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A strategic distribution model for an upscaling project at an emerging market

- and a blockchain technology use case approach to the supply chain

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Lund, May 2018

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Abstract

Title: A strategic distribution model for an upscaling project at an emerging market - and a blockchain technology use case approach to the supply chain

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Background: Globalization is a phenomenon which has been around since the mid-19th century, influencing companies to either expand existing markets or entering new markets, to seek new profits. For companies with a global supply chain, the total supply chain cost is a vital factor. It is of high importance to reduce the costs in the supply chain, as lower costs will increase the profit. The case company, where this report has been conducted, is on the verge of upscaling a new project on an emerging market, called the market, with limited previous presence. The new project, called Distributed Plant Project, referred to as DPP, aims on decentralizing the previous centralized production. Due to the uncertainty of placement of plants, different network scenarios have been investigated in a simulation model. Further on, as supply chains are getting more complex, an increased demand of transparency and traceability is desired as a matter of risk prevention and consumer- and labour protection. Due to this, blockchain technology has been investigated to see how DPP could benefit from the technology.

Purpose: The purpose of this master thesis is to investigate how a strategic distribution network could be designed for an upscaling of the Distributed Plant project (DPP) and to investigate how blockchain technology can be applied to the DPP.

Research questions: (1) How can the distribution network be designed for an upscaling of the Distributed Plant Project? (2) How can blockchain technology contribute to the Distributed Plant Project?

Methodology: The research study was designed as a mixed qualitative and quantitative case study with an abductive reasoning approach. The empirical data was collected through archive analysis, workshops, informal interviews and observations. The empirical data was then used to develop a simulation model and a report.

Conclusion: An initial distribution network was formed and presented. The network was divided into two separated *Phases; Phase* 1 aimed to provide material to setup the plant whereas *Phase* 2 aimed on providing consumption material for the ongoing production. A simulation tool was established to analyse how warehouse(s) could impact the future upscaling of the supply chain.

The financial advantage of having a well-functioning supply chain network was identified through the simulation model, but highly dependent on the surrounding conditions e.g. distances, transportation cost, emissions etc. The contribution to the MNC is to add a simulation model to design a distribution network, as it could increase the understanding of the logic in a supply chain and make it easier to tailor a solution in an unpredictable environment.

It was discovered that blockchain technology could contribute to DPP in different ways. Three use cases were established, which could contribute to minimized counterfeit, increased traceability, reduced administrative work, ensure customers the right requirements regarding e.g. quality. Further on, it can increase the environmental awareness at the market, it can improve the MNC´s CSR work and it can increase the motivation of employees with regards to cultural aspects

Key-words: Distributed manufacturing, upscaling, supply chain planning, network planning, scenario planning, blockchain technology, business development, supply chain management, simulation modelling, transparency, traceability

Sammanfattning

Titel: En strategisk distributionsmodell för ett expansions projekt hos fallföretaget och användningsfall för blockchain teknologi inom försörjningskedjan.

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Johan Mårtensson, handledare från företaget

Bakgrund: Globalisering är ett fenomen som har funnits sedan mitten av 1800-talet. Detta fenomen medför att företag väljer att expanderar befintliga marknader eller att söka sig in på nya marknader, i förhoppningen att generera nya vinster åt företaget. För företag med en global försörjningskedja är logistikkostnader är en stor del av företaget totala kostnader. Detta medför att företag bör optimera sina logistikkostnader då detta eventuellt ökar ett företags vinster. Fallföretaget, där denna rapport har genomförts, går in i en brant expanderingsfas för ett nytt projekt, med namnet Distributed Plant Project (DPP), på en tillväxtmarknad med målet att decentralisera den befintliga centraliserade produktionen. På grund av osäkerheten kring placering av produktionsanläggningar, har olika scenarios utformats och simulerats i ett simuleringsverktyg, som byggts från grunden. Vidare, då försörjningskedjor blir mer komplexa, är det önskvärt från både konsumenter och företag att öka transparensen och spårbarheten längs försörjningskedjan för att öka tilliten mellan olika parter. I och med detta, har blockchain teknologin undersökts för att se vilka fördelar det kan generera till DPP.

Syfte: Syftet är att undersöka om hur en strategisk distributions model kan utformas vid en expandering av plantor i Distributed Plant Project samt att undersöka hur blockchain teknologin kan tillämpas i Distributed Plant Project.

Research questions: (1) Hur kan ett distributionsnätverk designas för en expandering av Distributed Plant Project? (2) Hur kan blockchain teknologin bidra till Distributed Plant Project?

Metod: Studien är en blandning av kvalitativ och kvantitativ metod med en abduktiv metod. Den empiriska datainsamlingen skedde genom arkivanalys, workshops, informella intervjuer och observationer från fallföretaget. Datainsamlingen användes sedermera till att utveckla ett simuleringsverktyg och en rapport.

Slutsats: Ett distributionsnätverk presenteras uppdelat i två separata *faser(eng. Phases)*; *fas*1 som levererar material till att bygga upp en anläggning medan *fas* 2 ämnar till att förse anläggning med material för den löpande produktionen. Ett simuleringsverktyg byggdes för att analysera det strategiska alternativet att införa mellanlager (eng. warehouse) för framtida expansion av antalet produktionsanläggningar. Den finansiella fördelen att designa ett nätverk identifierades genom simuleringmodellens olika scenarion och visade sig vara beroende av yttre faktorer, exempelvis geografisk plats, transportkostnader och utsläpp. Bidraget från denna avhandling är möjligheten att använda en simuleringsmodell för att designa ett distributionsnätverk vilket kan öka förståelsen och möjligheten att skräddarsy en egen lösning i en oförutsägbara omgivningar.

Blockchain teknologin kan introduceras till DPP på olika sätt. Tre användarfall etablerades med olika syfte. De skulle kunna bidra till att minimera förfalskning av produkter, öka spårbarheten längs försörjningskedjan och minska det administrativa arbetet. De skulle även kunna bidra till kvalitetssäkring, en ökad miljömedvetenhet på marknaden och att fallföretagets CSR-arbete förbättras. Slutligen kan det öka motivationen hos företagets medarbetare då arbetet kring miljöförbättringar ökar.

Nyckelord: Distribuerad tillverkning, uppskalning, planering, nätverksplanering, scenarioplanering, blockchain technology, affärsutveckling, försörjningskedja, simuleringsmodellering, transparens, spårbarhet.

Vocabulary

Blockchain	A continuously growing list of records, called blocks, which are linked and secured using cryptography.
Intermediaries	The MNC´s customers at the market
Main production facility	The MNCs large production facility already existing at the market
Plant	A manufacturing facility within DPP, producing consumer products.
Simulation	The imitation of the operation of a real-world process or system
Warehouse	A warehousing facility for e.g. receiving, storing, shipping.
Consumption material	Rolls and consumables necessary for the ongoing production at the MNC.

Acronyms

DPP	Distributed plant project
MNC	Multinational Corporation
PF	Main production facility
ICT	Information & communication technology
DMS	Distributed Manufacturing System
3PL	Third-party logistics

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1. Introduction

In this chapter, a background, problem description and research questions are presented. Focus and delimitations will be introduced and discussed.

1.1. Background

Globalization is a phenomenon which has been around since the mid-19th century. The topic usually refers to international integration in commodity, capital and labor markets (Bordo et al., 2003). With the continuous changes in technology and the increased mobility, globalization is changing the world.

One of the aims with globalization is companies´ hunger of seeking profit. Many companies are prepared to exploit available sources of competitiveness by optimizing labor costs, capital costs, raw material costs and locational advantages (Nations, 1997). The worlds gross domestic product (GDP) has increased from 50 trillion USD in 2000 to 75 trillion USD in 2016 (UN, 2018). Companies are trying to take advantage of the benefits with globalization, by either expanding existing markets or entering new markets.

As the market segment increases due to globalization, the pursuit of profitability through economies of scale in volume may not lead to improved profitability – the reason is that in today's world much of the cost lies outside of the four walls of a company, in the wider supply chain (Christopher, 2011). Having an efficient supply chain becomes a strategic advantage, differentiating companies from each other. Daskin et al., (2003) claims that one of the most crucial and difficult decisions in an efficient supply chain is facility location i.e. location of production sites and warehouses. By clearly defining a thorough network design, resources can be allocated to meet supply and demand without unnecessary costs (Simchi-Levi, et al., 2003). Forming a well-functioning network with strategically chosen locations can be the difference between success and failure (Jonsson & Mattsson, 2011).

This master thesis was conducted as a case study at a global, manufacturing company, from here on referred to as the MNC (Multinational Corporation). Like other corporations, the MNC wants to increase its turnover by seeking new ventures. The MNC is on the verge of upscaling a new project in an emerging market with limited previous presence. The new project, called Distributed Plant Project, from here on referred to as DPP, challenges the original business model by decentralizing the previous centralized production. DPP have had a first plant up and running for a period of time, testing the new business model. Now, the MNC wants to expand the DPP in large scale, building plants across the market on yet undecided locations. As a part of the DPP, to meet the high pace of new plants, a distribution network will be designed. Due to the large cost impact related to setting up warehouses, the distribution network will focus on finding optimal number of warehouses. Apart from the primary cost focus, the MNC highly advocates sustainability and emissions which will be considered.

The unpredictability of future locations and pace for the MNC will be illustrated with a generalized simulation model. The static simulation model will be designed with different scenarios from not having warehouses in the supply chain into having warehouses. Due to the vast amount of new plants, the authors have divided the market into regions, assumed to be autonomous. The model will be easy to configure and therefore be applicable throughout the upscaling process.

An increased expectation of traceability and transparency is being put on large corporations. The DPPs unique character enables the MNC to, in a controlled and undeveloped environment, test new technologies. The blockchain technology challenges the ordinary way of information sharing and security throughout a company's business. The technology inspires enterprises to rethink their way of working and enabling transparency to customers and other stakeholders (Kshetri, 2018). Blockchain technology will be investigated with a minor focus in this master thesis. The investigation of blockchain technology is suitable due to the strong opportunities within the DPP along with the direct advantages it could create for the MNC.

1.2.Problem

For companies with a global supply chain, the total logistics cost covers a great part of the total supply chain costs (Zeng & Rossetti, 2003). It is of high importance to reduce costs in the supply chain, as a lower cost will increase the profit (Christopher, 2011). As there are several features of supply chain decisions that contributes to the complexity, it is important to understand the entire network of the supply chain. This is an important aspect when expanding or reshaping the current network with e.g. warehouse locations. The long term, strategic decision of expanding the supply chain will affect costs regarding transport, inventory investments and communication (Simchi-Levi, et al., 2003.). The large investments, for warehouses, have a large financial impact with possible high rewards (Daskin et al., 2003).

The MNC has established a first plant in an emerging market with positive response. Now, the MNC is entering a steep upscaling period of the project with hundreds of new distributed plants. The plants are manufacturing facilities located across the market. To enable the rapid pace and the burden on the existing supply chain, a distribution network will be constructed. Due to the uncertainties of location of these plants, a network will be designed and exposed in scenarios with varying identified key parameters. The scenarios will be run in a simulation model visualizing the scenarios of a significant period.

As supply chains are getting more complex, an increased demand of transparency is desired as a matter of risk prevention and consumer/labor protection (Abeyratne & Monfared, 2016). Blockchain technology is reshaping industries, a growing interest from the logistics and supply chain management community realizing the opportunities and how profundal this technology could be for the supply chain (Hackius & Petersen, 2017). Supply chain management experts are arguing that the blockchain technology could offer “enormous potential” (O´Marah, 2017). In addition, they believe that blockchain could be a “much-needed platform for economic renewal” (Case & Wong, 2017) and that blockchain can “transform the supply chain and disrupt the way we produce, market, purchase and consume our goods” (Dickson, 2016). As this technology is in a constant growth, the MNC wants to find out what kind of benefits could be obtained from using it and how it should be applied in the supply chain for the pilot project.

1.3.Purpose

The purpose of this master thesis is to investigate how a strategic distribution network could be designed for an upscaling of the Distributed Plant project (DPP) and to investigate how blockchain technology can be applied in the supply chain for DPP.

1.3.1. Research Questions

The research questions aim to capture the main attributes and to fulfil the purpose of the master thesis, following research questions are to be answered.

RQ1. How can the distribution network be designed for an upscaling of Distributed Plant Project?

RQ2. How can Blockchain contribute to the Distributed Plant Project?

1.4.Focus and Delimitation

- **The design of the distribution network between main production facility and plants will mainly focus on warehouses.** Due to the complexity and uncertainties in the DPP, a primary focus has been to investigate if warehouses can reduce total logistics cost.
- **Delimitations that all warehouses are assumed to have the same original setup.**
  This delimitation is mainly related to the phase 1 if the setup is identical regarding what equipment and material is to be sourced**.**
- **Cost of holding inventory will not be accounted for.** The cost of holding inventory will not be accounted for because it is not considered to be as important in this case. The cost is relevant, but not in our model or for the MNC at this stage.
- **Blockchain technology will be investigated from a business perspective.** Blockchain technology will not be explained and analysed from a deeper technical standpoint. Focus will lie on identifying key use cases from a business perspective.
- **A delimitation for this master thesis is the restricted time frame of 20 weeks.**
  The time frame for a master thesis is 20 weeks, hence the thesis will have this as a limit.
- **The primary target group for this master thesis will be the MNC and primarily the people involved in the project and stakeholders. The secondary target group will be the academia.** This master thesis will be conducted to help the MNC design their distribution network for the project at the emerging market. Therefore, the primary target group will be the MNC and stakeholders involved in the project. The secondary target is the contribution to academia and other people interested in the subject.

1.5.Disposition

Chapter 1: Introduction

In this chapter, a background, problem description and research questions are presented. Focus and delimitations will be introduced and discussed.

Chapter 2: Methodology

In this chapter, the reader is offered an in-depth description of the methodology behind the thesis. A research strategy and research design followed by work process, data collection and a credibility section is presented and discussed.

Chapter 3: Theoretical framework

In this chapter, a thorough review of the used theoretical framework is presented. It starts broadly with supply chain management, distribution, network- and scenario planning to being narrowed down to simulation. In the final part, blockchain technology will be introduced.

Chapter 4: Empirical findings

In this chapter, the case company and project, in which the thesis has been conducted in collaboration with, will be presented. Insights and findings from interviews, workshops and archive analysis at the MNC is described. In accordance, the MNC´s existing knowledge and work done with blockchain technology is presented.

Chapter 5: Analysis

In this chapter, empirical findings will be analysed against the theoretical framework. The analysis will follow a trajectory enabling the authors to form a recommendation using gathered data and theory.

Chapter 6: Recommendations

In chapter 6, the research questions will be answered. The chapter will also include suggestions for future research, both for the MNC and for academia literature.

2. Methodology

In this chapter, the reader is offered an in-depth description of the methodology behind the thesis. A research strategy and research design followed by work process, data collection and a credibility section is presented and discussed.

2.1. Research Strategy

A both qualitative and quantitative research strategy was chosen for the master thesis with an abductive reasoning approach.

The qualitative path for research strategy is suitable when the aim is to *"understand the phenomenon in its own terms"* (Hirshman, 1986). As the study focuses on creating a model for an existing project, a qualitative research approach was chosen to develop, gather and interpret information. The qualitative research strategy is suitable when the research questions aims to answer the questions "*Why?*" or "*How?*" in contrary to the quantitative approach which rather answers "*How much?*" or "*How often?*" (Hennink, et al., 2011). Thus, the qualitative research approach was chosen since the question was of explanatory nature answering the question; *How?* The quantitative research strategy was chosen to validate the qualitative by answering; "*How much?"* or in this case "*How many?".*

An abductive reasoning approach, see figure 2.1, was chosen to fit the study. By systematically combining theoretical framework, empirical fieldwork and case analysis into a singular reasoning approach, combining both inductive and deductive methods, an abductive approach is suitable (Kirkeby, 1994). The abductive method aims to investigate collected theoretical and empirical data to analyse it iteratively (Dubois & Gadde, 2002).

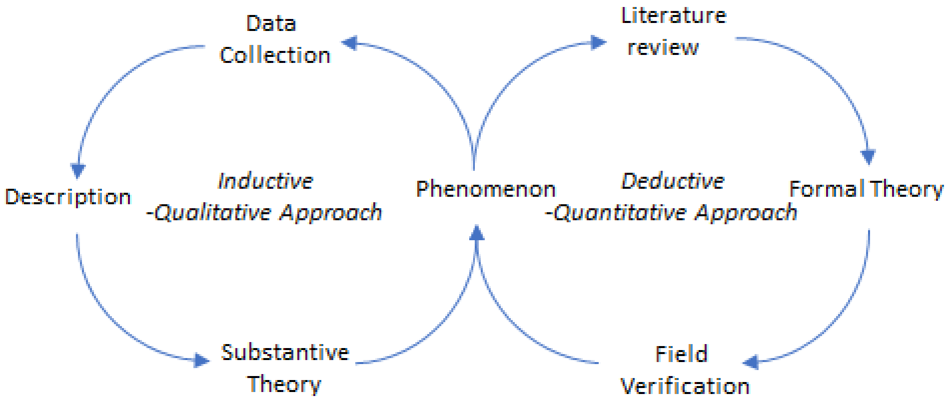


Figure 2.1 Abductive approach (Woodruff, 2003)

2.2.Research Design

A case study approach was selected as the research design with a distribution network as the main unit of analysis. The organization is the MNC and the group is a systems engineering department within the MNC where a few employees are dedicated to the DPP.

This research design aims to study the phenomenon in its natural setting and by understanding the variables and complexity answering the questions of "*What?*", "*How?*" and "*Why?*" (Meredith, 1998). The thesis is both descriptive in its current nature and exploratory in future settings which according to Höst et al. (2006) makes a case design appropriate. Fitzgerald and Dopson (2009) describes that the unit of the analysis can be an organization, part of an organization, or a division or group which strengthen the selected research design. The main unit of analysis is likely to be at the level being addressed by the main study questions according to Yin (2014). The research questions, RQ1 and RQ2, are both addressed to the distribution network even if the blockchain technology is more embedded within the DPP. The unit of analysis is therefore the distribution network.

2.2.1. Simulation Modelling

To answer research question one, "*How can the distribution network be designed for an upscaling of DPP?*", a simulation was constructed. A simulation is described by Sokolowski and Banks (2009) to be "*an applied methodology that can describe the behaviour of that system using either a mathematical model or a symbolic model.*" The system in this thesis will be the selected part of the supply chain between the MNCs existing main production facility and the future production plants. Sokolowski and Banks (2009) continues to describe how simulation can be applied to visualize, conceptualize and analyse current or new behaviours. The applicable areas are enabling a way of predicting real events in advance without going through the event.

Simulation modelling can be divided into different dimensions depending on which tool and what the purpose of the simulation is. To distinguish these dimensions for clarification purposes, Law and Kelton (2000) classified them according to following:

Static vs. Dynamic

A static simulation model is occurring at a specific time whereas a dynamic simulation model is time-varying (Law & Kelton, 2000).

This thesis aims to investigate future scenarios with the simulation model, with the aim to illustrate a logical flow. A static simulation was chosen at this stage as no dynamic functions where wanted for the model.

Deterministic vs. Stochastic

A deterministic system is a system in which no randomness is involved in determining the result, meaning that only input variables can have an impact on the output (Law & Kelton, 2000). If the system contains some probabilistic components, a stochastic system is more appropriable.

The thesis tries to capture the environment of a distribution network, from a strategic perspective where randomness in transport for example is not as relevant as it would be from an operational or even tactical level (Simchi-Levi, et al., 2003). A deterministic system is therefore to prefer.

Discrete vs. Continuous

Discrete simulation systems are characterized by events happening instantaneously whereas continuous systems change state overtime (Law & Kelton, 2000). Figure 2.2 illustrates the outlook of a discrete and continuous system (Milefoot, n.d).

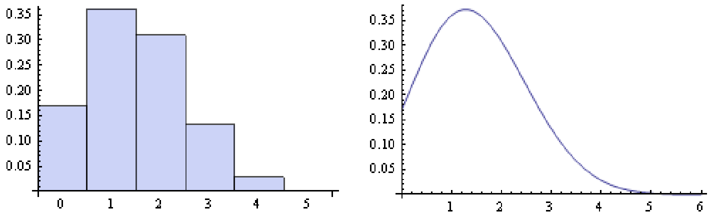


Figure 2.2 Discrete and continuous graph (Milefoot, n.d.)

The simulation aims to capture how time affect the simulation. However, the simulation is static, which basically means that it is not time varying. The model was constructed to be able to simply change inputs and compare, mainly to see how cost changes impact over time and when investments are suitable. The model is therefore considered to be continuous.

Type of scenario

This thesis is of an explorative and normative scenario type. The thesis is focusing on a strategic decision level whereas the explorative scenario fits, mainly with regards to RQ1, "*How can the distribution network be designed for an upscaling of DPP?*". In addition to this, both internal and external factors will be included when conducting the research for RQ1 and RQ2, "*How can blockchain technology contribute to the DPP?*". A further explanation of explorative scenarios could be seen in chapter 3.4.1 Scenario typology. The thesis will also be of a normative type, as a qualitative analysis is conducted. A further explanation of this scenario type could be seen in chapter 3.4.1 Scenario typology.

Summary of the simulation

Figure 2.3 illustrates a summary of the characteristics of the simulation model.

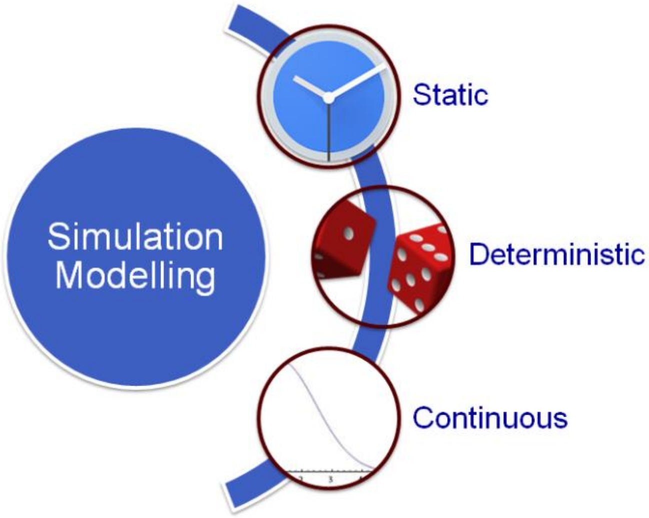


Figure 2.3 Summary of the characteristics of the simulation model

2.2.2. Simulation tool - SimEvents

The simulation tool that was used for the model is SimEvents. SimEvents is a discrete simulation tool developed by MathWorks. It is based on the SimuLink workspace, adding an additional graphical interface together with the ability to simulate in a dynamic environment. In addition to this, the software MatLab was used to parameterize input factors and perform various calculations. The link between MatLab and SimEvents enabled a collaboration between the software's that simplifies the usage for the end user since formulas and calculations can be separated, but still integrated, with the graphical interface.

The SimEvents simulation tool was a prerequisite from the MNC and therefore no other tools have been investigated or even considered.

2.3. Work process

The work processes of this case study were conducted in an iterative way.

Yin (2014) describes a case study as a "*linear but iterative process*" where criticality is a key to achieve a high-quality case study. In addition, Yin (2014) divides the case study research process in six elements; plan, design, preparation, data collection, analysis and reporting. Importance of a clearly stated research question was highlighted and, along with the following steps, also iterated and changed throughout the process of the thesis. Höst et al. (2006) points out the importance of an often-forgotten step, reviewing a solution, which is a natural part in the chosen iterative process.

Figure 2.4 illustrates the process during the master thesis. Two initial research questions were stated, followed by investigation of both a theoretical framework and archive analysis of existing data at the MNC. Together with the new information gathered, the research questions were revised. The two research questions were of different character meaning it was difficult to workd simultaneously with them, instead they were handled separately. Both of which, were followed by extensive data collection. RQ1 partly summed up in a simulation model, whilst RQ2 was more of a theoretical nature. Workshops and additional calculations were extra steps for the simulation model. Finally, both research questions were analysed and summed up to a final recommendation.

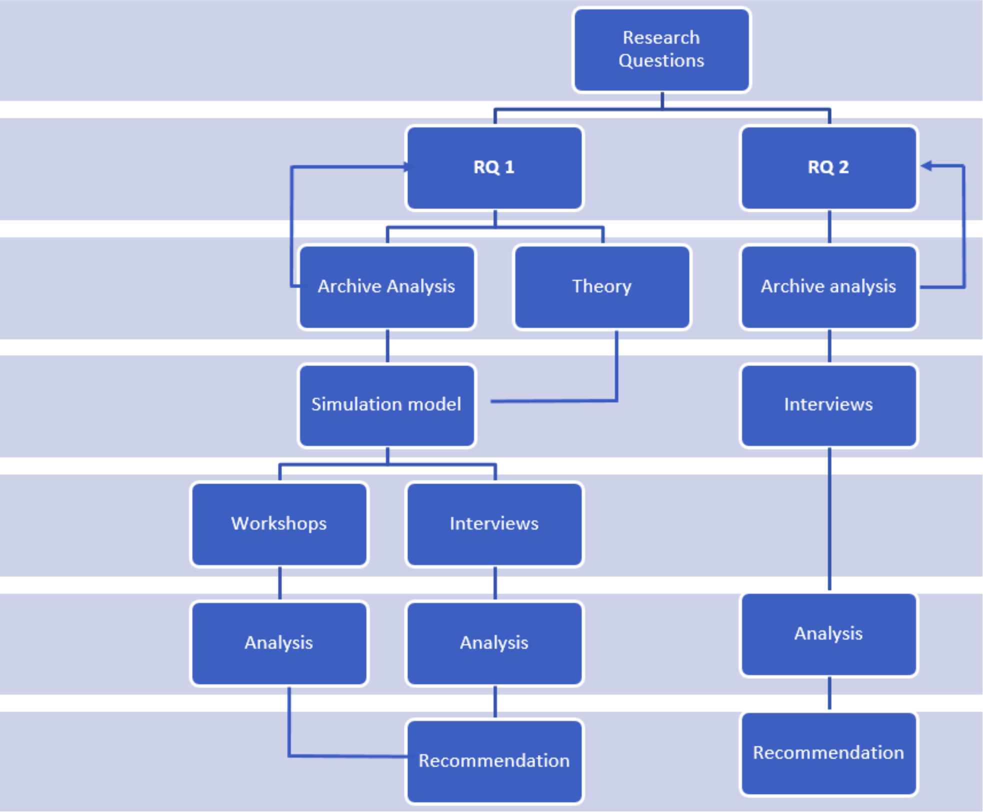


Figure 2.4 Work process for master thesis. (Authors design, 2018)

2.4. Theoretical framework

The purpose of a well conducted theoretical framework is to create a thorough foundation to build on (Höst et al., 2006). The case will mainly focus around areas such as *supply chain management*, *distributed manufacturing*, *network planning*, *scenario planning*, *simulation* and *blockchain technology*

The focus areas were investigated separately and in relationship to each other to find similarities. Below are two paragraphs explaining where the main parts of the primary and secondary information were collected. The following next paragraph explains frequently used terms or search words for information searching.

Sources

The primary information was collected from alternative databases such as Scopus, Elsevier, Google Scholar and Lund University Library.

