Exploratory modelling of trust within intra-organizational supply chains

Case study of a Dutch Military Logistics Centre

Written by: Karan Poeran

TU Delft

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By

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in partial fulfilment of the requirements for the degree of

Master of Science

in Engineering and Policy Analysis

at the Delft University of Technology,

to be defended publicly on Tuesday October 3nd, 2023 at 9:00 AM

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Acknowledgements

Dear reader,

Thank you for showing interest in and taking time to read my thesis. This thesis is conducted as part of my final graduation for the Engineering and Policy Analysis Master Programme at Delft University of Technology. It marks the end of six years of studying at the Technology, Policy and Management department of the TU Delft in which I had the privilege to learn a lot from experts in all different kinds of fields.

First of all I would like to thank Yvonne Lont for an opportunity of a lifetime to write my thesis for the Ministry of Defence. Since the first day we met she has been enthusiastic about my role during her PhD trajectory. Even though she always have a busy schedule herself, she has always been by my side during joyful but also during stressful times. I will forever be thankful for this opportunity and her support during my time at the Ministry of Defence.

I would also like to thank Iris Vendrik for all her support during the writing of this thesis. She have made me feel very welcome at the Logistics Centre of Woensdrecht. I was so glad to have a former TBM student working with me, which made her the perfect mediator between the TU Delft and the Ministry of Defence. I would like to thank her for always having a positive but critical view towards my writing and my model. I am certain that both could not have reached the level it is now without her help.

Moreover, I would like to thank Emke Westra for her positive attitude during our coffee sessions. She was always ready to listen to my presentations and gave me the energy and motivation to keep going.

Furthermore, I would like to Willem Auping for the countless sessions of guidance during the past year. Without his help, this thesis would not have reached the level as it has become.

When things became difficult for me, he always had the solution for me to keep making progress. I cannot thank him enough for all the time he invested in me during this process.

Ultimately, I want to thank Tina Comes for her support during this process. Her critical view has given me new insights during the writing of my thesis, and her advice has always been helpful, even during difficult times.

Karan Poeran, Delft, 2023

Contents

Executive summary

The ongoing war between Russia and Ukraine has shown the importance of a well-organized military logistic system. The Dutch Ministry of Defence has concluded that their military logistic system is not used most efficiently. The need to build greater confidence in the ability of a defence organization as a whole to meet and sustain logistic support for future tasks has been acknowledged in the past. One such driver to build greater confidence is that of ‘trust’

Previous research on trust building between supply chain partners has been done manifold. However, the Dutch Ministry of Defence is a unique organization where the roles of distributor and client are within the same organization. Thus we are dealing with an intra-organizational supply chain, rather than a common inter-organizational one. Additionally, as a military organization the main priority of the supply chain is the responsiveness of the supply chain, rather than the efficiency. The uniqueness of the organization is the reason that additional research is needed on the role of trust within the supply chains with these special characteristics.

Multiple variables and their underlying relations, which create complexity and uncertainty, need to be addressed to implement policies that stimulate tryst within the organization. An System Dynamics (SD) Modelling approach will be used to access the dynamic complexity and uncertainty. The Exploratory Modelling Analysis (EMA) workbench enables the use and development of SD models, characterized by dynamic complexity, and deep uncertainty.

The results of the several analysis have given plentiful insights to consider regarding the future of trust dynamics between military supply chain partners. The initial values in a system such as this one have a huge impact on the progress of the model runs. Since the system consists of two major reinforcing feedback loops, Thus the system either strengthens or weakens itself, depending on the initial state of the model. Thus it is important to get the system to such a positive state, since it is likely to remain in a positive state.

As for the policy levers present in this system, the correction capacity lever seems the policy lever to have the most impact on the model outcomes. The correction capacity is the speed of which the incorrect orders get corrected. The results of the analyses conclude that regarding the state of trust in the model, it is crucial to keep this factor as efficient as possible. Since too low performance regarding correcting orders results in such delays that the trust level in the system completely disappears and does not come back within the time frame of the model run.

To summarize, I applied SD modelling and scenario discovery to explore the trust dynamics between a distributor and their client in a military intra-organizational supply chain context. Hereby I proved the importance of the initial state of the system, which due to its structure of reinforcing feedback loops is a big factor for its outcome. Additionally, it shows that the policy lever regarding performance by the distributor has the most impact on the trust level in the system. This insight tells us that performance is the biggest levers to adjust by policymakers to improve trust dynamics within their organization. I recommend policymakers to formulate strategies that give this insight to employees functioning as the distributor as well as the client. The interdependencies between one another should be emphasized. This should give the employees more incentive to improve their performance and thereby build trust between their collaboration partners.

1 Introduction

The ongoing war between Russia and Ukraine has shown the importance of a well-organized military logistic system. The inadequacy of Russia's military logistic system has been a major factor in its inability to achieve its war aims (Ti, 2022). Key factors of this inadequacy include failures in planning and execution and the use of a relatively inflexible, centrally-driven, logistic demand system (Ti, 2022). Skoglund et al. (2022) add that logistics is not an integrated part of Russian decision-making at every level.

This shows the importance of research on military logistics (Yoho et al,. 2013). Each interruption or inaccuracy in military supply chains directly influences the capabilities of the armed forces (Prebilič, 2006). Serrano et al. (2023) claim that every military revolution was intrinsically caused by a military logistics revolution.

The Dutch Ministry of Defence has concluded that their military logistic system is not used most efficiently (Ministry of Defence, 2022a). This is worrying, since an inefficient military supply chain may cause soldiers to lose their lives in battle (Fan et al., 2010). The Chief of [UK] Defence Logistics acknowledged the need to build greater confidence in the ability of the defence organisation as a whole to meet and sustain logistic support for future tasks (DLO, 2005). One such driver to build greater confidence is that of 'trust' (Tatham, 2013).

This requires research on how to build trust between supply chain partners in a military context. Kwon & Suh (2004) claim that the presence of trust the chance of supply chain performance measurably increases, while the lack of trust among supply chain partners often results in inefficient and ineffective performance as the transaction costs rise. The study by Sherman (1992) reported that one-third of strategic alliances failed due to a lack of trust between trading partners. Bowersox et al. (2000) claimed that effective information sharing is heavily dependent on trust beginning within a firm and ultimately extending to supply chain partners. Working to build trust within buyer-supplier relationships improves supplier responsiveness (Handfield & Bechtel., 2002). Handfield & Nicolas (1999) describe relationship management as “perhaps the most fragile and tenuous” component to a supply chain management strategy. This is because a relationship only functions when there is mutual confidence in each other’s capabilities and actions (Handfield & Nicolas, 1999). Trust is considered the most important variable influencing interpersonal and inter-organizational behaviour (Kiessling et al., 2004). Parties that are dependent on each other have more to lose if they will not trust each other, thus it is important for both parties to be fair and trust each other (Jambulingan et al., 2011). Trust encourages cooperation, discourages opportunistic behaviour among supply chain parties, and minimizes potential conflicting issues, thereby reducing transaction costs (Beccerra & Gupta, 1999).

As mentioned above, numerous scholars performed research regarding the role of trust within supply chains. However, the supply chain systems within the Dutch Ministry of Defence are unique. Rather than a common supply chain where the distributor and client represent different organizations, within this thesis the parties are both represent the Dutch Ministry of Defence. This makes the supply chain intra-organizational, rather than inter-organizational.

The last aspect of this supply chain is that it is represented by an actor in the public sector. Herewith are the priorities of the performance of the supply chain different compared to those of organizations in the private sector. Whereas the main goals of a military supply chain is the responsiveness (the system’s ability to react speedily to military requirements, Tsadikovich et al., 2016), the main goal of supply chains in the private sector is efficiency.

The uniqueness of the organization is the reason that additional research is needed on the role of trust within supply chains with special characteristics. These specific characteristics in this thesis are its performance indicators and the intra-organizational actors.

To implement strategies that stimulate trust within an organization as the Dutch Ministry of Defence, multiple variables, and their underlying relations need to be assessed, which create complexity and uncertainty. Trust relationships are subjective and dynamic, and are therefore very uncertain (Gong et al., 2019). Trust relationships create unknowns and require that the trustor tolerate them (Smithson, 2008). In order to enter a trust relationship, there must be some non-surveillance and at least temporary non-accountability between trustees. This creates unknowns (Smithson, 2018).

An System Dynamics (SD) Modelling approach will be used to assess the dynamic complexity and uncertainty. This approach assesses the dynamic complexity, and uncertainty subjected to trust within a supply chain system.
This method will be combined with exploratory modelling analysis (EMA), which enables the use, and development of SD models, characterized by dynamic complexity, and deep uncertainty (Kwakkel & Pruyt, 2013). Complex issues, with feedbacks, and many variables are fallible for mental simulation, Therefore, computational simulation is required to experiment with the complex issues (Kwakkel & Pruyt, 2013).

SD combined with EMA has supported decision-making, by addressing dynamic uncertainty, and complexity, in various cases, and issues. SD has been used for discovering different types of dynamics related to metal and mineral scarcity (Kwakkel & Pruyt, 2013). SD has been used to foster understanding of possible dynamic behaviors of ‘concerted’ bank runs and to perform rough-cut policy/strategy analyses (Pruyt & Hamarat, 2010).

The goal of this thesis is to explore the dynamics of trust between supply chain partners within a military context under various scenarios within a two-year time frame. The impacts of certain trust building levers and other key uncertainties, are also considered. This is all done by employing dynamic simulation to create a model of trust building and damaging. In order to elaborate on concrete theories of the development of trust over time, the author chooses to limit his modelling effort to the particular case of interdepartmental trust. More specifically, the model presented in this thesis describes the dynamics of trust development in a dyadic context where a department within the Ministry of Defence acts as a distributor to their client represented by another department with which they interact on a regular basis. The trust dynamics within a military supply chain are explored with the following research question and sub questions:

How to improve trust relationships within intra-organizational military supply chains, without compromising the responsiveness of the supply chain?

- How to conceptualize the organizational structures and dynamics of trust within the supply chains of the Dutch Ministry of Defence to be used for SD modelling?
- How to implement the organizational structures along with the dynamic complexity of trust from sub-question 1 in an SD model?
- What are the effects of different scenarios on the trust relationship between distributor and client in a military supply chain?

In the remainder of this research, chapter 2 proposes the methods to answer these questions. Chapter 3 to 5 each aim to provide answers to one of the sub-research questions in order to be able to answer the main question as proposed above. Chapter 6 presents the discussion and chapter 7 will provide the conclusion of this research.

2 Methodology

This chapter provides an overview of the methods used to answer the different sub-questions formulated in chapter 1. The chapter argues that a method is necessary that copes with all kinds of uncertainty in the logistics system. Therefore, a combination of methods is presented.

Sub-question 1: How to conceptualize the organizational structures and dynamics of trust within the supply chains of the Dutch Ministry of Defence to be used for SD modelling?

This sub-question is answered with the support of a use case. Use cases are a simple yet powerful way to express the behaviour of a system in a way that all stakeholders understand (Bittner & Spence, 2003). Use cases allow description of sequences of events that, taken together, lead to a system doing something useful (Bittner & Spence, 2003).

To capture the elements of the system, secondary as well as primary research is conducted. Secondary research is done in the form of desk research. Internal documents of the Dutch Ministry of Defence are reviewed to gain a better understanding of the actors within the military supply chains are dependent on one another due the different processes taking place. Additional desk research is performed to gain insights of how to use a concept like trust in a SD model

Primary research is performed in the form of semi-structured interviews with a number of different actors within the military supply chains. The flexibility of this approach, particularly compared to structured interviews, also allows for the discovery or elaboration of information that is important to participants but may not have been thought as pertinent by the research team (Gill et al., 2008)

Sub-question 2: How to implement the organizational structures along with the dynamic complexity of trust from sub-question 1 in an SD model?

System dynamics (SD) is applied for addressing the dynamic complexity of trust within fragmented supply chain systems. SD is a multivariate computer simulation method, which is used to describe, model, simulate, and analyse the structure of dynamically complex issues and/or systems. One of its main advantages is that SD is able to display the systems evolutionary behaviour over time from the systems own structure (Kwakkel & Pruyt, 2013). The structure, and time evolutionary behaviour of a system is computationally simulated in SD, by using causal loops, and state variables, which represent complex feedback mechanisms as are seen in real complex issues (Kwakkel & Pruyt, 2013).

SD allows to identify desirable system changes in complex systems and/or issues from various important application domains, test them virtually, and thereby supports decision making. SD has application in numerous domains such as resources scarcity, social and organizational dynamics, and operations and supply chain management.

SD modelling has been used in many different contexts in supply chain management. Georgiadis et al. (2005) used SD for strategic supply chain management of food chains. Özbayrak et al. (2007) used SD modelling to portray a manufacturing supply chain system. Olivares-Aguila & ElMaraghy (2021) have used SD modelling to show the effects of disruptions on behaviour within supply chain systems.

The concept of trust has also been used in many different field where SD was used as modelling method. Luna-Reyes et al. (2008) used SD to generate a model where the role of knowledge sharing in building trust was shown. Analysis of the model suggests that trust depends on the pace of knowledge sharing among participants. Winch & Joyce (2006) used SD as a lens to interpret and understand the dynamic nature of building and losing trust in B2C eBusiness and reflect the structure of trust building systems. Rahman et al. (2008)

used a SD approach to apply strategies of how to stimulate trust between a contractor and subcontractor.

Research on the role of trust in supply chain systems is not so common, but has been performed by a number of scholars. Tseng et al. (2012) have conducted research on the role trust plays in the evolutionary process of supply chain collaboration by using SD modelling. However, the focus of this research lies on inter-firm trust. Rovers et al. (2017) have conducted research on trust in the field of pork and dairy supply chains. However, this research is solely focussed on trust from the customer to the supplier, rather than a two-way form of trust.

Sub-question 3: What are the effects of different scenarios on the trust relationship as well as the responsiveness and effectiveness of the supply chain?

To extend the use of SD, exploratory modelling and analysis (EMA) is applied, for addressing the dynamic uncertainty, subjected to trust within logistic systems. EMA extends the use of SD models, by computationally generating thousands of scenarios in view of exploring and analysing this ensemble of all plausible futures, and testing the robustness of policies in the entire uncertainty space. (Kwakkel & Pruyt, 2013). In order to perform thousands of simulations with the EMA methodology, computational models are required with a combination of Python with SD models (Pruyt & Kwakkel, 2012)

EMA has supported decision-making, by addressing dynamic uncertainty in numerous cases and problems. Kwakkel and Yücel (2014) tested reduction policies for CO2 in the Dutch electricity system using EMA. Vita (2015) used EMA to understand the uncertainty in the European biodiesel market.

To discover the scenarios of interest the PRIM algorithm and categorization is used to find the specific cases we are interested in. The PRIM algorithm will iteratively reduce the uncertainty space in multiple dimensions, where it optimizes for maximum density, mass and coverage.

Traditional sensitivity analysis techniques, like Sobol, require many model runs in order to perform a global sensitivity analysis. Jaxa-Rozen and Kwakkel (2018) present a technique that allows global sensitivity analysis to be performed that require less model runs: Extra trees feature scoring. The resulting feature scores provide an accurate approximate of Sobol indices. Since the influence of the input variables on the outcomes of interest is likely to vary over time, this thesis uses dynamic Extra feature trees scoring. The feature scores are examined for multiple time-steps in the model. The results of Extra trees feature scoring are shown in heatmaps, in which the individual effects of input variables of outcomes of interest are visualized.

