Introduction (NPI) is assumed to mean the same process, that is, “the sequence of steps or activities that an enterprise employs to conceive, design and commercialise a product”. (Badr and James-Moore 2004.) The literature review begins by introducing the basics of the traditional new product development process, traditional project management, such as waterfall, followed by describing the history of agile management, terminology used in agile, focused on the terminology that is in use in the target organisation, followed by agile values and roles, agile manufacturing, hybrid agile way of working and lastly summing the whole Chapter 2.

### **2.1 Traditional NPI/NPD & Gate Model**

Launching new products to market to follow the trends and requirements on the market is crucial. Organizations strive to identify new product ideas and opportunities and look for success and gain steady stream of profits of the new product. New product development is the riskiest tasks for organizations. While invested amount of money grows, the pressure of success and to achieve maximum profit increases simultaneously. (Brethaur 2002, 11.)

Developing new products and introducing them to market is a crucial part of the business nowadays. Kahn, Abbie, Evans, Slotegraaf, Steve, Wiley and Sons (2011, 3) state that 27.3 percent of the company sales comes from new products that were launched.

The traditional new product development begins by defining the stage-gate process and identifying necessary deliverables. The stages of the model must be defined, and they can be formed for example as follow:

- Stage 0: Pre-PRIDE
- Stage 1: Idea Concept
- Stage 2: Bench tests
- Stage 3: Pilot plant tests
- Stage 4: Plant tests
- Stage 5: Construction
- Stage 6: Implementation
- Stage 7: Post-Pride

After defining the stages, the new product development team creates a list of tasks that are important for a project. The next phase in a process is to organize the tasks and deliverables according to the stages; these tasks and deliverables

have to be completed and achieved before proceeding to the next stage is allowed(Figure 3) (Brethaur 2002, 132-134).

To process the following cases: new products or line extensions, applications, upgrade products/processes, new formulations, cost savings, and label changes.							
Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Pre-PRIDE	Idea Concept	Bench Tests	Pilot Plant Tests	Plant Tests	Construction, Installation or Dismantling	Implementation	Post-PRIDE
Champion-Idea Discussion	Target Market						Audit Idea/Product
Back of the Envelope Economics	Preliminary Business Plan		Business Plan (first draft)	Business Plan (finalized)			
Initial Product Specifications	Refine Idea/Product Concept & Lab Samples	Idea/Product Definition And Optimization	Idea/Product Further Optimization	Formulas Process Procedures SOP's		First Production Run	
Value of Positioning w/Customer	Customer Liaison		Internal Product Alpha Testing	External Product Beta Testing		Market Launch	
Core Team Identified	Environmental Implications		QA/Regulatory Requirements Environmental	Final Product Specifications		Process Debugging	
	Patent Search		Facility Concept		Finalize and Construct Facility		PRIDE Metrics
	Supplier Contact		Co-Packer Approval				
GATES:							
CYCLE TIME (months)							
Stage 0 Forms:	Stage 1 Forms:	Stage 2 Forms:	Stage 3 Forms:	Stage 4 Forms:			Approval Committee Review
(1) - New Idea Form	(3) - Business Plan	(4) - Bench and Pilot Worksheet	(4) - Bench and Pilot Worksheet	(5) - Request for Pilot and Plant Test			
(2) - Request for Ingredients				(6) - Co-Packer Approval			Steering Committee Review
				(7) - Product Formula			
				(8) - Request for Product Label			

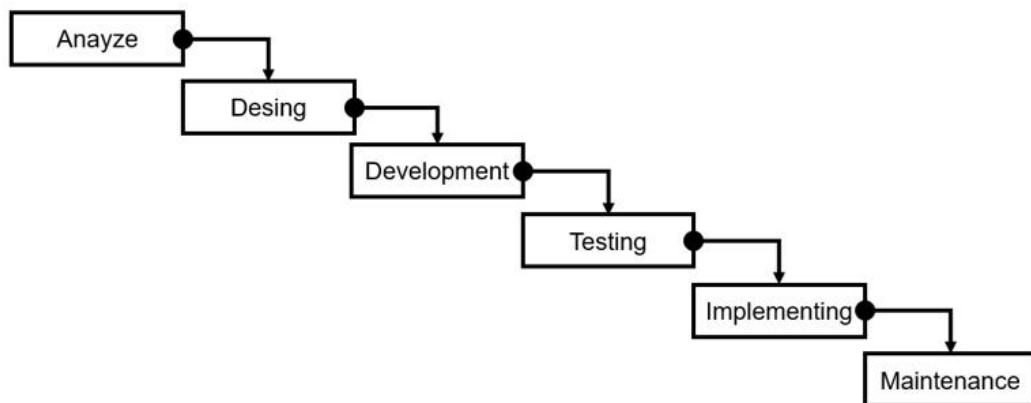
Figure 3. Stage-gate methodology (Brethaur 2002, 135)

## 2.2 Traditional Waterfall Project Management

Project management refers to controlling process within the organization. These processes can be, for example, the production process, communication, information flow, cooperation of people and/or the controlling budgets and time. (Verhaar and Eshel 2013, 15).

The waterfall model was originally introduced through a paper published by Winston Royce in 1970. (McCormick 2012, 1.) The characteristics of a project, it is a temporary entity of activities which will end and as an end result create a unique product, service or result, if not aborted. (Dobson 2015.)

The characteristics of traditional waterfall management refers to predetermined plan, including budget, scope, and schedule. In order to be successful this method requires environment, where projects typically are relatively simple, there is very little change during the project and proceeding is linear. (Lalmi, Fernandes and Souad 2021, 923-924.) This method runs through a sequential design process, where the progress flow is like a waterfall where the stream goes steadily downwards through phases (Figure 4). Before entering from phase to next phase all the activities must be completed. In the waterfall model, each step is frozen before the next step. The usage of waterfall model enables clear requirements before start, easy implementation, minimal requirements regarding resources and extensive documentation considering quality development. Even if the waterfall model enables great number of pros, this model does not enable any changes after the phase has been accomplished, some problems might arise afterwards, but they cannot be solved completely. (Balaji and Murugaiyan 2012, 27.)



**Figure 4.** Waterfall model

Markets are moving towards quickly changing environment, where organisations must be highly responsive, create better value for money, achieve higher customer satisfaction level and higher product quality in order to remain competitive. The traditional waterfall model emphasizes the early freezing of specification during the high-level designing phase, also numerous documents must be approved before entering the next phase. The above mentioned characteristics are unsuitable for a model that could respond quickly to changes. (Casteren 2017, 1.)

The agile approach instead has been developed to provide such an environment to organisations, where it is possible to achieve the mentioned features and more benefits which will be covered in the next chapter. (Axelos, 2016.)

### **2.3 Agile (Background in Software, Used in Hardware Development)**

Agile has been evolving slowly from the 1940s, from different IT governance and delivery frameworks, from “Toyota Way” by Ohno, Shing and Toyoda 1948, to “Lean start-up” by Ries, 2009. (Measey, Radtacm Berridge, Gray, Levy, Wolf 2015, 2-3.) In the 1990s, the developers decided to abandon the traditional structured, segmented, bureaucratic way of working in software development, the decision was to aim to more flexible development methods. The most used methods are

scrum, adaptive software development, dynamic systems development and feature driven development from 1995 and crystal clear and extreme programming from 1996. (McCormick 2012, 3.)