Search terms

The research sources required a large variety of search terms. The frequently used search terms have been: *Distributed manufacturing, upscaling, supply chain planning, network planning, scenario planning, blockchain technology, business development, supply chain management, simulation modelling, transparency, traceability.*

2.5.Empirical data collection

The chosen qualitative method for the performed case study involved a large amount of data collection. Höst et al. (2006) has given a list consisting of seven different methods for data collection whereas this study will focus on interviews, observations, workshops and archive analysis which are all common qualitative methods for data collection. Even though the thesis is of a qualitative character, it will contain elements of quantitative analysis in order to numerically validate results. A highly informal journal is kept since Höst et al. (2006) advocates the essence of continuously collect data because all information gathering is not intended, it can come unintentionally from informal encounters and therefore easily be forgotten.

2.5.1. Observations

This thesis consists of different observations made at the MNC. Observations are a general way to observe a phenomenon, and depending on the level of interaction made by the observer, Höst et al. (2006) distinguish on four categories. From being an active observer known by the observed population to being completely separated, not participating in the activity or even known by the population. Figure 2.5 illustrates a visual representation of the four categories (Höst et al., 2006).

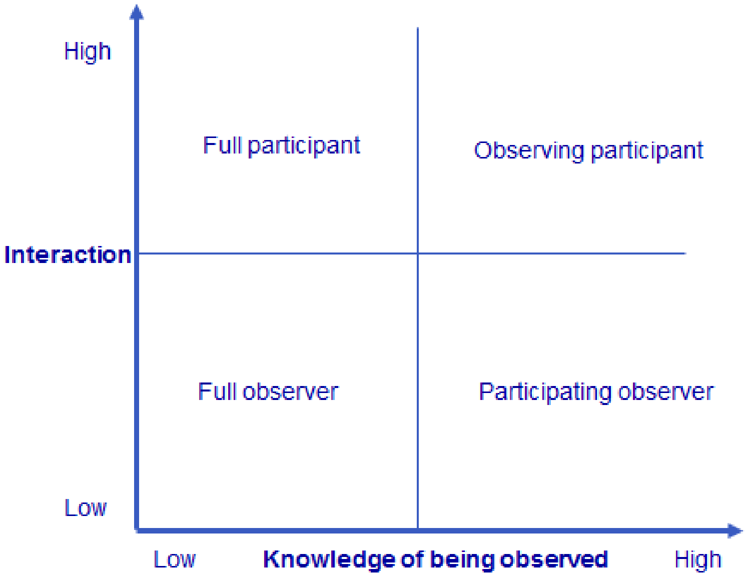


Figure 2.5 Four categories of observations. (Höst et al., 2006)

In this thesis the observers are partly interactive with the activity in the organization and known to the population driving the activity. This puts the authors between an observing participant and participating observer, characterized by not hiding the fact that the activity is being observed and remotely involved in the project. The purpose of the observations is to gain an insight into the project and get a deep understanding of the processes and vision to form the thesis. By sharing the knowledge of observing, information and knowledge is easily accessible and likewise is the goal.

2.5.2. Interviews

In order to get an in-depth understanding, interviews are a possible way of gathering information. Interviews are categorized as more or less systematic questioning of the interviewee and divided into *open-*, *semi structured-* and *structured interviews* (Höst et al., 2006). All methods are structured with an interview guide. The open interview allows the interviewee to speak freely about what he/she/they is/are willing to talk about with the risk of getting less directed information. A semi-structured interview is more directed and structured, but still less directed than a structured interview which is like a verbal poll inquiry.

Table 2.1 List of informants

Informant Group	**Title / Role**
Informant group 1: Systems Engineering	*Manager Systems Engineering / Project lead DPP*
	Systems Engineer 1 / Consultant
	Systems Engineer 2
	Systems Engineer 3
Informant group 2: Innovation engineering	*Leader Innovation Capabilities*
Informant group 3: MathWorks	*SimEvent Specialist 1*
	SimEvent Specialist 2

This thesis will mainly cover a more informal kind of interviews related to the open interview form, but to some extent also contain some information gathering through semi-structured interviews. The informal interviews were conducted through meetings and open questions in passing and is motivated by the need to get information more frequently and that some information time sensitive and needs to be accurate. However, the semi-structured interviews are important to create a stabile foundation. This means that the population chosen is highly dependent on problems arising, but will exclusively be from the case company. In table 2.1, the title/role of the interviewed employee is stated. In appendix C.1, interview guides for each interview can be found. In total, two semi-structured interviews were held.

2.5.3. Workshops

Workshop was chosen as a form of information gathering where the aim was to create a forum for discussions regarding the thesis. The workshop was held in a close environment with employees at the MNC, all of which were to some extent familiar with the purpose of the thesis. The workshop was also focusing on validating the process and thoughts yet done by the authors.

2.5.3.1. Workshop 1

The objective with the workshop was to validate results and get new insights of what the MNC requires. The workshop provided the authors with additional parameters to enhance the simulation model.

Table 2.2 Workshop 1 participants

Workshop	Title / Role of participants
Workshop 1: DPP concept model	Innovation Engineer
	Manager Systems Engineering / Project lead DPP
	Systems Engineer 1 / Consultant
	Systems Engineer 2
	Systems Engineer 3
	Systems Engineer 4
	Systems Engineer 5

2.5.3.2. Workshop 2

A second workshop was held after finishing the first draft of the model to verify the results and usability for the MNC. The chosen group of participants in Workshop 2 was also participants in Workshop 1.

Table 2.3 Workshop 2 participants

Workshop	Title / Role of participants
Workshop 2: Simulation model verification	*Systems Engineer 1 / Consultant*
	Systems Engineer 4

The objective was to see how the MNC and the participants reacted to the simulation model and how intuitive it was. Comments and further ideas that could not be applied instantaneous was used in section 5.2.4 *Discussion: Phase 2* and section

6.1 *Further research.*

2.5.4. Archive analysis

In a case study vast amount of research and knowledge have often been conducted in advance from related projects or in other contexts. Archive analysis is a technique where the purpose is to use existing documentation and research to gain knowledge for the new study (Höst et al., 2006). Since the archive analysis is based on reports, investigations and/or projects made with a different purpose in mind, it is important for the legitimacy of the study to cautiously consider the origin of the used data and the effects of using it (Höst et al., 2006). Thus, the technique is used in both qualitative and quantitative methods, especially in case studies where information exists within the case company, information that is difficult to find in other ways (Höst et al., 2006).

This thesis highly depends on internal information from the MNC. Information directly regarding the project itself will mainly be collected through archive analysis. In this case study, archive analysis will consist of internal reports, mid-review presentation material, excel spreadsheets and other internal documents made from earlier stages of the DPP.

2.6.Data analysis

Most of the data was collected at early stages to be able to proceed with the planned simulation model. Together with observations and archive analysis, in which have been a more ongoing process, the data is being processed and analysed. The data analysis has been partly of a quantitative character to build and develop the simulation model and of a qualitative character to support the model and the report. The data analysis for RQ2 have been made of a qualitative character.

A qualitative data collection, which this thesis to large extent is, highly depends on the final purpose of the study (Höst et al., 2006). Qualitative data is often analysed with sorting and categories, which is the typical method for a case study. The analysis focus on understanding the context of the problem in mind, connecting keywords and patterns to interpret a result. The quantitative data analysis mainly consists of statistics (Höst et al., 2006). A combination of qualitative and quantitative data often provides better understanding of the studied phenomenon (Seaman, 1999), i.e. what is sometimes called "*mixed methods*" (Robson, 2002).

2.7.Credibility

Björklund and Paulsson (2012) explained how a case study can be credible with regards to various factors; *reliability*, *validity* and *objectivity*. A research design is supposed to represent a logical set of statements, the quality can therefore be judged based on logical tests (Yin, 2004). The credibility can be analysed through three aspects that further have been supplemented by Höst et al. (2006), adding *transferability*. The four credibility aspects will be considered throughout the thesis and explained more below.

2.7.1. Reliability

Reliability is related to how data and analysis is collected and performed. A high reliability can be measured in the possibility to replicate the study, given used data, for someone else (Björklund & Paulsson, 2012). Thus, to achieve high reliability it is essential to consider origin of data, in particular when an archive analysis place an important part of the information collection (Höst et al., 2006). By being transparent with the information and where it originates from, a level of reliability can be achieved and by allowing external parties to review sources, weaknesses can be spotted (Höst et al., 2006). This case study has a relatively high reliability in the sense that it mostly consists of archive analysis from the MNC which is relatively unambiguous. The case study also contains observations and interviews which is complicated to replicate and is therefore just relatively high reliability. The simulation is, with accurate data, easy to replicate.

2.7.2. Validity

Validity refers to the connection between the research data and the research question. If the data directly can respond and answer the research questions the validity is considered high (Björklund & Paulsson, 2012). To enhance the validity of a study, triangulation can be used, which basically means that the same thing is being measured with different methods (Höst et al., 2006). The validity of a case study is often recognized to be high (Lekvall & Wahlbin, 2001). This thesis focuses exclusively to answer the research question(s) and therefore, the validity is considered high. However, the research question aiming at investigating usage of blockchain technology can lower the validity since it is outside of the primary scope regarding distribution.

2.7.3. Objectivity

All studies can be influenced by the authors, and to what extent the authors own values, judgements and opinions affects the result and the objectivity varies (Björklund & Paulsson, 2012). The objectivity places a large part in the qualitative research methods, especially important when interviews are being held and analysed. The quantitative research is in its nature objective, hence there is no space for interpretation of the numbers. The thesis will, as mentioned above, mainly consist of archive analysis data from reports from the MNC.

2.7.4. Transferability

If a study is transferable the solution is generalized meaning the results can be used in a general context (Höst et al., 2006). Further on, in a case study, transferability is rather high.

This case study is primarily conducted to be usable for the MNC. Therefore, most of the information gathered is from employees and internal sources. This makes the transferability, as Höst et al. (2006) discussed, to be lower in the sense that all data is internal. The simulation is made to be generic, which increases the transferability. The transferability is rather high for blockchain technology. As different use cases will be made, it is possible for other stakeholders to copy the ideas of the use cases.

2.8.Summary of Methodology

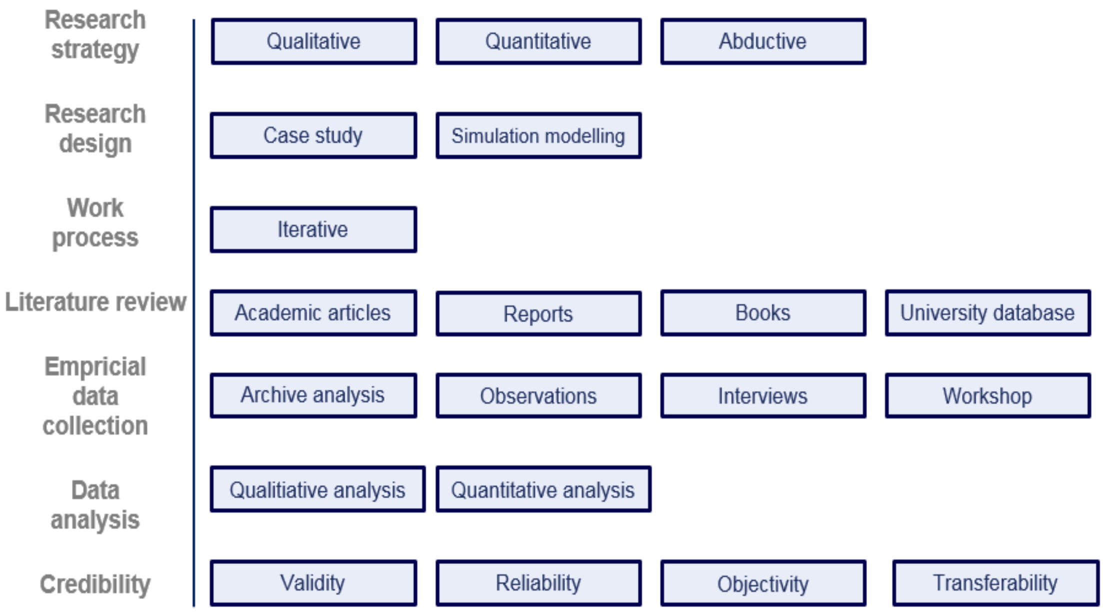


Figure 2.6 Summary of methodology

The research study was designed as a mixed qualitative and quantitative case study with an abductive reasoning approach. The empirical data was collected through archive analysis, workshops, informal interviews and observations from meetings with the MNC employees. The theory and the empirical data was then used to develop a simulation model and a report.

3. Theoretical framework

In this chapter, a thorough review of the used theoretical framework is presented. It starts broadly with supply chain management, distribution, network- and scenario planning being narrowed down to simulation. In the final part, blockchain technology will be introduced.

3.1. Supply chain management

There are different definitions to the topic *Supply Chain Management* and *Supply chain.* This section will define these two concepts.

3.1.1. Definition of supply chain

Mentzer et al., (2001) defines a supply chain as a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer.

Figure 3.1 illustrates a typical supply chain, from raw material to distribution of finished goods to customers (Christopher, 2011).

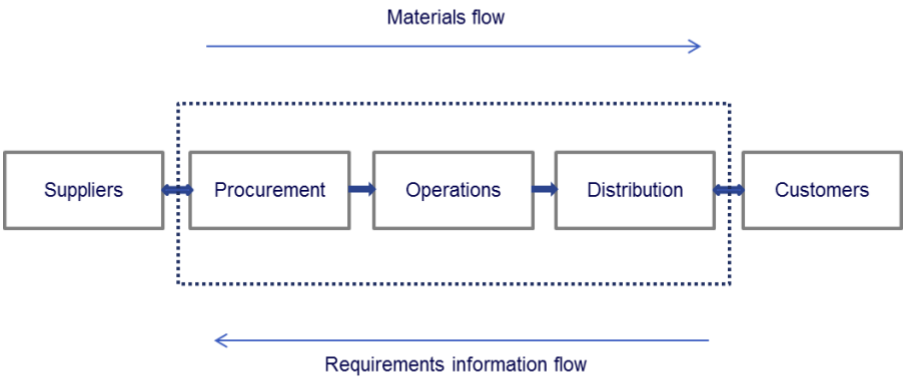


Figure 3.1 A general supply chain (Christopher, 2011)

3.1.2. Definition of supply chain management

There are different definitions of the topic Supply Chain Management. The authors Lambert and Cooper (2000) define Supply Chain Management as "*the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders*".

Mentzer et al. (2001) define Supply Chain Management as "*the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*".

Christopher and Peck (2004) define Supply Chain Management as "*the network of organizations that are involved through upstream and downstream linkages, in different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer*".

Christopher (2011) states that the importance of supply chain management for a company is a fundamental factor for a company's success. For long time it has been discussed that the profitability for a company depends on either cost advantages or value advantages. Traditionally, cost advantages have referred to greater sales volumes and by improving a company's market shares. The desire of economies of scale through increased sale volumes are a complex way in today's society, as the cost for a product lies far beyond only the four walls of a business. Today, the costs lie throughout the whole supply chain for a company. Hence, through having an efficient supply chain management where costs are decreased, a company can capture great profits.

3.1.3. Definition of distribution in the supply chain

The supply chain consists of different elements, where distribution is a major one. Distribution refers to the actions of moving finished goods from the supplier to the customer (Chopra, 2001). The overall profitability of a company is dependable on an efficient distribution network, as the distribution both impacts the supply chain costs and the customer experience.

One of the most crucial and difficult decisions in order to have an efficient supply chain design is where to locate different facilities, e.g. productions sites, warehouses or distribution centres (Daskin, et al., 2003). Facility location decisions are often decisions that are done on a longer time-horizon. They are often fixed and difficult to change due to the size of investment.

3.1.3.1. Network design in the supply chain

Figure 3.2 (Chopra & Meindl, 2004) illustrates a process for designing a global network, i.e. putting up facilities, and the process is done in four steps.

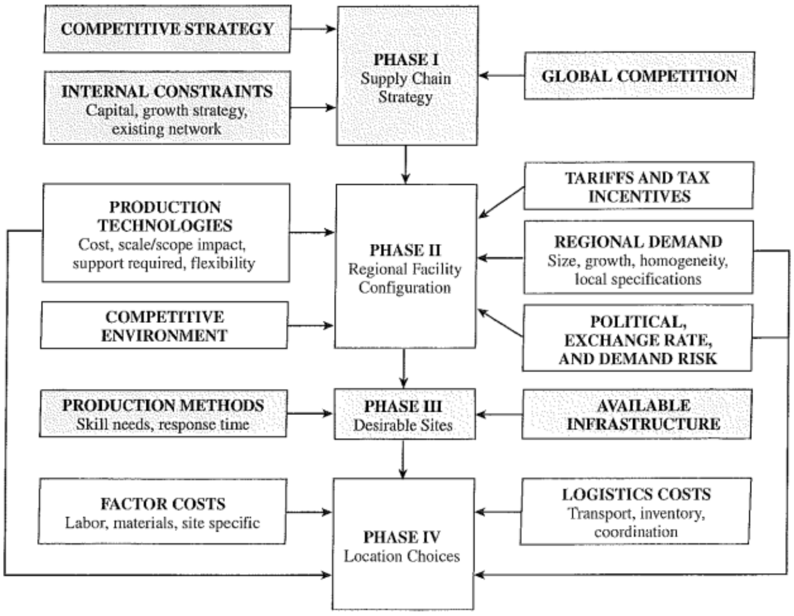


Figure 3.2 General process for designing a global network (Chopra & Meindl, 2004)

Phase 1: Define a Supply Chain Strategy

In this phase, the overall supply chain strategy for a firm is developed. This strategy should highlight which capabilities the supply chain must have to support the firm's current competitive strategy. The future competition should be evaluated and financial constraints should be investigated. In addition, the future growth of how many facilities the company will have should be evaluated.

Phase 2: Define the regional facility configuration

The aim with this phase is to identify where a company's facilities should be located, type of facility and the capacity each facility should handle. (Chopra & Meindl, 2004)

Phase 3: Select desirable sites

The objective with this phase is to propound different desirable sites where it would be possible to locate facilities. The selection could be narrowed down to location of facilities to a specific region. The number of sites should be larger than the amount of facilities that should be set up, in order to achieve a precise selection in phase 4. (Chopra & Meindl, 2004)

Phase 4: Location choices

In this phase, the selection of an optimal location and the capacity allocation for each facility should be carried out. The selection is restricted to the desirable facilities pinpointed in phase 3. The facility location decisions should be based on maximizing total profits for the network. (Chopra & Meindl, 2004)

3.1.3.2. Gravity location model

This location model can be useful to identify appropriate geographical locations within a region. The aim with gravity location model is to minimize the cost of transporting e.g. transportation of raw materials from suppliers and finished goods to the markets, by finding suitable locations. (Chopra & Meindl, 2004)

In the gravity model, a X-Y grid system can represent a market and the nodes represents the warehouses. The distances are calculated as the geometric distance between two nodes in the grid system. In these models, the transportation costs are assumed to grow linearly with the quantity shipped (Chopra & Meindl, 2004). The inputs to the model are the following ones:

X_n, Y_n = *Coordinate location of either a market or supply source (warehouse) n, n = 1...∞*

F_n = *Cost of shipping one unit for one km between the facility and either market or supply source n, n = 1...∞*

D_n = *Quantity to be shipped between facility and market or supply source (warehouse) n, n = 1...∞*

The formulation for the distance, d_n, between the facility (with coordinates (x, y)) and the market or supply source (warehouse) n, is as follows:

$$d_n = \sqrt{(x - x_n)^2 + (y - y_n)^2}$$

The total transportation cost (TC) is then given as:

$$TC = \sum_{k=1}^{n} d_n * D_n * F_n$$

The facility location should then be the one that minimizes the total transportation cost.

3.1.4. Inventory management

It is of great importance to discuss the trade-offs between the costs associated with keeping inventory versus the benefits of not holding inventory (Chambers & Lacey, 2011). One great benefit with holding inventory is the availability of goods and the possibility to serve customers just in time. The primary costs associated with inventory are the capital needed to purchase the inventory and storage costs. These costs could be opportunity costs, i.e. costs that could be used on other actions if not having inventories. The aim with inventory management is to optimize the inventory in a company and find the maximum net benefit - the benefits minus the costs - of the inventory.

It is possible to store a huge amount of different products/materials. These products/materials vary in profitability and in the utilization of space. A higher amount of stored inventory result in increased costs for factors such as storage, insurance and spoilage (Shim, et al., 2008). Successful inventory management aims to minimize inventory as it lowers costs and increase profitability. It is still of great importance for managers to appraise the adequacy of inventory levels. The inventory level depends on several different factors, such as:

- Sales
- Liquidity
- Available inventory financing
- Supplier reliability
- Delay in receiving new orders
- Production
- Seasonality.

3.2.Distributed manufacturing

The globalization and the high competitiveness for manufacturing companies in mature economies, are challenging the company’s ability to grow in the long-term, while providing quality jobs (Seregni, et al., 2015). The increased demand from customers and policymakers, asking for products which are more environmental friendly and social sustainable, has put pressure on companies to meet these demands. Manufacturing companies should be able to in a quick and smooth manner expand and reshape its supply chain to maintain their competitiveness.

Distributed Manufacturing Systems (DMS) are becoming a more “relevant” topic among academic debates as well as in the manufacturing industry (Seregni, et al., 2015). Figure 3.3 illustrates the shift from centralized manufacturing network to a distributed manufacturing system. The trend of going from centralized manufacturing to distributed manufacturing is partly due to two enabling technology developments; ICT technologies, i.e. Internet of Things and cloud technologies which enables better connectivity through the whole supply chain. ICT developments can support coordination, governance and control, and critically enable demand and supply to be managed more real-time. The other technology is additive manufacturing, i.e. 3D printing. DMS are supposed to reach a higher diversification and personalization level as the manufacturing sites will be placed closer to the customers, i.e. they need to adapt to the given circumstances. Additive manufacturing enables this shift. Further on, as logistics costs are decreasing, companies have started to place their production sites in geographically dispersed units (Ibid).

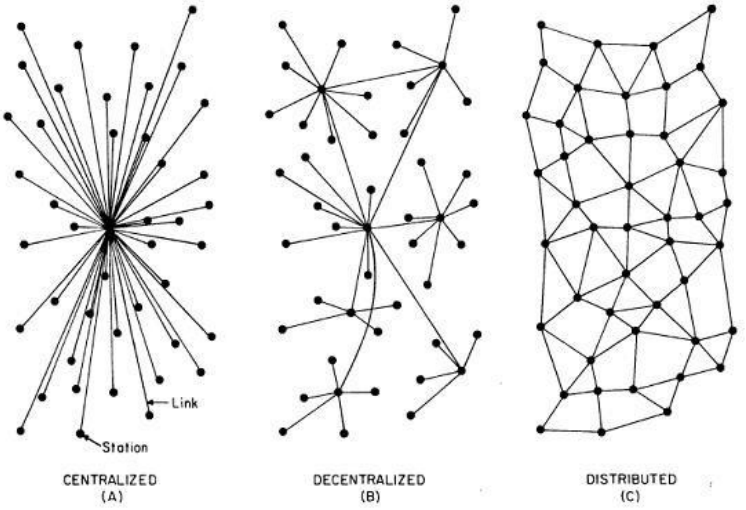


Figure 3.3 Different kinds of manufacturing networks. (Itrelease, 2018)

The trend of globalisation - the move from having a centralised value chain into sub-parts and sub-processes with production distributed across different locations - is an important characteristic within DMS (Rauch et al., 2015). Extending it further, collaboration with other companies and inviting them to participate in a company's value chain, has given small and medium sized enterprises the opportunity to become a part of the extended manufacturing value chain (Srai and Gregory, 2008). Rauch et al (2015) argues that small, flexible and scalable geographically distributed manufacturing units have the possibility to achieve the characteristics of modern operating systems which follows below:

- Just-In-Time (JIT) delivery.
- Nimble adjustments of production capacity and functionality with respect to customer’s needs.
- Sustainable production and supply chains.

Still today, the production locations appear to be too far away from end-customers, even though today's manufacturing is more dispreads. The concept of DMS enlights a change, from mass production and centralization, with respect to both location and scale, to more efficient production with respect to both location and scale but also consumer-producer relationship (Kohtala, 2015). Johansson et al. (2005) argues that the concept of DMS will be characterized by new business models, operating in "distributed economies" which is illustrated in figure 3.3. Distributed economies can be further explained as a network of different entities, working more together with the possibility to support each other. Hence, the close contact to the end consumer will indicate environmental benefits, as the utilization of local materials and other resources will increase. This will lead to more sustainable forms of production. One example is the fact that the transportation distance will be reduced which will reduce the emissions.

3.2.1. Factory-in-a-box concept

As globalization is challenging the manufacturing industry with higher competition, high quality and low cost are not always enough to guarantee a firm's position in the market (Jackson et.al, 2008). To successfully introduce new products and services, it is of great importance to be flexible. Companies needs to be successful in converting product/service ideas into reality. In order to achieve this, new production philosophies enable quick production realization as well as flexibility and reconfigurability within operations.

The research concept of factory-in-a-box was established in Sweden by different academic and industrial partners (Jackson et.al, 2008). The vision of the concept is *mobile production capacity on demand* with the aim to provide solutions that increases availability, mobility and flexibility of production capacity for Swedish industry. In order to achieve these factors, a company can focus on different actions, for instance (Jackson et.al, 2008):

- Increase the level of automation in manufacturing process
- Work with product structuring and increase the modularity in the product
- Move pre-fabrication of sub-systems closer to final assembly
- Closer collaboration with sub-contractors/sub-suppliers
- Develop and improve the logistics and IT-support

The key features of the concept are flexibility, mobility and speed (Jackson et.al, 2008). In general, the concept consists of different standardized modules that easily can be stored in containers and then transported. The transportation modes could be e.g. trucks, trains, ships, airfreight or other means of transportation. It is of great importance that the modules are easy to handle, i.e. it should be easy to combine different modules into complete production systems. In addition, it should be easy to reconfigure the different modules for new products and/or scaled to handle new volumes.

3.2.2. Copy Exactly! concept

The global computer chip manufacturer Intel developed a factory strategy in the 1980s streamlining the setup and running of separate factories globally. The factory strategy, called Copy Exactly! aims to meet the increasing demand and globalisation Intel were facing, by designing large volume factories with identical setup ranging from the same machinery to ambient humidity (Montoya & Williams, 2000). By controlling every measurable variable, new identical factories can be rebuilt in other locations, working similarly. The strategy was first implemented after locating a yield problem on their chip that occurred in multiple factories. By implementing the Copy Exactly! strategy, the problem itself was not solved, but they could guarantee that the same problem did not reoccur in multiple locations (Hruska, 2012).

3.3.Network planning

In order to optimize the performance of a supply chain with regards to conflicting objectives, uncertainties in demand and supply chain dynamics, network planning is a process that could be followed (Simchi-Levi, et al., 2003). The overall purpose with network planning is to match supply and demand in uncertainty by minimizing costs and to reduce the unnecessary usage of resources. Figure 3.4 illustrates the network planning process.