This approach therefore requires a combination of interviews and modelling. In chapter 3, we will elaborate on how the interviews form a basis for the model structure.

3 Problem Formulation

A case study of the relationship between Program Management and their client is used in this study as an addition to the theoretical study of trust dynamics within military supply chain contexts. To be able to execute this, the organizational structure in which Program Management and their clients are present within the Dutch Ministry of Defence is described. This should enable creating a flow chart that is used to create the process where the two parties are interacting with one another. This results in a more abstract representation that serves as input for the model.

3.1 Use Case Description

The Logistics Centre Woensdrecht (LCW) consists of a department Program Management (PM) and Support and Logistics Wing. Program Management is responsible for the material availability of all air force weapon systems and unmanned aircrafts. The Support and Logistics Wing consists of four squadrons, where each squadrons it responsible for different types of maintenance.

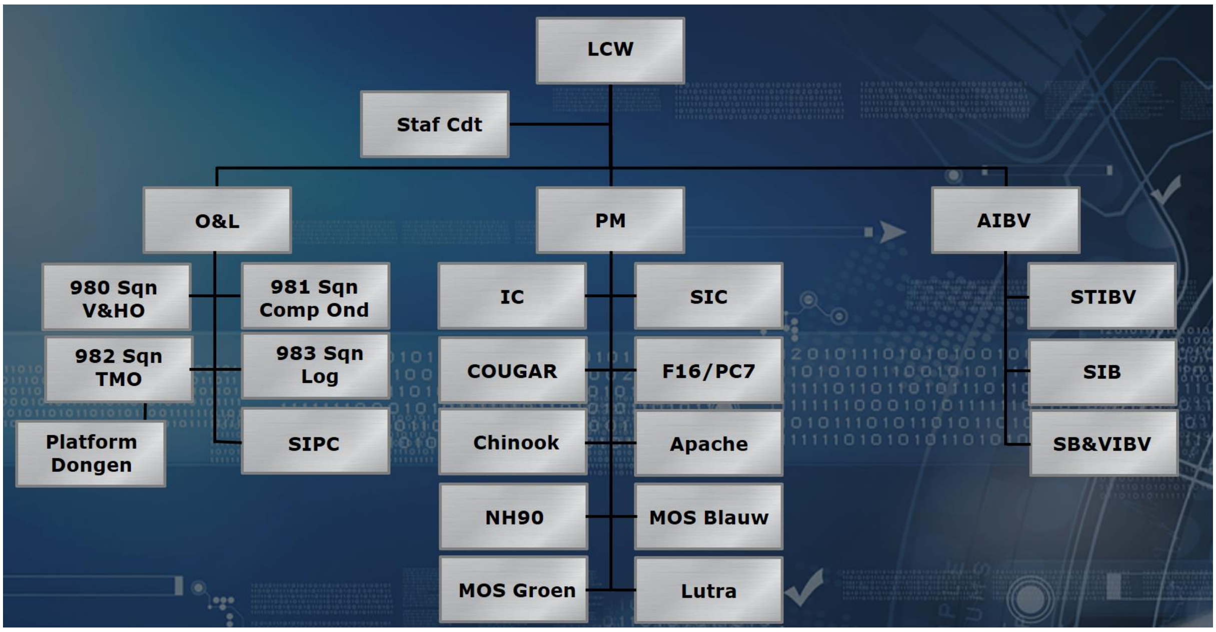

Figure 3.1 Organogram Logistiek Centrum Woensdrecht (Personal Communication; Vendrik, I (2023))

PM uses the ERP (Enterprise Resource Planning) system SAP (Systemanalyse Programmentwicklung; en: System Analysis Program Development) (Ministerie van Defensie, 2022b). An ERP system is a system which is found in many organizations. It is defined as a software package which collects important information from different departments within a company (Al-Mashari, 2003). An ERP-package enables the automatization of business processes, which increases productivity and reduces costs. Data regarding production, procurement, sales, logistics, and administration are linked together, which leads to the automatization of processes and, therefore, increased efficiency.

This thesis focuses on the application of MD06 within SAP at PM. MD06 is a transaction in SAP that shows the supply and demand of articles in a certain assortment (Ministerie van Defensie, 2022b). At PM, there are 11 different types of main assortments for each of the different weapon (support) systems regarding the Royal Dutch Air Force (Ministerie van Defensie, 2022c). Each assortment manager at PM is responsible for the logistics regarding their own assortment (Ministerie van Defensie, 2022b). This implies being up to date of current orders, inform the clients when delays occur and be aware of forecasting and material usage. MD06 helps the assortment mangers to display when there are scheduling conflicts regarding the ordered articles (Ministerie van Defensie, 2022b). The order for an article is called an “Aanvraag tot Behoeftestelling” (ATB) (EN: requirement request) in the context of the Ministry of Defence.

In the transaction MD06 a display is shown with a so-called traffic light system (Ministerie van Defensie, 2022b). When an ATB is displayed in SAP it enters with a green, yellow, or red light (see Figure 3.2). A red light means there is a scheduling conflict with means that the expected and realistic delivery date do not match. A green light means that there is no conflict as it stands, but when no action is taken, this green light turns into a red light. There is the option to use the yellow light, which gives you a warning when a green light ATB is reaching the conflict of becoming a red light. This happens when the assortment manager has not taken the appropriate actions in time to make sure the ATB is fulfilled.

	Stop...	Geld. van dat.	Artikel
			414L2410-1:77272
			179-60500-11:77272
			724VS201-1:77272
			414C3056-3:77272
			2-310-192-02:99193

Figure 3.2 Traffic Lights in SAP (Personal Communication; Vendrik, I (2023))

The main issue which hinders the assortment managers to properly carry out their job is that too many ATB’s enter SAP which cannot be fulfilled within the expected delivery date or even have an expected delivery date in the past (Ministerie van Defensie, 2022c). An expected delivery date in the past means that the ATB is not fulfilled in the time of the expected time. This problem leads to an unclarity of what the main priorities for the client are. Therefore the assortment manager has to make a best guess of what articles have priority and which don't.

This issue branches out in a number of other problems such as (Ministerie van Defensie, 2022c):

- Inefficient use of available capacity
- Design and analysis of assortments is hindered
- High costs due to rush orders
- Uncertainty for the client when their ordered articles arrive

There are a number of reasons why this chain of problems starts (Ministerie van Defensie, 2022c):

- The client does not take the delivery lead time into account, and therefore does not adjust to a realistic delivery date
- Articles which are not in stock need to be ordered
- The external supplier delivers too late

A common issue which is also visible in SAP is the presence of ATB's which have a delivery date of 3 years ago. Due to changes in the software, no one actually knows how to clear them from their view. Getting to the root cause of such problems takes a lot of time (Ministerie van Defensie, 2022c).

As of September 2022, there were around 2000 ATB's with a delivery date in the past in SAP (Ministerie van Defensie, 2022c). Compared to the ATB's which are in SAP with a green light, there are around 8000 green light ATB's present. This implies that there are only four times as many green light ATB's as red light ATB's.

3.2 Order Filing and Processing Description

3.2.1 Actors

Table 1 shows the present actors within this system. The actors all have a different role within the order filing process which is described in table 1.

Table 1 Actor Overview

Actor	Description
Technician	The technician who needs materials at his/her work location
Bedrijfsbureau (BB)	This party 'represents' the customers. They collect requests for materials in the field and checks whether the requests are justified (Ministerie van Defensie, 2013)
Logistics Support Element (LSE):	This party is responsible for translating the requests from the BB into ATB's (Ministerie van Defensie, 2018)
Assortment manager (Asset manager):	The person who is in charge of providing the logistic processes to get the materials to the customer. Each assortment manager is responsible for their own assortment of articles. The assortment manager is also responsible to contact the customer when changes need to be made when applying for materials or inform them of delays (Ministerie van Defensie, 2022b)

3.2.2 Process

This section provides a description of the process which occurs between the above mentioned actors in the order filing process. This section concludes with a schematic flow chart which visualizes the process along with the present actors and how they interact.

When a technician requires materials for a reparation he files a request at the BB (Ministerie van Defensie, 2022d). The BB collects the requests from the different technicians and after they are checked are forwarded to the LSE (Ministerie van Defensie, 2022d). The LSE translates the requests to ATB's and send them to the PM (Ministerie van Defensie, 2022d). The assortment manager checks whether the request is filled in correctly.

If the request is filled in correctly, the assortment manger fixates it (Ministerie van Defensie, 2022b). Thus the green light is given for the employees at transport to prepare the articles for shipping, or the assortment manager will reach out to the external supplier when the article is not in stock (Ministerie van Defensie, 2022b).

If the request is filled in incorrectly, the assortment manager has to check where the mistake has been made. This is either due to wrong master data or because there was a mistake in the request. In either case the assortment manager has to instruct the LSE to file in their request again. However, interviews with the assortment managers at PM have shown that this is not the case in practice (see appendix C). The frequent occurrence of incorrectly filed orders at PM has led to the reality that the assortment managers approach the ATB's with their best guess, rather than reaching out to their client.

This process shows that PM is not directly in contact with the technicians which require the materials. Rather the LSE and BB are mediators in the process of order filing. Having additional actors into the chain of information flow makes it difficult to build trust, since trust building requires frequent interactions between the same parties. The numerous actors within the flow of information makes it difficult to trace where possible mistakes have been made.

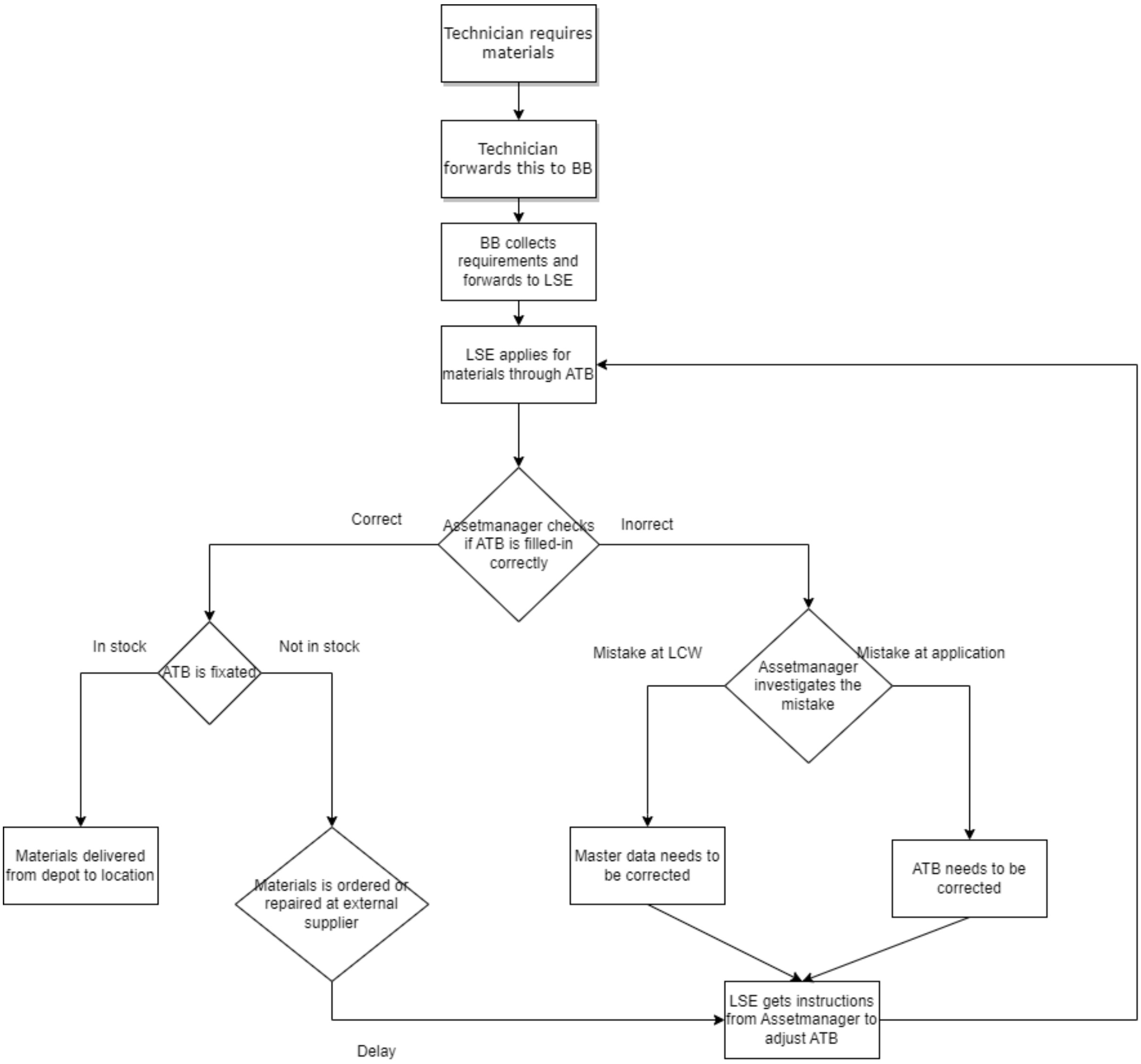

Figure 3.3 Process Description Order Filing & Processing

3.3 Conclusions from interviews

Interviews conducted within the Ministry of Defence have shown that the client is willing to cooperate when asked, but makes the same mistakes the next time (Ministerie van Defensie, 2022e). The assortment managers indicate that it is exhausting to keep correcting the client, and therefore rather try to fix the problem themselves (see appendix B). They claim that a lack of knowledge at the client is the reason that this situation has become as it is, and a lack of trust that the client is able and willing to learn is the cause for the situation which is now present at PM (see appendix B).

The interviews have shown that trust and knowledge are important concepts which are present in the situation. The internal documents regarding the organizational structures have shown that it is difficult the stimulate these concepts in the system. This is due to organizational fragmentation and the lack of direct contact between actors (see appendix B).

3.4 Current policies

The Ministry of Defence utilizes the concept of “job-rotation” to spread knowledge throughout the different departments of the large organisation. Job-rotation programs emerged in the 1908s and 1990s as organizational strategies aimed at increasing the performance and flexibility of workers (Kernan & Sheahan, 2012). Within the Ministry of Defence, employees take a different position every three years. However discussions with different employees within the organization have shown that this is regarded as a negative course of action within the fields of supply chains. The employees seek standardization and tacit knowledge. However, these concepts cannot grow in a system which is being changed continuously.

Another lever of policymaking within the supply chain between PM and their client is the correction capacity lever. Incorrect ATB’s need to be corrected by the asset manager in order to maintain an overview of all the incoming orders. This policy lever determines the speed of which this happens in the organization.

The last policy lever used in this thesis is the target delivery delay lever. The client expects their materials to arrive based on the target delivery delay. Therefore it is crucial that this target delivery delay is communicated with the client, so that they know when to expect their materials to arrive. This lever is used to determine how the trust dynamics between PM and their clients change based on a high or low target delivery delay.

3.5 Relation to System Dynamics Model

Based on the existing literature, internal documents and the results from the interviews, the XLRM framework is used as a basis for the model structure. In figure 3.4 the relevant external factors, policy levers, relationships in the system and the performance metrics that will be used in this research are visualised.