Agile and a manifesto of agile was born in 2001 by the pioneers of agile software development. The manifesto itself provides values and definition for agile framework. (Measey et al. 2015, 4.)

*“Individuals and interactions over process and tools.”*

*“Working software over comprehensive documentation.”*

*“Customer collaboration over contract negotiation.”*

*“Responding to change over following a plan.”*

*“That is, while there is value in the items on the right, we value the items on the left more.”*

(Beck et al. 2001)

The Agile development could be described as an umbrella term for different frameworks and principles that are based on the agile manifesto. Agile focuses on the people that do the work, how they collaborate and that differentiates agile from other approaches. Collaboration between self-organizing and cross-functional teams is in the middle of agile development culture. (Agile alliance, 2021.) These kinds of teams enable quick respond to a change in requirements, even if these changes would occur in a later phase. (Balaji and Murugaiyan 2012, 28.)

The Agile concept in manufacturing has been developed to enable flexible and rapid response to a manufacturing and reduction of time to reach the market with a product that satisfies the customer and responds to requirements of the customer. (Gunasekaran 2001, 5.)

### 2.3.1 Agile Terms, Tools and Methodologies

Agile has its own terminology which is crucial to understand in order to follow how the agile way of working proceeds. Tools and methodologies presented below focus on the tools and methodologies that are in use in the target organization; therefore the terminology does not cover all terms used in the agile approach and these terms have been modified to correspond the terms that are in use in the target organization.

**Demo** is an event part of the scrum which is held at the end of the sprint and the development team presents the results and accomplishments from the sprint.

**Development Team** “is a cross-functional group of 5-11 individuals, who define, build, test and deliver an increment of value in a short time box”. (Scaledagile-framework 2021.)

**Epic** is a new product or a product that is under development.

**Feature** is a prioritized item or development entity that is defined by the product owner based from the customer and stakeholders’ requirements.

**Increment** is a time period which consist typically of 3 to 4 sprints. At the end of every increment, a demo event will be held, the demo at the end of increment is wider than the demo held after sprints.

**Kanban** is developed by Japanese to manage continuous flow of development, delivery of products and team tasks. The term translates as “signboard” or “story card”. The main focus of Kanban is to visualise and highlight the constraints to that flow. Successful Kanban follows the rules identified by David Anderson (2010):

Visualize your work so that you can see the work and in context with other work. Limit the work in progress (WIP) using a pull system so there isn’t an overflow of work at any step along the way and so pace is understood. Manage the flow of work, applying measures so the team knows how much work to commit. Make the process policies explicit so that improvements

can be made to acknowledged baselines. Improve collaboratively so there is the opportunity to improve the working process and workflow.

**PI Planning** PI is an acronym that comes from words product increment. During this PI planning the upcoming increment will be planned according the prioritized features from product owner.

**Product Backlog** “is a list of functional and non-functional requirements that, when turned into functionality, will deliver the vision”. (Schwaber 2004.) It consists of features and stories based on customer desires and requirements.

**Red Flag** Impediment causing a threat to achieve desired outcome.

**Scrum** is not an acronym; therefore, it is not written in all capitals. Scrum is framework for the incremental and iterative approach which also, defines roles, events, artifacts, and rules.

**Sprint** is part of scrum. It is a time period including planned team activities and it lasts typically 1 to 4 weeks, at the end of the demo event is held.

**Sprint Backlog** “the tasks in the sprint backlog emerge as the sprint evolves” (Schwaber, 2004).

**Sprint Retrospective.** During the event the teams reflects to previous sprint and identifies what went well and what could be improved during the upcoming sprint. The reflection focuses on activities, team dynamics, processes, tools culture (Axelos, 2016) and recognizes their own mistakes, by following the rule that everything is possible to be improved. (Hoogved, 2018.) This event ends the sprint.

**Stand up** is a weekly meeting where team members share their progress.

**Task** is a small part of feature that will be divided to certain doer or team to complete. The duration of tasks lasts typically days.

### **2.3.2 Agile Values and Benefits of Way of Working**

The agile manifesto (2.2.1) sets a frame for the agile way of working, agile values and principles. (Moreira 2013.) The agile is more than using tools and methods, such as Kanban, sprint, and scrum. What are included the way of working, it is also, way of acting and mindset. The agile way of working is an enabler for different advantages. (Axelos,2016.)

The key benefit what agile will enable is teams that are able to react quickly to change and redirect their efforts according the business priorities. This is achieved by small, empowered teams with goals. These teams focus on delivering value early and often. This enables organization to understand benefits sooner. (Axelos, 2016.)

In the central of the agile way of working is creating the best value for money. The focus is removing the waste and maximize the value added by prioritizing efficient use of resources, such as money, time of employees, tools, and equipment. Prioritizing also allows reacting quickly to changes and moving resources and budgets to other initiatives if more value for money can be reached by doing that. (Axelos, 2016.)

In order to remain competitive, companies must please internal and external customers and focus their needs. True customer satisfaction can be reached by continuous and transparent feedback loop, frequent on-time deliveries, high quality solutions meeting the requirements that adds value to it and giving change for the customer to affect business decisions. By these methods, the customer will feel real ownership of the solution and that will have an effect for customer satisfaction level. (Axelos, 2016.)

An Agile organisation or agile team consists of cross-functional teams with the same targets. Adding value and pleasing the customer remains as a main focus

area. Collaboration between the cross-functional teams, needed stakeholders involved and the customer will create transparent and innovative environment. As an end result products and services that satisfy the customer and respond to the need and requirements of the customer are achieved by contributing the customer from the beginning of product and/or service development until the end of product and/or service lifecycle. This gives an opportunity to fix discovered issues in a solution at an early phase. This is a change that has happened over the years. In the past the products and services were develop with very little or none feedback from the customer before very late of the process. A competitive business edge can be achieved by highly motivated individuals who have maximum performance in cross-functional teams. Teams that share the common target and focus on collaboration, will become a unit where employees enjoy working together. (Axelos, 2016.)

In the research byTorkkola (2019) the following strengths of the agile way of working were identified by interviews. The agile way of working improves communication, increases collaboration, transparency, support controlling the entity of program, develop planning of work and help further co-learning.