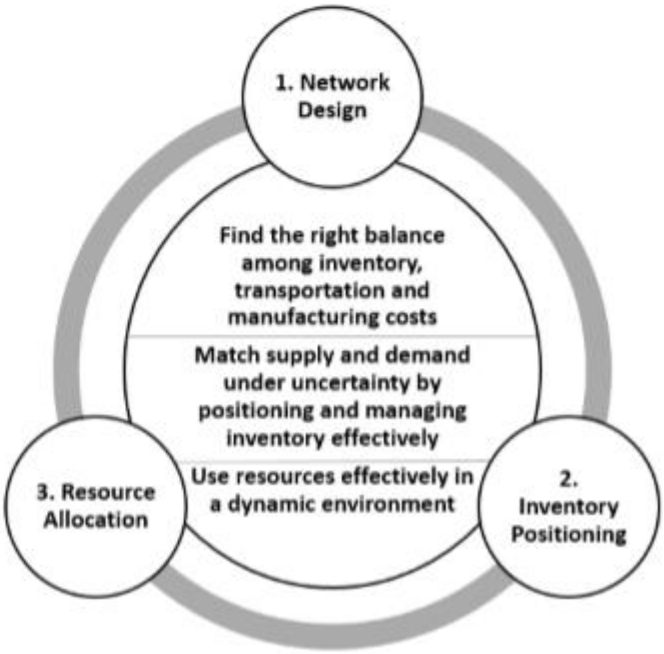


Figure 3.4 Network planning, a process in order to obtain an optimized supply chain. (Simchi-Levi, et al., 2003.)

Network planning can be categorized into three phases: network design, inventory planning and management and resource allocation, seen in Figure 3.4. The first one, network design, is on a strategic decision level (Jonsson & Mattsson, 2011) (Simchi-Levi, et al., 2003.). Compared to the tactical and operational level, the strategic level has the longest time horizon whereas decisions can have an impact several years ahead. The most common decisions made are regarding warehouse placement and investments which can be seen in table 3.1. Decisions made on a tactical level are mainly regarding sourcing and inventory policies with a typical one-year horizon. The operational level, decides mostly topics such as purchase orders, routing and scheduling happening in the near future, on a day to day level.

Table 3.1 Decision levels and their timeframes and characteristics of decisions. (Simchi-Levi, et al., 2003)

Level	Strategic	Tactical	Operational
Time frame	Long term (several years)	Intermediate (0.25-1 year)	Short term (day-to-day)
Decisions	• Warehouse placement • Investments	• Sourcing • Inventory policy	• Purchase orders • Routing • Scheduling

3.4.Scenario planning

One of the challenges with optimizing a supply chain is the uncertainty of supply and demand (Simchi-Levi, et al., 2003). Scenarios can be used to prepare for varying outcomes and scenario planning is the theoretical tool which could be applied. This tool supports the supply chain to prepare for multiple possible outcomes and highlights their implications, timing and nature (Amer, et al., 2013) (Bishop, et al., 2007). Scenario planning can be used in different environments and time frames, thus, it tends to be more useful for long term planning (Amer, et al., 2013). Amer et. al (2003) argues that with scenario planning, different bottlenecks could be illustrated and analysed in order to understand the behaviour of the bottlenecks.

In literature the subjects "*scenario planning*" and *"scenarios"* have different definitions. A well-known definition of scenarios, stated by Herman Kahn (1967), is *"a set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points"*. Examples on other definitions are *"alternative futures resulting from a combination of trends and policies*" and "*description of a future situation and the course of events which allows one to move forward from the actual to the future situation"* (Amer, et al., 2013). In addition to the definitions, the term scenario is also referred in some literature as '*an alternative future*' (Bishop, et al., 2007). This is in some sense considered as a broader definition. Further on, *"scenario"* and *"forecast" "are* two terms closely related to each other. These terms deal with the future to some extent, both considering predictions or plausibility. These terms have been discussed for a long time and different authors states they refer to different aspects of studying the future. The term *"scenario"* refers more to plausible futures while *"forecast"* refers more to probability (Simchi-Levi, et al., 2003).

3.4.1. Scenario typology

Three main types of scenario categories can be used, see figure 3.5; *Predictive, Explorative and Normative* (Börjeson, et al., 2006). In each of these scenarios, the following questions can be discussed with regards to what a user want to pose about the future. The questions are the following; "*What will happen?", "What can happen?" and "How can a specific target be reached?".*

To obtain a distinct scenario, it is of importance to investigate two additional factors (Börjeson, et al., 2006). The first factor is the concept of *system structure*, which means the connections and relationships between different parts of the system. In addition to this, the boundary conditions, which sets the requirements for a system, should be involved. Continuing, the second important factor to investigate is the distinction between internal and external factors. Internal factors are controllable by the actor in the question while external factors are not controllable, i.e. they are outside the scope of influence of the actor.

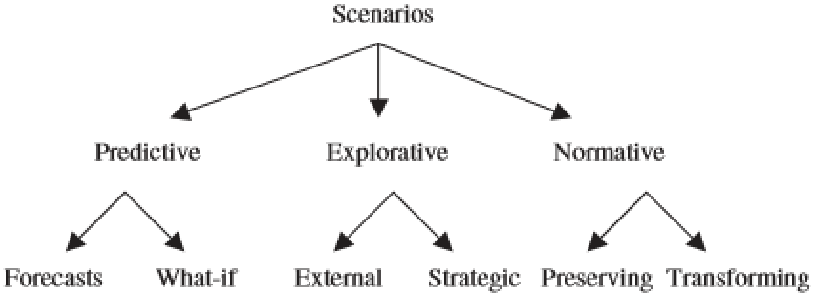


Figure 3.5 Scenario typology with three categories and six types. (Börjesson, et al., 2006)

The aim with *Predictive Scenarios* is to try to predict what is going to happen in the future (Börjeson, et al., 2006). Concepts such as probability and likelihood have a close relationship to predictive scenarios since trying to estimate what will happen in the future has to relate to some kind of likelihood of different outcomes. *Forecasts* is one of the scenario types in the *predictive scenarios.* A *forecast* is made to see what will happen if the most likely development unfolds. The result from a *forecast* may turn into a reference, with an upper- and lower bound, indicating a span. The second scenario type is "*What-if"* scenarios which aims to investigate what will happen on more specified near future events. A *"What-if"* scenario can consist of both external and internal events or just one of them.

The aim with *Explorative Scenarios* is to find situations or developments which are possible to happen, from different perspectives (Börjeson, et al., 2006). Often, a lot of different scenarios are investigated and analysed in order to broaden the scope of possible developments. These scenarios are based on long time-horizon, to allow for more structural and profound changes. Explorative scenarios have often their starting point in the future, compared to "*What-if*" scenarios, which often starts in the present. External scenarios are one of the scenario types in e*xplorative scenario* and focus only on factors beyond the control of the relevant actors. The external scenarios are typical used to enlighten possible strategy development of a planning entity. Due to the broad scope of exploratory scenarios, these scenarios can be produced with a rather broad target group. Further on, strategic scenario is the second type of explorative scenarios. The overall aim with these scenarios is to describe a range of possible consequences of strategic decisions. All strategic scenarios are based on internal factors, i.e. factors that the actor can affect, thus external aspects can be included.

The final scenario type is "*normative scenarios"* which consist of preserving scenarios and transforming scenarios (Börjesson, et al., 2006). The overall aim with *normative scenarios* is to find out how a specific target can be reached in an efficient way. In order to do this, both optimising models and qualitative analysis can be used. The first type, preserving scenarios, investigates how targets can be reached, by adjustments to the current situation. The second type, transforming scenarios, investigates how targets can be reached when the prevailing structure blocks necessary changes in the system.

3.5.Simulation

Location problems are often solved with optimization. To test if the solution is feasible, simulation is often used (Persson, et al., 2013). The design of the location problem can be illustrated in a dynamic environment with a simulation and tested with a stochastic behaviour.

Facility location problems are usually solved by using mathematical formulas to optimize location based on flows. Simulation is often associated with optimization where solutions are being tested repeatedly to establish a statistical certainty. Daskin (2008) divides location models into subgroups of analytical, continuous, network and discrete models. Analytical and continuous models allow for locations to continuously float in space with a demand given by a continuous distribution. In network models, facilities can only be placed on fixed nodes with links with demand tied to the nodes (Daskin, 2008). The discrete location models are divided into two additional groups, covering-based which aim to cover all customers within some time limit (e.g. healthcare facilities and telecommunications) and median-based which are often used when distribution is essential and weights the demand and locates the facilities close to large customers (Persson, et al., 2013).

Simulation models are often constructed to verify and illustrate a logical pattern for the optimization problem. A simulation can treat both dynamic problems with continuous varying inputs and stochastic problems. The advantage is that the solution is tested in a dynamic environment and possibly at a higher level of detail with variability in input values and executed for a period of time (Persson, et al., 2013). The simulation based models are often discrete-event continuous-time models, which, in opposite to a discrete-time model treats time as a continuous variable and are more suitable for logistical optimization problems. In the simulation model, separate entities can be separated and changed and will affect each other in a way that a logical supply chain would do. To grasp the full spectra, network planning (section 3.3) is used to map the different objectives and performances within the supply chain.

3.6.Blockchain technology in the supply chain

This section will give insights in what blockchain technology is and how different firms have used the technology.

3.6.1. General about blockchain

The blockchain technology is a fairly new technology (introduced 2008), mostly famous for being the underlying technology for the cryptocurrency Bitcoins (Kshetri, 2018). However, supply chain, power and food/agriculture are three areas that are expected to use the non-financial applications of blockchain technology in a broader spectrum, as they arguably fit with blockchain technology. Further on, technologies such as radio-frequency identification (RFID) tags, sensors, barcodes, GPS tags and chips, will make it easier to locate and track products throughout the supply chain. This possibility will develop a thirst for secure methods for confirmed identity in IoT applications. With this in mind, one of the great benefits with blockchain technology is its ability to identify important features (Alam, 2016). With the blockchain technology, one can identify who, where and when the activity is performed.

One goal with using blockchain technology is to eliminate the middleman, to work more efficient and to reduce the costs (Koetsier, 2017). Different intermediaries such as lawyers, brokers and bankers might not be necessary anymore (Iansiti and Lakhani, 2017). Instead, individuals, organizations, machines and algorithms will interact and work together with little friction, which is a great potential with the blockchain technology. Further on, once input tracking data are put on a blockchain technology ledger, they are immutable. This means that more stakeholders in the supply chain have access to the information, e.g. suppliers can track shipments, deliveries and progress. In figure 3.6, five basic principles are illustrated to introduce how blockchain technology works in a general way.

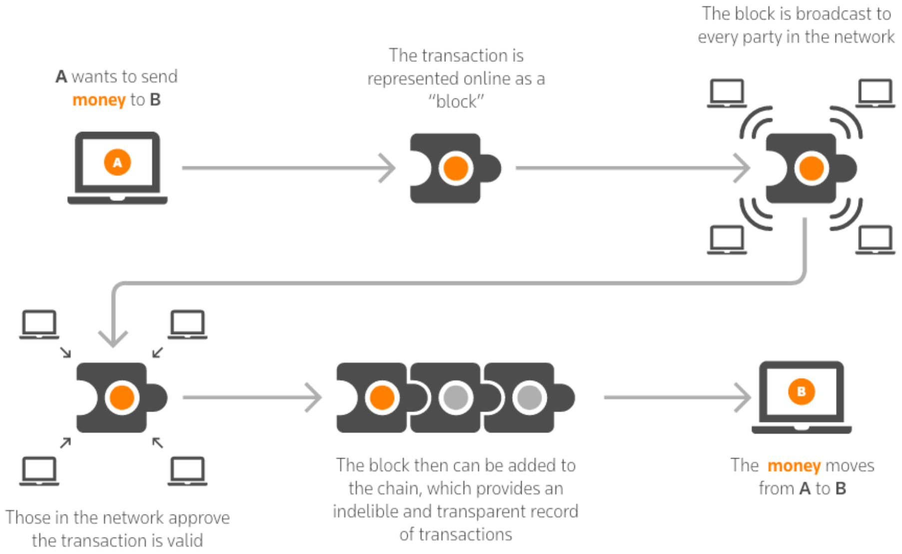


Figure 3.6 How blockchain technology works described in 5 basic principles. (Financial times, 2015)

3.6.2. Benefits with blockchain

Blockchain technology can improve the supply chain management of a company in several ways. First of all, it can improve transparency and accurate end-to-end tracking (Abeyrante & Monfared, 2016) (Deloitte, 2017). From doing a consumer's survey, more than 90% of the participants listed food product transparency as a crucial factor that impact consumers purchases. Due to this, the consumers expect manufacturers to provide information regarding origin and how the food has been handled. In addition to the importance of transparency for consumers, it was also discovered that approximately 55% or more would pay an over-price for services from companies promoting social responsibility (Deloitte, 2017). With the blockchain technology, it is possible to interconnect physical assets through digitalization and enable tracking of the assets, from production to delivery. This improves the transparency and increases the visibility, both to businesses and consumers.

Deloitte (2017) argues that blockchain technology could help businesses reduce counterfeit. By introducing blockchain technology, a company could understand how ingredients and finished goods are handled throughout the whole supply chain, from subcontractors to end customers. The reduction of counterfeit will reduce the loss of profit and the confidence from customers will increase.

Continuing, Deloitte (2017) and Abeyrante & Monfared (2016) argues that blockchain technology can increase the control of outsourced contracted manufacturing. The introduction of blockchain technology will provide each party within respective supply chain the access to identical information. This can lead to reduced communication- and transfer data errors, which in turn will lead to less time spent on validation of data. Hence, more time can be spent on producing goods and delivering services - improving quality or reducing costs, or both.

Finally, the use of blockchain technology can make the administrative processes more efficient which will reduce costs (Deloitte, 2017). By introducing blockchain technology, the processes that involves manual checks for compliance or credit purposes, which could take weeks to audit, can be accelerated by using a distributed ledger of all relevant information.

Figure 3.7 Benefits with blockchain technology (Deloitte, 2017)

3.6.3. Key success factors for introducing blockchain

The blockchain technology is still a unmatured technology, thus it is continuously improving and new potentials for the technology are being discovered (Deloitte, 2017). As it is today, there are four main factors that needs to be addressed in order to achieve an efficient introduction of the technology. Concerns regarding how to integrate the technology is the first factor. As an introduction of blockchain technology solution to a business require significant changes to or replacement of existing systems (i.e. it is easier with less existing systems), it is of importance to have a long-term mindset at an early stage. A company needs to identify transition requirements for systems required to support blockchain technology adoption at an early stage, as this will make the integration of the technology smoother.

The second factor for successfully introduce blockchain technology is the digitalization of products and services (Deloitte, 2017). Blockchain technology requires tagging of products digitally which can increase the work burden for the supply chain. In order to decrease the work-burden, it is important to incorporate a strategy at an early stage on how to physically track objects. In addition to this, a company should start with the digital tagging at an existing supply chain in order to prepare the business for the implementation of blockchain technology.

The third success factor is the importance of finding a suitable blockchain technology solution provider (Deloitte, 2017). As there still are cybersecurity breach concerns with blockchain technology, it is of great favour to use the knowledge from an expert and work together to ensure security and that privacy needs are satisfied as well as other concerns a company could have, regarding the use of blockchain technology.

The final success factor for a successful introduction of blockchain technology, is to socialize the idea of blockchain technology in the company (Deloitte, 2017). As blockchain technology is a new technology, it will lead to different changes in the company. The trend of going from centralized to decentralized network is significant with using blockchain technology, which will affect the whole company. It is important to include all stakeholders at the company, both employees and external parties. In this way, the adoption risk could decrease as well as the excessive costs an implementation could mean.

Figure 3.8 Key success factors for introducing blockchain. (Authors design, 2018)

3.6.4. Blockchain case at multinational companies

Multinational companies such as Maersk, Provenance and Alibaba have tried the blockchain technology (Kshetri, 2018). This section will illustrate how these companies have applied blockchain technology into their supply chain.

Use case 1: Maersk

A.P Möller Maersk is the largest container carrier company in the world, with a market share of 18 to 20% (Kshetri, 2018). They have successfully introduced the blockchain technology in an attempt to reduce the tremendous paperwork with each container. With the technology, the company could track its shipping containers around the world. In addition to locating the containers, they were also able to measure the temperature in each container as well as other conditions.

Use case 2: Provenance

Provenance is a platform that empowers brands to take steps toward greater transparency by tracing the origins and histories of products (Provenance, 2018). The company started a pilot project in Indonesia to increase the traceability of tuna in the fishing industry (Kshetri, 2018). The project was successful. Provenance managed to track fish caught by fishermen in Indonesia for the first six months of 2016. They did this by using mobile phones, blockchain technology and smart tagging.

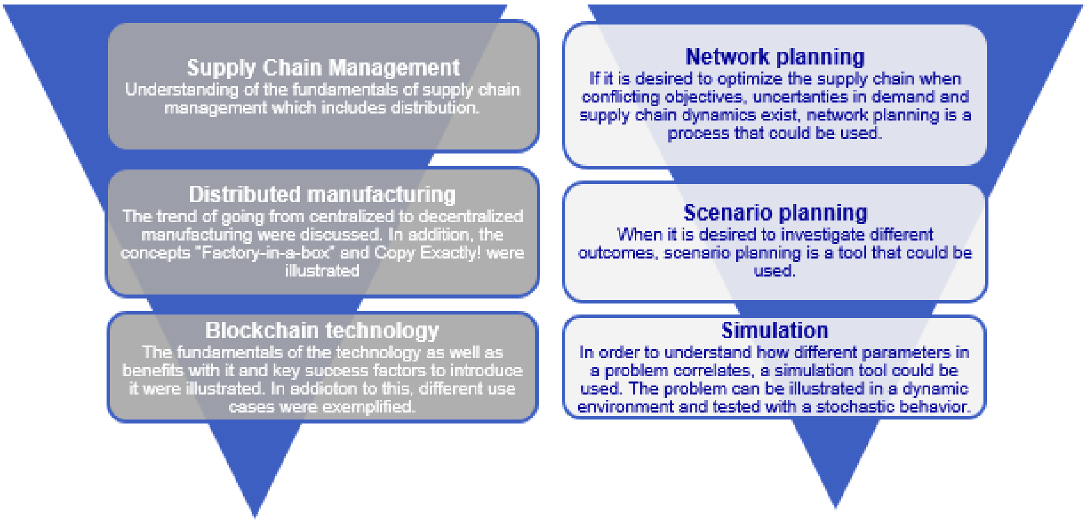
Use case 3: Alibaba

In order to fight food fraud (selling lower quality foods often with counterfeit ingredients), Alibaba got allied with AusPost, Blackmore and PwC to explore the possibilities of using blockchain technology as a technology to reduce the fraud (Kshetri, 2018). The aim for the companies was to conduct a “Food Trust Framework” that would increase the traceability and integrity on the global supply chains. They are still working to develop this pilot blockchain technology solution model, which would enable participants throughout the whole supply chain to use the model.

Conclusion of the case studies

The overall aim in each case study is to make the the supply chain more secure and transparent (Kshetri, 2018). The four cases shows insights made within the field of blockchain technology in different industries. The key insights are that whether the purpose is to apply blockchain technology deep in the organisation as *case 1: Maersk* or to fight fraud as in *case 3: Alibaba,* there are multiple possibilities to integrate blockchain technology to an existing function (Ibid).

3.7.Frame of references



Supply Chain Management
Understanding of the fundamentals of supply chain management which includes distribution.

Distributed manufacturing
The trend of going from centralized to decentralized manufacturing were discussed. In addition, the concepts "Factory-in-a-box" and Copy Exactly! were illustrated

Blockchain technology
The fundamentals of the technology as well as benefits with it and key success factors to introduce it were illustrated. In addioton to this, different use cases were exemplified.

Network planning
If it is desired to optimize the supply chain when conflicting objectives, uncertanties in demand and supply chain dynamics exist, network planning is a process that could be used.

Scenario planning
When it is desired to investigate different outcomes, scenario planning is a tool that could be used.

Simulation
In order to understand how different parameters in a problem correlates, a simulation tool could be used. The problem can be illustrated in a dynamic environment and tested with a stochastic behavior.

Figure 3.9 Summary of theoretical framework. (Authors design, 2018)

A summarization of the literature review was established and it is illustrated in figure 3.8. The literature review is divided into two different areas, where one includes *Supply Chain Management, Distributed manufacturing and Blockchain technology*. The second area includes *Network planning, Scenario planning and Simulation.* Supply chain management is the broad scope of the thesis and is narrowed down to distribution and distributed manufacturing. From this, network planning is complementing the study with how different conflicting objectives could be overcome. To try different possibilities of solutions for a distribution network, the study is being complemented with scenario planning perspective, which makes it easier to build different scenarios. These scenarios were then applied in a simulation model. On top of this, blockchain technology is following a thread from supply chain management to distributed manufacturing, where the theory of blockchain technology should try to give insights of how to use it throughout the supply chain.

4. Empirical findings

In this chapter, the case company and project, which the thesis has been conducted in collaboration with, will be presented. Insights and findings from interviews, workshops and archive analysis at the MNC is described. In accordance, the MNC´s existing knowledge and work done with blockchain technology is presented.

The empirical data collection for the case study presented in this chapter is divided into different parts to create a logical presentation of gathered information. Initially, section 4.1 will describe the existing network of the MNC at market. Data regarding the capabilities and limitations of the current supply chain and to what extent it can be applied will be further discussed. This section will also cover the environment surrounding the project and how it will have an impact on DPP. Section 4.2 will present the scope within the MNC where focus will be on the DPP. A description of the project will follow together with a projection of how it will develop further on. Section 4.3, will present the supply chain of the DPP in order to explain how the authors have interpreted the supply chain in section 4.4. Section 4.5 will briefly describe the model and what data has been used in the simulation model. A more accurate explanation of what figures have been deducted and what assumptions have been made will be described here.

4.1. Introducing the MNC

The MNC operates in the business to business (B2B) market. The MNCs customers are other manufacturing companies (from now on referred to as intermediaries) which in their turn have consumers as customers. The MNCs products are available in more than 175 markets worldwide divided into five geographical clusters. The MNCs business, focuses on manufacturing of large industrial machines and consumption material for the machines. Next to the manufacturing, the MNC handles service of the machines. This thesis has been conducted for a department within the Europe and Central Asia cluster, more specifically within the

Development and Service Operations (DSO) organisation as can be seen in figure 4.1. The DSO work across multiple clusters with a central unit, meaning that projects can range over several clusters but origin from the Europe and central Asia cluster. The case study targets a distributed plant project at the MNC, abbreviated as DPP at an emerging market denoted as the market.

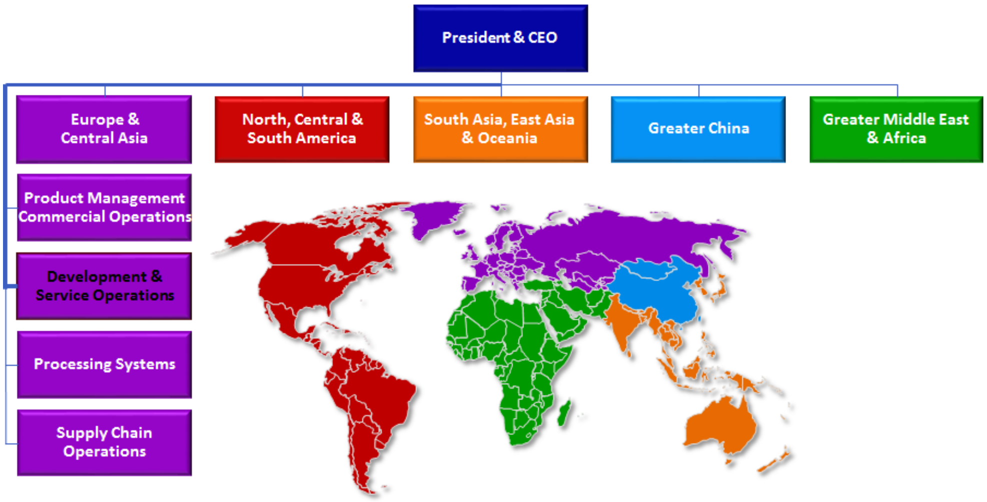


Figure 4.1 The MNCs geographical organizational chart (Authors design, 2018)

4.1.1. The MNC at the market

The MNC is today present at the market with a larger production facility. The main production facility will from here on be called PF. PF is the company's second largest site overall, spread over an area of 180 000 m^2, with a provision to double its existing capacity (*information from the MNC´s internal database*). The state-of-the-art facility is the main facility where everything entering the DPP market will pass through and if necessary, be refined at. This means the first part of the distribution network at the market will be the PF.

Today, PF is supplying material to more than 30 markets and is expected to meet increased demand, due to an upscaling of DPP. Basically, the MNC´s business is to sell machines to the intermediaries for an initial onetime cost and then, arrange with service agreements and continuously sell the consumption material on a running basis to enable the intermediaries to create the consumer products for their customers.

4.1.2. The market

The market is the world's largest market both regarding producing and consuming the consumer product with an industry value of 62 billion euros in 2016 (*Market research done at the MNC)*. As the largest actor in the world, the MNC´s presence at the largest market is highly valued. Penetrating the market has for a long time been difficult for the MNC along with other international competitors due to the markets cultural and social beliefs. The market tends to value point of origin of the product over price of the product which has been investigated by the MNC by looking at local consumers at the market.

The market investigations have been conducted by local employees of the MNC showing favourable results for the product and market. The result showed that the market clearly is underpenetrated by organized players and highly dominated by local actors. The product differs from the local and unorganized producers as the organized producers package and quality tests the products before distributing it to the stores whilst the local producers distributes the raw product. For simplicial reasons, the local distributors will be called unorganized actors. Figure 4.2 shows how the distribution idea differs between the organised and unorganized actors. The unorganized producers have, for a long time, been struggling with margins to supply the products to consumers. They have switched from producing the product to alternative products, reckoning that organized actors will conquer the market according to studies (*Market research done at the MNC*).

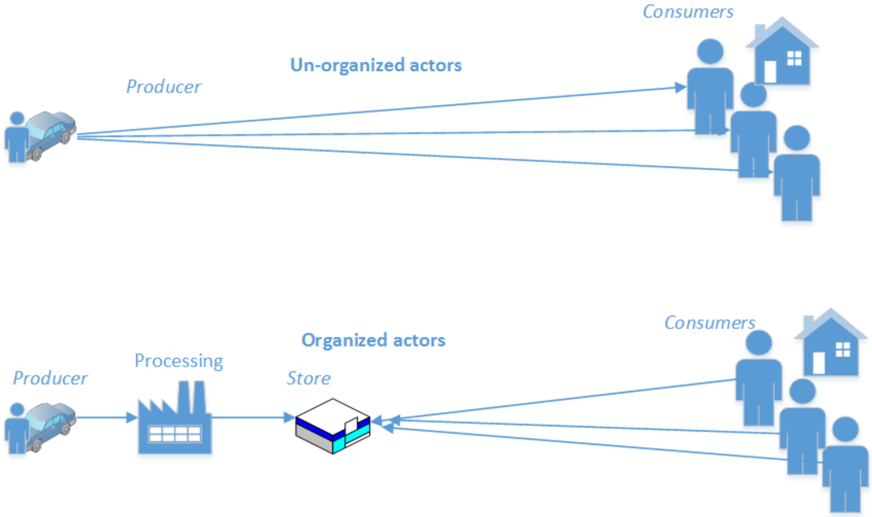


Figure 4.2 Difference between the organized- and unorganized actors. (Authors design, 2018)

The DPP have had a trial period to get a chance to test the concept on the market. Manager Systems Engineering (2018) highlights the importance of understanding the market before entering in a larger scale. By reviewing the advantages for large companies to enter markets quick and sizable, taking advantage of the economies of scale is theoretically profitable. However, he states that too often this ends up in losses since the company cannot adapt to the market. The idea of distributed plants evolved from using the competence and resources from the MNC together with local entrepreneurs' knowledge of the market. Following this paragraph, a description of the DPP will be further introduced.