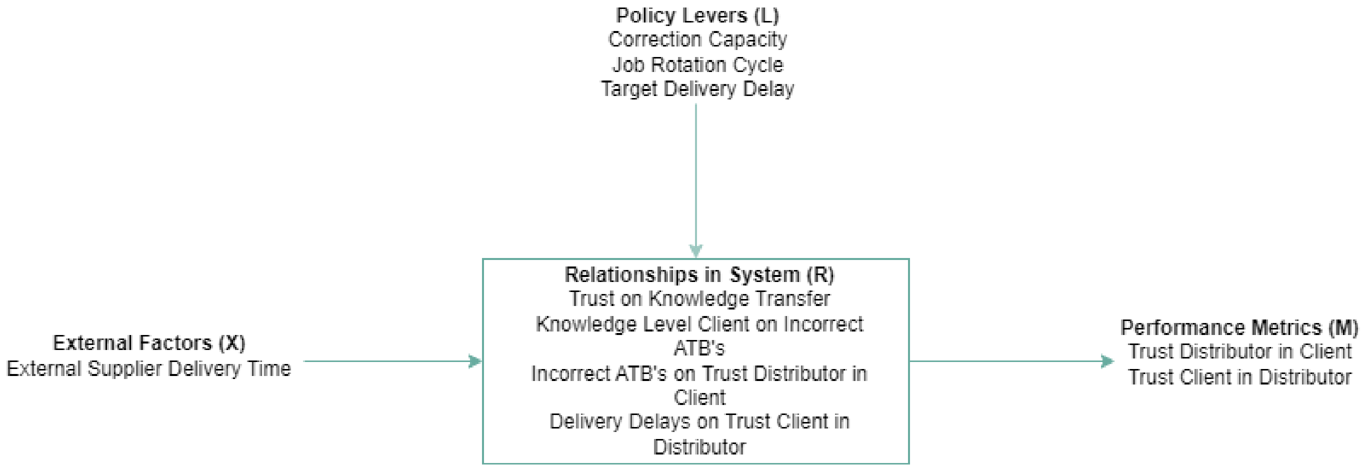

Figure 3.4 XLRM Framework

The interviews have provided a basis to conceptualize the model used in this thesis. Two concepts which came forward where those of a lack of trust and knowledge. Therefore the model has to show how these two concept interact with one another. Outcomes of the interviews have also shown that the trust is very low from the distributor in the client due to poor performance by the client. However, the trust from the distributor in the client is deemed high, due to the distributor being reliable. This indicates that trust is determined by different performance metrics for the two parties. This implies that the model has to show two different dynamics of trust which are dependent on different factors, but indirectly do affect one another. Chapter 4 will elaborate on the model structure and the interactions between the different sub-models.

4 Model

The military supply chain model consists of five different sub-models. These sub-models pertain to trust from distributor to client, trust from client to distributor, knowledge transfer, order filing performance and logistics. Figure 4.1 shows how these various sub-models interact. Examples of relations between the various sub-models are: an increase in trust causing improved knowledge transfer and a higher order filing performance leading to a higher logistics performance.

4.1 High level overview of the system

When examining the model's structure, five sub-models are identified, namely the trust distributor to client sub-model, the trust client to distributor sub-model, the knowledge transfer sub-model, the order filing performance sub-model and the logistics sub-model. First of all, the trust distributor to client sub-model provides insights into the trust relationship from the perspective of the distributor between Program Management and their client. The trust client to distributor sub-model provides insights into the trust relationship from the perspective of the client. Subsequently, the knowledge transfer sub-model displays the knowledge levels of the previously mentioned actors and the transfer of knowledge between them. The knowledge level of the client gives an indication of how many of the filed ATBs in the ATB sub-model are filed in incorrectly. These ATBs create a backlog which causes delays in the logistics sub-model. The structure of the model is developed in a such a way that they show the dynamic interactions between the various sub-models. This indicated that dynamic interactions occur not only within the sub-models but also between the sub-models adding the complexity of the actual military supply chain system to the model.

The Causal Loop Diagram below shows the most important interactions between the different sub-models. The relation of trust between Program Management and their client has its effect on the knowledge transfer from Program Management to their client. When trust rises between the two parties, this stimulates knowledge transfer. A high amount of knowledge transfer leads to a higher knowledge level of the client. Thus the amount of incorrect ATBs drops which increases the level of trust between the two parties. Therefore this is seen as a reinforcing loop. However the opposite is also true when the level of trust decreases between Program Management and their client. This halts the knowledge transfer to their client which leads to a lower knowledge level. Consequently, this increases the number of incorrect ATBs which disrupts the trust relationship between Program Management and the client. The order filing performance also has its effects on the performance of logistics within the system. The faster the ATB's are processed, the faster the materials arrive at their destination. When materials arrive on time, this stimulates trust within the system. However, when delays occur within the shipments of materials, this causes delays for the tasks at the client. This reduces trust between the distributor and the client. In conclusion, it is seen that the model captures the most important interactions between the different sub-models.

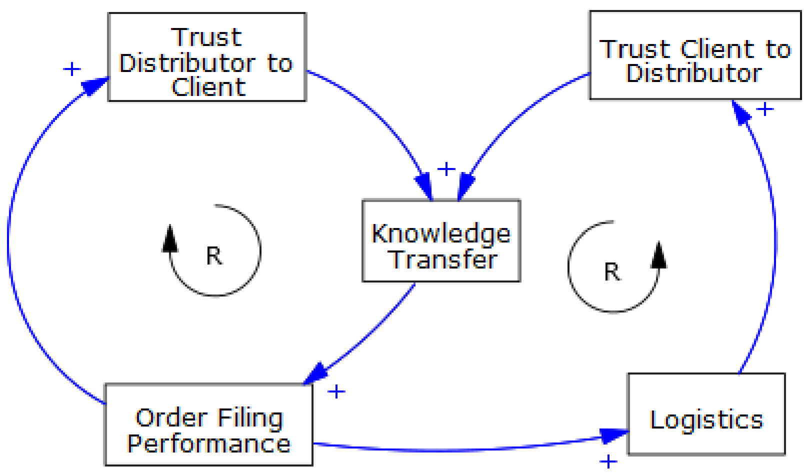

Figure 4.1 Sub-system Diagram

4.2 Defining key concepts

4.2.1 Trust dynamics over time

Most of the research in trust refers to it as a dynamic phenomenon (Heimer, 2001). Numerous research claim that this dynamic characteristic is frequently associated with a series of reinforcing processes that characterize collaborative relationships. (Hardin, 2001; Kramer et al., 1996). Collaboration provides an opportunity to trust, and through the accumulation of experiences, the persons involved in the process get to know each other to further develop trust, or to develop distrust (Hardin, 2001).

The development of trust over time consists of an asymmetry, namely differences between the processes of building trust versus destroying it (creating distrust) (Lewicky & Bunker, 1996). Empirical and theoretical analyses of trust are consistent in pointing out that while building trust is a gradual process, it might be destroyed very quickly by single events or inconsistencies on the trustee's behaviour. This observed asymmetry has led to some researchers to observe trust and distrust as two different constructs that increase or decrease independently, moving in different continua (Kramer et al., 1996). However the modelling and simulation experiments described in this thesis, suggest that asymmetries might exist in a single continuum, considering distrust as the lack of trust, and not a different and conceptually different construct. The trust dynamics within this thesis are shown in sub-models 1 & 2. We will elaborate on these sub-models within this chapter.

4.2.2 The role of trust on knowledge transfer

A common assumption in the trust literature is that trust facilitates knowledge transfer. Knowledge transfer is hereby defined as the exchange of knowledge between a source and a receipt unit, so it can be applied (Ko et al., 2005). Numerous researches have concluded that the relationship between trust and knowledge transfer is positive. Such researches have been performed in different contexts such as a mentoring, a relationship between a consultant and client in interorganizational cooperation, where it facilitates open communication and knowledge gaining. A study by Zand (1972) has suggested that trust encourages parties to share accurate and timely information, which results in problem solving.

A decision whether to accept or devolve knowledge is based on trust (Renzl, 2008). The perceived link between trust and knowledge transfer in the literature is so strong that some scholars even equalize trust with knowledge transfer (Sankowska, 2013). How knowledge transfer is modelled and how it is related to trust is shown in sub-model 3 of this thesis. We will elaborate on this sub-model in this chapter.

4.3 Trust Distributor in Client

In the trust distributor in client sub-model (see Figure 4.2), trust is calculated within the military supply chain system. Trust fluctuates as a result of order filing performance. The order filing performance is measured on the basis of the ratio of green versus red ATB’s. A higher number of green ATB’s stimulates trust building, while a higher number of red ATB’s enhances trust damaging. The gradual process of building trust is displayed by the trust building delay.

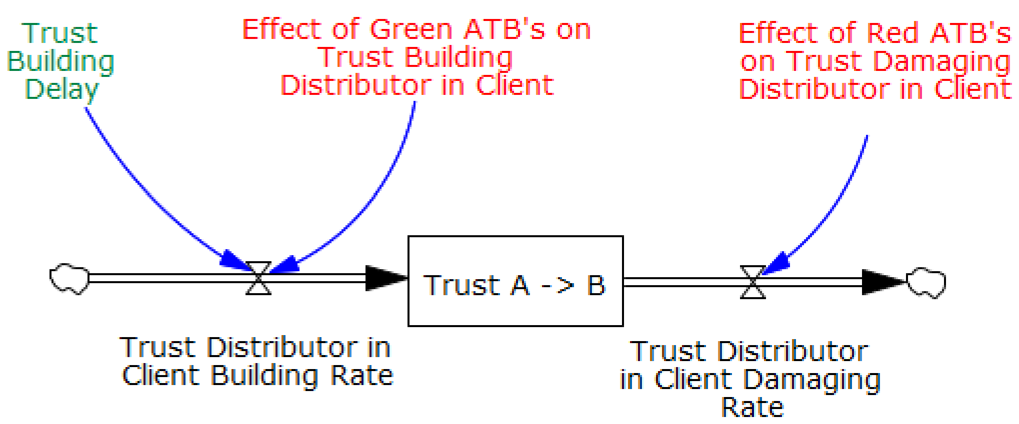

Figure 4.2 Sub-Model Trust Distributor to Client

4.4 Trust Client in Distributor

Trust from the client in the distributor is affected by delays in shipments from the logistics sub-model (see Figure 4.3). A difference between the real delivery delay compared to the target delivery delay creates a delay gap. When there is a gap, this damages trust at the client, because this implies that their required materials arrive with a delay. Similar to the previous sub-model, trust is built with a delay.

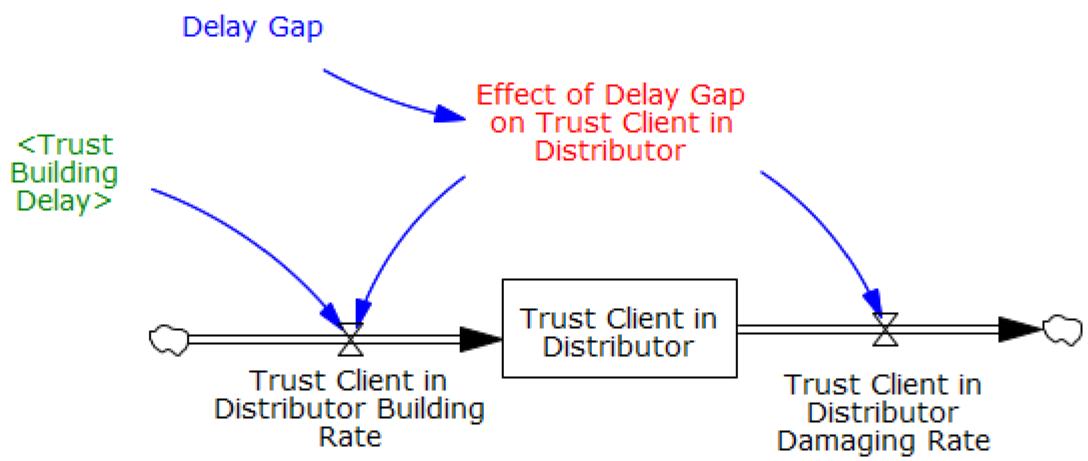

Figure 4.3 Sub-Model Trust Client to Distributor

4.5 Knowledge Transfer

In the knowledge transfer sub-model (see Figure 4.4), knowledge transfer occurs from the distributor (the knowledge sender) to their client (the knowledge receiver). The speed of this knowledge transfer is dependent on the trust level in the system. If the trust level increases, knowledge transfer also increases.

The knowledge gap is the difference in knowledge between the knowledge sender (the distributor) and the knowledge receiver (the client). The level of trust between the distributor and the client determines the speed of knowledge transfer, whereby a higher level of trust leads to a faster knowledge transfer rate. This knowledge transfer stops when the knowledge gap becomes zero. Since it takes time to apply the knowledge which has been transferred there is a knowledge processing delay.

Knowledge is removed from the knowledge level stocks through job rotation. Job rotation is a common procedure within the Ministry of Defence where each employee within the Ministry of Defence gets a new function within the organization. Thus specific knowledge regarding the order filing is lost after every job rotation cycle.

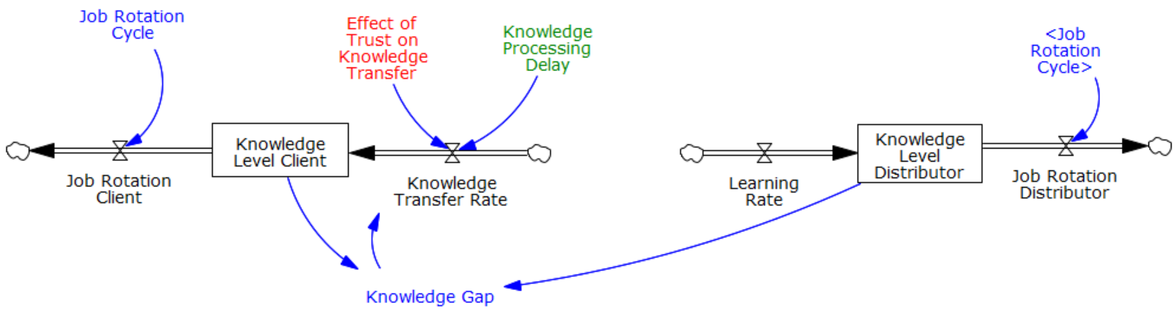

Figure 4.4 Sub-Model Knowledge Transfer

4.6 Order Filing Performance

Previous interviews within the Ministry of Defence have concluded that a lack of knowledge at the client results in a significant amount of incorrectly filed orders at the distributor. In the order filing performance sub-model (see Figure 4.5), order filing performance is calculated as a ratio of correct and incorrectly filed ATB's. The incoming ATB rate follows from material demand from the logistics sub-model. Based on the level of knowledge of the client, ATB's are distinguished as either correctly (Green Light) or incorrectly (Red Light) filed. Incorrect ATB's need to be corrected, which increases order filing processing time. How much ATB's are corrected within a certain time span is dependent on the correction capacity. Correct orders are fulfilled based on the shipment rate in the logistics sub-model.