### **2.3.3 Roles in Scrum and Scrum Way of Working in Agile**

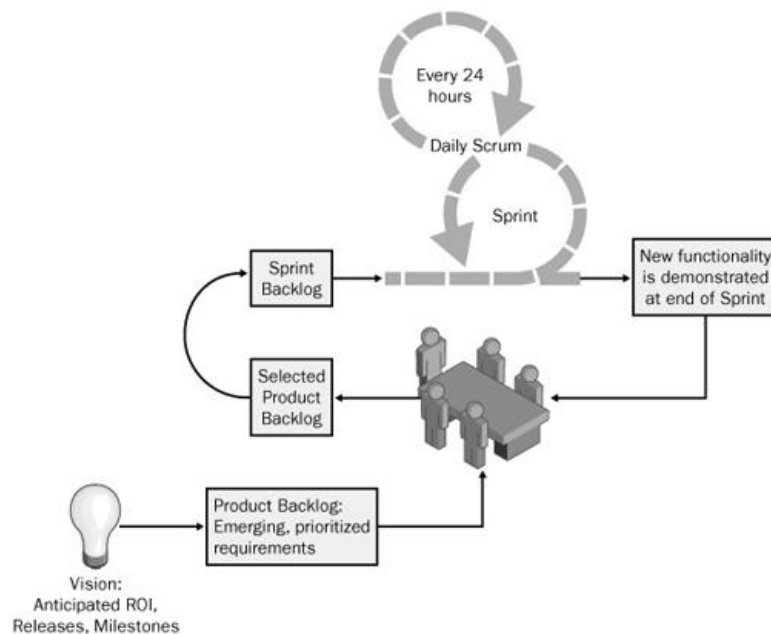
The scrum team consists of different defined roles and responsibilities. The roles are scrum master/agile coach, product owner and development team. The Scrum master/agile coach is a coach of the team who is responsible for promoting agile values, arranging, and facilitating scrum events, such as sprint planning, sprint review and sprint retrospective. He or she is also, responsible for ensuring that artifacts and rules are understood. (Moreira, 2013). The scrum master/agile coach is not a project manager because the team member has filled that position as their own (Hoogved, 2018). The product owner operates as a contact point between customer and scrum team. The main responsibility of the product owner is to understand what increases the value of product and/or the service from the customer's point of view also, he or she is responsible for prioritizing issues from the

product backlog. The development team consists of cross-functional skilled engineers, which are capable of building a product with engineers that are involved to team. The scrum team should have an environment where the members are empowered to make decisions and therefore, gain a feeling of real ownership of their own work. (Moreira 2013.)

The scrum way of working begins with a vision to develop; the vision gets clearer along the project proceeds. The product owner prioritizes the product backlog by the possible value that an item will generate, the most valuable item has the top priority and then the product owner will propose releases. The priorities in the product backlog will change during the whole lifecycle of the product. These changes will reflect to changes in business requirements, and the effectiveness of team could be measured how fast or slow they will transform the product backlog into functionality. (Schwaber 2004.)

Work will be performed in sprints. These sprints begin with a sprint planning meeting where the decisions will be made in collaboration with the product owner and the development team. The decisions concern what will be done during the upcoming sprint; these decisions are based on the priority in the product backlog. The product owner shares the desired outcome to development team and the team tells the product owner how much and what they believe is possible to transform into functionality during the upcoming sprint. The sprint planning will start by the product owner's presentation of the list items with highest priority in the product backlog. The development team gains information of content, purpose, meaning, and intentions of the product backlog by questioning the product owner. After gaining enough information they will select as much items in product backlog they believe they can complete to increment potentially shippable product functionality before the end of the sprint. Then the development team plans the upcoming sprint by identifying tasks and placing them to the sprint backlog. (Schwaber 2004.)

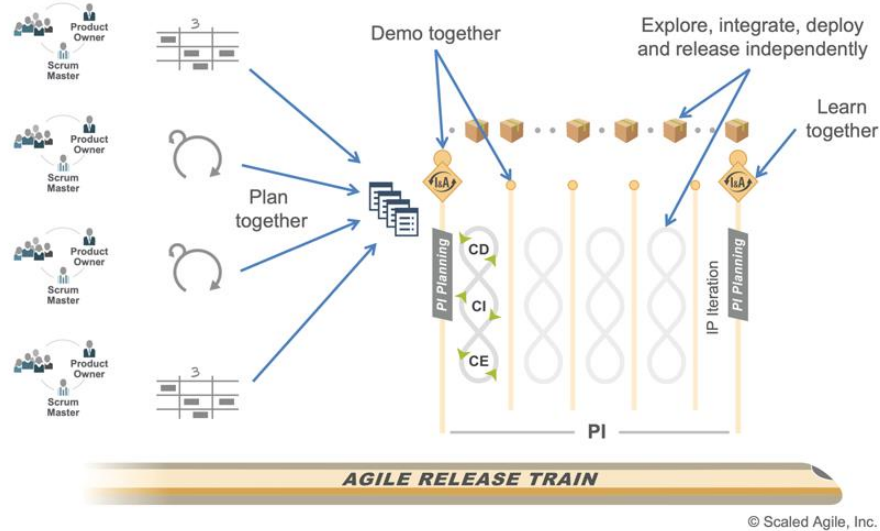
During the sprint the development team will have daily meetings called a daily scrum. During these meetings the team members points out what they have done since the last daily scrum, what they have planned to achieve before the next daily scrum, and they point out if there are any red flags threatening their sprint plan. During these daily scrums, the team members will synchronize the work of all members. The development team will present their accomplishments during the demo meeting which will be held at the end of sprint. This meeting will be attended by besides the development team and product owner, other stakeholders who want and see value of attending to it. The retrospective will be facilitated by the scrum master/agile coach after the demo session and then the whole scrum cycle will begin again, see Figure 5 (Schwaber 2004). The sprint retrospective is great time for the scrum team to reflect the previous sprint and to recognize their own mistakes, by following the rule that everything is possible to be improved. (Moreira, 2013; Hoogved, 2018.)



**Figure 5.** Illustration of Scrum in Agile (Schwaber, 2004.)

### 2.3.4 Scaled Agile Framework

The Scaled Agile Framework known as SAFe teams utilizes agile methods of their choice, primarily Scrum, Kanban, and Extreme Programming. With the chosen methods agile teams build and evolve solutions and “operates as a high performing team-of-teams”. This high performing team-of-teams is on a so-called agile release train. The agile train is powered by collaboration which leads to increased value of working solution. In this train the methods and tools are aligned, such as demo, sprint plan, and retrospective. Continuous learning culture is part of SAFe and it is supposed to challenge the organizations to create an environment of fast and effective learning in the teams. The learning is not limited only to retrospectives, the learning is meant to happen continuously during the agile release train proceeding progress, see Figure 6.



**Figure 6.** Scaled Agile 2021.

### 2.3.5 Agile Manufacturing

Competition on a market has led to a situation where attention is being paid more and more to customer satisfaction, which means that more customized services according to customer wishes and high product quality has become a must. (Markets has become highly uncertain, global and continuously unpredictable.)

The need for a method of rapid and cost-effectively developing products, production facilities and supporting software, including design, process planning and shop floor control system has led to concept of agile manufacturing. (Gunasekeran, 1998.)

The target organisation operates in an environment where it must deal with increasing volatility and uncertainty, new trends and innovations. According to the research by Oliver Moerth-Teo, Felix Wager and, Christian Ramsauers (2021) agile concept enables companies operating in such an environment to remain competitive.

Agile as a term is more than just reflecting flexibility on an organizational level. In order for the organization to reach agility, they must master uncertainty and focus on changes. People and knowledge play the key roles of organizational assets. Im-

portant characteristics of agile organization are also organizational learning, capability to reconfigure and capability to invent new responses to market demands. (Gunasekaran 2001, 54.) Agile manufacturing aims to a capability of produce in volume and simultaneously grow variety to market. The target is to be able to respond quickly and delivery instantly even small quantities of products that meet varying specifications. To be agile organizations must go through a transformation where processes and products will meet expectations of customer in customisation, responsiveness. (Gunasekaran 2001, 25.)