4.2.Distributed Plant Project (DPP)

The distributed plant project (DPP) started off as a market entry idea at the market for the MNC. Based on the knowledge of some less successful attempts to establish a position at the market, the MNC wanted to find new ways to enter the market. The DPP has been ongoing for approximately 5 years and is now entering something called generation 1, leaving generation 0, the first plant, behind. Generation 1 involves a steep upscaling of the project with several new distributed manufacturing plants. The idea behind distributed plants is that processing is done by the producer of the product. Ordinarily the machines are sold by the MNC to intermediaries who process the product which they in their turn receive from other producers. Basically, the aim with DPP is to co-own machines and plants with local entrepreneurs of whom collect the product and sell it to stores. By doing this, the MNC can use existing industrial knowledge and gain knowledge from local entrepreneurs about the market, together with risk diversification between the actors. When the MNC distribute and de-locate the plants, they will automatically be located nearby customers and not be obliged to build large manufacturing facilities everywhere to meet demand.

4.2.1. DPP future roadmap

The roadmap has been introduced earlier and is important in order to fully grasp the width of the project and where this master thesis will fit in. The generation 0 (G0) is the first DPP plant at the market. The next generation, generation 1 (G1), is active and started mid-2017 and is expected to deliver 50 machines per year, starting year 2020, to different locations within the geographical market, see figure 4.3. Following the G1, G2 is initiated with a maximum of 100 machines per year. In total, over 1000 machines will be distributed during the coming 10 years. To coordinate the high pressure on the logistics for the DPP, a supply chain will be introduced in the next chapter.

Due to the short timeframe and high implementation frequency where many plants should be built and ready to run in a short period of time, a well-functioning distribution network is essential. The future locations of the plants have yet not been decided because the MNC wants to observe the response and demand from the market. The uncertainties of locations complicate the process of developing a distribution network. Many aspects such as distance, infrastructure and volume etc. should be taken into account when designing a network. To predict future events, with the ability to vary input variables as the DPP evolves and changes, different scenarios will be established.

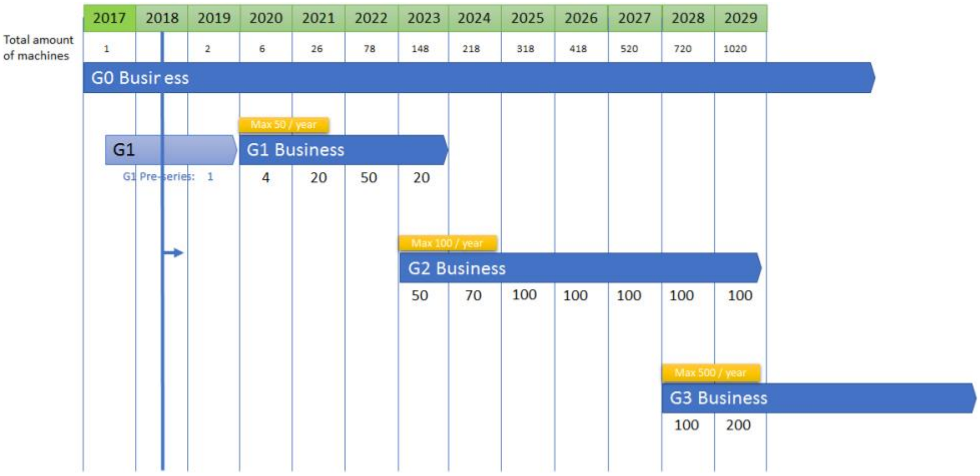


Figure 4.3 Time schedule of when to introduce plants at DPP. (Report at MNC, 2018)

4.3.MNCs supply chain in the market for DPP

The MNC is present on the market today, as they produce and sell goods there based on the original business concept. The overall breakdown of a supply chain for the DPP is illustrated in figure 4.4 divided into two "*Phases*".

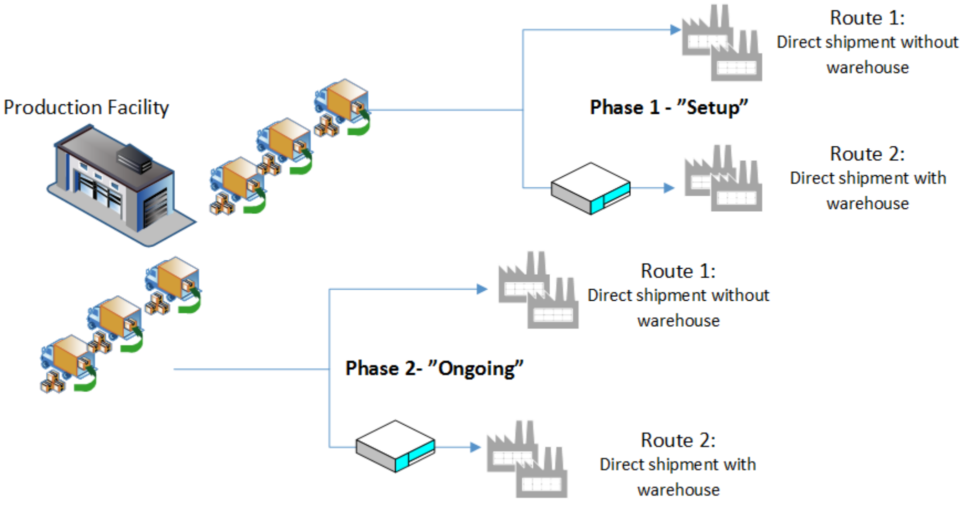


Figure 4.4 Overall supply chain for DPP. (Authors design, 2018)

PF

When the machines arrive to the PF, they are restored. At the PF, other materials that should be used in the ongoing business for the MNC, are produced and stored. All the materials which should be used in the DPP are produced at the PF. After producing and restoring machines, they are being stored together with consumption material. As it is today, they have been shipped to the DPP directly, see figure 4.4, Phase 2-Route 1. The shipments have been executed with trucks a few times per year, consisting of consumption material for one week of demand. When the shipped goods arrive to the DPP plant, they are stored on-site. There is a dedicated area for the incoming goods, which is handled by the plant owner. The machines and production equipment is shipped once for *Phase 1*, which also will be further explained in section “phase 1”.

Introduction to phase 1

This phase focuses on setting up the plant with machines and necessary production equipment. This phase is crucial in the beginning of the project as it affects the production at the new plant (Manager Systems Engineering, 2018). This is a reason why the company wants to investigate the possibility to introduce warehouses in the supply chain to store machines and other production equipment.

Introduction to phase 2

Phase 2 focuses on the ongoing replenishment of the plant and will be further discussed in section ‘phase 2’. Manager Systems Engineering (2018) argues that this phase will affect the DPP most as this phase will be done on an ongoing basis, thus it is desirable to investigate the possibility of setting up warehouses.

4.4. Situation at the market

The MNC has decided that the existing plant will portrait as a model for all upcoming plants. To make the illustration of the processes for each plant easier, two phases were established. These phases illustrate how the MNC is setting up a new plant and how the ongoing operations will be executed. These phases will be further described in 4.4.1-2.

4.4.1. Phase 1

Aim

To distribute everything to the DPP plants in order to build and make the plants carriageable.

Description

Phase 1 focuses on preparing the plant for production, i.e. setting up a plant. The plant is primarily assumed to be built by local contractors, with the aim to complete all necessary installations to make the plant run. To get the plant fully functioning, machines and other equipment which makes the plant run, will be sourced from the PF. The manager for the DPP, has calculated that in order to get all necessary material to the plant, a fleet of three large trucks (for size, see appendix A.3) are needed, hence no further calculations will be done. The transportation time from the PF to the plants will differ. Manager Systems Engineering (2018) says that the trucks the MNC are using are running with an average velocity of 30 km/h, due to the infrastructural limitations. As it is today, the MNC is using a 3PL for distribution of the machines on the market. This is done because, at this stage, the company do not want to make a large investment in the market. They believe that there are greater benefits in outsourcing the distribution. The plant is designed to store one week of safety stock and receive one week of material.

Transport

Mode of transport: Large truck(s)

Shipment frequency: Once/plant

Limitations

The phase is only done once per plant and is very resourceful, hence the size of the trucks limits the alternatives. This means, each time the actions for phase 1 are done, three trucks are estimated to go back and forth.

4.4.2. Phase 2

Aim

To provide the plants with consumption material and additional material for the ongoing production.

Description

This phase is about providing the plant(s) with consumption material in order to produce the products. In this stage, the material is being shipped from the PF with trucks. As it is today, the shipments are done on a non-persistent way, i.e. shipping is done when there is a demand. Today, the MNC has a 3PL taking care of all shipments and on average a half large truck is sent each time (Manager Systems Engineering, 2018). This is due to a low production rate at the plant. In some cases, the 3PL uses small trucks as well for the shipments. When the material arrives to the plant, it is stored at a dedicated area at the plant. As in phase 1, the plant-owner takes care of the handling of the material. However, for the future roadmap, a constant demand will be accounted for which is limited by the machines capacity at plant. This means that the sourcing of material from the PF will be limited to the capacity the plant can produce (see *Table A.2.1 Requirements for consumption material* in Appendix A.2).

Transport

Mode of transport: Small & large truck(s)

Shipment frequency: Once/week per plant

Limitations

In the thesis, the flow of spare parts will not be accounted for, even though it would be a natural part of this phase. Routing will not be a scope for this thesis, meaning that a truck probably would try to combine the route of two plants instead of going back and forth. This, however, is a possible extension to the result and model. A reason for this is the chosen size of the truck which is a limitation and therefore, a truck will not be able to bring one week of consumption to multiple plants.

4.5. Simulation model

4.5.1. Purpose

The purpose of the model is to support the MNC in decision making for sourcing and distribution with the DPP. The model contributes with a logical pattern in the design of the distribution network to use identified cost drivers. Initially, the primary goal with the model is to identify the inflection point for investing in one or more warehouses for the DPP´s supply chain.

4.5.2. Problem

The market encircles a geographically large area which challenges the current distribution network. By handling one or two plants, the distribution network will not be too complicated but adding a few hundred plants, minor changes can have large impact. In the model, few scenarios will be investigated by considering the impact of adding warehouses and how the warehouses could be designed in terms of size.

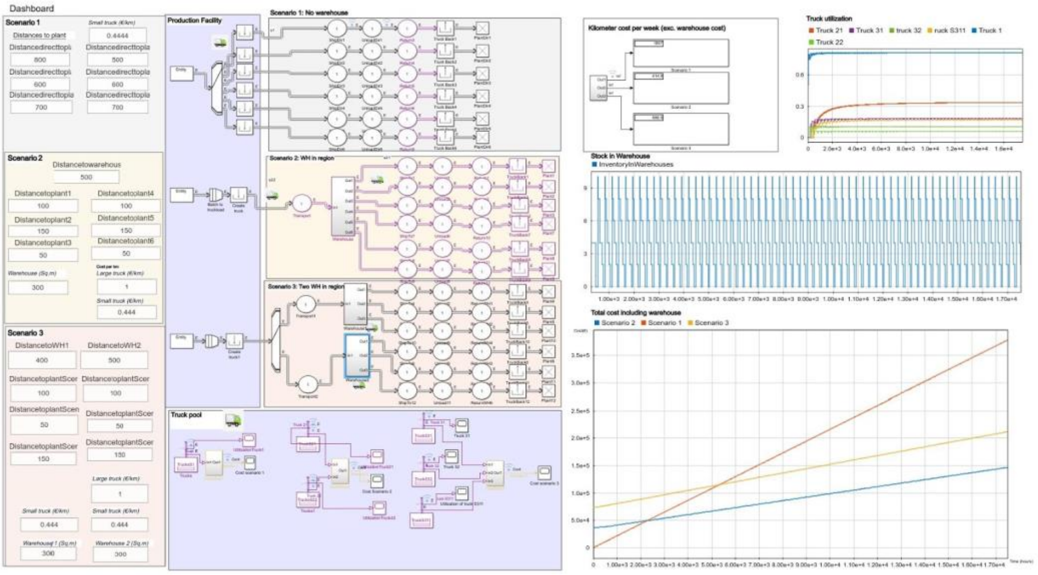
In the following section *4.5.5 Scenarios* the authors have presented the key requirements for the distribution network from the MNC.

4.5.3. The model

The model is a static model consisting of scenarios. The scenarios aim on capturing how warehouses have an impact on the distribution costs. The design of the model is as simple as possible for two major reasons;

1. The model should be intuitive to understand and illustrate a logical supply chain.
2. The model should be easy to replicate and reconfigure.

These two reasons are underlying requirements from the MNC in order for the MNC to use the model for future endeavours. Figure 4.5 illustrates the interface of the simulation model with dashboard, model and graphs.



Dashboard

Scenario 1

Distances to plant

Small truck (€/km): 0.4444

Distancedirecttopl: 800

Distancedirecttopla: 500

Distancedirecttopl: 600

Distancedirecttopla: 600

Distancedirecttopla: 700

Distancedirecttopla: 700

Scenario 2

Distancetowarehous: 500

Distancetoplant1: 100

Distancetoplant4: 100

Distancetoplant2: 150

Distancetoplant5: 150

Distancetoplant3: 50

Distancetoplant6: 50

Warehouse (Sq.m): 300

Cost per ton

Large truck (€/km): 1

Small truck (€/km): 0.444

Scenario 3

DistancetoWH1: 400

DistancetoWH2: 500

DistancetoplantScer: 100

DistancetoplantScer: 100

DistancetoplantScen: 50

DistancetoplantScer: 50

DistancetoplantScer: 150

DistancetoplantScer: 150

Large truck (€/km): 1

Small truck (€/km): 0.444

Small truck (€/km): 0.444

Warehouse 1 (Sq.m): 300

Warehouse 2 (Sq.m): 300

Figure 4.5 Snapshot of the interface of the simulation model with dashboard, model and graphs.

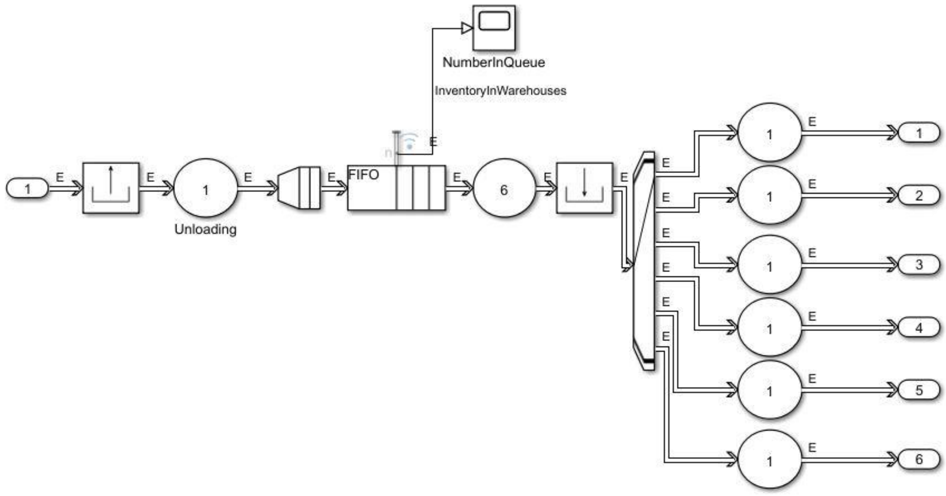


Figure 4.6 Subsystem for warehouse in scenario 2.

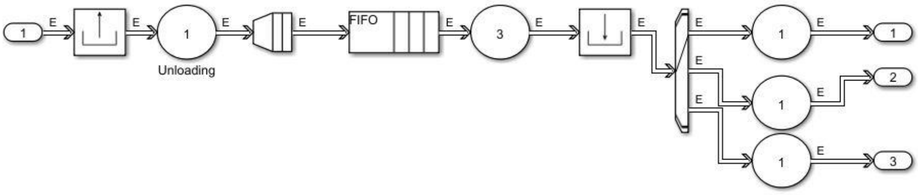


Figure 4.7 Subsystem for warehouse 1 in scenario 3.

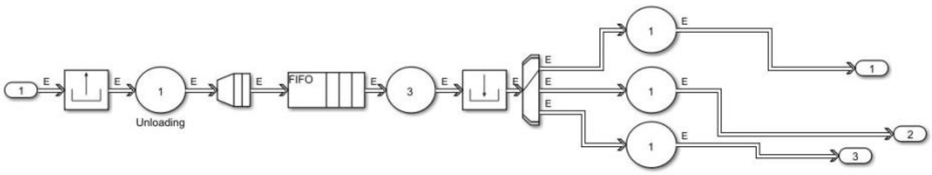


Figure 4.8 Subsystem for warehouse 2 in scenario 3.

Figure 4.6 represents a subsystem within *Scenario 2.* The subsystem corresponds to a logical warehouse where a truck enters, unloads products and puts it into storage and then returns. In storage, the products are stored according to the FIFO principle, meaning that the first products that arrive will also be the first to departure from the warehouse. After being summed, the products will be loaded to a new truck and driven to the chosen plant. The subsystems or warehouses in *Scenario 3*, which are illustrated in figure 4.7 and 4.8, works in the same fashion as the warehouse from Scenario 2, see figure 4.6, a truck arrives, unload products which is put into storage and then delivered to plants.

The model in figure 4.5 is an example of the simulation model for the distribution network with six plants. In the "*Production Facility*" box, the MNC´s PF is illustrated and is the first step of the distribution network. The simulation is creating "entities", which is occurring in the *entity creator* in PF. One entity can be whatever, one person in a queue or a truck load of material. The model is only interested in understanding one week of consumption, assuming that when the trucks are picking up one entity, it is pre-packaged as one week of consumption. One entity is therefore equivalent with one week of standardized consumption necessary to meet the demand for the plant.

Within the PF, still in the "*Production Facility*" box, three separate entity creators with the same distribution is created to generate identical scenarios. Below, an attempt to guide the reader through each scenario is being made. Keep in mind that the scenarios are similar in most parts. A larger example of the model, figure 4.5 exists in appendix A.5.

4.5.3.1.Scenario 1

One of the identical entities is being distributed in a time interval enabling each plant to receive one shipment per week. When the entity reaches the *splitter*, it is being separated in three alternative ways. What happens is that the *splitter* guarantees that the first shipment is sent to plant 1, the second shipment to plant 2 and so on. Assume this is the first entity shipped from the PF, it will be distributed to plant 1 in the *splitter* and accompanied with a truck. The truck is occupied for as long it takes to transport the entity to the plant, then to unload and finally travel back to the PF. This in order to ensure that an unlimited amount of trucks is not being used, and to observe the utilization of the trucks. The first circle defines the time it takes to drive the determined distance between PF and plant, divided with the speed of the truck. The second circle is the unloading time at the plant and finally, the third circle is the time, after the truck has left the plant, it takes to return the truck.

4.5.3.2.Scenario 2

This scenario differs from *Scenario 1* where the truck was expected to drive all the way from PF to plant. In this scenario, a regional warehouse is located at a strategic position, see 3.1.3.2 Gravity Location model, where an intermediate handling is occurring. The identical entity distributed from the PF is being batched together with more than one week of consumption and shipped to the regional warehouse where the consumption material is put into storage. The batch is accompanied by a truck which is driving back and forth between the PF and the regional warehouse, hence it is not being used in the distribution from the warehouse to plants. When the batch reaches the warehouse it is being separated, unpacked and put into storage. From the warehouse to the various plants the consumption material is being shipped as entities, still as one week of consumption in the same way as in *Scenario 1*. This means that it will be accompanied by a truck, delivered, unpacked and the truck returns.

4.5.3.3.Scenario 3

Scenario 3 is almost identical to *Scenario 2,* apart from having two regional warehouses instead. The truck from the PF will transport enough material to each of the two warehouses to meet required demand. In our model, this is half the amount required for one warehouse in *Scenario 2*. Otherwise, the theory of delivering, storing and receiving material is identical to *Scenario 2*.

4.5.4. Scenarios

From the created simulation model, different kinds of information can be measured. From utilization of trucks to capacity within the warehouse. The MNC has categorized what type of information is prioritized. Manager Systems Engineering (2018) argues that most information matter in some way, but basically it all boils down to the cost parameter because the project needs to be profitable. Apart from the cost, the MNC highly emphasize the sustainability and in particular the emissions generated in the distribution network. The two scenarios are therefore mainly focusing on identifying cost drivers and the payback time for the investments.

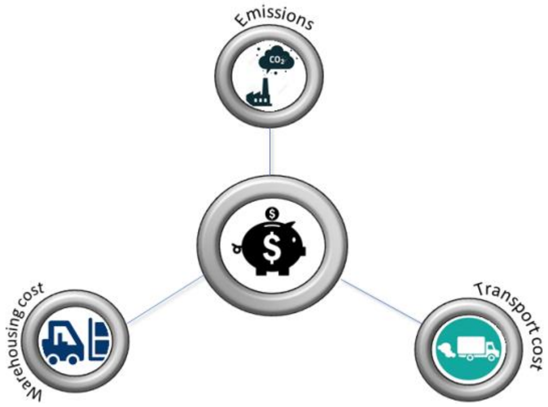


Figure 4.9 Cost drivers. (Authors design, 2018)

Together with the requirements from the MNC, scenarios have been constructed. The scenarios aim to show how changes in costs will affect the distribution network. To explain more thoroughly, the cost to convey a truck with one week of consumption one kilometre could be seen in appendix A3. This cost is depending on variables such as price of vehicle, consumption of fuel, etc. Depending on how this cost varies, *Scenario 1*, *Scenario 2* and *Scenario 3* can have different inflection points for when it is e.g. time to invest in a warehouse.

4.6. Blockchain at the MNC

This section includes the company's overall goal with blockchain technology, the current status of blockchain technology at the MNC and challenges and opportunities with blockchain technology at the MNC.

4.6.1. The company's overall goal with blockchain

The MNC believes transparency and traceability are important for the existing business, and by understanding how blockchain technology can be applied, enormous benefits could be attained.

Leader Innovation Capabilities (2018) and Systems Engineer 3 (2018) are confident that blockchain technology is one of the technologies that will revolutionize industries in the near future. Both argued it is of great importance to understand how blockchain technology can be applied to the MNC's businesses and that maximum gain will be achieved when implementing the technology throughout the supply chain. As of today, the main goal with blockchain technology for the MNC is to understand the capabilities and opportunities with the technology and where it fits into the current business. The immaturity of the technology extends the adaptivity within the industry because it is hard to trust new technologies. This is particularly the case when the technology allows transparency which can hurt the business. However, to be innovative and in the forefront of the development, the MNC work in cooperation with multiple partners to move further.

4.6.2. The MNC´s status with blockchain

The MNC has six employees working with blockchain technology, whereas three works on a daily basis and have been responsible of investigating blockchain technology since its introduction to the MNC. As of today, the company has yet not introduced blockchain technology on a large scale. However, the MNC is involved in an attempt to roll out blockchain technology on an existing market. The project aims to introduce smart contracts on a blockchain technology in order to increase traceability and transparency. Both Leader Innovation Capabilities (2018) and Systems Engineer 3 (2018) argues that traceability and transparency are important factors for the company's business. Hence, the MNC tries to find different ways of optimizing these factors.

The MNC has a started a collaboration with a large IT provider, which are also involved in the previously mentioned project, to further explore the potentials with blockchain technology. The MNC has participated in several workshops together with the IT provider, where they together developed business use cases for the MNC, focusing on how to introduce blockchain technology to the MNC´s business. Workshops combined with a variety of market contacts and collaborations is how the company is expanding its knowledge base of the technology. In addition to the workshops and other guidance from the IT provider, the idea is that the IT provider will be responsible for the installation of all blockchain technology within the MNC.

Like IT systems in general, the Leader Innovation Capabilities (2018) and Systems Engineer 3 (2018) claims that, implementing a blockchain technology onto existing systems is complicated. To have systems working on top of each other is manageable, but not optimal and that is why the project at the existing market is interesting due to its immaturity and low system integration. DPP is, similar to the project, even more undeveloped and will therefore be deeply in focus for the thesis related to blockchain technology.

4.6.3. Future of blockchain at the MNC

Leader Innovation Capabilities (2018) and Systems Engineer 3 (2018) argues that the introduction of blockchain technology will be carried out in a cautious way. They are both convinced that pilot projects are good ways of introducing blockchain technology and that is where DPP fits into the description. In the following section, future opportunities and challenges with blockchain technology for the MNC are stated.

4.6.3.1. Possibilities

From discussing with Leader Innovation Capabilities (2018) and Systems Engineer 3 (2018) there are three possibilities the MNC investigates now. The possibilities are called *business differentiation, marketplace utility and new market model* and these are further clarified below.

Business differentiation

Business differentiation is about finding ways blockchain technology can differentiate the current business to stay competitive. This segment focuses more on the internal use of blockchain technology and how it could optimize the internal work at the company. An example is if administrative work could be reduced by optimizing some areas with blockchain technology.

Marketplace utility

Marketplace utility focuses on finding opportunities for blockchain technology with regards to consumers and other stakeholders for the MNC. It could for example be to make contact between the MNC and consumers smoother or to make it easier to understand the customers' needs. Typically, traceability and transparency are desirable in this segment.

New market model

This segment is considering the use of blockchain technology to reach undeveloped markets with little to none existing IT infrastructure. In these markets, the MNC can, at an early stage, introduce blockchain technology together with their traditional systems. Further on, this segment focuses on reinventing new ways of how traditional tasks have been handled, e.g. how origin of perishables is being determined.

4.6.3.2. Challenges

To make the blockchain technology effective, it is of great importance to introduce and connect more stakeholders to the blockchain technology (Leader Innovation Capabilities, 2018). This is one of the crucial challenges for the MNC. Systems Engineer 3 (2018) further explained that the MNC is working on enlighten other stakeholders of the benefits with blockchain technology and how there could be symbiosis of using it, but the resistances and uncertainties are still large. It was further mentioned that a considerable factor to that was lack of trust amongst the stakeholders and that other stakeholders did not believe in the robustness of the technology yet. The difficulty to build trust along the whole supply chain makes the introduction of blockchain technology more difficult (Leader Innovation Capabilities, 2018).

Another challenge for the MNC with blockchain technology is the limited experience with the technology (Leader Innovation Capabilities, 2018). As the technology is in a maturing stage, it is difficult to predict costs and savings, whereas top management does not fully realize the opportunities or want to invest as much in it.

The final challenge with blockchain technology is the transformation, going from a small to a large implementation (Leader Innovation Capabilities, 2018). Due to the limited experience of blockchain technology projects, there is a large difference of going from a pilot project, where minor mistakes are acceptable, to making it run on a large scale. Systems Engineer 3 (2018) also argues that there could be infrastructural limitations through the supply chain, which could make an upscaling of a pilot project more difficult.