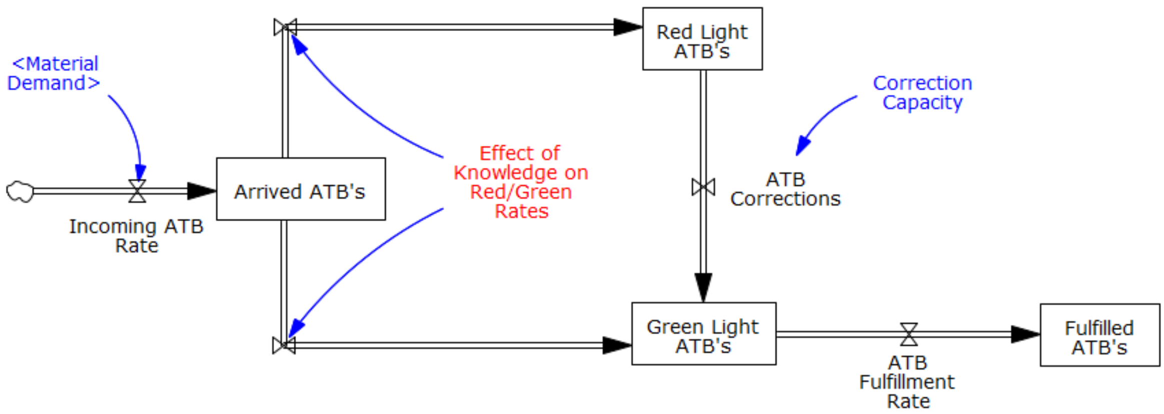

Figure 4.5 Sub-Model Order Filing Performance

4.7 Logistics

In the logistics sub-model, the supply chain of materials is shown from the external supplier to the inventory of the client, where the distributor acts as the link between the two. Clients use materials for their regular set of tasks. The adjustment which has to be made for their inventory generates material demand. The previous sub-model has shown how the orders for material demand is processed. New material for the client arrives from the inventory of the distributor with the speed of the shipment rate. The shipment rate is dependent on the maximum shipment rate, as well as the desired shipment rate. Due to materials leaving the inventory of the distributor, they also make adjustments for their inventory. The materials they lack are ordered at the external supplier. The external supplier delivers the materials with a delivery delay.

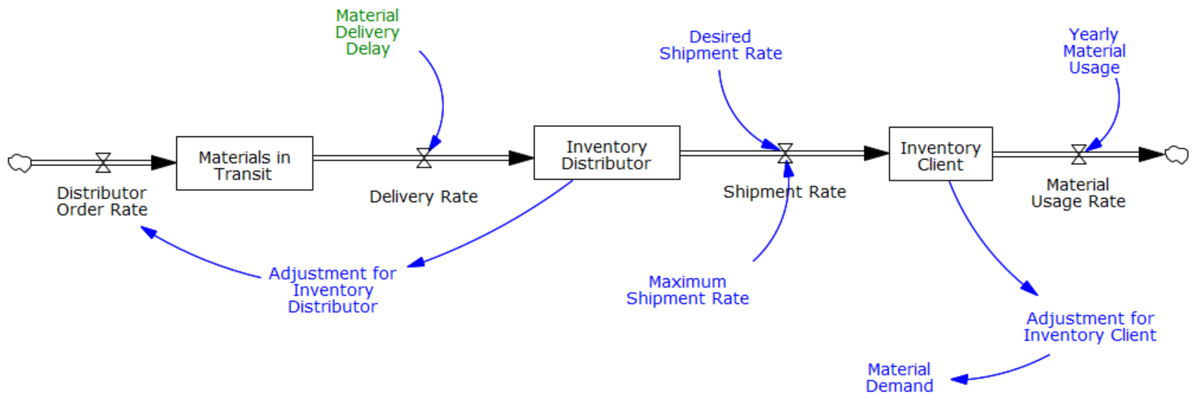

Figure 4.6 Sub-model Logistics

4.8 Model Assumptions

Several structures in the model are based on assumptions made by the modeller. These assumptions are found in table 2 below.

Table 2 Model Assumptions

Sub-Model	**Structure**	**Argumentation**
Trust	Trust as a stock	Trust and distrust may coexist and even complement each other in social interaction (Bachmann & Hanappi-Egger, 2014). This implies the concept of trust might be considered dynamic rather than static. Based on this reasoning the concept trust has been modelled as a stock. This stock represent the dynamic level of trust within the system.
	Trust building and trust damaging	Dirks et al (2009) have researched the field of trust building and trust damaging in supply chains. These processes have been modelled as in- and outflow of the Trust stock.
Knowledge Transfer	Knowledge as a stock	Since the willingness to send and receive knowledge are dependent of the knowledge level of the knowledge sender and receiver, the knowledge level of both the knowledge sender and the knowledge receiver have been modelled as stocks. Since these knowledge levels might also be observed as dynamic since it is dependent on how much knowledge is transferred, the decision has been made to model them as stocks.
	Learning Rate	The assumption is that the knowledge level of the knowledge sender increases due to more experience and technological innovations. These concepts have

		been modelled within the *Net Learning Rate*.
Orders	Output knowledge on correct rate	Internal discussions and the interviews with the assortment managers have concluded that a lack of knowledge about correctly filing orders is the main reason that so many incorrect orders are filed. This reasoning is modelled with the lookup variable *Output knowledge on correct rate.*
	ATB's into Green & Red	The application MD06 in SAP designates the colours of a traffic light to each order that arrives. A green light shows no delivery date conflict, while a red one does. This has been modelled by designating the ATB's that arrive into either a *Correct ATB* or *Incorrect ATB* stock.
	Link Green & Red ATB's to Trust building and damage	The interviews with the assortment managers have concluded that the amount of ATB's arriving with an incorrect delivery date have a negative influence on the amount of trust between them and their client. Vice versa is true for ATB's that have a correct delivery date. Therefore the amount of correct and incorrect ATB's have been separately divided by the total amount of unfulfilled orders to get a greenlight and redlight ratio. The greenlight ratio impacts the trust building rate, while the redlight ratio impacts the trust disruption rate.
	Corrections	Orders with a redlight need to be corrected by the assortment manager. This changes the order from a redlight into a green light. This is modelled with the *Corrections* flow.
	Fulfillment Rate = Shipment Rate	Orders are only fulfilled when the materials have arrived at their destination. This indicates that the order fulfilment rate has to be equal to the shipment rate.
	Desired Material Orders = Order Rate	The assumption has been made that every demand for a single material is filed through a single ATB. This indicates that the desired materials orders is equal to the order rate.
Supply Chain	Two inventories structure	The supply chain sub-model is based on CH. 18 of Sterman (2000). These show the inventory at the LCW and the inventory at the Work Location. The deliveries and desires for materials are similarly modelled as in CH. 18 of Sterman (2000).
	Materials in Transit	Internal discussions with the assortment managers at PM have shown that the deliveries from the external supplier to their inventory might take a very long amount of time. To represent the orders waiting to be fulfilled at the external supplier, the materials in transit stock is added. This makes it visible to see how many materials are expected from the external supplier but not delivered yet.

4.9 Model verification and validation

Model verification tests have shown that the model does not contain any unit errors and the integration method and time steps in the model have been deemed appropriate for this model (see appendix A).

Model validation is carried out consistently throughout the model development process. Multiple validation tests as defined by Forrester & Senge (1980) are used to assess whether the model is fit for purpose. Below are the used validation tests, followed by an evaluation of whether or not the model is fit-for-purpose.

4.9.1 Boundary adequacy

This exploratory research demonstrates the dynamics of trust between a distributor and their client. The outcomes of interest are therefore the trust from the distributor in the client and the trust from the client in the distributor. Because of their dynamic nature both phenomena are modelled as stocks which remain between the boundaries of 0 and 1.

The knowledge levels of the distributor and the client are similarly modelled as the trust sub-models, where the distributor and the client have their own stock of knowledge. These stocks also remain between the boundaries of 0 and 1.

The order filing and logistics sub-systems are related through the material usage which generate orders to be filed. They remain equal to one another, due to the assumption that each material requires its own order to be filed.

4.9.2 Behaviour anomaly

The behaviour anomaly test has been a continuous process during the modelling cycle. Unexpected and unrealistic behaviour was tracked down to improve the model. The values of trust and knowledge were monitored extensively, to ensure its values to remain between the boundaries between 0 and 1.

Table 3 Validation Tests

Validation type	**Validation test**	**Short argumentation**
Structural	Structure verification test	Use of scientific sources & interviews
	Parameter-verification tests	Comparing logistics data with data provided by the Ministry of Defence
	Extreme-Conditions tests	Implicit to robust decision-making
	Dimensional consistency	Built-in tool in Vensim
	Boundary adequacy tests	Model contains relations for proof of concept purposes
Behavioural	Behaviour characteristic	The principle of "Trust takes time to develop; it is easy to lose and hard to regain" by Reina & Reina (2009) is shown in the model outcomes
	Pattern prediction	Reinforcing behaviour of trust is seen from both the distributor and the client due to the double reinforcing feedback loop structure of the system
	Behaviour-anomaly	Flaws in the model were found by testing different options. Several model iterations were performed based on strange results such as extremely high number of incorrect ATB's and trust dynamics which did not behave as expected
	Behaviour sensitivity	The model outcomes have shown how sensitive the model is to its initial values of trust.
	Changed behaviour test	Plausible impacts of policy interventions are demonstrated
	Policy sensitivity	The correction capacity lever has shown that the model is sensitive to this lever

A validation test which has not been performed in this research is the extreme policy test. An extreme policy lever which could have tested the resilience of the supply chain is a lever which deals with a system crash. This could represent an extreme situation such as materials which cannot be delivered due to logistic failures.

4.10 Experimental setup

The SD model is implemented in the Vensim DSS Version 9.3.5 modelling software (Ventana System, 2010), which is software tailored specifically for SD models. The model is simulated for 104 weeks (2 years) with a time step of 0.0078125, using the Euler numerical integration method (see Appendix A). This model is thereafter tested in the Python environment using the Exploratory Modelling Workbench, a library which was created specifically to perform EMA (Kwakkel, 2017). For the uncertain input variables, Latin Hypercube sampling is used, with uniform distributions between the minimum and maximum as described in table 4. Furthermore, 3 switches were included, to switch on and off policy levers. In this way, 1000 samples are generated. The files for the analysis are found on https://github.com/KaranPoeran/TrustModel

Table 4 shows an overview of the input variables in the model, their range as used as input to EMA, and the source for these values. Parametric uncertainties are in the form of scenarios, which are more elaborate combinations of parameters, or individual parameters in the model.

All variables listed here are included in the first runs of the model, which are used to identify the most influential input variables to the model. The model is run using values sampled from a predefined range using Latin Hypercube sampling (McKay, 1979). The uncertainties which are included are so-called structural uncertainties. These are uncertainties that apply to system boundaries, the conceptual model or the computer model structure (Van der Linden, 2020). This includes the assumptions and structures present in the model. The uncertainties are found in the table below. These consists of the constants used in the model, which are based on assumptions made by the modeler or estimations from data provided by the Ministry of Defence. Since many of the parameters in this thesis are uncertain, the choice was made to use the Scenario Discovery Tool that the EMA workbench provides to show insightful results. The scenarios are created based on the many runs that are performed with the EMA Workbench. Each combination of a different value for the input parameters is in fact a different scenario in which the model operates. Therefore the EMA Workbench enables the modeler to approach the many uncertainties present in this model.

Table 4 Uncertain Input Variables

Sub-Model	Parameter	Unit	Min	Max
Trust Distributor in Client	Initial Trust Fraction Distributor	Dmnl	0	1
	Trust Building Delay	Week	1	4
Trust Client in Distributor	Initial Trust Fraction Distributor	Dmnl	0	1
Knowledge Transer	Initial Knowledge Client	Dmnl	0.1	0.5
	Initial Knowledge Distributor	Dmnl	0.5	0.9
	Learning Rate	1/Week	0.001	0.005
	Knowledge Loss Factor	Dmnl	0.1	0.25
Order Filing	Information transmission delay about correct ATBs	Week	1	4
Supply Chain	Material Delivery	Week	1	26

	Time			
	Yearly Material Usage	Year	900	1000

The model structure deems the soft variables of trust and knowledge to be between 0 and 1. Therefore are the initial values of trust from the distributor and the client set between 0 and 1. The lack of knowledge at the client is modelled in such a way that its knowledge level initiates from the values between 0.1 and 0.5, compared to the knowledge level of the distributor whose initial values are varied between 0.5 and 0.9. Since there is no situation where there is no knowledge at all or complete knowledge, the boundaries of 0 and 1 are not included in the variations of these input values.

The *Trust Building Delay* is based on the claim of Li et al. (2008). They claim that the development of trust involves a gradual process to build. However, the opposite is true for trust damaging. As claimed by “Trust takes time to develop; it is easy to lose and hard to regain” (Reina & Reina, 2009; p.10). Knowledge processing is also modelled with a delay. The assumption is made that newly obtained knowledge cannot instantly applied to improve work processes. It takes time and practice to be able to perform new skills.

Due to experience and technological innovations is the knowledge sender able to increase its own knowledge level. This is translated into the *Learning Rate* variable. Knowledge is lost at both the distributor and the client due to job rotation. Its effect is modelled as a knowledge loss factor. Because it is not possible to give an exact number of how much knowledge is lost due to a colleague leaving, it’s boundaries have been modelled between 0.1 and 0.25. A knowledge loss of 0.1 would mean that 10 percent of knowledge is lost. This implies an colleague without crucial experience and tacit knowledge. An colleague leaving with crucial knowledge and tacit knowledge is modelled as a knowledge loss of 0.25.

Whether an ATB is correctly or incorrectly filed does not have its impact immediately on the trust from the distributor in the client. This effect takes place over a delay which has been modelled as the *Information transmission delay about correct ATBs.*

The material delivery time is very uncertain regarding employees at PM. Therefore there is a very wide range of *Material Delivery Time* used in this model. The yearly material usage is provided by the employees of PM for one specific type of spare part.

In this thesis we analyse a wide range of potential policies represented by levers. These levers are based on routines and (un)written rules within the Ministry of Defence. The aim is to explore their impacts on the trust dynamics between the distributor and the client. These policy levers are shown in table.

Table 5 Policy Levers

Lever	**Value**	**Unit**	**Description**
Job Rotation Cycle	Lever = 0, 78 Lever = 1, 26	Week	This lever determines the length of the job rotation cycle in the system. The shorter this cycle, the more knowledge is expected to be lost due to more employees leaving in the same period of time.
Target Delivery Delay	Lever = 0, 4 Lever = 1, 1/7	Week	This lever determines the target delivery delay for the distributor. When the delivery delay is longer than its target, this damages the trust in the distributor from the client. A longer target delivery delay would therefore improve trust, but reduces its responsiveness
Correction Capacity	Lever = 0, 1 Lever = 1, 4	Order	This lever determines how many ATBs are expected to be corrected by the asset managers. The lever switched on means that the asset managers are expected to work harder no matter the trust within the system.

Using PRIM on the global variables that are the core focus for this research – trust between the distributor and the client– scenarios of interest are defined. Typically policy levers are not included in the prim sensitivity analysis, but in this case, policies have been included as uncertainties in our analysis. The PRIM algorithm helps to determine the subset of uncertainties (and policy levers) that will lead to the desired outcome.

5 Results

This chapter will discuss the results from the multiple modelling steps. This chapter starts with exploratory runs to determine whether the model follows the predicted behaviour. Afterwards an uncertainty analysis of the model is performed and this chapter concludes with a policy analysis.