### **2.3.6 Developing Agile Manufacturing**

To achieve wished agility in manufacturing it is reasonable to reevaluate the manufacturing process and further develop it if requirements for it occur. Developing the manufacturing process aims to develop an innovative, agile, and competitive environment. The developing process idea would come from managers and employees who would have unreleased ideas and capabilities to develop new solutions. According to agile values the environment should be collaborative and innovative to capture ideas and knowledge about the current state of company. Ideas based on the experience of managers and employees often have great potential to develop the process and competitiveness. (Gunasekaran 2001, 56.) Developing process will consist of the retrospective events (2.2.1) that will take a place where managers and employees will be involved. During these events task teams will present the results from the last increment to evaluate the success. After this an event will take a place where the agenda for next increment will be planned.

Gunasekaran (2001, 56) introduces a five-phase process to develop the process to follow agile methods. First in the initiation phase the starting point should be clear and the scope should be defined, therefore the process should be prepared and planned. This plan should include the width of the process, if it concerns the whole organization, certain production facility or a production cell and it should be

aligned with strategy of organization. The required resources must be defined during this phase. An unclear direction of manufacturing, uncertainty or unknown surrounding will cause difficulties to create the vision for manufacturing development process.

The second phase is to identify the requirements for the change, dominant trends on the market and challenges of the organization. The commonly shared picture what is under the need of change is one of the most important prerequisites. This picture will create a base for a successful development process. (Gunasekaran, 2001, 60.)

The third phase is to create a vision for manufacturing development. The vision should be developed through a collaboration with managers and employees from different functions. (Senge, 1990.) This experimental environment filled with different competencies should also provide future predictions and enable visions for new ideas and solutions considering developing manufacturing vision. (Gunasekaran, 2001, 60.)

Forth phase is evaluating the ideas captured from dialogue. The evaluating process identifies challenges, risks and resources required during the implementing the development vision. This evaluation process should be done from different perspectives for instance, sales, purchase and product development. During the evaluation process all participants will identify advantages and constraints of the vision. (Gunasekaran 2001, 61-62.)

The fifth and the last phase is used to plan how to proceed with the created momentum, potential of manufacturing vision and criticality of different sections, such as manufacturing system, management system, corporate culture, and capabilities in organizational changes. An important part of the last phase is to identify the holistic time horizon per solution, such as short-term, a medium-long-term

and long-term solution. The participation of the middle management and employees will have been proved to have a positive impact on supporting the change implementation of paradigm shifts and cultural changes. (Rauch and Matt, 2017.)

Gunasekaran (2001) presents a mini factory in a factory concept in his case study. The organization divides the portfolio tasks into different categories. The categories vary, category to category by volume and flexibility of requirements needed. Mini factories will focus on developing a manufacturing vision for a certain category. The developing process will concern specific ideas for production planning, production processes, work organization and management. The aim of mini factories is to combine efficiency and flexibility to produce mass-customized products.

Agile manufacturing is an ability to respond to quick changes, rapid introduction of new modified products, production process is reconfigurable, and products have a possibility to be upgraded and customized.

Lee (1998) presents three different practices how to increase agility in a manufacturing system. Firstly, the design of system must consider the layout of machine cells, factory floor, modular design of equipment and tools secondly, the constraints of machine locations are limited, and lastly a multi-directional material flow is enabled. The component design is one of the factors to enable agile manufacturing. Component design, constraints selection of precedence, precedence relationship, and route of components have an effect on agility. The aim is to assemble first the components with the shortest maximum completion time of machining operations, assembly sequence following this rule has a significant impact on machine utilization, reducing bottlenecks during subassemblies idle time, etc. Ability to reconfigure the manufacturing system have a connection to flexibility. Reconfiguration may involve system changes, relocating machines, retooling machines, and reassignment of operations. The system should allow the reconfigurations with minimum cost and with the minimum movement of equipment. With analysing the relationships between mentioned changes in system enables meeting the production change demand and adapt variety of products. (Lee, 1998.)

Hormozi (2001) suggests five points to effectively implement agile manufacturing. Industry must have a cooperative environment and that must be created by the government. "The lack of infrastructure, or weaknesses in integrating components, can undermine the benefits that agile manufacturers gain from in-plant changes and slow their response to global market signals". (Kasarda and Rondinelli, 1998.) Strategic alliances and virtual organizations are requirements of agile manufacturing and currently there are laws that do not encourage to such a partnership among organizations. Secondly, Hormozi presents that organizations must become more flexible, creative, and create better design products that can be upgraded aftermarket or have possibility for retrofits. Thirdly, in order to be able to conduct electronic commerce and facilitate information flow, organization must embrace the latest information technology at all times. Fourth, processes must be re-evaluated and reconstructed to achieve higher efficiency and effectiveness. The last point considers employees and their behaviour. Employees should be more creative, more open to challenges when performing their jobs, willing to conduct an agile mindset, accept the challenges that comes with changes from agile manufacturing and conduct the idea of lifelong learning. (Hormozi, 2001.)

#### **2.4 Hybrid Agile Way of Working**

The aim of hybrid approach combining agile and traditional is to take advantages and benefits from both approaches and eliminate the weaknesses they have. While in the agile approach all functions operate together, the traditional approach provides predictability. When implementing the hybrid model to a project, the flexibility is the most important principle to emerge a good approach. While projects are unique, the hybrid model must be created so it matches requirements, demands, and characterises of project. A well-designed hybrid model suits great for a large project with a well-defined content, stable requirements, high level of complexity, many risks which create a need for continuous changes and high level of uncertainty. (Lalmi et al. 2021.)

The hybrid approach in the target organization is designed to increase project success by reducing cost, faster time to market, increase customers satisfaction level by more accurate products and services according the need.

## **2.5 Summary**

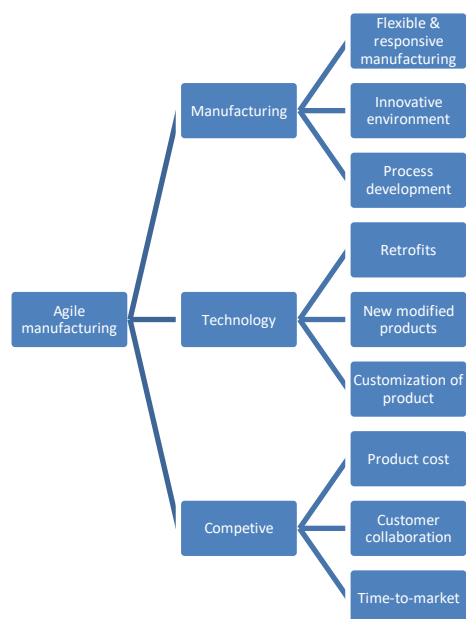
The main focus in the previous chapters 2-2.4 is to describe tools and methods that are available for project management and new product development. These chapters give a holistic view how markets are changing and demands rapid responses. Traditional tools and methods are getting old fashioned and too slow to respond for market change, therefore the chapters provide alternative agile tools and methods that could be combined with the current methods. By combining provided agile tools and methods, the organization could reduce time to reach market with new products that satisfy customers and response requirements of customers.

To achieve the positive outcome of agile way of working, it does not only mean new tools and methods, it also requires a change in the mindset of employees and environment. These methods and tools create a frame for way of working what the organization must adjust and specify to fit their need and create a value for organization and customers. Inside the organization, this agile way of working would provide a more transparent way of working and improve communication between teams throughout events such as retrospectives and demos, for example.