5. Analysis

In this chapter, empirical findings will be analysed against the theoretical framework. The analysis will follow a trajectory enabling the authors to form a recommendation using gathered data and theory.

5.1. Introduction

The introduction will give the reader a foundation explaining how the analysis have been conducted and the logical path that has been followed, this is important for RQ1. The analysis will be divided in four sections to answer the two research questions, stated in section 1.3.1. Initially, an introduction will explain some of the choices that have been made which lead on to *Phase 1* and *Phase 2*, both examples of analysis made early in the process. RQ2 is combining theory and empirical findings from the blockchain technology sections to conduct the analysis.

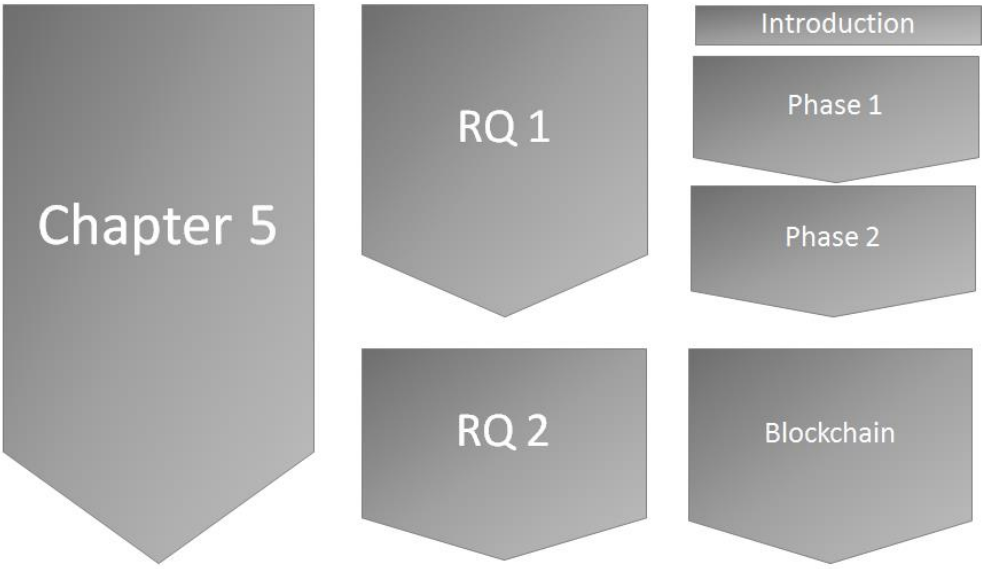
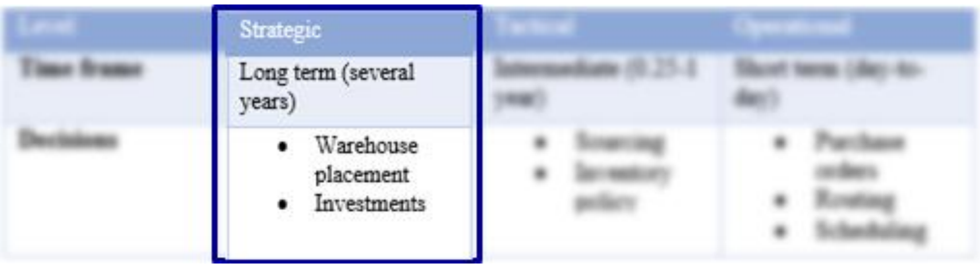


Figure 5.1 The general form of the analysis. (Authors design, 2018)

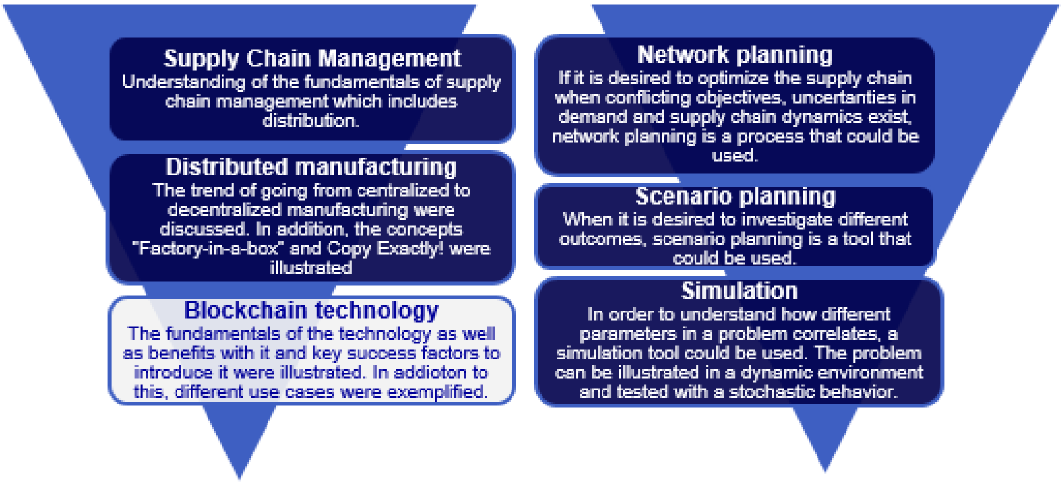
The strategic focus for the research questions has been present throughout the report. In table 5.1 (*copy from Section 3.4, Network planning*) the strategic decision model has been brought forward to remind the reader of the primary target of warehouse placement and investments from a strategic perspective.

Table 5.1 Part of decision levels table (Simchi-Levi, et al., 2003.)



Strategic
Long term (several years)
• Warehouse placement • Investments

RQ1 embraces the five theoretical areas highlighted in figure 5.2. The analysis will involve all these areas and connect them as the authors consider relevant. RQ2 is, in the same way, following a thread of highlighted theoretical areas shown in figure 5.3.



Supply Chain Management
Understanding of the fundamentals of supply chain management which includes distribution.

Distributed manufacturing
The trend of going from centralized to decentralized manufacturing were discussed. In addition, the concepts "Factory-in-a-box" and Copy Exactly! were illustrated

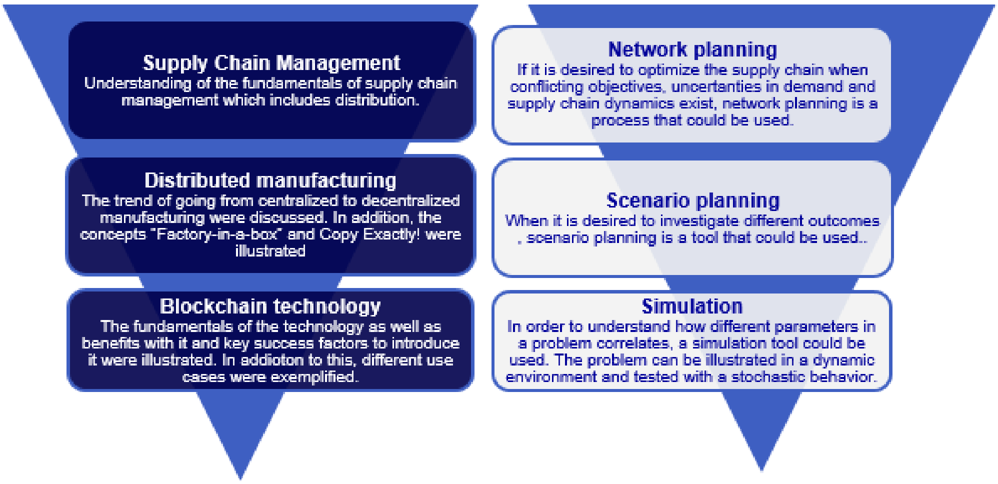
Blockchain technology
The fundamentals of the technology as well as benefits with it and key success factors to introduce it were illustrated. In addioton to this, different use cases were exemplified.

Network planning
If it is desired to optimize the supply chain when conflicting objectives, uncertanties in demand and supply chain dynamics exist, network planning is a process that could be used.

Scenario planning
When it is desired to investigate different outcomes, scenario planning is a tool that could be used.

Simulation
In order to understand how different parameters in a problem correlates, a simulation tool could be used. The problem can be illustrated in a dynamic environment and tested with a stochastic behavior.

Figure 5.2 Theoretical areas used in analysis for RQ1 (Authors Design, 2018)



Supply Chain Management
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When it is desired to investigate different outcomes , scenario planning is a tool that could be used..

Simulation
In order to understand how different parameters in a problem correlates, a simulation tool could be used. The problem can be illustrated in a dynamic environment and tested with a stochastic behavior.

Figure 5.3 Theoretical areas used in analysis for RQ2 (Authors Design, 2018)

5.1.1. Regions

The market, in which the MNC is expanding on, has been described as a large market. It is not an understatement, and because of the size, several assumptions have been made to cope with the geographical area. The authors have, in consent with the MNC, divided the market into regions. All regions will be based on the predefined assumption that necessary material will be provided from the existing production facility, PF.

The regions are assumed to work autonomously, meaning they are self-providing and will not consider other regions apart from the PF. This constraint is made solely for the simplification factor for the simulation model. Hence, it is a theoretical sectioning, in practice the MNC would probably do it without constraints.

The regions have been divided based on area and market size. The incentive to regionalize the market is to be able to present how many plants one warehouse shall provide for. If the thesis were to estimate the entire market in its whole, a lot of generalized assumptions had to be drawn which would create even more estimations than the regional option did. The market is also considered to be extremely segmented with heavy demand, spread out on different locations.

5.1.2. Scenarios

In figure 5.1, the general shape of the analysis has been illustrated. Both *Phase 1* and *Phase 2* are parts of the RQ1. To briefly remind the reader, *Phase 1* aims to set up a completely new plant from the ground to a fully functioning production plant. *Phase 2* on the other hand, aims on providing material for the ongoing production. Since *Phase 1* is fairly standardized in the sense that it will always require three trucks, see section 4.4.1, which will go back and forth without any intermediate handling. This means that the purpose of the thesis regarding warehouses and facility locations is inapplicable to this phase. Further analysis for this conclusion will follow in 5.2.1-3.

In *Phase 2* however, the ongoing distribution of material to the plants highly depends on where and if warehouses will be located, especially when expanding the number of plants. Therefore, this is the only phase where a simulation was considered necessary. The *Phase 2* simulation were divided into scenarios, with either no warehouse, one warehouse or two warehouses. The scenarios have a total of six plants, but are easily configurable to other amounts. From these scenarios, an attempt to find out how many plants an average warehouse should handle, will be done.

5.2.RQ1: How can the distribution network be designed for an upscaling of DPP?

RQ1 has been the preliminary focus for this thesis. The interconnection between the DPP at the MNC and RQ1 has been high and as the thesis progressed, changes were made continuously in the DPP which affected the thesis moderately. The continuous development in the DPP enabled the authors to get accurate up-to-date information.

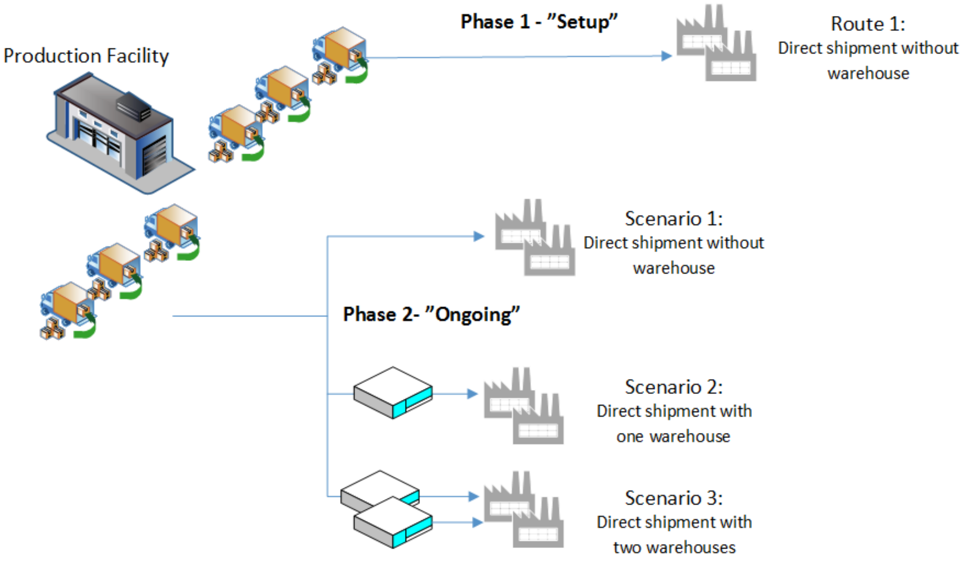

Figure 5.4 Phase 1 & 2 with additional concepts (Authors design, 2018)

Figure 5.4 illustrates how *Phase 1* and *Phase 2* differs and the three different concepts in *Phase 2*. The analysis will aim to capture the red thread by following the picture, starting with *Phase 1* followed by *Phase 2*.

5.2.1. Analysis: Phase 1

In the figure 5.4, Phase 1 is receiving necessary material from PF in order to establish a new plant. To distribute necessary machines and material to get the plant up-and-running, three trucks are needed. These trucks will only be departed once between the PF and the plant.

Phase 1 is different from Phase 2 due to its unpredictability. At this point, the MNC has yet not decided when and where to set up new plants, instead this process within the Phase 1 is bound to be a bit more spontaneous in the sense that if new opportunities arise within the market, the MNC wants to be flexible to meet the demand rapidly. A simulation has not been conducted for Phase 1 due to these circumstances.

The analysis will try to first explain what happens in the PF, and then follow the chronological flow of goods from PF to the plants.

5.2.1.1.Production facility

The production facility, PF, located at the market, is expected to initially meet the required demand from DPP. Early on, in section 4.1.1, the authors pointed out the possibility to expand the existing PF. The DPP heavily relies on the PF since it is supposed to provide the machines and manufacture the consumption material. Due to this large, rapid upscaling which DPP is facing, the authors have estimated an increased demand at PF directly related to the setup of the plants. By estimating how much resources are required for the DPP, the PF can be prepared for uncertainties. In section 3.3 *Network planning,* Simchi-Levi, et al., (2003) described the essence of planning to meet supply and demand in uncertain and volatile times in order to reduce unnecessary usage of resources. If the PF where to expand the space to meet future demand at this point, it would imply a risk that a lot of resources would be unutilized. In figure 3.3, Simchi-Levi, et al., (2003) further enhances the importance of network design in network planning by saying it is important to find the balance between inventory, transport and manufacturing. By roughly estimating the increased flow, the MNC can use the figure as a benchmark made on a few assumptions. Jackson et.al, (2008) describes factory-in-a-box concept as a standardized module, easily stored in containers and then transported, as a way to stay flexible and mobile to meet volatility. The factory-in-box concept is somewhat applicable in the sense that the MNC should aim to standardize the modules for Phase 1 as much as possible.

On a 10-year horizon, a maximum of 100 machines will be delivered per year as could be seen in figure 4.3 at section 4.2.1. Using the previous assumption that in order to transport a setup package, three large trucks will be needed, the same volume is assumed to be available in the PF. In appendix A1 calculations were made for the storage capacity needed to meet demand in the setup phase, only counting the volume for three large trucks. Based on these numbers, an estimation of monthly demand of volume was done, assuming that the machines in average will not be stored for more than a month, to a maximum space of 7500 m^2. In the context, PF is today 180.000 m^2, with a provision to double its capacity, which makes the DPP setup volume nearly negligible. Considering an expansion of the PF is not a concern if only using these numbers, since it is not fully utilized in this moment. However, in phase 2 an additional amount of storage will be requested for the ongoing demand.

5.2.1.2. Transport

The transport in Phase 1 is previously described as standardized in volume, but not in frequency. Estimating these costs is difficult due to uncertainties and how it will impact the foresight for the MNC. Delivering the material for the setup, the size of the trucks and how much one can transport, are bottlenecks and this will also prevent the possibility of doing multiple setups with one transport fleet, even if the plants are geographically close to each other. In appendix A3, an estimation of the transportation cost of large respectively small trucks per kilometre is illustrated. Included in these costs presumption that the MNC buys the trucks, despite the fact that the MNC uses a 3PL today. It is considered to be a useful benchmark deciding on transport option. The factory-in-a-box concept by Jackson et.al, (2008) with standardized modules, simplifies the transport and by applying that theory, the MNC can seize opportunities to optimize multiple stages in the supply chain, e.g. loading, unloading and transporting.

5.2.1.3. Plant

The plant is planned to be built by local contractors. In a logistical perspective, this means there will be less material to transport between the PF and the plants. The cost to build the plant is not included in the scope of this thesis and has therefore not been accounted for since the main purpose is to design and estimate the distribution network from a strategic perspective.

5.2.2. Discussion: Phase 1

Since the part of the purpose of this master thesis is to suggest if the MNC should invest in warehouses for an upscaling of the DPP in research question 1 in particular, Phase 1 is considered to be remotely out of scope. To have warehouses between the PF and the plants were reckoned to be a waste of resources and an additional unnecessary expense for the company. It was, in consent with the MNC, confirmed that the trucks will go from PF to plant without any intermediate handling. This is due to some reasons, where one is the uncertainties in where these plants will be located which means that all warehouses have to have extra storage area to meet these demands and also the challenge by unload and load the trucks at a potential warehouse. As a conclusion, no warehouses will be considered in this process. Due to the unpredictability, the authors together with the participants from workshop 1 did not find an objective to use a simulation model for this reason. As a side note, the MNC has been briefed how the model (*simulation model*) can be configured to fit this phase for future purposes.

5.2.3. Analysis: Phase 2

Planning how to provide the ongoing material for a yet not designed distribution network is a complicated strategic decision. Looking at the full supply chain, there are enormous number of parameters to consider from the PF to plants. Using the categorization made in table 3.1 (Simchi-Levi, et al., 2003) with varying time frames from operational-, tactical- and strategic decisions, different decisions are in focus. Due to DPPs time horizon, strategic decisions are most appropriate to consider, and therefore the purpose of the thesis is captured by investigating warehouse placement and investments. Unfortunately, the MNC are not aware of future locations for the plants, and therefore a simulation model was suitable in order for the MNC to simulate and configure it to the best of their intentions. In the introduction of the analysis, sections 5.1.1 and 5.1.2, the authors described that the first part of the analysis was made early in the process where the distribution network were identified and requirements were established. The requirement that all regions will be autonomous, meaning that it was much easier to quantify how many, if any, plants should be sourced from a warehouse, hence the market was then limited with geographical and technical constraints. The scenario section 5.1.2 was a further analysis made, going deeper into Phase 2, comparing scenarios with none to two warehouses with varying amount of plants. If the regionalization of the problem did not occur, the model would have to be able to consist of hundreds of plants. Figure 5.3 shows an illustration of the scenarios in phase 2. The figure is an example with two different plants and three scenarios.

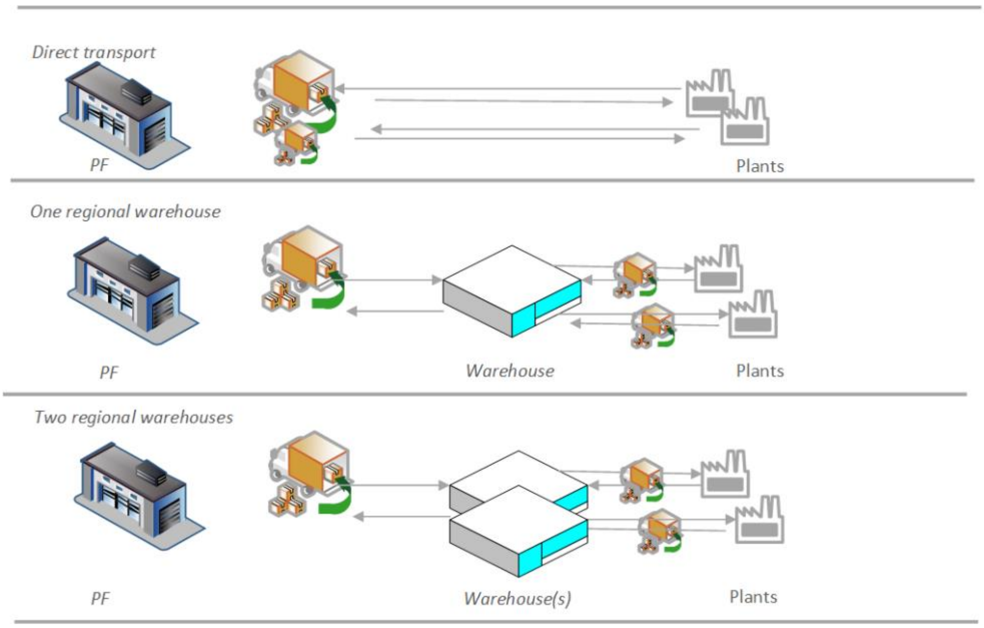

Figure 5.5 Illustration of analysis in phase 2. (Authors design, 2018)

5.2.3.1. Production facility

PF should be able to meet the demand from the ongoing Phase 2 in the upscaling process. The consumption material (i.e. rolls and consumables) will be manufactured and distributed from the PF to the plants, with an intermediate handling in between. The time necessary to manufacture the consumption material will not be accounted for. In figure 4.5, the number of rolls needed for one week of maximum production is 35 rolls. In appendix A4, two graphs have been constructed, showing how the number of rolls and corresponding volume will increase to meet future demand. The volume of rolls is difficult to put into context to understand, but what can be interpreted is that compared to the modest number of 7500 m^2 from ‘Phase 1’, the rolls will possess a volume of above 250 000 m^3 per week. Notice that the rolls have been analysed in cubic meters because they can be stacked on top of each other in contrary to the machines.

5.2.3.2. Transport

To plan transport in advance without knowing locations and distances makes it a predictive modelling scenario. With a steep upscaling curve, with plants widespread across a large geographical market, a thorough analysis of the supply chain and in particular the distribution network can generate substantial cost reductions according to Christopher (2011).

Today, there is one truck travelling more than 1000 km from PF to plant. If the number of plants would have been higher, this seems to be a resourceful process with possible improvement areas. Due to the large distances covered by the DPP, the transportation cost from the PF will increase dramatically if nothing changes. Implementation of regional warehouses is a form of decentralization where the MNC can have intermediate storage across the market, not solely rely on PF, which, according to Seregni, et al. (2015) is relevant in a risk diversification purpose as well as getting closer to customers (Rauch et al., 2015).

The trucks travelling time is calculated from the distance divided by the velocity. Due to the low average velocity of 30 km/h, transportation is a time-consuming activity. Since the model is static, no unplanned problems occur affecting the time, e.g. no service time, breakdowns, traffic jams and so on. Initially, figure 5.6 shows the utilization of the trucks for each scenario. Since the truck at scenario 1 could not meet the required demand, an additional truck has been added. The simulation is done representing two years of distribution.

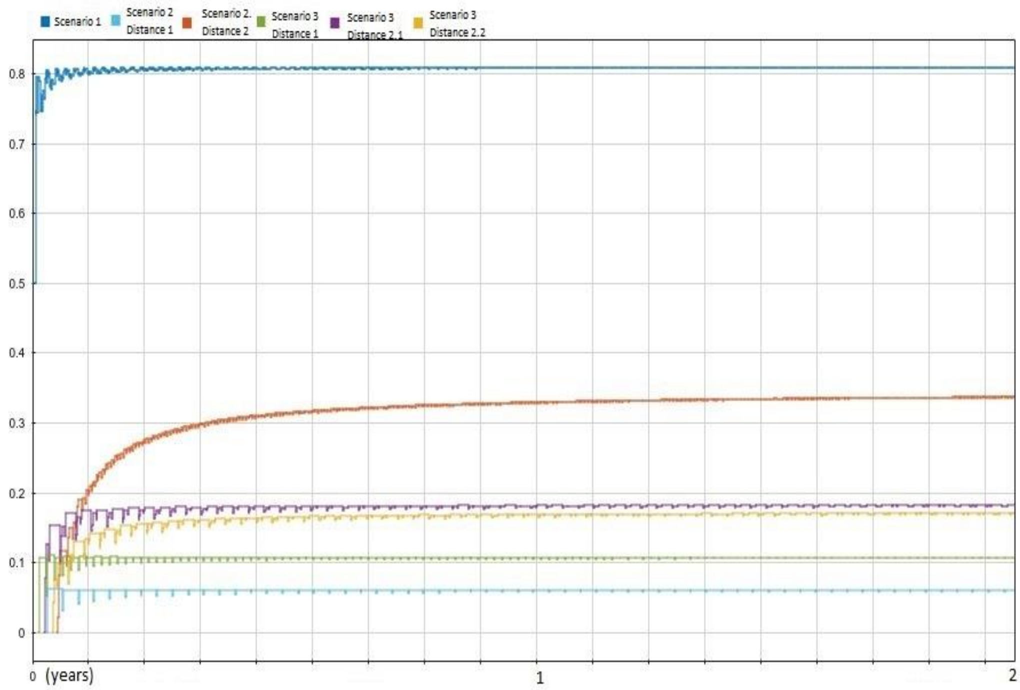

Figure 5.6 Truck utilization for two years

The truck utilization for all the different trucks in each scenario is accounted for in the graph. The curves are named chronologically based on which order they appear in the supply chain for each scenario, e.g. *scenario 3 Distance 2.1* is the truck from warehouse 1 in the scenario 3 to plants. Remarkable in the graph is that the utilization seems to be rather low for all trucks except for the truck in *Scenario 1,* whereas earlier mentioned, two trucks are needed to meet the demand. It is relevant to discuss that the demand is in a perfect environment where traffic jams, breakdowns etc. does not occur. This has partly been accounted for since the average velocity of the truck is 30 km/h. Bottom line is that a utilization of 80 % is relatively high for the trucks, and assume that one of the trucks needs maintenance and is not possible to use, then the utilization would increase to 100%.

Shifting focus to the other trucks with low utilization, they all have a few parameters in common. The trucks driving *distance 1* in Scenario 2 and 3 only drives one distance back and forth with ten weeks of consumption, and will then be standing at PF until it is necessary to provide more consumption material. According to the model, see figure 4.6, there are six plants which means that ten weeks of consumption will force the truck to leave the PF about every 10th day to meet the demand for the six plants. Basically, the truck travels the distance back and forth for approximately 30 hours every 10th day which gives the low utilization. The low utilization of trucks opens the debate for continuous use of a 3PL to handle the transport of material for phase 2. In this case, the authors counted with purchasing a truck and necessary costs it would involve e.g. depreciation, fuel, salaries. The calculations were made, assuming that the trucks would travel around 50000 km per year, and every km shorter will add to the cost per unit of distance. This is a motivation why it can be logical to use a 3PL to source material for a higher but stabile cost.

5.2.3.3. Warehouse

A warehouse is a large investment often made on a strategic horizon (Simchi-Levi, et al., 2003). Upscaling the DPP will involve transporting huge volumes of heavy material across a large geographical area. A common investigated way to minimize transport is to locate warehouses for storage of goods, between plants. Having warehouses closer to production does not only minimize transportation distances, it also creates a faster responsiveness to fluctuations (Shim, et al., 2008).

In the simulation model seen in figure 4.6, there are three warehouses in the supply chain. The idea of a warehouse is to store material delivered from the PF. By having a warehouse, the MNC can transport bulk of ten weeks of consumption from PF to the warehouse at once, and as can be identified in figure 25, the inventory will then decrease when material has been delivered to plants. Shipping bulk loads decreases the distances travelled and the question is if the cost of the warehouse is too expensive for the reduced transportation costs. If the decreased distance weights up the cost of setting up a warehouse with all relevant costs associated with the investment, then after a period of time, it would become more profitable to have a warehouse.