5.1 Exploratory Runs

Prior to analysing the uncertainties and policy lever of the model, a number of exploratory runs have been performed to determine whether the model shows the behaviour which is expected. It is expected that the outcomes of trust follow the previously mentioned principle by Reina & Reina (2009): “Trust takes time to develop; it is easy to lose and hard to regain”. Exploratory runs have been performed by varying the initial trust fraction of the trust from the distributor in the client. The other variables in the model remain constant. This provides the following results as are shown in figure 5.1 below:

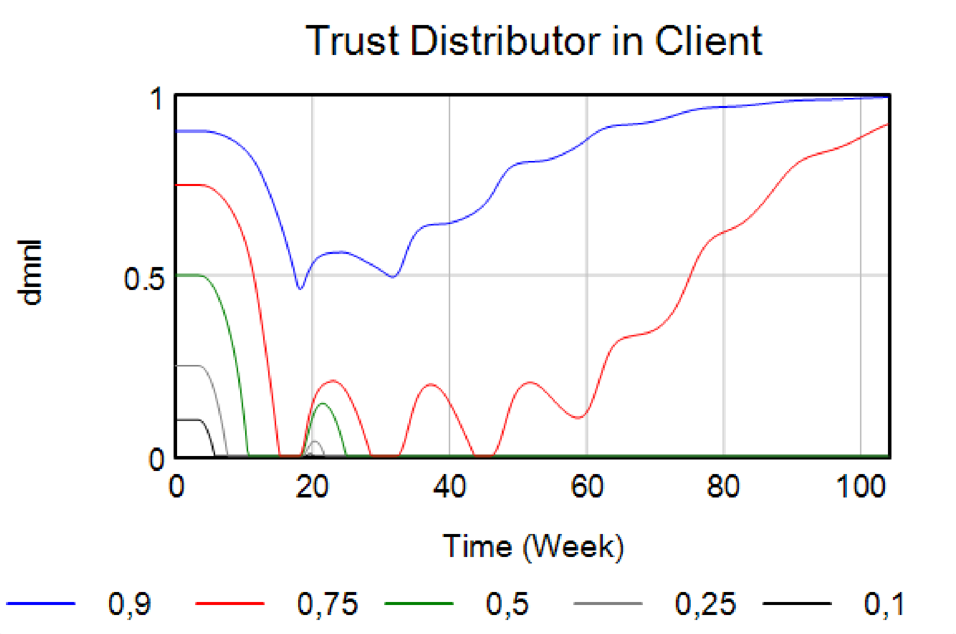

Figure 5.1 Exploratory Runs Trust Dynamics

The figure shows that despite the initial trust fraction of trust from the distributor in the client, every model run starts with a significant drop of trust, even at an initial value of 0.9. Trust behaviour confirms the principle that trust drops very fast when trust is lost. The other part of the principle is also confirmed. Figure 5.1 shows that trust does not restore as fast as it drops. In scenarios where the initial trust is 0.5 or below, the results show that trust is not restored at the end of the model runs. If trust is able to restore, it is also visible that this happens step-by-step rather than a steep curve upwards. These results confirm the principle of trust by Rein a& Reina (2009).

5.2 Uncertainty Analysis

In exploratory modelling, we are interested in understanding how regions in the uncertainty space and/or the decision space map to the whole outcome space., or partitions thereof. Systematic sampling of the uncertainty or decision space is also known as open exploration. Open exploration is used to stress test promising mappings from the decision space to the outcome space under a whole range of possible resolutions to the various uncertainties.

The uncertainties and decision levers are sampled simultaneously by generating 1000 scenarios and 3 policies, and see how they jointly affect the outcomes. A scenario is understood as a point in the uncertainty space, while a policy is a point in the decision space. The combination of a scenario and a policy is called experiment. The uncertainty space is spanned by uncertainties, while the decision space is spanned by levers. By default, the workbench will use Latin Hypercube sampling for generating both the scenarios and the policies. Each policy will always be evaluated over all scenarios.

5.2.1 Scenario Discovery

The first method to initiate the uncertainty analysis is applying a rule induction algorithm called *Patient Rule Induction Method (PRIM)* to the model. The PRIM algorithm searches the input variable space, to find values result in outputs that are considerably different than the average value over the entire output domain. In addition it is usually desired that these regions be describable with rules to specify the input values. (Friedman & Fisher, 1999). PRIM describes these subspaces in the form of boxes of the model input space (Pruyt & Kwakkel, 2012).

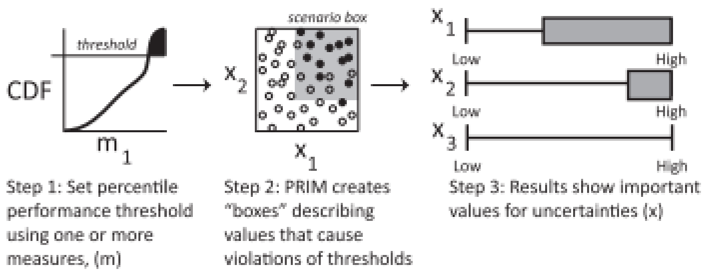

Figure 5.2 The three main steps of PRIM (Kasprzyk et al., 2013)

To discover the scenarios of interest the PRIM algorithm and categorization is used to find cases where the trust from the distributor to the client ends up below a level of 0.001. The PRIM algorithm will iteratively reduce the uncertainty space in multiple dimensions, where it optimizes for maximum density, mass and coverage. The trade-offs between coverage and density are explored using the show trade-off function, after which the suitable box is inspected that is created with the peeling and pasting trajectory.

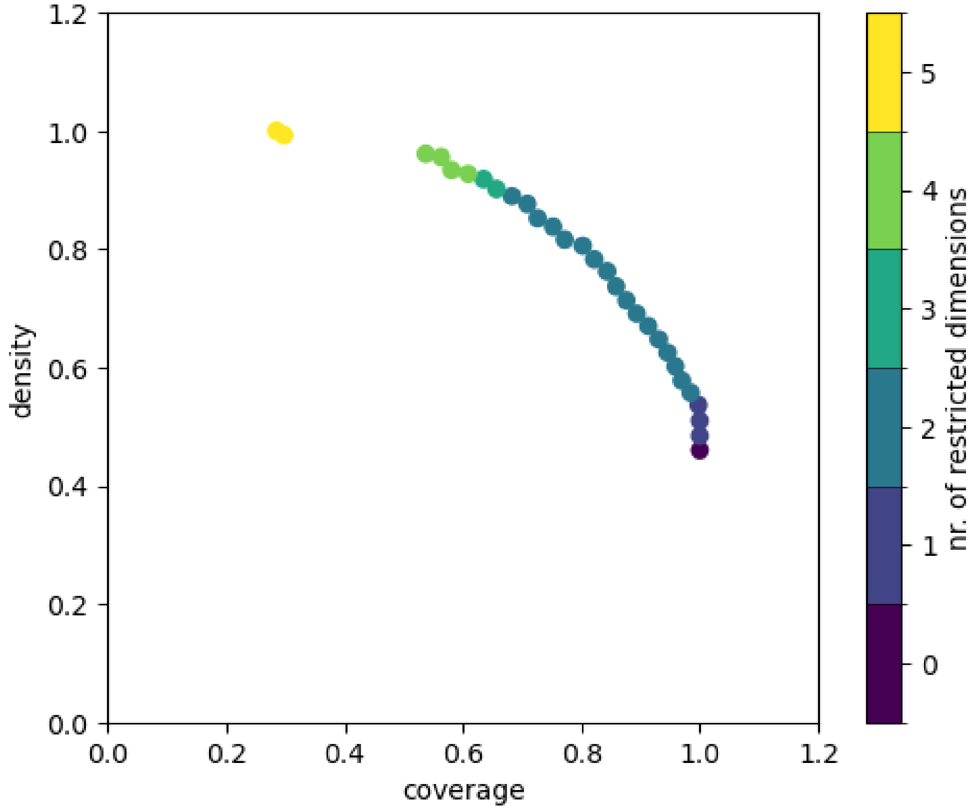

Figure 5.3 Trade-off graph for trust from distributor to client below 0.001

Figure 5.3 shows that by restricting three dimensions, almost complete coverage is achieved while maintaining a density of approximately 60%. The scenario space with restricted dimensions called a PRIM box and is shown in Figure 5.3. On the left side, the uncertainties are shown, followed by the p-value and the range of the restricted dimensions. Figure 5.4 shows that he initial knowledge level of the client are significant on the outcomes of trust from distributor to client that ends up below the level of 0.001 percent. This result implies that a low level of trust is be reached when the initial knowledge are of a somewhat low level already.

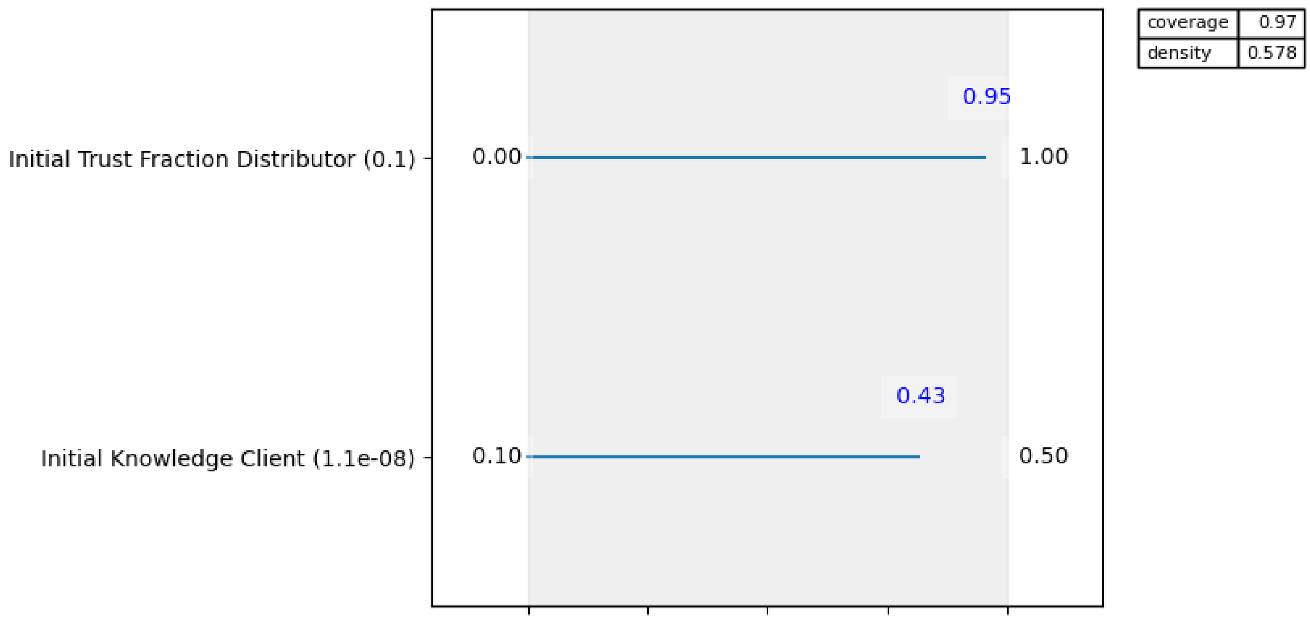

Figure 5.4 Box 5

Additionally the PRIM algorithm is also applied for the trust level from the client to the distributor. The threshold chosen for this analysis is all scenarios where the trust level reaches above 0.9. The trade-off box is shown below in figure 5.5.

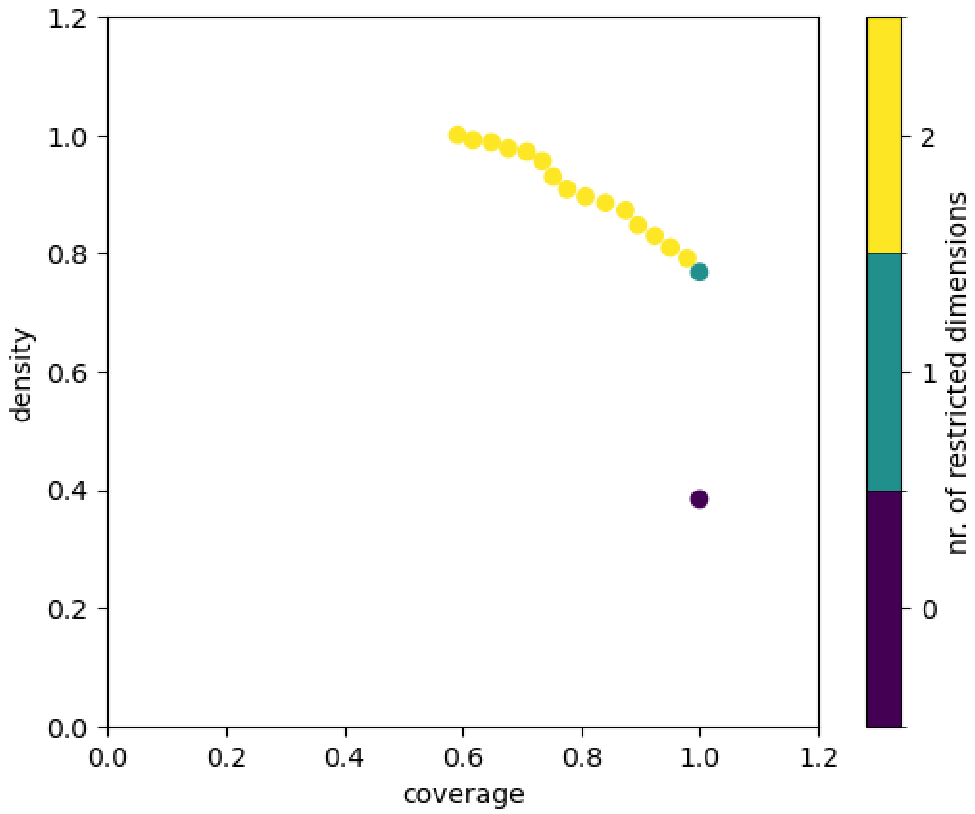

Figure 5.5 Trade-off graph for trust from client to distributor

Figure 5.5 shows the trade-off graph between coverage and density. By restricting three dimensions, almost 90% coverage is achieved while maintaining a density of around 85%. The PRIM box and is shown in Figure 5.6.