The first step towards agile manufacturing is to recognize the drivers for it and their importance. Based on the previous chapters, the recognized drivers towards agile manufacturing are manufacturing, technology, and competitiveness. The management could be seen as a driver towards agile manufacturing as well, but it has been ignored, based on the fact that the Torkkola's Master thesis (2019) covered that topic of agile way of working in management. After these drivers has

been identified, the importance must be evaluated, this evaluation is done by utilizing an analytical hierarchy process which will be explained in Chapter 3, the results and findings are in Chapter 4.

Along the drivers the same analytical hierarchy process is done to enablers considering the driver. There are three enablers per driver and these enablers for manufacturing are flexible and responsive manufacturing, process development, and innovative environment, for technology; customization of products, new modified products, and retrofits and upgrades. Lastly, for competitiveness identified enablers are time-to-market, customer collaboration and product costs. Figure 7 illustrates the selected drivers and enablers.



**Figure 7.** Illustration of drivers and enablers.

### **3 METHODOLOGY OF STUDY**

The purpose of this study is to find out the key enablers of implementing agile manufacturing practices for new product development. The combination of a structured survey interview and analytic hierarchy process (AHP) was chosen to gain an understanding which of the chosen enablers are the most important to focus on. The method used in this thesis was a quantitative case study. The case study focuses collecting detailed and intensive information from an individual case or several cases related to each other. (Hirsijärvi et al. 2009, 134.)

#### **3.1 Data Collection Method**

The data collection method for this thesis was structured interview. This data collection method is always a standardized and structured way, where the shape and order for the questions is structured. The collected data via a survey is usually treated as a quantitative study, as it has been treated in this thesis. (Hirsijärvi, 2009 et al, 194.) The type of the questions was scaled questions where the interviewee had to complete pair-wise comparisons between two drivers or two enablers, the scale is shown in Table 1 (Hirsijärvi et al. 2009, 200).

Eight employees were selected to be interviewed from different roles in order to get different perspectives. The roles of interviewees were, process developer, project manager, development engineer, design for manufacturing specialist, product specialist manager, development project manager, program manager and supply project manager. The experience of interviewees varied from 1 year to 13 year in their current position.

#### **3.2 Analytic Hierarchy Process**

The analytical hierarchy process is a decision-making tool used in project management. Guru and Kumar present in 2016 how the AHP is used step by step. Their theory is used as a base for this chapter. The AHP mitigates the identification of what is the most critical driver and most critical enablers for a company to increase

the agility level in manufacturing. The drivers and enablers have been identified in Chapter 2.5 Summary. The analytical hierarchy process itself will be explained in this chapter, how to use it and logic behind the calculations. The process is based on the pair-wise comparisons which have been completed by the interviewer for each interviewee alone. The comparisons have been completed according the scale that has been presented in Table 1.

**Table 1.** Scale for Pairwise Comparisons.

Explanation	Numerical Scale
If option A (Driver 1) and B (Driver 2) have the same importance	1
If option A is moderately more important than option B	3
If option A is strongly more important than option B	5
If option A is very strongly more important than option B	7
If option A is extremely more important than option B	9
Choose even number for intermediate evaluation	2,4,6,8

In this thesis the analytical hierarchy process is used to identify critical drivers to achieve agile manufacturing and the importance of drivers. The process began by identifying the critical success factors from literature. The second step was to create a survey for interviewees. These surveys are structured surveys where the pair-wise comparisons are easy to complete. Table 2 is an example of how the driver comparisons were completed. Note that the following tables in this chapter are based on this example table and does not describe the results of the interviews. The driver comparisons were done between, manufacturing, technology, and competitiveness. The same process was completed to the enabler, as well.

**Table 2.** Example of Pairwise Comparison

Driver 1	9	8	7	6	5	4	3	2	1 equal	2	3	4	5	6	7	8	9	Driver 2
MANUFACTURING											X							TECHNOLOGY
MANUFACTURING										X								COMPETITIVE
TECHNOLOGY									X									COMPETITIVE

Based on the pairwise comparison in Table 2, a pairwise comparison matrix was created, which always is a square matrix. The pairwise matrix is shown in Table 3. Values shown in Table 3 were taken from table 2. In Table 2 technology and competitive have been valued as having the same importance, but in order to make the example adapt more to interviews from the thesis, the example shows a little lack of consistency. Therefore, competitive has been rated with value 2 compared to manufacturing, which means it is between the same value and moderately more important manufacturing and technology has been rated value 3 compared to manufacturing, which means moderately more important than manufacturing. Based on the rating 1 (same importance) between technology and competitive, the results should be the same when comparing to manufacturing, but this example describes better the process when it is not ideal.

The table follows the logics that the driver in the column is compared to the driver on the top row, due to that manufacturing to technology is 1/3, technology to manufacturing is 3 and competitive to manufacturing is 2 and so on.

**Table 3.** Example of Results of Pairwise Results.

	MANUFACTURING	TECHNOLOGY	COMPETITIVE
MANUFACTURING	1	1/3	1/2
TECHNOLOGY	3	1	1
COMPETITIVE	2	1	1

The next step was to calculate the sum in the column, as shown in Table 4.

**Table 4.** Sums of Columns.

	MANUFACTURING	TECHNOLOGY	COMPETITIVE
MANUFACTURING	1	0.333	0.5
TECHNOLOGY	3	1	1
COMPETITIVE	2	1	1
SUM	6	2.333	2.5

The sum is for the next step where the normalized values were calculated for each decision drivers. The normalized value was calculated by dividing all values by the sum of the column, as seen in Table 5.

**Table 5.** Calculation of Normalized Values.

	MANUFACTURING	TECHNOLOGY	COMPETITIVE
MANUFACTURING	1/6	0.333/2.333	0.5/2.5
TECHNOLOGY	3/6	1/2.333	1/2.5
COMPETITIVE	2/6	1/2.333	1/2.5

Next step is to convert values from table 5 to decimals, as shown in table 6.

**Table 6.** Converting Normalized Values to Decimals.

	MANUFACTURING	TECHNOLOGY	COMPETITIVE
MANUFACTURING	0.167	0.143	0.2
TECHNOLOGY	0.5	0.429	0.4
COMPETITIVE	0.333	0.429	0.4

The next step in AHP was to calculate the driver weight, which takes place calculating the average value of all rows, as shown in Table 7. Note, the driver weight total must add up to ~100%.

**Table 7.** Driver Weight Calculated.

	MANUFAC- TURING	TECHNOLOGY	COMPETITIVE	DRIVER WEIGHT
MANUFAC- TURING	0.167	0.143	0.2	0.17
TECHNOLOGY	0.5	0.429	0.4	0.443
COMPETITIVE	0.333	0.429	0.4	0.387
<b>TOTAL</b>				<b>100%</b>

In order to gain knowledge whether to make an operational decision or not, the consistency ratio (CR) must be calculated. The CR is a measurement to measure the reliability of judgement. In this case, the CR helps to judge if the driver weight is good enough or not. The mathematical formula to calculate CR is,

$$CR = \frac{\text{Consistency index}(CI)}{\text{Random consistency index}(RI)}$$

Saaty (1980) stated that the optimal consistency ratio is 0.10 or less. The first step towards the consistency ratio is to consider the pairwise comparison without normalized values and driver weight, as shown in Table 8. The coefficients are from Table 7, to make it easier to follow the values have been coded with the same colour.