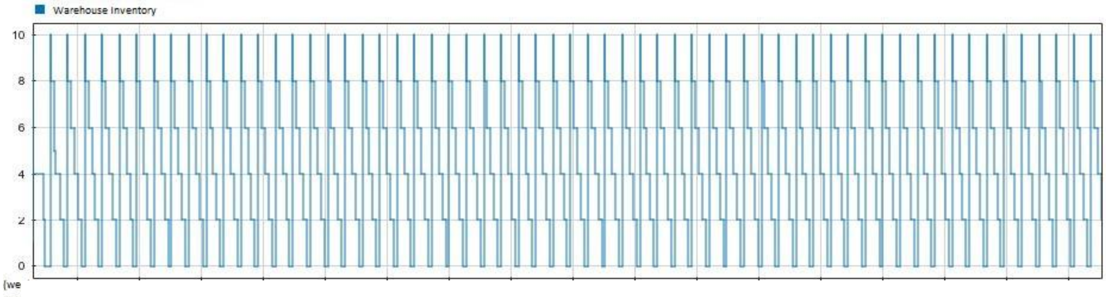

Figure 5.7 Warehouse inventory

Designing a new warehouse is a sensitive matter. Depending on the number of plants it should provide for, a certain amount of space is necessary. Deciding to build a larger warehouse than necessary with lower utilization in order to fill it up later on can be a strategic strategy, but also a costly and resourceful alternative initially. Due to variations in supply and demand, Simchi-Levi, et al. (2003) described the challenge of optimizing a supply chain and promoted scenarios and scenario planning as an effective tool. The scenarios in our model is mainly designed to analyse the cost, by changing distance, cost per km, number of trucks and warehouses, to find the most suitable alternative. In figure 5.7, a warehouse inventory graph is shown to visualize the steady flow of products in to each of the warehouses. The graph is identical in all three warehouses from Scenario 2 and Scenario 3. What happens in the graph is that ten weeks of consumption enters the storage in the warehouse, and each week six units of one week of consumption is departing from the warehouse, one to each of the six plants.

The figure 5.8 shows a graph, visualizing how cost changes over time for the scenarios. Chosen input data can be seen in Appendix A5. The first and second warehouse built in scenario 2, respectively scenario 3, have a setup cost combined with a lower transportation cost. From an analytical standpoint it is noticeable that chosen figures crosses the “scenario 1 cost” within a year. The authors consider this to be a very optimistic payback time, but not completely inaccurate with existing circumstances where everything flows optimally. In this case, a loss of income from not being able to use the warehouse in the setup phase is not accounted for but reckoned to be like the cost it takes to use scenario 1 but will not affect the time horizon significantly.

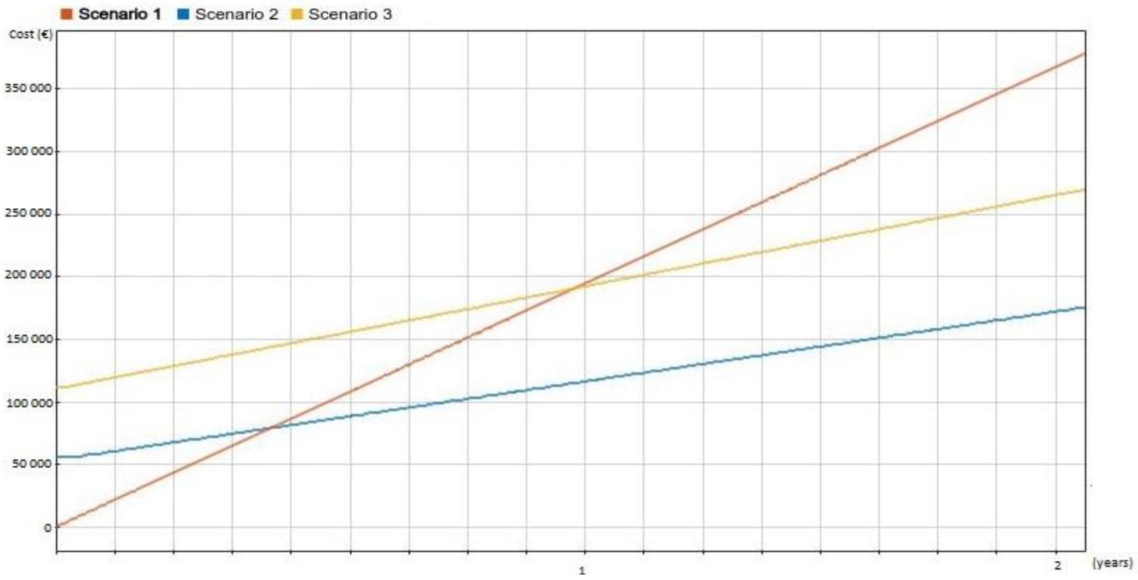

Figure 5.8 Cost over time for all scenarios

The implementation of warehouses will add additional costs for the MNC in order run the facilities. Next to the initial substantial investment, the running costs of maintaining the facility is nearly negligible in the context, but still accounted for in the model. Salaries is a minimal cost and does not change the time horizon noticeable even though both warehouses are equipped with five employees each. This is mostly due to the low salaries at the market.

Reviewing the input data to discuss the sensitivity of the output, some parameters have been touched upon. The variable costs consisting of salaries, electricity and maintenance did not account for a substantial factor to the bottom line. Altogether, the effect of the distance could be reviewed as a critical factor, and therefore where the cost per unit of distance a contributing factor with large impact. By changing the cost factor for the small trucks with 20%, the payback time decreases with approximately 25%. This is fore and most because the factor affects scenario 1 to a larger extent due to the large distance covered by the trucks. Moving on to the second to largest factor, the investment cost for the warehouses, it can be visualized in figure 5.8 that the impact between scenario 1 and the other two scenarios does not have a too large impact, since it has been earned through decreasing the travelling distances throughout a year. However, by comparing scenario 2 and 3 to each other, a difference is clearly pictured. Clearly, it is not worth having two warehouses covering three plants each, instead of having one warehouse covering six plants. With this information, it seems logical to continue investigating a scenario with x number of plants to see when a new warehouse is appropriable. Everything that have been mentioned in this paragraph highlights the fact that it all depends on the circumstances, especially the distances. To present a list, with estimated distances is therefore considered to be unnecessary and the reason why this simulation model has been created. The model enables the user, the MNC, to configure and reconfigure their given circumstances in order to suit their specific preferences.

The MNC highly promotes their engagement in sustainability and is therefore concerned about emissions from the DPP. Moving into a new market and spread CO_2 emissions is not something the MNC wants to be related with, quite frankly the opposite. The MNC wants to continue to do everything in their power to be more and more sustainable and is therefore having this as a requirement for the project. The emissions are, as mentioned earlier, deeply connected to the distance travelled by the trucks which leans towards scenario 2 and 3, but in these scenarios the emissions for setting up a warehouse have to be accounted for. Even if these emissions are a onetime occurrence, it is worth noticing and also in the choice between manufacturers in the emerging market.

5.2.3.4. Plant

The transport will, independent on chosen alternative, deliver one week of demand to each plant. Due to the large distances within the market, the MNC wants to have one week of safety stock and provide one week of consumption material with each delivery. From section *5.2.4.1 Transport*, the calculations showed that the rolls will be most resourceful in terms of space. The plant shall have space to fit 7+7 days of production, safety stock and weekly consumption, which is approximately 70 rolls (14 m^3) (see appendix A2). The safety stock of seven days might be considered high depending on what concept is chosen. Having storage at two separate locations, warehouse and plant, is an additional cost, and an unnecessary utilization of space.

The “Copy Exactly!” factory strategy by Intel has similarities with DPP. One similarity is how Intel faced the globalization and increased demand by designing their factories in an identical fashion to easily predict outcomes of failures. Having similar standardized design has earlier been advised for transport purposes, but as Montoya & Williams (2000) says it can also have an advantage in the production. The “Copy Exactly!” rose in the 1980s and is for that reason a bit old fashioned in the sense that new technology can help prevent some of these outcomes which were more difficult before. Examples are risk prevention which can be addressed with machine learning technology where the machines learn from themselves, and further prevent it from happening at different plants through cloud technology (ICT) or track and trace origin through blockchain technology. The conclusion of the paragraph is that similar design is applicable, even if outdated reasons does not apply, but new use cases are developed. This short analysis about new technology will be discussed further in the blockchain technology part of the analysis.

5.2.4. Discussion: Phase 2

The authors consider the simulation model to be a backbone for future refining, appropriate for a strategic decision support tool at this moment but with capabilities to be further enhanced, e.g. dynamic features, route planning etc. The simulation model is a generic tool aiming on providing a logical supply chain. The fact that a static simulation model has been built in a dynamic environment have created some minor unnecessary connections with the underlying program MatLab. These connections are unnecessary in a way, meaning that they could have been calculated in MatLab directly quite easily, but in order to use the dynamic environment and create an intuitive and visual model they have been connected back and forth between the softwares. This sounds more complicated than it in fact is, it just means that in this stage, the model does not use the full capacity from the SimEvents software. Since one of the objectives from the MNC was to be more acquainted with the software, this is a good way to understand the different capabilities and limitations with the software.

The static factor in the Phase 2 model differentiates the result from being a real problem with existing environment to being more of a logical model in optimal circumstances. Together with the participants at workshop 1 and 2, the authors have had an ongoing discussion if it is necessary to have a dynamic model to fill the purpose of designing the distribution network. Estimating statistical distributions for e.g. truck failures, road works and other problems, are simple to add in the model, but considered not to be of priority at this point, where the time frame of the master thesis was one reason why it was not implemented.

Routing of trucks is made from a very simplified way where they are assumed to basically go back and forth between the PF/warehouse to the plants instead of doing routing where several plants can be covered with the same delivery. In the earlier parts of the thesis, options of routing were investigated but also excluded because it is considered an operational factor colliding with the strategic purpose of the thesis. This was also confirmed by the participants in workshop 2. They believed routing was an optimization event and should be carried out at another stage.

The size of the trucks has also been considered as a constraint for two reasons;

1) The trucks that are transporting the equipment for the setup or Phase 1 is limited to three trucks, which is commented in section 5.2.1.2

2) the large trucks can only transport ten weeks of consumption material to the warehouses.

In the model, an estimated truck cost has been calculated, see Appendix A3. This cost can easily be changed but was calculated for the MNC to compare the cost of purchasing the truck and handling the transportation by themselves instead of outsourcing to a 3PL.

The robustness of the model is at this moment high due to the low number of parameters and links made. However, since the model can be configured from two systems, MatLab and SimEvents, data is transferred across multiple platforms and the robustness might be affected due to more decentralized data. The usability is a primary factor due to the expectation from the MNC to be able to use the tool after the end of the thesis. Therefore, the model is configured to be able to steer all variables from the visual interface.

Emissions is always a critical factor when designing a distribution network, and the DPP supply chain is not an exception. The MNC takes a lot of pride in being sustainable and want to strive to be even better. The carbon footprint for this thesis is mainly connected with the distances transported and the footprint for building the warehouse. A more thorough analysis has to be made to find the optimal option considering emissions, since there are more factors to consider than what has been reviewed in this thesis.

Further on, by entering emerging markets, the MNC could be seen as a role model for other companies. Even though the company's main purpose is to increase their market share at the market, they also create new opportunities for the society, in the sense that they are creating jobs and increasing the entrepreneurial spirit at the market by engaging with local actors. The MNC´s willingness to enter the emerging market could enlighten other companies of the growth potential at the market, making them want to invest at the market, which further could increase the standard at the market.

During the research and work with RQ1, focus on creating credibility through reliability, validity, objectivity and transferability has been persistent in the process. This paragraph will from an objective standpoint discuss the four criteria’s in RQ1. The study holds a high level of reliability for the MNC. Due to the large amount of data collection from archive analysis in comparison to number of interviews and other data gathering methods which are harder to replicate, the reliability is high. Hence, the DPP has a restriction, transparency of sources to external parties will not occur. Instead, the authors have tried to verify and validate sources internally and with supervisor from academia. The validity of the case study in RQ1 is considered high but can, according to Höst et. al, (2006), be verified through triangulation. The case study is being observed from a theoretical perspective with qualitative analysis and from a quantitative perspective with statistical measures through the simulation.

The authors believe this could be enough to verify the validity the study. The objectivity can, in the same way as the reliability, be analysed through the data collection. As the study got more quantitative, numbers and figures from the MNC, is assumed to be as accurate as possible. Inaccuracy in the numbers would only impact the MNC, and since it is not publicly shown, the authors have a high trust and confidence in the numbers. This leads on to the transferability, which in accordance to the previous comment in section 2.7.4 is low. The data and findings directly related to the MNC is strictly confidential and will be kept that way, but the contribution for academia will be published accordingly.

5.2.5. Framework for upscaling of distribution network

The step-by-step framework developed by the authors is similar to the fourth part of the general process for designing a global network by Chopra & Meindl (2004) in figure 3.2. The figure below (5.9) illustrates how determination of location is an essential parameter in designing a global network.

1) Determine location of plants.
2) Regionalize the market.
3) Iterate the locations with the simulation model to find an appropriate strategic investment strategy.
    a) Choose suitable parameters e.g. transportation cost, truck velocity, warehouse size, distance.
    b) Determine critical factors e.g. lead time, final cost, number of trucks etc.
4) Design the warehouse to meet a profitable number of plants.
5) Use the gravity location model to find the optimal warehouse location based on demand.

6) Reiterate the process.

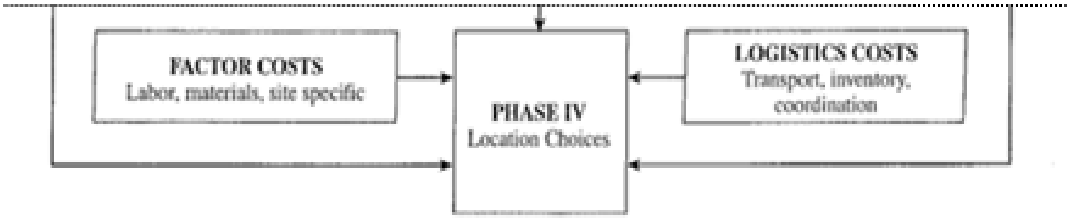

Figure 5.9 Part of a global network by Chopra & Meindl (2004)

5.3.RQ2: How can blockchain contribute to the DPP?

5.3.1. Analysis

The blockchain technology is an interesting technology of which many companies want to, or are in the loop of, introducing into their businesses. The MNC is not an exception, in the current situation, they want to increase the transparency and traceability in different business areas. The goal is to create a secure and safe supply chain where actions made are of an honest character, i.e. having a transparent and traceable supply chain. This is something that could be achieved with blockchain technology according to Deloitte (2017).

The MNC has limited experience of blockchain technology. Due to that reason, they have started a collaboration with a large IT provider with technical experience and knowledge of blockchain technology, to evolve their experience and knowledge. Deloitte (2017) argues that one of the key factors for introducing blockchain technology in a proper way is through establishing long-term collaborations with a blockchain technology solution provider. Hence, the MNC´s way of collaborating with the large IT provider is a good way to proceed with the implementation of blockchain technology to the MNC. The existing blockchain project is a first step for implementing blockchain technology to the MNC, which has been done in a controlled environment but still within the organisation. An additional idea has been to consider the possibility of implementing blockchain technology to DPP. DPP is a unique project due to its character of being nearly separated from the MNC but still with a plan to expand quickly. The environment offers the MNC to test blockchain technology within a basically newly established supply chain. Deloitte (2017) argues that one key factor for establishing blockchain technology is by introducing it to a project where there are no existing systems. With this in mind, DPP is a good environment as there are none, or nearly no, existing systems established yet

5.3.1.1. Three use cases for the MNC

In the following section, the authors along with Leader Innovation Capabilities (2018) and Systems Engineer 3 (2018) from the MNC have developed three use cases, to find ways of how the MNC could introduce blockchain technology to DPP.

Use case 1: Blockchain technology for tracking machines and spare parts

The MNC produces industrial machines. Even though the machines are made to work perfectly, there are always risks they will break or need service. In DPP, the machines are restored at the PF, hence spare parts could be added to the machines. A possibility could be to introduce blockchain technology and build a network for the machines. With the blockchain technology, information regarding e.g. specification for the machine, when spare parts were introduced and by whom, could be stored in the blockchain. In addition to this, activities such as services of the machines could be added, and from this, performance measures could be done. The machine owner could measure the performance of the equipment before a service and after, in order to see if any changes have happened. Tags could be placed on the machines which could enable the company to follow the machines and track the actions of it. The shipping company, A.P Möller Maersk (see section 3.6.2, use case 1) did an equal attempt where they wanted to track their shipping containers around the world, and they succeeded with the attempt, whereas they reduced tremendous paperwork with each container.

Pros:

1. As all machines will be tagged and logged to the blockchain, it will be easy for all stakeholders at the blockchain to control what is being introduced to the blockchain. In this way, it will be easier to identify if e.g. the right spare part is being introduced. This action can lead to minimized counterfeits as the origin of the spare part will be shown. As a lot of machine will be restored at the PF, it is of importance to introduce the right kind spare parts.
2. When introducing blockchain technology to all machines, the traceability of each machine could increase. As the equipment will have a unique identification from adding tracking IDs on them, it will be easier to trace where the equipment is in the supply chain. As the DPP aims on an upscaling from one plant to approximately 1000 plants, it could for example mean that the number of spare parts introduced to the machines could be of a large volume. For the company to have control of all spare parts introduced to the supply chain, a blockchain technology solution could be a proper choice.

3. Due to the huge amount of spare parts that could be added to the machines, the administrative work related to each spare part can result in a lot of non-value adding activities. As Deloitte (2017) argued in section 3.6.2, the introduction of blockchain technology can reduce the amount of administrative work. This reduction of unnecessary actions could be added on other aspects at the MNC, which can make the processes move smoother.

Challenges:

1. As the amount of new spare parts added to the supply chain could be large, it can be time-consuming to tag each spare part. This factor can affect the MNC´s costs, as it is an extra activity.

2. As of today, the MNC has a mix of spare parts; some are produced by the MNC and the others are distributed from suppliers. This can be a challenge for the MNC as they need to customize the purchased spare parts with digital tracking ID´s, in order to introduce them to the blockchain. In some cases, the supplier may not be able to add the tracking ID to the spare part, which can make it difficult to introduce the spare part to the blockchain.

Use case 2: Blockchain technology for identifying origin

The intermediaries sell perishables. The origin of the perishable is a crucial factor for their consumer as seen in section 4.1.2 *Market*. Blockchain technology could be introduced to DPP in order to identify the origin of the product and enable traceability for the consumers. Each time the perishable is handled, the information of e.g. quality could be stored in the blockchain. Different sensors could be attached to important parts of the supply chain for the perishable, whereas the information could be distributed in the blockchain. The company Provenance did an equal attempt in order to achieve greater transparency, see section 3.6.2, use case 2. The company managed to track fish caught by fishermen in Indonesia. Hence, this case made by Provenance is an example of where blockchain technology could work.

Pros:

1. As the origin of the sold product is of great importance for the intermediaries’ customers, a blockchain technology solution can make the supply chain more transparent. In this way, it can be easier to track what actions have been executed to the product. The transparency can make the customers more confident in their choice of intermediary. In addition to this, the transparency can minimize counterfeit, as all actions can be controlled. The company Alibaba, see section 3.6.2, use case 3, is also trying to increase the transparency in their supply chain. They want to fight food fraud (selling

lower quality foods often with counterfeit ingredients), thus other companies find blockchain technology as a solution for increased transparency.

2. With the use of blockchain technology, the MNC could be able to provide the intermediaries and their customers with important factors, such as quality of the product. This can lead to increased customers satisfaction, which could turn into increased sales for the MNC.

Challenges:

1. As DPP will lead to a large supply chain network at the market, a challenge with introducing blockchain technology could be the size of the project. Hence, it could be difficult to ensure that important factors such as quality are logged in the right way at the blockchain, throughout the whole supply chain.

2. The collaboration and willingness to work with blockchain technology from other stakeholders in the supply chain could be difficult to achieve, as different parties could have different incentives. This can make it difficult to introduce blockchain technology, as the technology is dependent on connecting the whole supply chain into a network.

Use case 3: Blockchain technology for recycling

As the MNC aims to continue being an environmental friendly choice, the MNC could put effort on increasing the recycling activities from the MNC's customers and their customers. The MNC could start an initiative where recycling could be rewarded. The concept could be that consumed products could be collected and then returned to the plant owners of the DPP. When returning the consumed products, the consumer will earn e.g. cryptocurrency as a reward. This reward mechanism will be logged in a blockchain technology which will be open for all stakeholders. The responsibility will be at the plant owner to take care of the recycled material, either by sending it back to the PF or by reuse it onsite. The plant owner will also be the person who will distribute data to the blockchain as a sign that a stakeholder (in this case a consumer) has returned consumed material.

Pros:

1. With the blockchain technology solution, cryptocurrency could be earned by recycling the material. This could give incentives to the intermediaries and their customers to recycle material at the market. The recycling can then lead to environmental benefits at the market.

2. As the MNC has an aim on being even more environmental friendly, the action of giving incentives for recycling at the market can benefit the MNC´s reputation when it comes to CSR aspects. With the cryptocurrency being connected to the amount of recycled material, it can easily be visualized how much material has been recycled, as the blockchain technology solution will keep track on the cryptocurrencies.

3. If this use case is implemented, there could be motivating aspects that could motivate the employees at the MNC. They can feel proud of the company's work with improving the environment, which could make them work even harder towards environmental goals.

Challenges:

1. Cryptocurrencies are a rather new currency which could make it difficult for stakeholders to understand the use of it. This could interfere with the introduction of blockchain technology, as the reward system will be dependent on cryptocurrencies.

2. The introduction of recycling can lead to increased price for the intermediaries' customers. This can affect how willing the intermediaries or the intermediaries' customers are to pay an extra price for recycling.

In table 5.2 the pros and challenges with each use case are summarized.

Table 5.2 Summary of pros and challenges with each use case

Use Case	Pros	Challenges
Blockchain technology for tracking machines and spare parts	Minimize counterfeits (1)	Time-consuming to tag all spare parts (1)
	Increase traceability (2)	Mixture of spare parts – need of customization (2)
	Reduce administrative work (3)	
Blockchain technology for identifying origin	Minimize counterfeit (1)	Technology challenges (1)
	Ensure customers the right requirements, e.g. quality (2)	Willingness to join the blockchain (1)

Blockchain technology for recycling	Increase environmental awareness at the market (1)	Cryptocurrency as the reward mechanism (1)
	Improve the MNC’s CSR work (2)	Price increase (2)
	Motivation of employees with regards to cultural aspects (3)	

5.3.1.2. Use cases into opportunities

As could be seen in section 4.7.3, *Future of blockchain technology at the MNC,* the MNC have three primary opportunities they are investigating as of today; *Business differentiation, Marketplace utility and New market model.* With these possibilities in mind, the three use cases mentioned, correlates as follows:

Business differentiation	Use case 1: Blockchain technology for tracking machines and spare parts
Marketplace utility	Use case 2: Blockchain technology for identifying origin
New market model	Use case 3: Blockchain technology for recycling

The *business differentiation* possibility is about finding ways how blockchain technology can differentiate the current business to stay competitive. The company could reduce the administrative tasks and focus on value adding activities. This is a way where the MNC could differentiate themselves, as they will focus on making their internal activities more streamlined.

Use case 2 fits under *marketplace utility* as it focuses on finding ways of making it easier to work with intermediaries or other stakeholders. As the use case focuses on identifying the origin of a product, the transparency towards intermediaries and other stakeholders could increase.

Use case 3, *Recycling,* is placed under *new market model*. This segment is about introducing blockchain technology at an early stage at underserved markets or reshaping the MNC´s current way of doing a task with the use of blockchain technology. As the environmental aspects are important for the MNC, they have the possibility to create their own way of working with a sustainable approach. The reward system with cryptocurrency could help the underserved market to reach a better state as well as the MNC could introduce blockchain technology early, and lead the development of it.

5.3.1.3. How to overcome challenges

As mentioned in section 4.7.3.2, the MNC has three major challenges with regards to blockchain technology. The challenges are the following:

1) Introduction of more stakeholders to blockchain
2) The MNC´s limited experience with blockchain
3) Transformation of a pilot project to a large-scale system

1) Introduction of more stakeholders to blockchain technology

To overcome this challenge, Deloitte (2017) argues the importance of socializing the idea of blockchain technology within the company and to external parties. In order to understand the benefits with the technology, the MNC needs to highlight the opportunities enabled with the technology and what can be achieved by collaborating with others. The partnership with the IT provider is an example, but in order to reach further, more parties needs to be included. By including the entire supply chain, mutual gains can be achieved e.g. transparency of spare parts.

2) The MNC´s limited experience with blockchain technology

Deloitte (2017) argues that one success factor to introduce blockchain technology is by partnering with a blockchain technology solution provider. The MNC has already made partnership with a blockchain technology solution provider. In order to gain more experience, the MNC needs to try different projects where blockchain technology is included. By extending the partnership with the blockchain technology solution provider, long term goals with blockchain technology can be established and the MNC could find different projects that fits within the business. In addition to this, creating long term goals is a confirmation both internally, but also externally, that the MNC is serious with blockchain technology which creates credibility.

3)Transformation of a pilot project to a large-scale system

Accelerating a project to a large-scale system, Deloitte (2017) argues that a key success factor is to have a long-term mindset at an early stage. In addition to this, it is easier to introduce blockchain technology to an unformed environment. As could be seen, DPP is a project with bare minimum in terms of systems and technology, which makes it a good environment for an introduction of blockchain technology. After an introduction to DPP, the MNC could easier control the environment and together with the blockchain technology solution provider, develop strategies for how to transform the project into a large-scale system.

5.3.2. Result

After analysing the opportunities of introducing blockchain technology to DPP, three use cases were established. The authors believe that each use case could contribute to DPP, and the result is illustrated in table 5.3.

Table 5.3 Blockchain opportunities for the MNC

Three different blockchain opportunities for the MNC	
Blockchain technology for tracking machines and spare parts	Build a network that connects all machines and spare parts to control all actions with regards to each machine or spare part.
Blockchain technology for identifying origin	Trace the origin of each perishable and all actions made on each perishable to ensure critical requirements.
Blockchain technology for recycling	Make a recycling network based on cryptocurrency that will work as an incentive for recycling.

In addition to the opportunities, some advices are illustrated in table 5.4 to overcome the challenges analysed in section 5.3.1.3.

Table 5.4 Advices to overcome challenges

Advices to overcome challenges	
Introduction of more stakeholders to blockchain	Socialize the benefits with blockchain and continuing to build the partnership with the blockchain solution provider
The MNC´s limited experience with blockchain	Establish long-term goals and collaborate with the blockchain solution provider to increase the knowledge of blockchain.