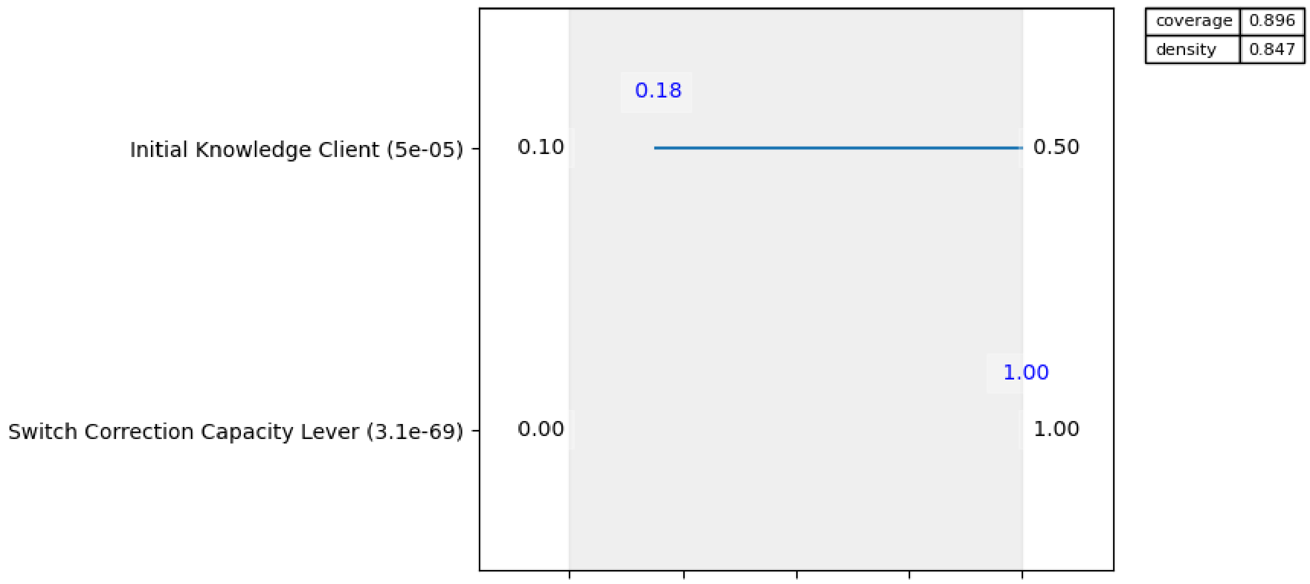

Figure 5.6 Box 5

The PRIM box shows two unexpected results. While it was expected that an high initial trust value of the client would have significant impact on the result of this analysis, it is the knowledge level which is shown in the PRIM box. The initial value of the knowledge of the client determines how many incorrect ATB's are filed during the first time steps of the model run. This has an effect on the trust from the client in the distributor through the delivery delays. The PRIM box also shows that the correction capacity is significantly important for high outcomes of trust from client to distributor. This is explainable due to the effect of incorrect ATB's on the delivery delay. The delivery delay is namely calculated by the number of correct and incorrect ATB's in the system divided by the fulfilment rate. Thus higher the number of incorrect ATB's in SAP, the higher the delivery delay will be.

5.2.2 Extra trees feature scoring

Traditional sensitivity analysis techniques, like Sobol, require many model runs in order to perform a global sensitivity analysis. Jaxa-Rozen and Kwakkel (2018) present a technique that allows global sensitivity analysis to be performed that require less model runs: Extra trees feature scoring. The resulting feature scores provide an accurate approximate of Sobol indices. Since the influence of the input variables on the outcomes of interest is likely to vary over time, this thesis uses dynamic Extra feature trees scoring. The feature scores are examined for multiple time-steps in the model. The results of Extra trees feature scoring are shown in heatmaps, in which the individual effects of input variables of outcomes of interest are visualized.

Figure 5.7 shows that the initial trust fraction has a very substantial impact on the trust from distributor to client in the first months of the model runs. This behaviour is explainable because the system has not had the time to influence the trust level from the distributor to the client in the first months of the model. Therefore has the initial value been leading in what the actual value might be during the first months of the model run. As expected does the influence of the initial value of trust from distributor to client decrease as time passes on in the model runs. This is because the trust level from distributor to client gets affected by other factors in the model rather than its initial value.

Additionally does the extra trees feature scoring show that the initial knowledge level of the client keeps its impact throughout the entire model run. This is explainable through the entire loop of interconnected sub-models. The initial knowledge level of the client determines how much incorrect ATB's are filed. This number of incorrect ATB's determines how much the trust from the distributor to the client is damaged.

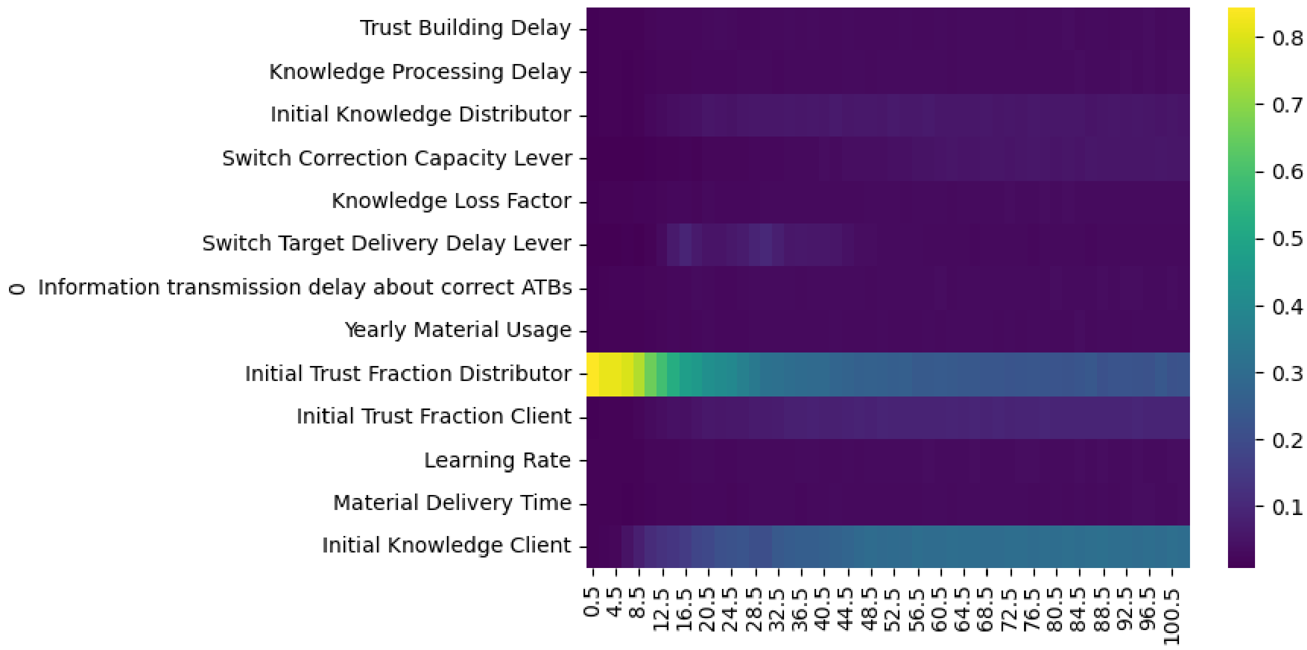

Figure 5.7 Results from Extra Trees Feature Scoring: most influential variables on Trust from Distributor in Client over time

Just as the initial trust fraction for the distributor, has the initial trust fraction of the client a crucial factor in the first time steps of the model runs. This explanation is similar to the trust from the distributor to the client. However, the result of the extra trees feature scoring show that the correction capacity has the same impact throughout the entire model run. The PRIM analysis has shown the impact of the correction capacity on the trust from client to distributor. The extra feature trees scoring confirms this relationship.

The most striking result is the huge impact the correction capacity lever has throughout the entire model run as seen in figure 5.8. In the policy analysis section of this chapter, we will elaborate on this strong relationship.

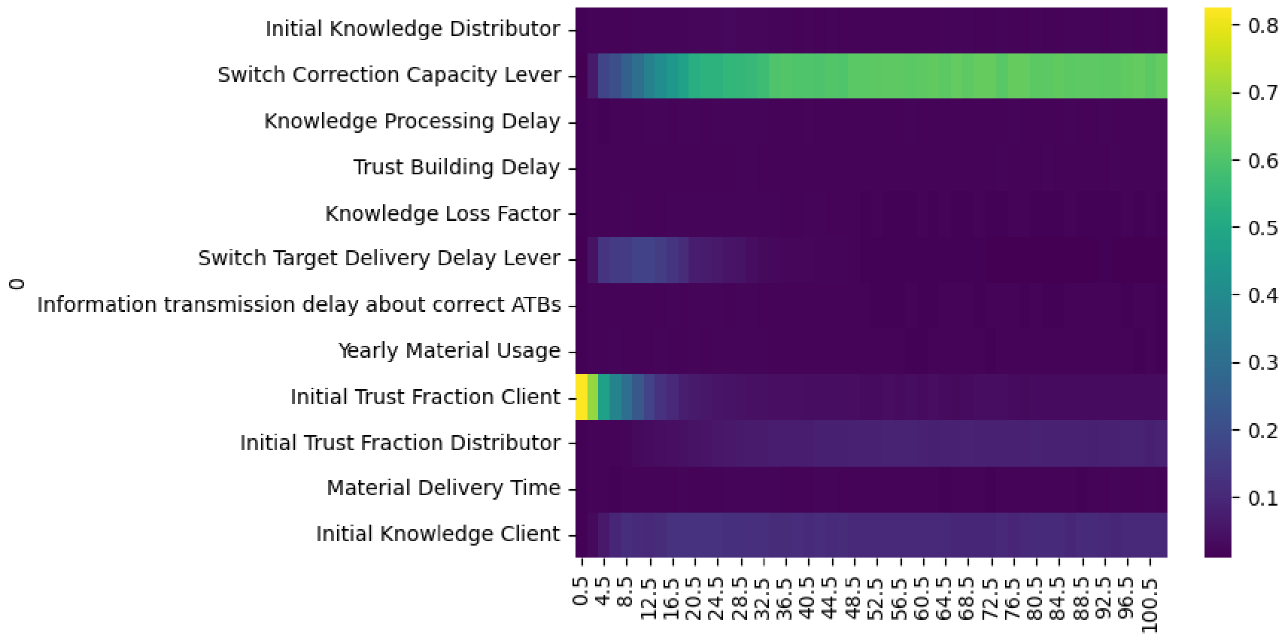

Figure 5.8 Results from Extra Trees Feature Scoring: most influential variables on Trust from Client in Distributor over time

5.3 Policy Analysis

Figure 5.9 shows that the speed of correcting ATB's has not only an effect on the trust from the client in the distributor, but also the other way around. This is explainable due to the relationship between the trust distributor in client, knowledge transfer and order filing sub-models. A high number of incorrect ATB's means that the delivery delay will increase. This is because the delivery delay is calculated by the number of correct and incorrect ATB's divided by the ATB fulfilment rate. A higher delivery delay causes trust damaging from the client in distributor trust. This reduces the amount of knowledge transferred from the distributor to the client and will therefore lead to more incorrect ATB's. Therefore it shows not matter the amount of trust in the system, it is crucial that the asset managers work to their best of their abilities to tackle the incorrect ATB's in the system. This will eventually improve knowledge transfer due to a higher level from the client in the distributor, which leads to a higher trust form the distributor in the client as well.

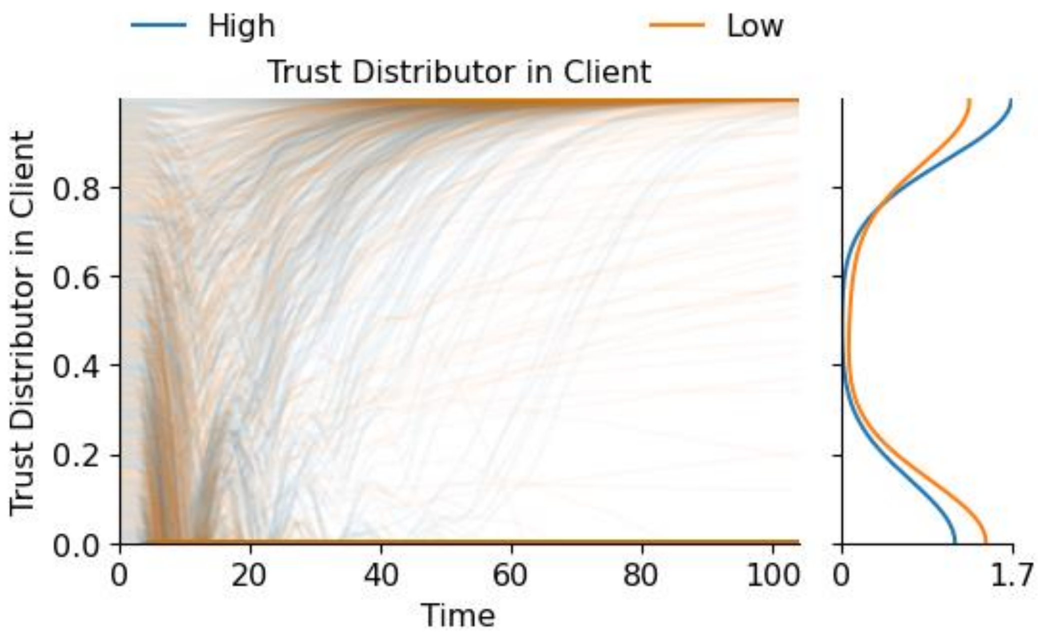

Figure 5.9 Correction Capacity Lever Trust Distributor in Client

Figure 5.10 shows that the correction capacity lever is of crucial importance to the trust from the client in the distributor. When the correction capacity is too low, this results in too much delay regarding the shipment of materials. This is explainable by the same reasoning as figure 5.9. This results emphasizes the huge impact the correction capacity has on the system. Therefore is the correction capacity a vital key for the level of trust in the system. Asset managers should therefore take into account to always aim to correct as much incorrect ATBs as possible. This will eventually result in a higher level of trust within the system, which should reduce the amount of incorrect ATBs.

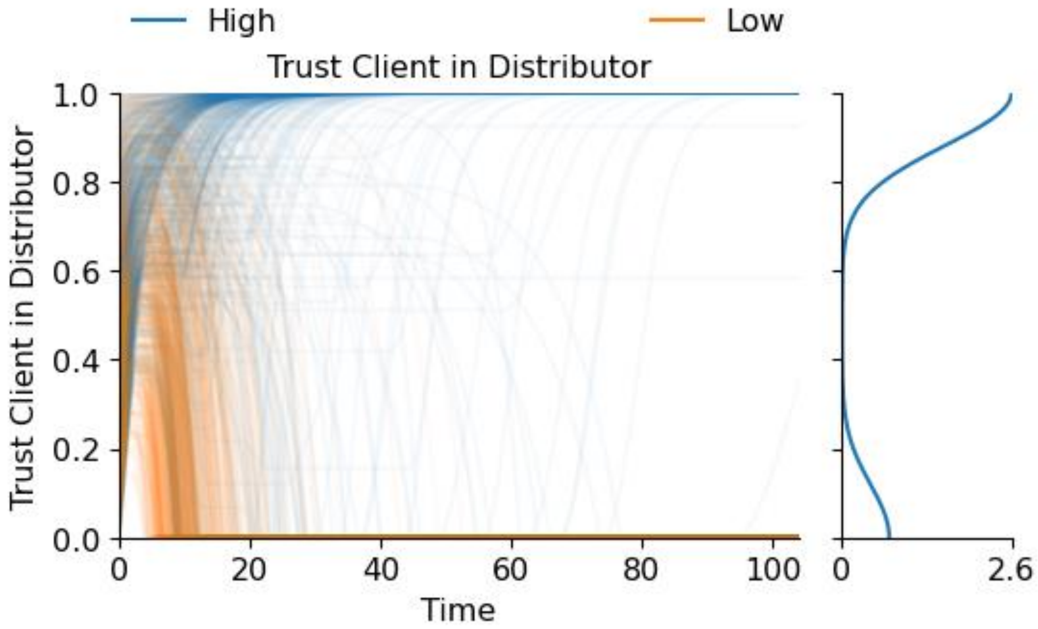

Figure 5.10 Correction Capacity Lever Trust Client in Distributor

Figure 5.11 shows that a job rotation cycle of 18 months results in more outcomes with a high level of trust from the distributor in the client compared to a job rotation cycle of 6 months. This behaviour is explainable due the relationship between job rotation and knowledge in the organization. As mentioned previously in this thesis is tacit knowledge and experience crucial in the order filing for materials. The loss of such knowledge and experience frequently means that it takes more effort to retain such knowledge and experience in that department of your organization. While job rotation is a well-thought policy to spread knowledge throughout the organization, it rather hinders the modus operandi regarding order filing in this system.