**Table 8.** Pairwise Values Multiplied by Driver Weight.

	MANUFACTURING	TECHNOLOGY	COMPETITIVE
MANUFACTURING	1*0.17	0.333*0.443	0.5*0.387
TECHNOLOGY	3*0.17	1*0.443	1*0.387
COMPETITIVE	2*0.17	1*0.443	1*0.387

Table 9 has the results from table 8.

**Table 9.** Results of Multiplications from Table 8.

	MANUFACTURING	TECHNOLOGY	COMPETITIVE
MANUFACTURING	0.17	0.148	0.194
TECHNOLOGY	0.51	0.443	0.387
COMPETITIVE	0.34	0.443	0.387

The next step was to calculate the weighted sum based on the values in Table 9, as in Table 10.

**Table 10.** Weighted Sum Calculations.

	MANUFAC-TURING	TECHNOLOGY	COMPETITIVE	WEIGHTED SUM
MANUFAC-TURING	0.17	0.148	0.194	0.512

TECHNOLOGY	0.51	0.443	0.387	1.34
COMPETITIVE	0.34	0.443	0.387	1.17

After calculating the weighted sums, the next step was to calculate the ratio of the weighted sum value to the driver weight, as seen in Table 11.

**Table 11.** Weighted Sum Ratio to Driver Weight.

	These values are from table 10.	These values are from table 7.	
	Weighted sum	Driver weight	Ratio of weighted sum value to driver weight
MANUFACTURING	0.512	0.17	0.512/0.17 = 3.012
TECHNOLOGY	1.34	0.443	1.34/0.443 = 3.025
COMPETITIVE	1.17	0.387	1.17/0.387 = 3.023

The next step was to calculate the maximum value for lambda ( $\lambda_{max}$ ) i.e. the average of weighted sum value to driver weight, as follows

$$\lambda_{max} = \frac{(3.012 + 3.025 + 3.023)}{3} = 3.02$$

Then the consistency index (CI) was calculated, as follows

$$\text{Consistency index (CI)} = \frac{\lambda_{max} - n}{n - 1}$$

The  $n$  in equation is number of drivers, in this example it is 3 (manufacturing, technology and competitive).

$$CI = \frac{3.02 - 3}{3 - 1} = \frac{0.02}{2} = 0.01$$

The final step was to calculate the consistency ratio, which is CI to a random index (RI). The RI comes a randomly generated pairwise comparison matrix by Saaty (1980), these values are standardized values of RI.

**Table 12.** Random Index (RI) for Randomly Generated Pairwise Comparisons with 3 First Driver from the Matrix (Saaty, 1980).

N	1	2	3
RI	0.00	0.00	0.58

$$\text{Consistency ratio (CR)} = \frac{CI}{RI} = \frac{0.01}{0.58} = 0.017$$

Based on the consistency ratio, it is possible to state that the judgement in this example is reliable.

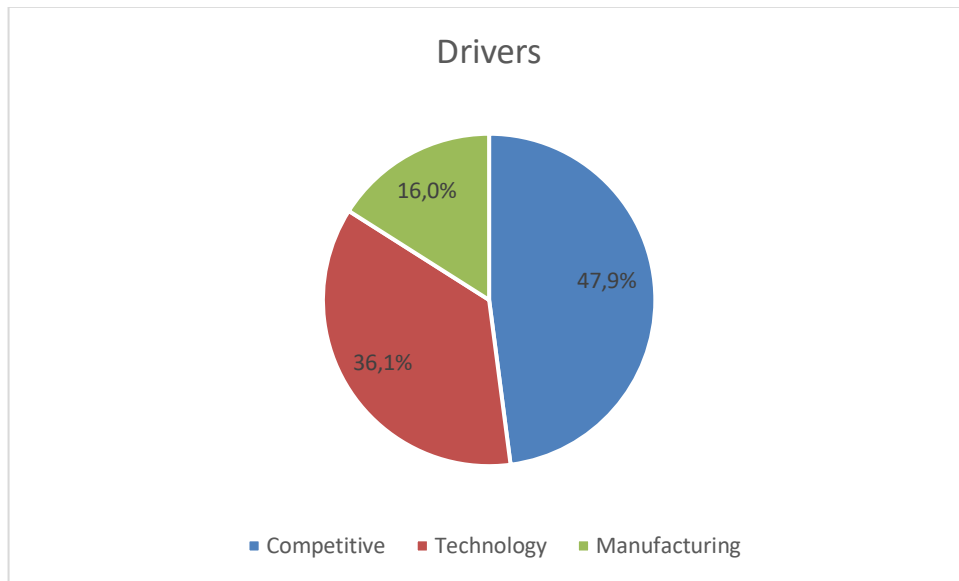
## 4 EMPIRICAL FINDINGS

The purpose of this thesis was to identify the most critical focus driver considering agile manufacturing. The combination analytical hierarchy process and structured-survey-interviews were utilized as a support to the identification process.

### 4.1 Results of the Analytical Hierarchy Process

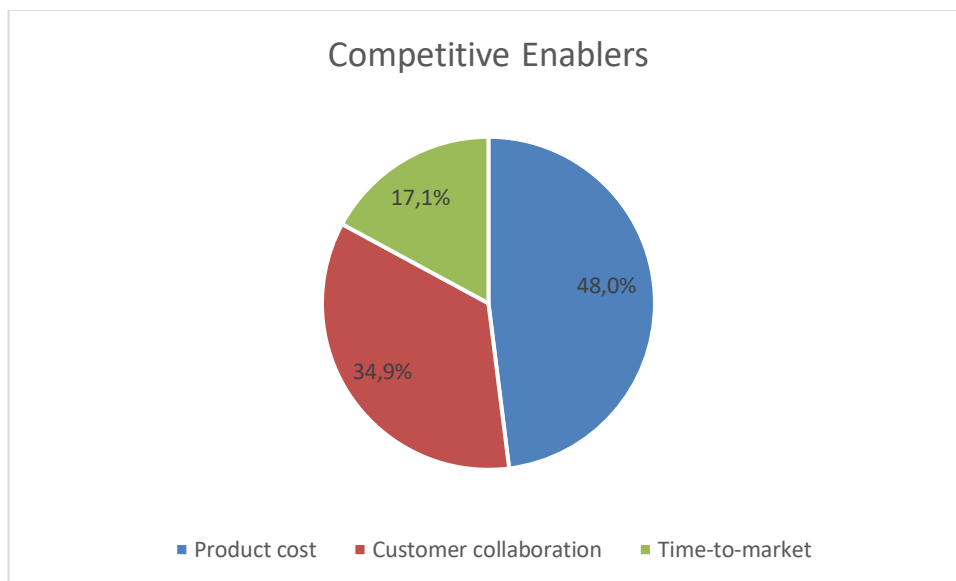
Due to fact that to eight interviewees participated in these interviews, the result must represent the average values. At first, the results were inspected to be valid, meaning that the consistency ratio was under the mentioned 10%. The calculated average consistency ratio for the drivers was 3,28% and for the manufacturing enablers 0,93%, for technology enablers 0,81% and for competitive enablers 4,31%. Based on these average values, it can be stated that the results are valid. The results from the interviews vary by the weight values and which driver or enabler was selected as the most important.