Transformation of a pilot project to a large-scale system	Have an early mindset that contributes to involving blockchain to the business in a natural way, e.g. digitalize products early. In addition to this, choose clever environments to start different project, e.g. environments with less existing systems,

5.3.3. Discussion

As the technology is rather new, there could still be tremendous benefits to discover with the technology. If the MNC implements blockchain technology at this stage, and make blockchain technology an accessible technology, the MNC might not only take advantage of the benefits with the technology, but also be a leader of how it could be used. The authors believe that the collaboration with the blockchain technology solution provider is of great value and an initial important step in accordance with theory from Deloitte (2017). By doing this, the cooperation could advance in a quicker pace, which could save both time and money.

In section 5.3.2, *Result*, the MNC were presented with three use cases they could introduce to DPP. The authors believe that the MNC could gain great benefits of introducing each use case. However, it could gain the MNC even more if the implementation of blockchain technology is done with a systematic approach, i.e. the use cases are interacting. In this way, the blockchain network could develop and avoid linear thinking. So, instead of having different blockchains, the use cases can be implemented in a large blockchain. This is something that the MNC could investigate further, when they have gained more knowledge and experience.

In section 5.3.1, *Analysis*, the analysis of each use case involved different challenges for the MNC which are not further discussed. In order for the MNC to introduce the use cases, it is of great importance to further investigate the challenges in order to see how they can be overcome and how the MNC could implement the use cases in the leanest way. The presented result in section 5.3.2, *Result,* does not show which use case to prioritize, as the authors are limiting the scope to only finding applicable use cases, and not on how to implement them.

During the research and work with RQ2, focus on creating credibility through reliability, validity, objectivity and transferability have been persistent in the process. This paragraph will from an objective standpoint discuss the four criteria's in RQ2. The study holds a low level of reliability as the main data gathering is based on interviews and the solution was made on judgements and opinions from the interviews combined with additional theory. The validity of this study is not on a high level. As Höst et al. (2006) mentioned, triangulation can be used to enhance validity of a study, which basically means measuring the same thing with different methods. In this case, there is nothing to measure, the study is based on finding future opportunities. The objectivity is both high and low. The interviews were held with two employees, leading the initiatives with blockchain technology at the MNC. Hence, the authors judgements and opinions were not affecting the interviews, as the authors have limited experience of blockchain technology which means that the objectivity was high. However, the established result was based on judgements and opinions from the authors, which makes the objectivity low. Finally, the transferability is quite high. The ideas presented by the authors will be possible to use to other supply chains at other companies. However, it will be difficult to transfer directly since DPP is rather rare in how it is set up. The DPP has its own supply chain that might differ a lot from other supply chains and the MNC have different stakeholders involved in the DPP, which other companies may not have. Hence, the transferability will be possible but it will be difficult to copy the ideas right off, as DPP is a customized project that fits within the MNC´s business.

6. Recommendations

In this chapter, the research questions will be answered. The first two sections will answer RQ1 and RQ2. The third section will be appointed to the case company and to academia, where future research is discussed.

6.1. RQ1: How can the distribution network be designed for an upscaling of DPP?

RQ1 describes how the distribution network shall be conducted, both by setting up the plants (Phase 1) and the ongoing distribution of consumption material (Phase 2). A framework is proposed in section 5.2.6, *Framework for upscaling of distribution network,* describing a general approach for the MNC to address the problem. The financial advantage of planning and designing a supply chain network and more specifically a strategic distribution network is frequently stated in articles and journals (Jackson et.al, 2008) (Daskin, et al., 2003). The complexity added with uncertainties of location and demand led to using scenarios to try to predict future outcomes to optimize the result (Simchi-Levi, et al., 2003). By first addressing the supply chain by categorizing it into phase 1 and 2, and then designing a simulation model with built in scenarios, the MNC can reconfigure the model after future requirements, to plan a distribution network. Due to the financial impact from warehouse investments in a distribution network, the simulation model aims to capture scenarios where the warehouse investment was in centre of attention.

The conclusion regarding Phase 1 is that there is no idea to put an extra effort in designing the distribution network for the setup of new plants. Since the idea is to be flexible in time and location, it is nearly impossible to optimize it. In phase 2, the simulations showed that depending on how the network is formed, introduction of warehouses may be an effective solution. The identified critical parameters were transport distance, cost per unit of transport and warehouse investment cost. The simulation model shall be used, together with the gravity location model to support the strategic distribution decisions. The emissions will be directly related to the distance and the warehouse and will be important to consider both when designing the network, but also when deciding on contractors for the warehouse or 3PL to distribute.

An answer to how the distribution network can be designed is explained in a simple six-step framework which could be seen in section 5.2.6, *Framework for upscaling of distribution network.* In appendix A6, an example of a distribution network was designed together with the MNC. The framework was used to design the network and to illustrate how the framework can be implemented on an actual scenario. The contribution from this thesis is adding a simulation model to the equation which is believed to give a greater understanding and the possibility to tailor the solution in the upscaling of DPP for the MNC. The previously untested software and usage of a simulation tool is of high value for the MNC, and by using it to design this solution, the interest and knowledge have been enrichening for future endeavours.

The recommendation is that a simulation model can be used for strategic decisions regarding the supply chain. The approach fits partly into the theory of network planning and network design where a balance between transportation, inventory and manufacturing cost should be obtained to optimize the supply chain according to Simchi-Levi, et al. (2003). On the other hand, it was nowhere to be found how to plan a future market entry and upscaling on a new market, and how simulation can be used was an even more absent part. By using scenarios in a simulation model, two previously well-analysed theoretical areas were combined to form a distribution network. The result where a contribution to how our findings can contribute and add value to existing theory as well as a simulation tool for the MNC to continue to develop and use in the upscaling of the DPP.

6.2.RQ2: How can blockchain contribute to the DPP?

As could be seen in section 5.3.1.1, *Three use cases for the MNC* were established and analysed. All these three use cases can contribute to the DPP in different ways. Use case 1, *blockchain technology for tracking machines*, enables the MNC to minimize counterfeit, increase traceability and reduce the administrative work that is connected to the machines and spare parts. Use case 2, *blockchain technology for identifying origin*, enables the MNC to minimize counterfeit. In addition to this, they can ensure customers the right requirements regarding e.g. quality. Use case 3, *recycling*, can increase the environmental awareness at the market, it can improve the MNC´s CSR work and it can increase the motivation of employees with regards to cultural aspects.

The authors further recommend the MNC to investigate which of the three use cases, if not all, is most suitable for the MNC at the moment. When this is done, the MNC should try to implement blockchain technology early in the upscaling of DPP. In this way, the technology can mature throughout the project. The MNC should also continue to investigate possibilities with blockchain technology, as the authors believes it is a future technology. The investigations do not need to be limited to DPP, contrariwise, it should be extended to other business units as well. Due to the large financial impact of supply chain costs in the finished product and the increased pressure from consumers to see what they are consuming the use cases are in line with Abeyrante & Monfared (2016) ideas of blockchains possibilities of improving transparency and accurate end-to-end tracking. It is obvious in the use cases from Maersk, Provenance and Alibaba that the blockchain technology can be used in many ways. The theoretical findings made in the report is reckoned to be a complementary nature to existing theory rather than being new findings. The subject is yet to be further analysed before gaps can be found whereas our contribution will be from a commercially perspective showing how environment and industry will affect the use cases.

6.3.Further research

During this report, the authors have found some findings which could complement the report. These findings are further divided into future research for the MNC and future research for academic literature.

6.3.1. Further research for the MNC

This study aimed on investigating how the MNC could design a distribution network for DPP and how they could implement blockchain technology to the DPP. The distribution network design was supported by using a simulation tool. It could be beneficial for the MNC to investigate how these kind of simulation tools could create additional value for the MNC, at other business units and other projects as well. In addition to this, it could be beneficial to investigate if there are other simulation tools that could be aligned even more, regardless the type of project.

The simulation tool has been discussed on and off during the thesis due to its capabilities and the authors previous limited knowledge. To continue the journey with SimEvents or other similar tools, the authors wants to say a few words regarding ideas that came up in the process. Initially, partly due to the strategic focus of the model, no dynamic features were added. However, when doing more tactical or even operational simulations e.g. routing, it can be effective to use statistical distribution features to simulate traffic jams, truck breakdowns etc. On a tactical level, it is relevant to overlook the inventory policy and do a more advanced inventory system where the system considers additional factors apart from the linear distribution of goods which has been accounted for in the model. From both a tactical and operational level, regionalizing might not be the optimal solution. It has been previously discussed that this in fact will not be the case since there are more effective ways to collaborate between the warehouses and plants. In the process of building the model, the authors got acquainted with some functions where more intelligent solutions were applied e.g. optimal routing and inventory policies.

Further on, the simulation model is expected to be used in an iterative process. The idea is that the more accurate the information entered in to the model is, the better the results are from the simulation.

6.3.2. Further research for academic literature

The authors believe there could be further research done on the connections between blockchain technology and distribution network design, since the theory found was scarce. In addition to this, it could be interesting to conduct research on how simulations tools can contribute to distribution network designs, since theory found was scarce.

A field within distribution network which the authors considered was relatively undeveloped was *how companies expand within new markets, where the uncertainties of locations are high*. Due to the globalization, the authors thought that this should have been a commonly investigated subject. For globally expanding industries, the importance of strategic planning is a financial matter where risks can be eliminated and cost reduced before entering the unfamiliar market.

The research could aim on the following:

- How can a simulation tool be established in order to design a distribution network?
- How can a company plan a new market expansion?
- How can blockchain technology be implemented from a practical perspective and not a theoretical standpoint?

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Appendix

A.1 Phase 1

Table A.1.1 Data for phase 1

Year	Number of Machines	Volume (m^3)	Monthly number of machines	Monthly maximum (volume)
2017	0	0	0	0
2018	0	0	0	0
2019	1	300	0	25
2020	4	1200	0	100
2021	20	6000	2	500
2022	50	15000	4	1250
2023	70	21000	6	1750
2024	70	21000	6	1750
2025	100	30000	8	2500
2026	100	30000	8	2500
2027	100	30000	8	2500
2028	200	60000	17	5000
2029	300	90000	25	7500

Tabell A.1.2 Explanation for table A.1.1

Coloumn Title	Explanation
Number of machines	See figure A.1.1
Volume (m^3)	Three large trucks: 100 m^3 per truck.
Monthly number of machines	Number of machines / months per year (12)
Monthly maximum Volume	Volume / months per year (12)

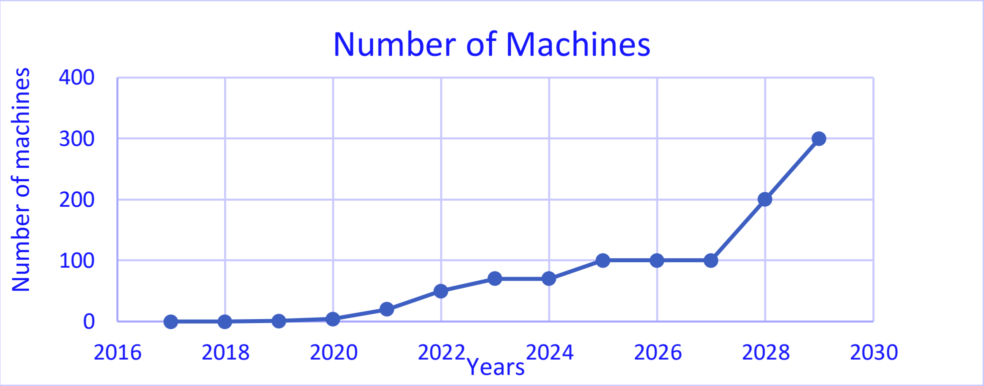


Figure A.1.1 Graphical representation of the number of machines per year for DPP

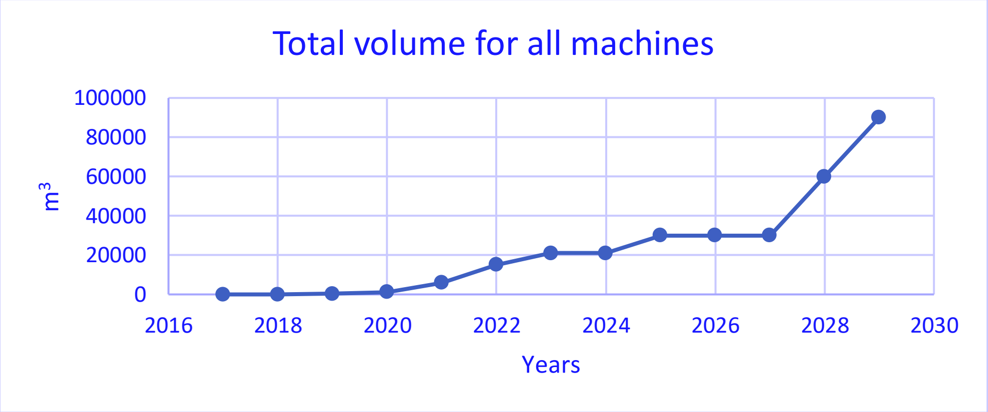


Figure A.1.2 Graphical representation of volume of all the produced machines per year

A.2 Calculations of consumption material

Table A.2.1 Requirements for consumption material

Unit	Value	Explanation
Diameter *d* (m)	1,15	
Width *w* (m)	0,2	
Products per roll (#)	7200	
Volume per roll(m^3)	0,20763	$V = (d/2)^2 \times \pi \times w$
Piece volume (dm^3)	0,5	Standard
Production per machine	18000	Maximum demand
Total number of products	36000	Production per machine x Piece volume
Safety stock (days)	7	One week of demand

Table A.2.2 How many rolls are necessary for 10000-18000 dm^3 *of production. (e.g. 35 rolls for 7 days of production at 18000 dm*^{3} *demand.) See formula A.2.1 for explanation.*

Rolls / dm^3	10000	12000	15000	18000
1	0,36	0,3	0,24	0,2
2	0,72	0,6	0,48	0,4
3	1,08	0,9	0,72	0,6
4	1,44	1,2	0,96	0,8
5	1,8	1,5	1,2	1
6	**2,16**	1,8	1,44	1,2
7	2,52	2,1	1,68	1,4
8	2,88	2,4	1,92	1,6
9	3,24	2,7	2,16	1,8
10	3,6	3	2,4	**2**
11	3,96	3,3	2,64	2,2
12	4,32	3,6	2,88	2,4
13	4,68	3,9	3,12	2,6
14	5,04	4,2	3,36	2,8
15	5,4	4,5	3,6	3
16	5,76	4,8	3,84	3,2
17	6,12	5,1	4,08	3,4
18	6,48	5,4	4,32	3,6
19	6,84	5,7	4,56	3,8
20	7,2	6	4,8	4

21	7,56	6,3	5,04	4,2
22	7,92	6,6	5,28	4,4
23	8,28	6,9	5,52	4,6
24	8,64	7,2	5,76	4,8
25	9	7,5	6	5
26	9,36	7,8	6,24	5,2
27	9,72	8,1	6,48	5,4
28	10,08	8,4	6,72	5,6
29	10,44	8,7	6,96	5,8
30	10,8	9	7,2	6
31	11,16	9,3	7,44	6,2
32	11,52	9,6	7,68	6,4
33	11,88	9,9	7,92	6,6
34	12,24	10,2	8,16	6,8
35	12,6	10,5	8,4	**7**

Formula A.2.1 Calculations for number of rolls for X demand.

$$\frac{Products\ per\ roll(st) \times rolls(st)}{Production\ per\ machine(\mathrm{dm}^3/day)/Piece\ volume(\mathrm{dm}^3)} = days\ production\ per\ roll$$

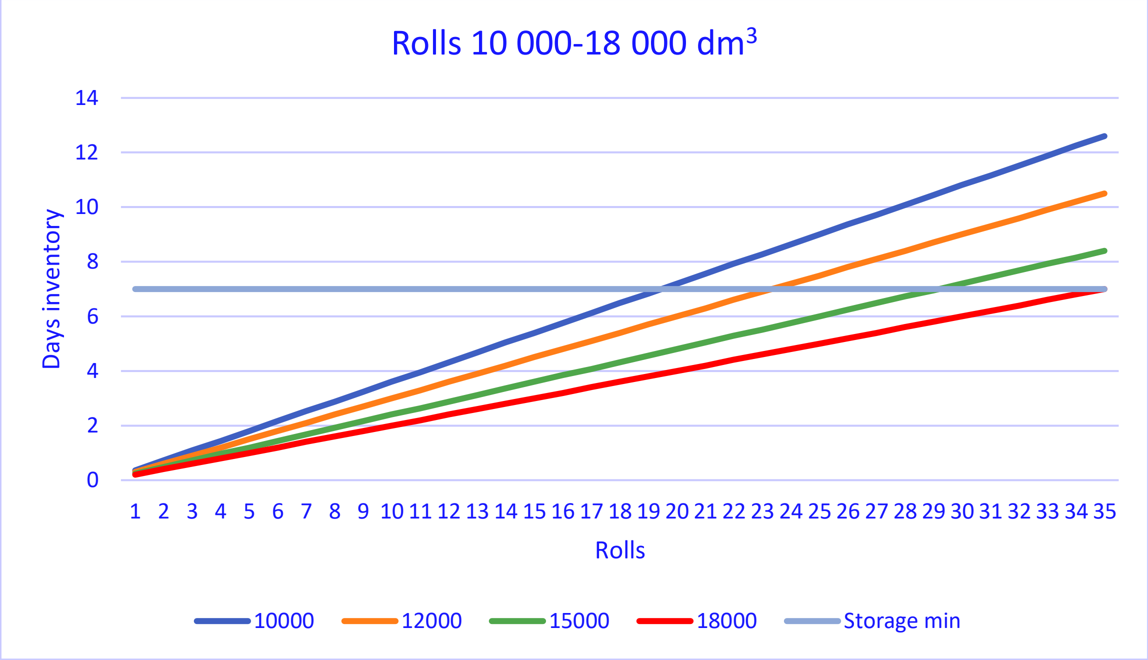


Figure A.2.1 Visual representation of table A.2.2. Number of rolls to have 7 days inventory

Table A.2.3 Specifications for consumption material and additional material.

Type	Measure	Value
Dimension of consumption material	*[diameter, length, width] (m), [weight] (kg)*	*[1.15, 8000, 0.2], [45]*
Additional material	*[weight] (kg)*	*[43,5]*

Table A.2.3 Additional material included in the transport to plant (Nearly neglible)

Material	Weight	Explanation
X (kg)	33,53	Per week
Y (kg)	10	Per week

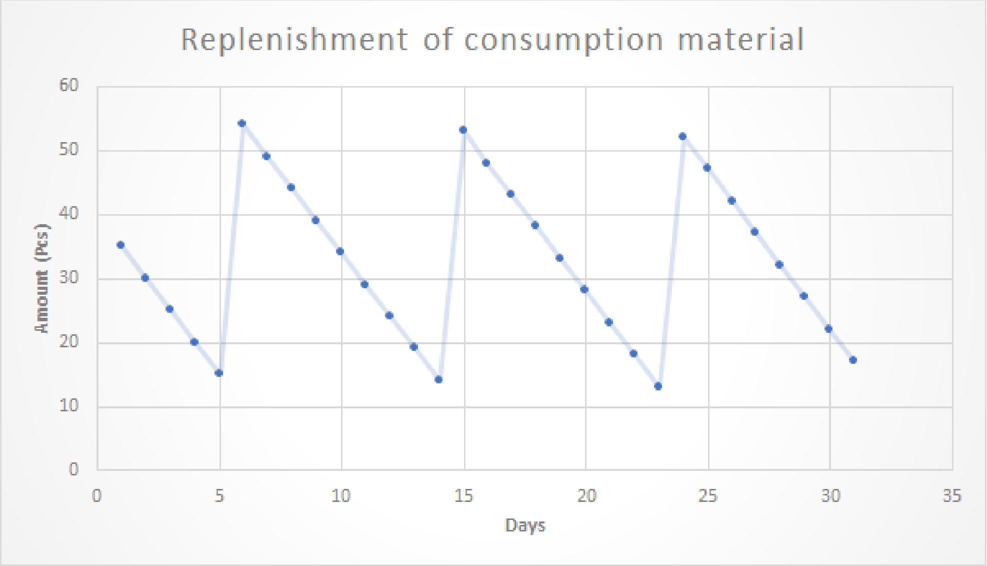


Figure A.2.2 Replenishment of consumption material of rolls for a plant.

The diagram is an estimation of the number of pieces (pcs) of consumption material needed for the plant at maximum production. The chart is not considering the time it takes to transport the material from the PF to the plant. The dimensions per piece of consumption material is listed in table A.2.3.

A.3 Parameters used in phase 1 and phase 2

Table A.3.1 Data for trucks, distances, number of plants and warehouse employees

Type	Measure	Value
(1) Size of carry load for large truck	*[width, length, height] (m), [weight] (kg)*	*[2.6, 13.0, 2.4], [17540]*
(2) Size of carry load for small truck	*[width, length, height] (m), [weight] (kg)*	*[2.095, 3.085, 2.06], [3550]*
(3) Cost of large truck	*(euro)*	*[35400]*
(4) Cost of small truck	*(euro)*	*[8400]*
(5) Consumption large truck	*[litre/km]*	*[0.20]*
(6) Consumption small truck	*[litre/km]*	*[0.13]*
(7) Average velocity of trucks	*[km/h]*	*[30]*
(8) Salary for driver	*[euro/h]*	*2.25*
(9) Yearly truck cost	*[euro]*	*500*
(10) Truck expectancy lifetime	*[years]*	*10*
(11) Average driving distance for 1 truck	*[km/year]*	*50000*
(12) Distance from PF to warehouse	*[km]*	*[variable]*

(13) Distance from warehouse to plant	*[km]*	*[variable]*
(14) Number of plants to set up	*[pcs]*	*[1020]*
(15) Warehouse employee salary	*[euro/h]*	*[0.4]*

Explanation of table A.3.1

Size of carry load for large truck (1) - Consumption small truck (6)

In phase 1 and phase 2, specific data for each phase have been illustrated. In table APPENDIX other general data is illustrated. The data (1) to (6) are gathered from the large truck specifications and from the small truck specifications (DAF, 2018) (forcemotors, 2018).

Average velocity of trucks (7)

Manager Systems Engineering (2018) states that the "*Average velocity of trucks*" is 30 km/h. He argues that the infrastructural network at the market is underdeveloped.

Salary for driver (8)

The salary for a driver were estimated by dividing the average monthly salary for a driver at the market with 160 hours, as it is the restricted amount of working hours for one month **(**Payscale, 2018).

Yearly truck cost (9)

The yearly truck cost were estimated to 500 euro. It is assumed that the 3PL has a yearly cost that will cover insurance, service and other relevant additional cost for the truck.

Truck expectancy lifetime (10)

The expectancy lifetime of a truck is ten years. The MNC´s depreciation is ten years, hence this will be the limitation for the truck. After 10 years, the MNC need to use other trucks, either by using the current 3PL or by owning own trucks.

Average driving distance (11)

The average driving distance for one truck is 50 000 km. It is based on the fact that a truck in USA drive approximately 62 000 km/year (bouletfreightmanagement, 2007). As the infrastructure at the market is bad, it is assumed that the average yearly distance for a truck is less, hence a further reduction of 62 000 km/year was done.

Distance from PF to warehouse (12) - Distance from warehouse to plant (13)

These factors varies depending on where the warehouse and plants are located.

Number of plants to set up (14)

The MNC´s long term goal is to set up 1020 plants at different places at the market. This number can change in the future.

Warehouse employee salary (15)

A standard warehouse employee earns about € 0,40 per hour based on currency transformation 20180426.