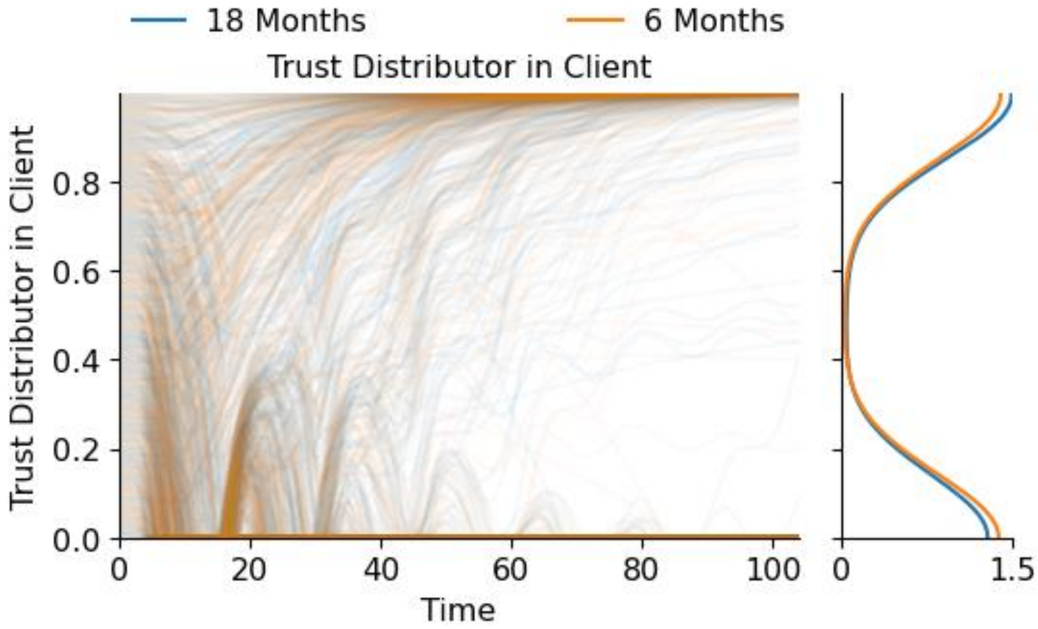

Figure 5.11 Job Rotation Cycle Lever Distributor in Client

The results shown in figure 5.12 show that job rotation hits the client just as hard as it hits the distributor. This behaviour was expected since job rotation is modelled identically for the client as for the distributor. A striking result however is that even though the distributor is deemed to have more knowledge over the course of the model run compared to the client, the amount of trust lost due to job rotation has the same effect.

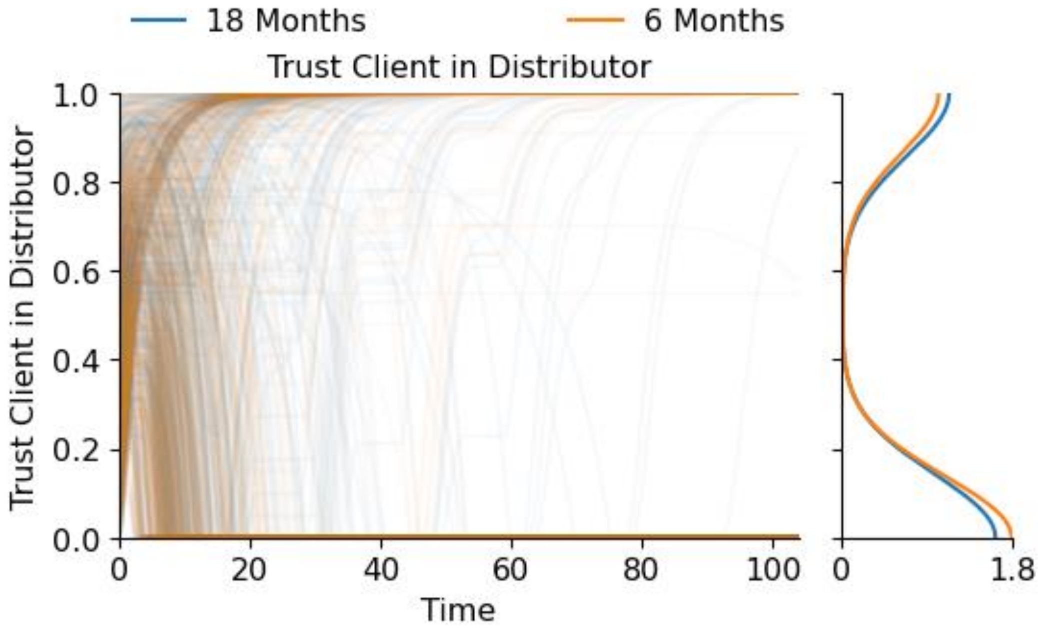

Figure 5.12 Job Rotation Cycle Lever Trust Client in Distributor

Figure 5.13 confirms the expectation that a high target delivery delay would result in a higher level of trust in the system compared to a low target delivery delay. A higher target delivery delay means that the delay gap cannot grow as high compared to a low target delivery delay. This is because the delay gap is calculated by the difference between the delivery delay and the target delivery delay.

Another striking result shown in figure 5.13 are the oscillations of blue lines in the first halve of the model run. This behaviour shows that with a target delivery of one day trust from the distributor in the client oscillates and it either reaches high outcomes of trust or low outcomes of trust. Trust is able to build during periods when the system is running in a positive way and the materials are delivered within the target delivery delay of one day. This raises trust from the client in the distributor, which leads to better knowledge transfer. However, when the system generates delays, this trust drops just as fast. This shows how sensitive trust is to the material delays in the system.

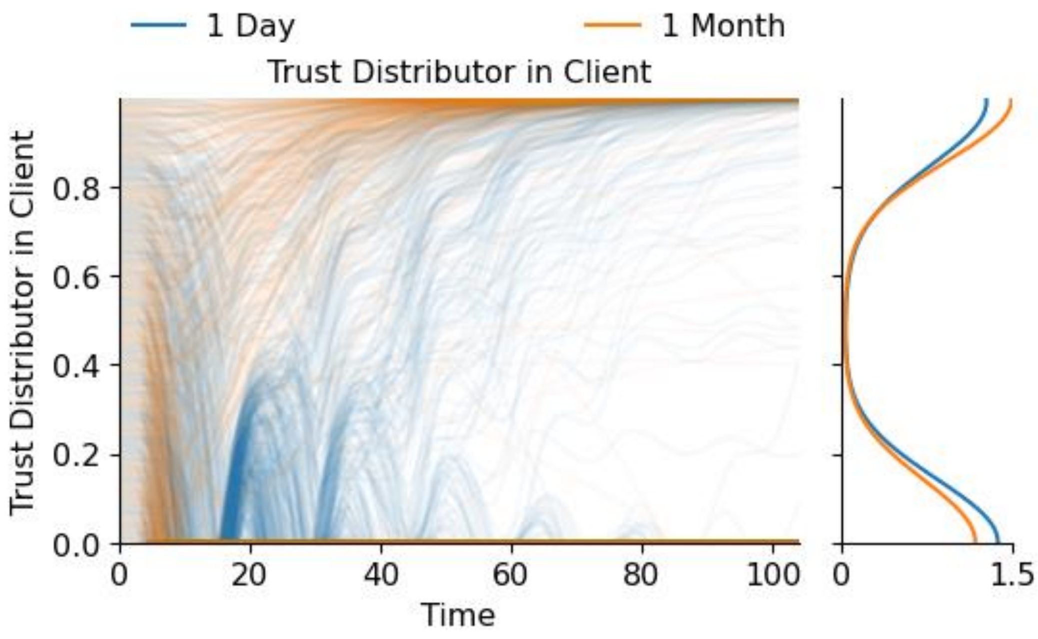

Figure 5.13 Target Delivery Delay Lever Distributor in Client

Figure 5.14 shows similar behaviour for the trust from the client in the distributor as the other way around.

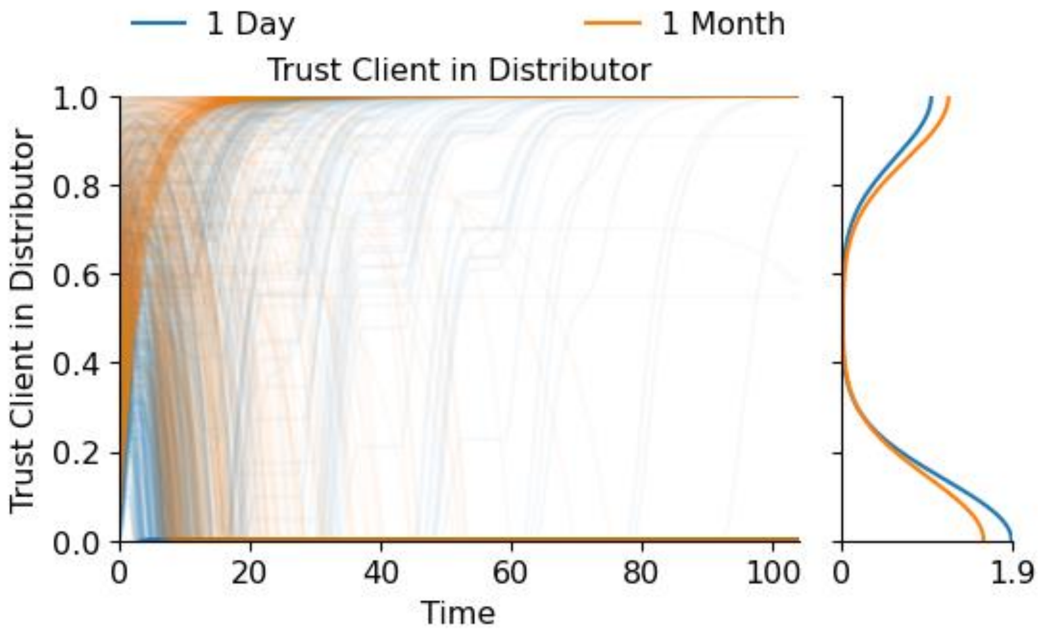

Figure 5.14 Target Delivery Delay Lever Trust Client in Distributor

6 Discussion

The research goal of this thesis is to get a deeper understanding of trust dynamics between a distributor and their client in an intra-organizational military supply chain context. The results indicate that performance is the greatest indicator for trust to either build or damage in the system. The study also demonstrates how trust in turn stimulates good performance.

The results of this study contradict the claims of Mushkin & Suryanto (2021) that trust has no effect on supply chain performance. The results of the analyses have shown how incorrect ATBs and delivery delays impact trust within the system. Additionally, the feedback on these relationships is shown in this study. Trust has an effect on the supply chain performance indicators (number of incorrect ATBs & delivery delays) in this study. However, the results of this study seems to be in line with the results from the study by Chen et al. (2013). Their study have shown the positive relationships between trust, knowledge exchange and supply chain performance within a hospital setting. These positive relationships are also clearly visible within the intra-organizational systems of the Ministry of Defence. Ke et al. (2015) performed research on trust in a construction supply chain setting. Results of their study have shown that different dimensions of trust have shown influence on cooperation and performance. While the study performed in this thesis has not regarded different types of trust, the results also show that trust has a positive influence on cooperation and performance.

The results of this study build on existing evidence of the importance of trust between collaborating partners (Fawcett et al., 2012). However, the experiments provide new insights into the relationship of trust and performance by both of the collaborating partners. The results of this study show how both the trust in one another affect performance, and how both of their performances impact the trust in one another. These results should be taken into account when considering how to design strategies to bring the distributor and client closer to one another. The insight is needed from both sides how their performance affect each other’s work.

The generalizability of the results is limited by the data provided by the LCW. The dynamics between the LCW and their client are unique due to their place within the Dutch Air Force. It is possible for other departments in the organization of the Ministry of Defence that the processes of order filing function differently. This makes it harder to apply the model into a different setting within the Ministry of Defence. However, policymakers in other departments of the organization certainly benefit from the insights about the interdependency of trust and performance. Due to the lack of data on costs made by PM for inventory and shipments, the results cannot directly support policymaking for the Ministry of Defence. However, policymakers should keep in mind to formulate policies that aim to improve trust and performance between the supply chain partners.

An oversimplification in this study is the homogeneity of the materials which are present in the system. The real-world system contains a huge variety of materials which have different expiry dates. However the model considered all materials equal, and therefore are all orders also filed and processed the same way. This is not the case in reality, where there are many factors which need to be taken into account when requesting materials. Materials have different expiry dates and materials might be replaceable rather than filing an order for new materials. This aspects are not taken into account in this model.

Additionally, there are some sub-processes present in reality regarding order filing which has not been included in the model. The most obvious example is the process of forecasting. Forecasting is performed at PM to predict the amount of materials needed to have them ready before there is a demand for it at the work location of the client. Including this process into the model would bring it closer to reality and therefore give a better model design of the supply chain processes between the LCW and their clients.

Using the combination of interviews with modelling has provided insight which were not possible when performing research with only one of the two options. Without modelling is would not have been possible to analyse and visualise the interdependence of the distributor and the client. The model has shown how behaviour of one party affects the other one, and how the quality of one's performance is an indicator for the other parties quality of performance. The interviews have provided the modeller the insight of what concepts were root causes of the problems which came forward from the distributor's side. The interviews made it possible to hear from the people in the field how their work is impacted by the other party and what frustrations arise from that. These interviews gave the modeller the starting point of exploring the dynamics of trust between the distributor and their client.

However, such a combination of methods could be improved by using a research approach called Group Model Building (GMB). GMB is an approach which stimulates intensive interaction and exchange between stakeholders (Vennix, 1999). This approach is very suitable in combination with SD modelling due to the insights it provides in dynamics between the stakeholders. However, this was not possible to perform during this research. Reasons for this are the geographical distance between the stakeholders, as well as the lack of communication between them.

As mentioned during the validation tests were there no tests performed on extreme policies. Such test would provide insights into the resilience of the supply chain. However, this test has not been included in this thesis. The main purpose of the model is to provide insights into the dynamics of trust based on performance by the two parties. Such extreme policies tests were therefore not included, but are certainly recommended when testing the systems resilience.

Further research is needed to establish the complete picture of which performance measurements regarding supply chain performance are affected by trust within the system. This study regarded trust as the performance measurement from both the distributor and client side. However, the role of trust on different performance indicators might be expanded. This would give a better understanding of the role of trust between supply chain partners. Additionally, the literature mentions that trust exists in different types (Zhu et al., 2013; Lindgreen, 2003). This study regarded trust as one concept, but dividing trust into different types would give insight into which type of trust lacks between supply chain partners. This would give policymakers a specific target of which type of trust to approach.

Avenues of future research include the similarities of the hospital and the military setting. The study performed by Chen et al. (2013) have been performed in a hospital setting. The hospital context include supply chains that determine life of death, large organizations with many departments and a hierarchical structure regarding different functions within hospitals. A study by Gonul Kochan et al. (2018) regarding hospital supply chain performance has been performance with an SD framework. I argue that the insights form supply chain studies in hospital settings are useful for military contexts.

7 Conclusion

This chapter is dedicated to answering the main research question which was formulated in chapter 1. Additionally, this chapter provides a recommendation about how policymakers might interpret the results provided in chapter 5.