During interviews four interviewees selected the competitive driver as the most important and 1 interviewee selected technology and competitive as the most important with the same value, the average weight value for the competitive driver was 47,9%. Based on the number of selections as the most important and the average weight value, it is possible to state that competitive is the most important driver towards agile manufacturing. Technology was selected as the most important driver twice alone and once with another driver option and its average weight was 36,1%. Manufacturing was chosen once as the most important driver with the same importance than technology and its average weight value was 16%, as seen in Figure 8.



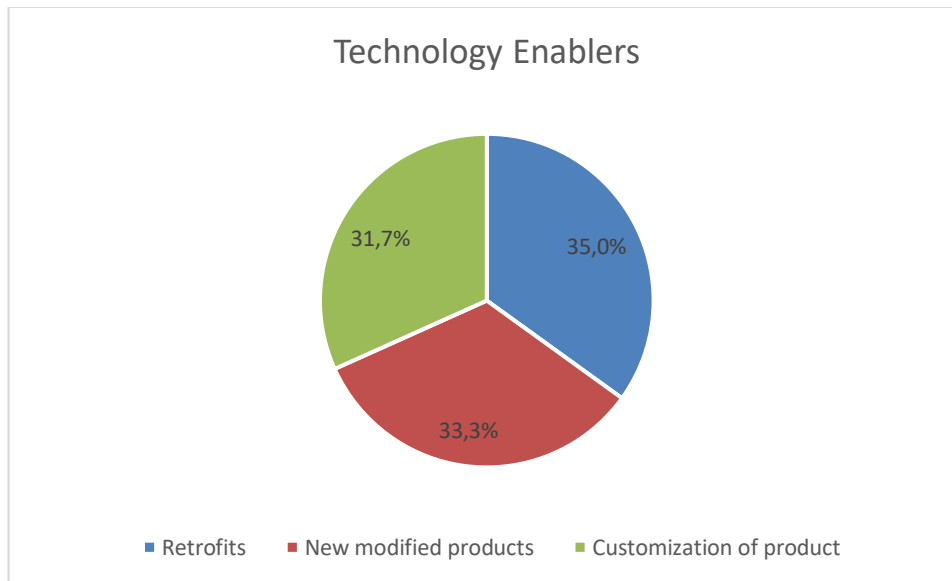
**Figure 8.** Average Driver Weights.

Now it is possible to go through the most important driver, which is competitive. Inside the competitive enablers are product cost, customer collaboration and time-to-market. Product cost was selected four times as the most important enabler and twice the most important with the same importance than customer collaboration and the average weight for product cost was 48%. Customer collaboration was selected once as the most important enabler and twice the most important with the same importance than product cost, the average weight of customer collaboration was 34,9%. Time-to-market was selected once as the most important enabler and its average weight is 17,1%, as seen in Figure 9.



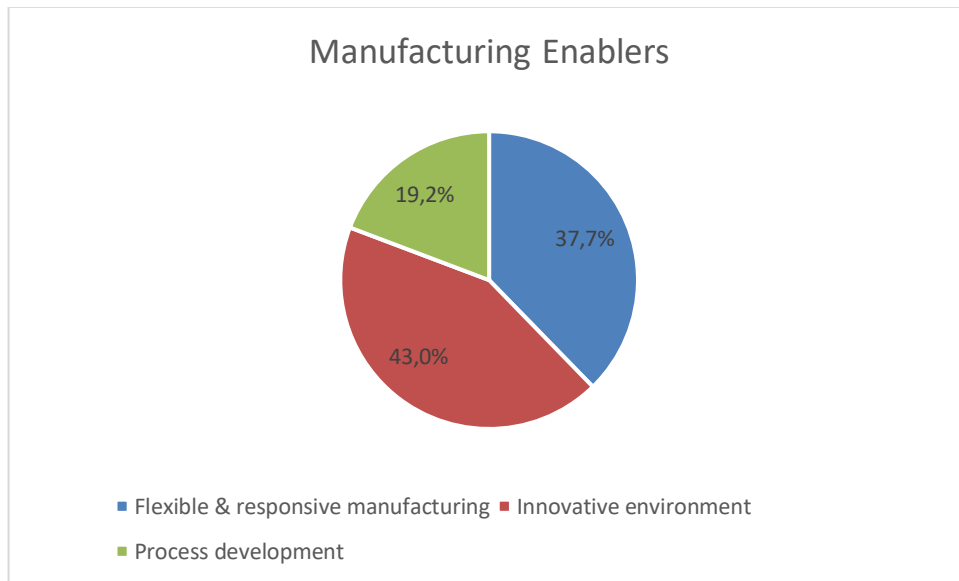
**Figure 9.** Competitive Average Enabler Weights.

Based on weight and selections as the most important driver, I will go through technology and enablers, retrofits, new modified product and customization of products. These enablers were only ones, where one interviewee valued all the enablers with the same importance. Retrofits was selected as the most important enabler three times and once it was valued as important as another enabler, the average enabler weight for retrofits was 35%. New modified products and customization of products were selected as the most important once each, once together with the same importance and once all with the same importance; however the new modified average weight was 33,3% and the customization of products was 31,7%, as seen in Figure 10.



**Figure 10.** Technology Average Enabler Weights.

Manufacturing gained least selections and weights as the most important driver. In manufacturing, enablers are flexible and responsive manufacturing, innovative environment, and process development. Flexible and responsive manufacturing, and innovative environment were both selected as the most important enabler four times alone and twice with the same importance; however the innovative environment had the average weight as 43% and flexible and responsive manufacturing had the average weight as 37,7%. Process development was not selected as the most important enabler and its average weight was 19,2%, as seen in Figure 11.



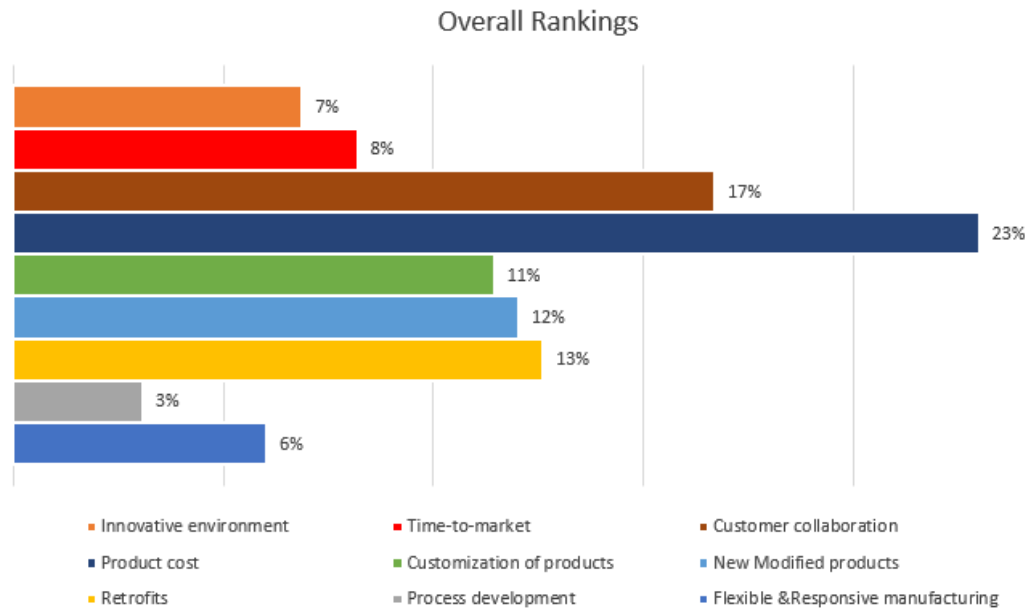
**Figure 11.** Manufacturing Average Enabler Weights.