How calculations were made:

$$Total\ cost\ (small\ truck) = (4) + (9) \times (10)$$

$$Total\ cost\ (Large\ truck) = (3) + (9) \times (10)$$

$$Cost\ per\ km\ (small\ truck) = \frac{Total\ cost\ (small\ truck)}{(11)}$$

$$Cost\ per\ km\ (large\ truck) = \frac{Total\ cost\ (large\ truck)}{(11)}$$

$$\begin{aligned} &Cost\ per\ km\ inc.fuel\ and\ driver\ (small\ truck) \\ &\quad = Cost\ per\ km\ (small\ truck) \\ &\quad + (6) \times 65 \times 0{,}012(\frac{€}{local\ currency}) \end{aligned}$$

Formulas A.3.1 Calculations for truck

A.4 Phase 2

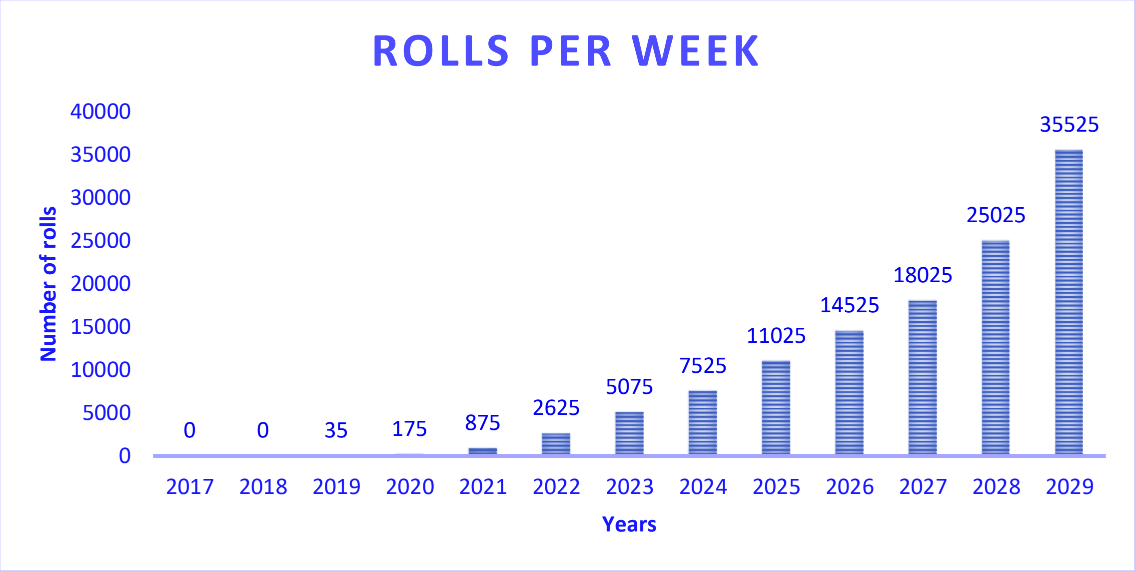


Figure A.4.1 Number of rolls in PF based on the assumed expansion from the MNC

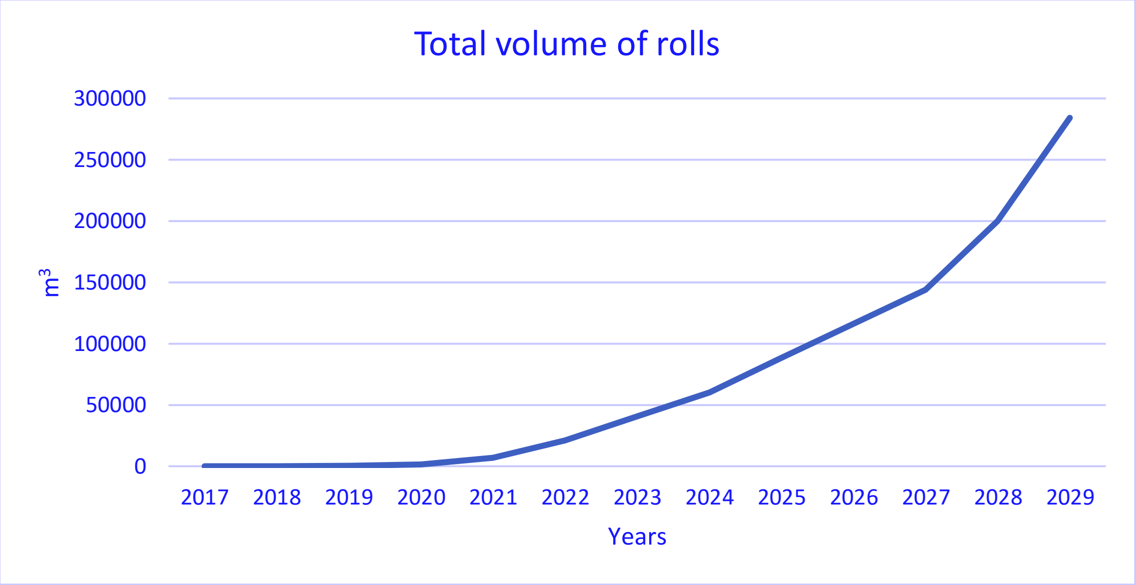
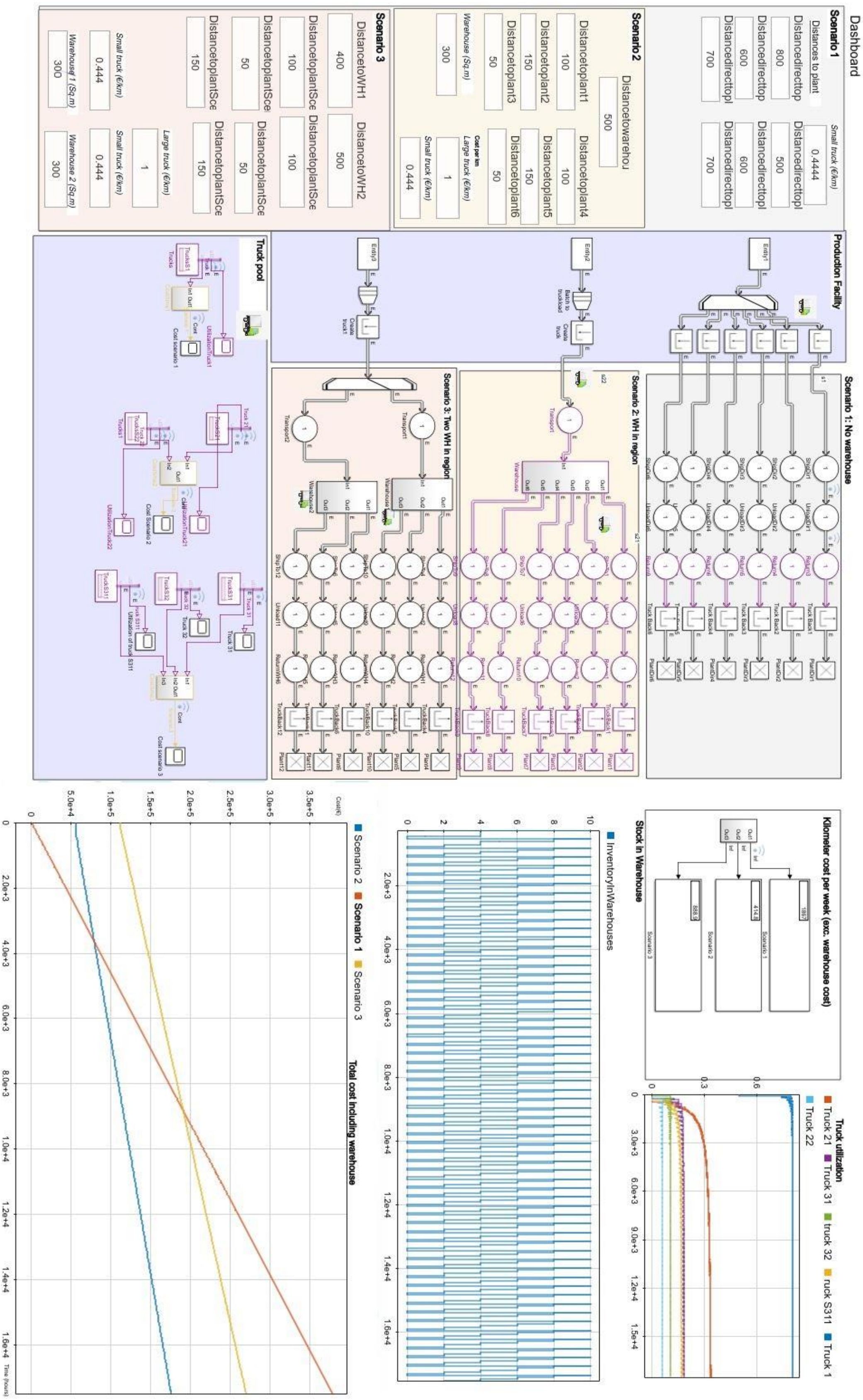


Figure A.4.2 Volume of rolls (m^3) based on the assumed expansion from the MNC

A.5 Chosen input variables in simulation model



Dashboard

Scenario 1

Distances to plant

Distancedirecttop 800

Distancedirecttop 600

Distancedirecttopl 700

Small truck (€/km) 0.4444

Distancedirecttopl 500

Distancedirecttopl 600

Distancedirecttopl 700

Scenario 2

Distancetoplant1 100

Distancetoplant2 150

Distancetoplant3 50

Warehouse (Sq.m) 300

Distancetowarehou 500

Distancetoplant4 100

Distancetoplant5 150

Distancetoplant6 50

Cost per km

Large truck (€/km) 1

Small truck (€/km) 0.444

Scenario 3

DistancetoWH1 400

DistancetoplantSce 100

DistancetoplantSce 50

DistancetoplantSce 150

Small truck (€/km) 0.444

Warehouse 1 (Sq.m) 300

DistancetoWH2 500

DistancetoplantSce 100

DistancetoplantSce 50

DistancetoplantSce 150

Large truck (€/km) 1

Small truck (€/km) 0.444

Warehouse 2 (Sq.m) 300

Kilometer cost per week (exc. warehouse cost)

Scenario 1 1867

Scenario 2 414.8

Scenario 3 888.3

Figure A.5.1 Chosen input variables in simulation model in 4.5.3

B.1 Example of a distribution network

The geographical location and figures are not taken from the MNC. The idea is to illustrate how the framework from section 5.2.5 is to be used and how the results can be interpreted.

1. Determine location of plants.

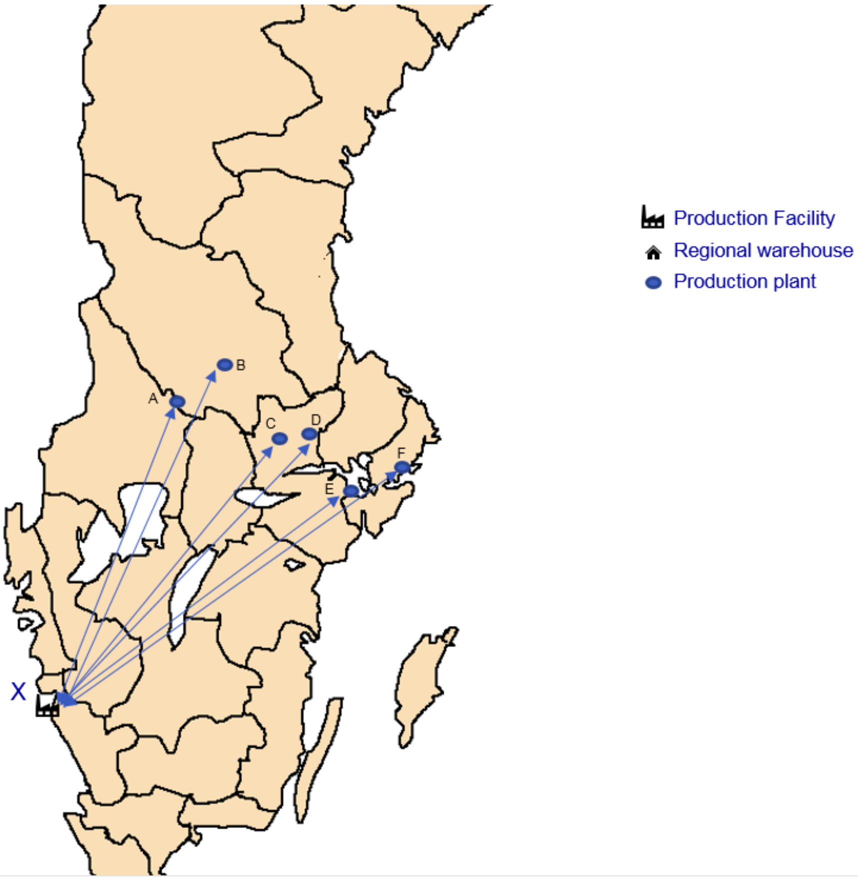


Figure B.1.1 Scenario 1

The production facility is located to the left in the picture. The production facility is providing material for six plants (A-F). The distances are shown in table XX. In this case, no additional regional warehouses have been added. Only scenario 1 is visualized in this figure, later on, both scenario 2 and 3 will be shown.

Table B.1.1 Distances from point X to A-F at figure B.1.1 (Note. Distances are not accurate for the chosen map.)

X to	**Distance (km)**
A	1172
B	1408
C	1325
D	1413
E	1502
F	1733

2. Regionalize the market.

The market can be regionalized however suits the case the most. In figure B.1.2 an example is illustrated which separates if there are one or two warehouses.

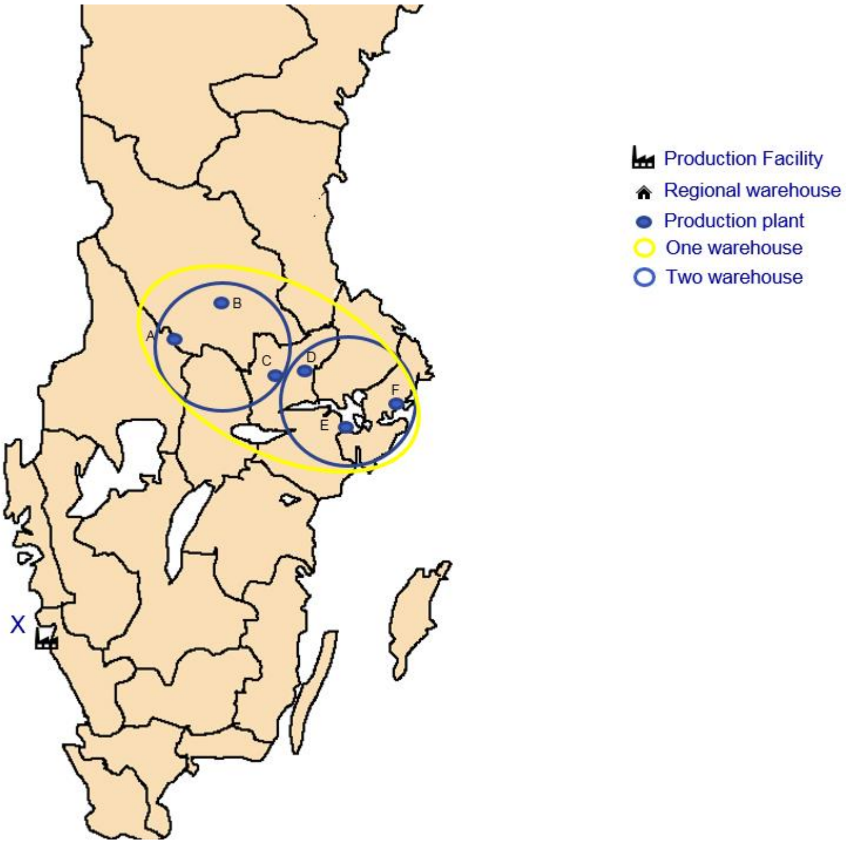


Figure B.1.2 Regionalize the market

3. Iterate the locations with the simulation model to find an appropriate strategic investment strategy.

a) Choose suitable parameters e.g. transportation cost, truck velocity, warehouse size and distance

Depending on if we are looking without a warehouse (see figure B.1.2) or if we are using one or two warehouses as can be seen in figure B.1.3 and B.1.4.

Table B.1.2 Used values for Example of a distribution network

Parameters	**Value(Scenario 1, Scenario 2, Scenario 3)**
Transportation cost (€/km)	
Small truck	0,44
Large truck	1
Truck velocity (km/h)	30
Number of trucks	3, 4, 3
Warehouse size (m^2)	300
Number of warehouses	0, 1, 2

b) Determine critical factors e.g. lead time, cost, number of trucks etc.

If the cost is the critical factor, multiple changes can be done to the input data to lower the cost e.g. Warehouse size, bulk loads.

If the lead time is critical, more trucks can be added.

By iterating the different input data, different scenarios can occur.

4. Design the warehouse to meet a profitable number of plants.

In appendix A2, a brief description of the size of the material is shown. If the plant is expected to store 7 days of consumption plus an additional 7 days of safe stock, it is necessary to ensure that a warehouse can provide for X number of plants. From table B.1.2, the authors choose a size of 300 m^2.

5. Use the gravity location model to find the optimal warehouse location based on demand.

Scenario 2

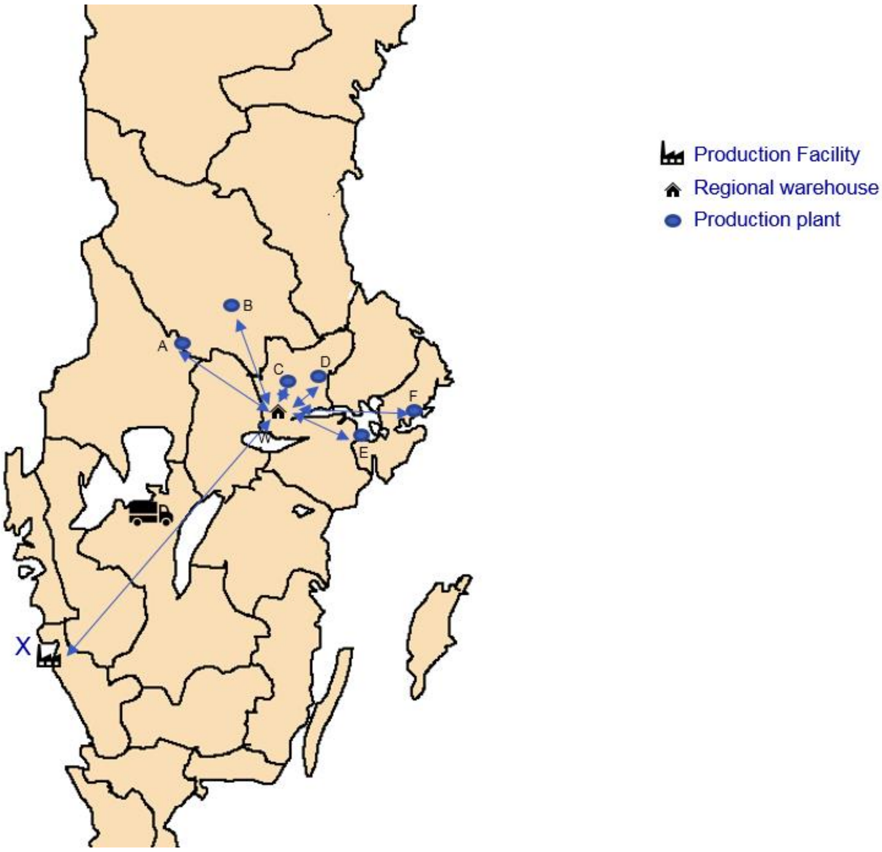


Figure B.1.3 Scenario 2

Gravity location model have been used in this example to find the optimal location to place a warehouse. The new distances between the different locations are shown in table B.1.3.

Table B.1.3 Distances from point X to warehouse, and from warehouse to A-F at figure B.1.3

X to	**Distance (km)**
W (Warehouse)	1093
W to	
A	449
B	456
C	228
D	396
E	823
F	553

Scenario 3

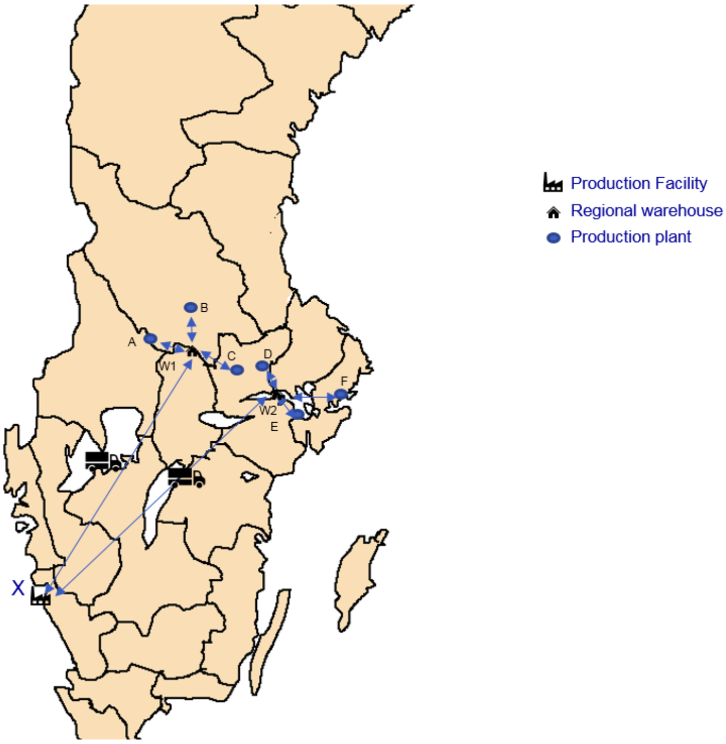


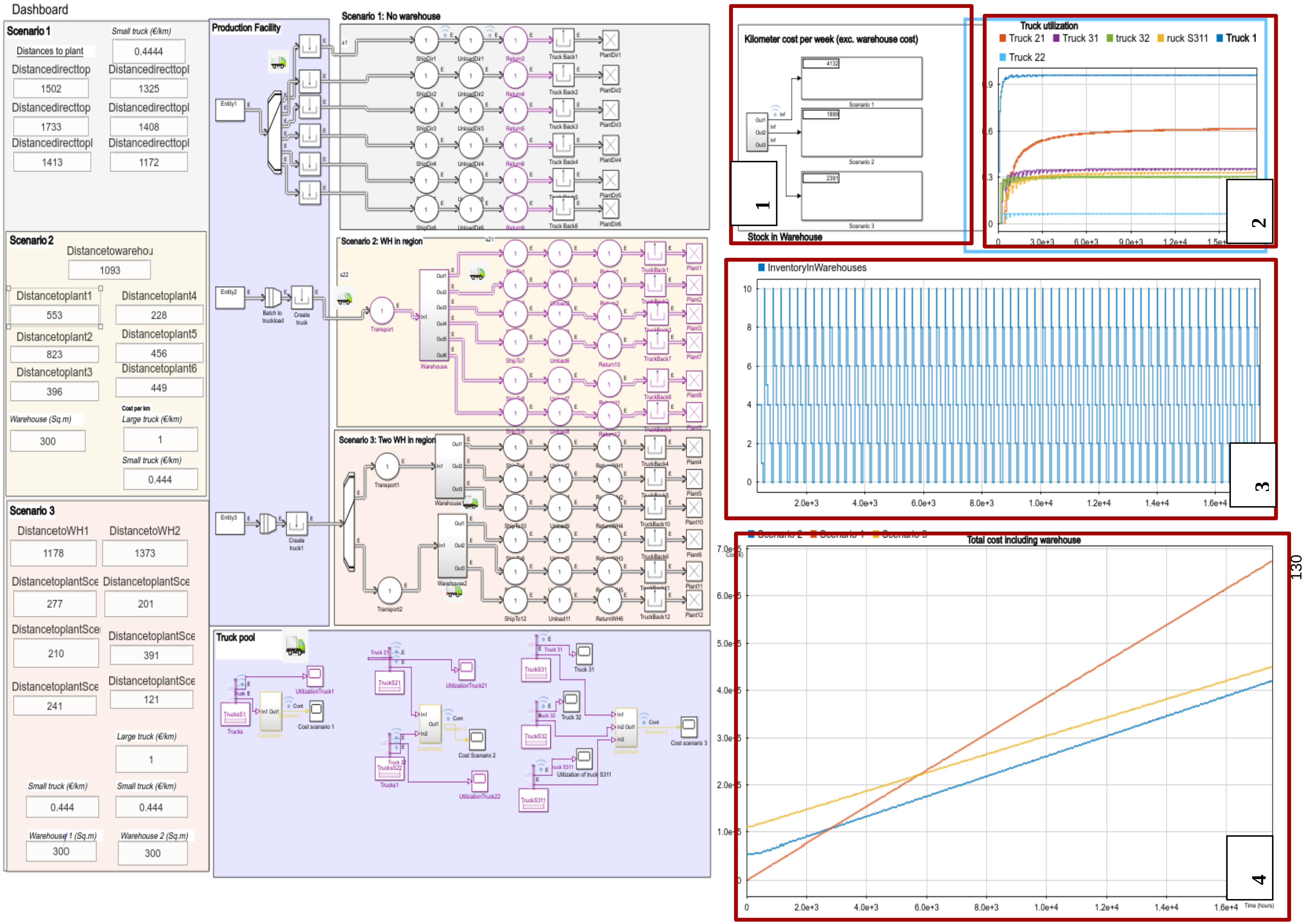
Figure B.1.4 Scenario 3

Gravity location model have been used in this example with two warehouses to find the optimal location to place the warehouses. The new distances between the different locations are shown in table B.1.4.

Table B.1.4 Distances from point X to warehouses, and from warehouses to nearest A-F at figure B.1.4

X to	**Distance (km)**
W1	1178
W2	1373
W1 to	
A	241
B	210
C	277
W2 to	
D	201
E	121
F	391

The result from the simulation for two years have been presented in the figure below.



Dashboard

Scenario 1

Distances to plant

Small truck (€/km) 0.4444

Distancedirecttop 1502

Distancedirecttopl 1325

Distancedirecttop 1733

Distancedirecttopl 1408

Distancedirecttopl 1413

Distancedirecttopl 1172

Scenario 2

Distancetowarehou 1093

Distancetoplant1 553

Distancetoplant4 228

Distancetoplant2 823

Distancetoplant5 456

Distancetoplant3 396

Distancetoplant6 449

Cost per km

Warehouse (Sq.m) 300

Large truck (€/km) 1

Small truck (€/km) 0.444

Scenario 3

DistancetoWH1 1178

DistancetoWH2 1373

DistancetoplantSce 277

DistancetoplantSce 201

DistancetoplantSce 210

DistancetoplantSce 391

DistancetoplantSce 241

DistancetoplantSce 121

Large truck (€/km) 1

Small truck (€/km) 0.444

Small truck (€/km) 0.444

Warehouse 1 (Sq.m) 300

Warehouse 2 (Sq.m) 300

Kilometer cost per week (exc. warehouse cost)

Scenario 1 4132

Scenario 2 1899

Scenario 3 2391

In the figure, the user can view the four different parameters. Unfortunately, it is quite hard to see some of the numbers. In the list below, the varying graphs are interpreted.

1. *Kilometer cost per week excluding warehouse cost.*
   This shows the cost to transport the material. Just to give the user a number, and not just graphs.
2. *Utilization of trucks*
   All trucks have varying utilization. Can help the user to motivate choosing a 3PL due to the low utilization of many trucks
3. *Inventory in warehouse*
   The inventory in the warehouses are shown to illustrate how it is utilized and the average stock on hand.
4. *Total cost including warehouse*
   The forth graph shows the different scenarios and when they are intercepting each other. The graph is during two years.

5. **Reiterate the process.**

C.1 Simulation Matlab code

```
%% TRUCKS
nbroftrucksScen1=3;
nbroftrucksScen21=2;
nbroftrucksScen22=2;
nbroftrucksScen31=1;
nbroftrucksScen311=1;
nbroftrucksScen32=1;

avgtruckvelocity=30;

costperkmSmall=.44444;
costperkmLarge=0.60988;
%% Warehouse cost

costperkvm=   123.84*1.5;    %50%    extra    for
additional  meterials  such  as  IT,  fork  lift,
pallets
sizeofWH=100;
salaryperhour=0.40*6; % 30 INR/hour  (26/4 2018
currency) * 6 persons
```

```
workingtime=(5/7)*(8/24)

%% SCENARIO 1
Distancedirecttoplant1=1502;
Distancedirecttoplant2=1733;
Distancedirecttoplant3=1413;
Distancedirecttoplant4=1325;
Distancedirecttoplant5=1408;
Distancedirecttoplant6=1172;



%% SCENARIO 2
%Time to transport to warehouse (Scenario 2)
Distancetowarehouse=1093;

timeTowarehouse=Distancetowarehouse/avgtruckvel
ocity;

%Time to transport to plant from warehouse
(Scenario 2)
Distancetoplant1=553;
```

```
Distancetoplant2=823;

Distancetoplant3=396;

Distancetoplant4=228;

Distancetoplant5=456;

Distancetoplant6=449;


%Time to unload at plant

unloadTime=2;


%Time to load at warehouse

loadingTime=1;


%% SCENARIO 3

DistancetoplantScen31=277;

DistancetoplantScen32=210;

DistancetoplantScen33=241;

DistancetoplantScen34=201;

DistancetoplantScen35=391;

DistancetoplantScen36=121;

DistancetoWH1=1178;

DistancetoWH2=1373;
```

D.1 Interview guide

Interview guide 1, Distributed plant project

Before the interview

1) Determine time and place for the interview
2) Send the overall questions to the interviewee

During the interview

General

1) What is your name and what position do you have?

Network

2) How is the current supply chain network designed at the market?
    a. Production sites?
    b. Warehouses?
    c. What is being shipped from the production facility?
    d. Transportation modes?
        i. What kind of vehicles?
        ii. Local provider?
        iii. Transport time?
        iv. Frequency?

Collaboration

1) How is the collaboration between different site(s) and warehouse(s) at the market performed?

Challenges

1) What kind of challenges are there in the distribution network at the market?

Future

1) How much are the company prioritizing DPP? How important is it for the company?

2) Is this a business model that could be used on other markets as well? If yes, where?

Requirements / important factors

1) Budget for the DPP?
2) When designing a distribution network at the market, what would you say is important to consider?
3) What is not of great importance for DPP?
4) What would you say is important for the customers?

Interview guide 2, Blockchain technology at the MNC

Before the interview

1) Determine time and place for the interview
2) Send the overall questions to the interviewee

During the interview

General

1) What is your name and what position do you have?

Current situation

1) How is the company using blockchain today?
    a. Projects?
    b. Areas (markets)?
    c. Aim?
    d. Additional information?
2) Is blockchain important for the company?
    a. If yes, why?

Knowledge

1) How is the company "keeping up" with Blockchain?
2) Are there enough knowledge within the company to use blockchain?
    a. If not, how is it gathered?
        i. Collaborations?

Possibilities

1) In which areas do you see most leverage of Blockchain?
2) How do you think blockchain could be used in DPP?

Challenges

1) What are the challenges with implementing Blockchain?
    a. In general?
    b. For DPP?