After all the necessary steps considering the pairwise comparison had been completed it was time for final stage. In AHP the final stage is formation of overall matrix. This matrix gives the overall weightage values of each factor. The ranking is based on the performance value which concludes the AHP technique. Table 13 shows the overall results of AHP matrix. In Table 13, the priorities have been named by one letter as follows.

#### 4.2 Key Enablers

Based on previous chapter where the identification of the main driver and enabler were completed. This chapter suggests key enablers for enabling manufacturing practices for new product development. As stated in the previous chapter, the competitive was chosen as the most important driver and as enablers were product cost, innovative manufacturing environment where employees are encouraged to present their ideas to improve process, product, and facilities and lastly retrofits and upgrades. Figure 12 illustrates the importance between the chosen enablers and as it can be noticed, even the Innovative environment was the most important enabler from the manufacturing point of view in overall rankings it is

3<sup>rd</sup> to last, based on the fact that manufacturing as a driver scored so low importance between other drivers.



**Figure 12.** Overall AHP Rankings.

### 4.3 Key Performance Indicators

The competitive driver gained most importance among experts, most important enablers are product cost, customer collaboration and retrofits and upgrades, but the most important enabler for the manufacturing driver was the innovative environment, which will be dealt as well during this chapter. Banu (2017) presents technique how to create key performance indicators for innovation and this same process was applied to create KPIs for defined enablers. First Banu states that the project objectives must be defined and understood, second, the results of the project must be defined and described, the third is to design and describe project activities and lastly to develop and describe key performance indicators.

As stated in the results, the product cost, customer collaboration, retrofits and upgrades, and innovative environment were defined as the most important enablers in the process to increase agility in manufacturing. These enablers can be defined also as project objectives. For these objectives the results must be defined and described. The result of product cost is to lower the price, which is clear, but how to measure it for a new product.

Activity for product cost is to decrease it. The similar product must be identified on the market and if it is available in the portfolio of organisation, it mitigates the process. The target price for the product can be based on the benchmarking and studies by experts. When the target price has been identified, the goal is to decrease the price as much as possible, but also to secure the best possible quality of product. The decreased price here itself is the measure for the key performs indicator. The success of the process can be measured how much the prices have been decreased during the new product introduction process.

The second enabler for the agile manufacturing was customer collaboration. The objective in this case is to secure great customer collaboration during the new product development process. The target in customer collaboration is to involve the customer in the product development process. Based on the feedback from the customer of the product and development suggestions, the organisation can produce innovative solutions to further develop the product. Here the success can be measured by the number of feedback and development suggestions and measure even further by measuring the rate how many of the ideas will be implemented to the product. These measures then can be compared to the previous similar product development cases and then the evaluation can be done, if the customer collaboration has increased or not.

The third defined enabler was retrofits and upgrades. The objective of this project is to secure the long lifetime of the product and design the product according to the current knowledge what retrofits and upgrades might be useful to assemble to the product in future and secure the possibility for these upgrades and retrofits,

and design the upgrades and retrofits so they fit the old products. The activity for this is to maintain the high level of knowledge of upcoming trends and regulations. As a KPI operates the percentage of installed upgrades and retrofits for the product in future, the percentage is possible to compare the upgrades and retrofits for other similar products that organisation sells which will work as measurement.

The most important manufacturing enabler for the agile manufacturing was innovative environment. The objective of this project is to increase the level of innovation in manufacturing environment. As a result of innovative environment in manufacturing, the target organisation should get ideas from the employees considering manufacturing process, facilities, tools, and product. As activity towards the number of ideas during the manufacturing phase should be calculated to understand how much employees present their ideas currently and the organisation could collect data how they could encourage the employees present their ideas more and act according the results of the data.

## **5 CONCLUSION AND RECOMMENDATIONS**

### **5.1 Advantages and Challenges**

During this thesis a few challenges were encountered. The main challenge was definitely the rush, not only mine. The time the thesis was written, and the interviews were completed in the new product development program was in a hectic phase and everyone who was chosen to participate in the interviews were busy. However, the experience from the company and knowledge of employees in the company that was gained earlier while working there as trainee helped a lot. Another challenge that could be mentioned was that the analytical hierarchy process was selected in the middle of thesis progress, it had to be studied while writing the thesis and it caused lot of changes to it. Even if the analytical hierarchy process was a new for writer the thesis supervisor supported and taught the process properly.

### **5.2 Lessons Learned Based on the Research and Conclusion**

This thesis has taught me how to utilize the analytical hierarchy process right from the beginning. The interviews considering the analytical hierarchy process also taught me interaction between people from different positions. The topic was wide, but relatively new, therefore it required a lot of research and evaluation of what references are solid and what are not. The agile and agile manufacturing are stated to be the way what most of the companies will adapt to their way of working on some level, therefore this thesis gave me great knowledge of the topic what I will most likely be using in the future. This thesis was written alongside working at the target organization and it required a lot of time and taught the writer a lot of the importance of relevant time management.

### **5.3 Reliability and Validity of Research**

This thesis utilizes a lot of different references to reach maximum reliability and validity of the study considering the topic and reach satisfying results. Most of these references are under 10 years old and can be evaluated as valid sources.

The management was not included in this thesis since this was an extension study to a Master thesis. Involving management in these importance ratings would have been different, but the purpose of this thesis was to evaluate the importance of selected drivers and enablers and place them in order by importance, based on the interviews of experts. The experts for this thesis were chosen from different roles to get answers of experts from various areas, perspectives knowledges and backgrounds.

The study has been done alongside working for the target organization and therefore, the writer has gained a better understanding of the target organization and the field where the organization operates and the way of working in the organization.

### **5.4 Proposal for Further Study**

A proposal for a further study is to consider agile manufacturing after the new product development process has been completed and when it is not a new development product anymore, when the product reaches the production phase. This was mentioned after several interviews and the interviewees stated that the result would be totally different if the product was in the production phase, then the concentration would be in different driver and enablers.

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**LEVEL 3: COMPARISON AMONG Enablers****Enabler (MANUFACTURING, Comparisons among the enablers)**

Enabler 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enabler 2
Flexible & responsive manufacturing																		Process development
Flexible & responsive manufacturing																		Innovative environment
Process development																		Innovative environment

**Enabler (TECHNOLOGY, Comparisons among the enablers)**

Enabler 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enabler 2
Customisation of products																		Retrofits & upgrades
Customisation of products																		New modified products
Retrofits & upgrades																		New modified products

**Enabler (COMPETITIVE Comparisons among the enablers)**

Enabler 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enabler 2
Time-to-Market																		Customer collaboration
Time-to-Market																		Product cost
Customer collaboration																		Product cost

Position: \_\_\_\_\_

No. of years: \_\_\_\_\_

Thank You