7.1 Answering Main Research Question

The overarching research question of this thesis is formulated as:

How to improve trust relationships within military supply chains, without compromising the responsiveness of the supply chain?

This research has shown the relationship of trust between a distributor and their client and performance considering logistic processes. Desk research has shown that many actors have a role in the ordering of materials, which emphasizes the need of collaboration within the organization. Interviews with both the distributor and the client have resulted in insights used in the course of this thesis. These insights contain the knowledge gap between the distributor and the client along as the lack of trust from the distributor to the client.

Additional literature search on the role of trust on knowledge sharing and the dynamics of trust over time have been the basis for the System Dynamics model used in this thesis. This modelling method has been chosen because it shows adequately dynamic behaviour over time and gives the opportunity to experiment with policies.

However, modelling trust and knowledge brings many uncertainties into the model. Therefore the EMA workbench has been used to approach these uncertainties. The EMA workbench enables to run thousands of model runs with varying ranges of uncertain inputs, which therefore deals with the uncertainty that this situation brings.

The uncertainty analysis has shown that the model outcomes are sensitive the its initial input values, which is expected in a model run over time. As shown in the extra features tree scoring does this effect diminish over time. The PRIM analyses have also shown that the model outcomes are affected by its input values. However, two striking results are interesting to take into account. The PRIM analyses have shown that the outcomes of trust from the client to the distributor is dependent on the inintal value of trust from the distributor to the client. This shows how trust is a two-way street which has effect on both parties. Additionally has the PRIM analysis shown that the role of the correction capacity has significant impact on the trust from the client in the distributor.

Trust relationships can be improved within military supply chains by performing your jobs well regarding the state of trust within the system. The analyses show how important it is to keep the model in a positive state, since a positive state will keep the system positive. Since the system consists of two major reinforcing feedback loops, having the system in a negative state makes it very difficult to get out of that state. Therefore is it important to build trust from good performance. Regardless of the state of trust in the model, the only way to make it better is by good performance. Bad performance from either the distributor or client side results in a drop of trust in the system and makes it even harder to build that trust.

7.2 Recommendations for the policymakers

The results of the policy analysis have shown that the correction capacity lever is the only lever which has significant impact on the outcomes of trust within the system. Therefore it is recommended for policymakers to emphasize the importance of the job the asset managers do, and let them know how important it is to keep correcting incorrect ATBs in the system. No matter the amount of trust in the system at a certain level, neglecting the incorrect ATBs in the system results in scenarios where there is no trust from the client in the distributor at all. This will eventually mean that the system cannot function and therefore will the military logistic processes completely shut down. As a military organization it is a matter of life or death to get materials on time at their destination, and therefore it is not acceptable to let such important supply lines underperform due to a lack of trust in the system.

However, the uncertainty analysis also gives a number of insights to take into account regarding this system. As the PRIM and extra features trees scoring analyses show are the initial values of trust and knowledge in the system have a big impact on the outcome of the model runs. In a system which consists of two major reinforcing feedback loops as this system, it is crucial to keep in mind how all the sub-models are interconnected. Thus when you enter a situation where the trust is high, it is likely to stay high. While you are in a situation where the trust is low, it is very difficult to build that trust. Therefore is it important to perform the tasks within the supply chain as good as possible, from the side of the distributor as well as from the client. Good performance builds trust, and will therefore have more chance to reach a state of the system where the trust stays high and therefore good performance continues to occur.

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Appendix A Model Testing

This section of the report critically assesses whether the model developed in this study is appropriate for its intended use. In this study, the modelling objective is to create a depiction of the dynamics between a distributor and their client in a supply chain within a military context so that policies levers are assessed. To find out whether this is the case, a boundary adequacy test was executed first. In addition, the dimensional consistency of the model was validate. Lastly, the integration error, time step and simulation length were mapped.

Boundary Adequacy

According to Senge & Forrester (1980), the boundary adequacy test's performance requires evaluating the model's applicability in light of its structure, behaviour, and policy. Since there are other test that examined the behaviour of the model in this study, the focus was primarily on the structural and policy implications of the model. In order for this to be possible, the model's structural relationships were examined to determine whether they were sufficient for fulfilling the modelling objective. Therefore the model's aggregation level and structure are examined in the sections below.

Aggregation Level

In this study, the miliary supply chain dynamics were chosen to be modelled from a high aggregation level, since this makes the most sense when examining the effects of general policies on collaboration within military supply chains. This is because all departments involved in military supply chains must abide by these policies. This has led to the development of a model that aggregates the actors that work on the same location, even though their functions differ. This has the benefit of making it simple to observe the two different aggregated actors present in this model. Another form of aggregation is the material usage in this model. Spare parts for the Royal Air Force come in many different types. For the sake of simplicity the decision was made to see spare parts in the developed model as homogenous. The fact that Vensim lacks the functions of different classes, this decision was even more encouraged. However, these degrees of aggregations have the disadvantage that the model is unable to distinguish between different types of spare parts which each their own usage rate. Additionally, the model cannot portray dynamics within a group at the same work location. Thus the supply chain dynamics are only analysed for specific distributor and client actors. However these dynamics and their ramifications do not significantly affect the model output and are thus excluded from the scope of this study because information about distributor-client relationship is what is required for developing policy on this matter. It can be concluded that this level of aggregation is adequate to accomplish the goal of this model.

Dimensional Consistency

Orders and Materials are the two most significant dimensions in the military supply chain dynamics model created in this study. With the aid of the *dmnl* unit, the level of trust was calculated. As mentioned previously in this thesis, this variable is a soft variable which therefore represents a value between 0 and 1. Subsequently, the knowledge works in exactly the same manner with the *dmnl* unit. Only this is displayed as two different stocks containing a knowledge level for Program Management as well as for the client. The *orders* unit represents the amount of ATBs which flow through the model. The *materials* unit shows the material flow within the model. Finally, *Week* was selected as the unit of time to examine the dynamics between distributor and client in a military supply chain context. The numerous processes that are present in the model such as material deliveries and order corrections are measured in days. Therefore the most logical time unit to choose for this study was

Week. To ensure that the model's parameters didn't have any conflicting dimensions, the dimensional consistency test was utilized. Fortunately, the Vensim simulation software has a built-in " unit check" function. As a result, several unit tests were actively carried out during the model's development to make sure that the equations accurately reflected real-world notions. No unit errors were discovered once the test was completed, indicating that the dimensions of the model parameters are properly implemented in Vensim.

Integration Error, Time Step, and Simulation Length

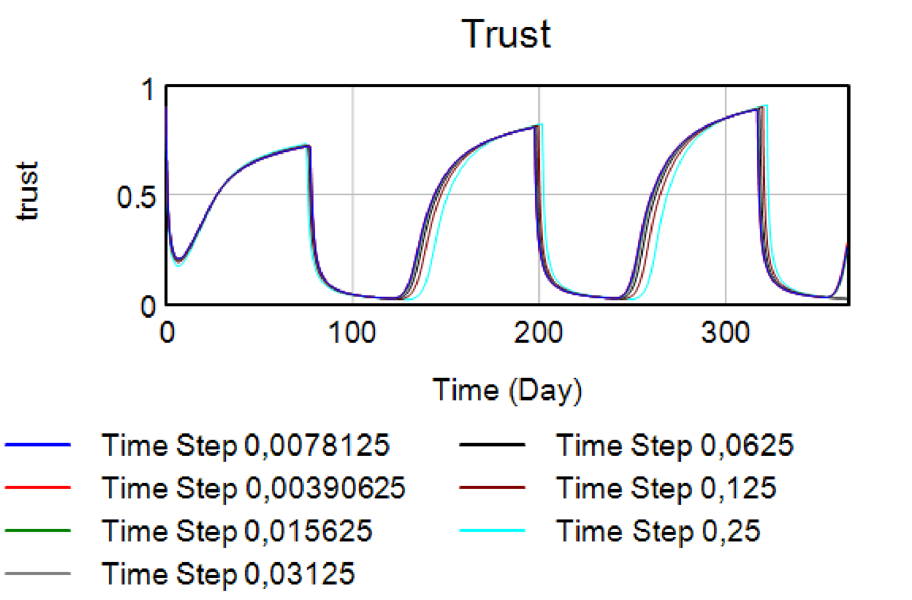
The model settings are assessed in this section of the report. First, the integration error is examined. Following that the time step and simulation length of the military supply chain model developed in this study are evaluated.

Integration Error

Euler, Runge-Kutta4 (Rk4), and Runge-Kutta4 auto (RK4 auto) are the numerical integration methods that are frequently seen in system dynamics packages, according to Pruyt (2013). Research shows that RK4 is appropriate for continuous models without significant variations in the speed of dynamics and possibly oscillatory behaviour, whereas RK4 auto is suitable for continuous models with significant variations in the speed of dynamics. Models with discrete functions, on the other hand, work best using Euler. However, Euler is not sufficiently accurate for many models and patterns unless a very tiny time step is selected (Pruyt, 2013). The various equations used in the military supply chain model lead to the conclusion that this model is made up of a number of discrete events. Some equations that contributed to the execution of these events include "Knowledge Gap" and "Adjustment for Inventory LCW" which use MAX functions, "Output knowledge on correct rate" and "Order Fulfillment Ratio" which use WITH LOOKUP functions, and IF THEN ELSE functions for the several policy levers used in the model. Given that the model being employed is made up of numerous discrete events as indicated above, it was decided to use Euler as the integration method with a relatively small time step to increase the model's accuracy. For further information regarding the time step applied in this model, consult the following section.

Time Step

In a SD model, a time step is described as the period of time between recalculations. In a model with days as the time unit, for example, a time step of 0.25 indicated that the model's formulas are updated once every 0.25 (or 6 hours). The outcome of a model is more precise the smaller the time step. Unfortunately, precision comes at a cost – running the model may take longer than it would with a larger time step. Therefore, a few tests steps were necessary to determine the ideal step size for this particular SD model. Particularly, the time step for this study's model was 0.25 at the beginning. Then , every time, this value was cut in half until there is no longer any difference in the behaviour of a given time step and the smaller time steps. This is because a time step decrease that is not appropriate for the generated model causes the model's behaviour to significantly changer compared to that of earlier time steps. The behaviour over various time steps is depicted in the figure below. This figure demonstrates that the model behaviour does not significantly change for time step 0.0078125 or less, indicating that this particular time step is suitable for the model in question.



Appendix B Interviews

This appendix contains the interview questions along with summaries and conclusions used in the thesis. Due to the informal setting of the interviews not all questions were asked directly and improvised follow-up questions came up during the interview sessions.

Interviewvragen Defensie Helikopter Commando Breda

Inschieten ATB proces

- In welke situatie doorloop je welke stappen om iets te bestellen in SAP?
    - Aan de hand van onderhoudsplan
    - Correctief onderhoud wanneer iets kapot blijkt te zijn
- Hoe ervaar je deze stappen? Is dit makkelijk of moet je hier goed je aandacht bij houden?
- Wat loopt er goed in deze stappen en wat gaat er nog wel is mis?
- Ben je tevreden over je eigen SAP skills of zou je deze nog naar een hoger niveau willen brengen?

Communicatie met Assetmanagers

- Hoe verloopt de communicatie met de assetmanagers?
- Op welke manier wordt er gecommuniceerd?

Acties te late bestellingen

- Wat voor effect hebben vertragingen op jullie werkzaamheden?
- Ga je actief achter te late bestellingen aan? Of in welke gevallen doe je dit?

Vertrouwen

- Is er vertrouwen in het werk van collega's?
        - Monteur die aangeeft dat iets benodigd is
        - Assetmanager die het afhandelt/ contact opneemt bij vertragingen
    - Zo ja, welke sterke punten zorgen hiervoor?
    - Zo nee, wat zijn daar de oorzaken van?
- Hoe betrouwbaar acht je het LCW als leverancier?
    - Komen de bestellingen aan op de aangegeven leverdatum
    - Word je ingelicht bij vertragingen
- In hoeverre werk jij mee wanneer een assetmanager actie van jou vraagt?
- Heeft het ontbreken van vertrouwen invloed op de manier/frequentie van communiceren met de assetmanagers?

Fragmentatie

- Denk je dat assetmanagers jullie zorgen begrijpen?
- Op welke manier denk je dat je de assetmanagers beter begrip kunnen krijgen voor jullie manier van werken?

Interview Questions Defensie Helikopter Commando Breda

Process Filing ATB's

- In which situations do you take which steps to make an order in SAP?
    - On the basis of a maintenance plan
    - Corrective maintenance when something seems to be broken
- How do you experience these steps? Is it easy, or does it require your full attention?
- What goes right during these steps, and what goes wrong?
- Are you satisfied with your own SAP skills, or would you rather bring them to a higher level?

Communication with the assetmanagers

- What is your opinion on the communication with the assetmanagers at PM?
- Which methods of communication are used?

Actions delayed orders

- How are your daily tasks affected by delays?
- Are you actively investigating delayed orders? Or in which cases are you inclined to do so?

Trust

- Do you trust your supply chain partners in doing their job well?

        - A technician requesting for materials on time
        - The assetmanager handling delays/ reaching out when delays occur
    - If yes, which qualities make that happen?
    - If no, what might cause this?
- How reliable is LCW as a supplier?
    - Do the materials arrive at the provided delivery date?
    - Are you informed when delays occur?
- How cooperative do you deem yourself when an assetmanager asks for changes?
- Does the lack of trust have influence on the way/frequency of communication with the assetmanagers?

Organizational Fragmentation

- Do you think the assetmanagers at PM understand your concerns?
- How do you think the assetmanagers can get a better understanding of your way of doing your job?

Interviewvragen Assetmanagers LCW

Controleren ATB proces

- Kun je een indicatie geven over hoeveel procent van de ATB's in het verleden komen te staan?
- Wat zijn de oorzaken van onjuiste stamdata in SAP?
- Zijn jullie proactief bezig met het zoeken naar onjuiste stamdata? En wordt dit ook gelijk aangepast?

Communicatie met klant

- Neem je proactief contact met de klant wanneer een ATB aangepast moet worden/vertragingen zullen optreden?
- Hoe verloopt de communicatie met de klant?
- Op welke manier wordt er gecommuniceerd?
- Acht je het zoeken naar- en controleren van fouten als jouw werk? Of vind je dat het vooral belemmerend werkt in je daadwerkelijke werkzaamheden?

Vertrouwen

- Is er vertrouwen in het werk van collega's?
  - Zo ja, welke sterke punten zorgen hiervoor?
  - Zo nee, wat zijn daar de oorzaken van?
- In hoeverre is de klant bereid te luisteren naar jullie adviezen?

- Heeft het ontbreken van vertrouwen invloed op de manier/frequentie van communiceren met de klant?

Fragmentatie

- Denk je dat de klant begrijpt wat voor gevolgen hun acties hebben op de rest van de keten?
- Op welke manier denk je dat je de klant dit beter kan begrijpen?

Interview Questions Assetmanagers LCW

Verifying ATB process

- Can you give an indication of how much percent of the ATB's get a delivery date in the past?
- What are causes of incorrect master data in SAP?
- Are you pro-actively looking for incorrect master data? And is this adjusted immediately?

Communication with the client

- Do you reach out proactively to the client when an ATB needs to be adjusted/ delays will occur?
- What is your opinion on the communication with the client?
- What methods are used for communication?
- Do you believe that looking for and checking mistakes as a part of your job? Or does it mostly hinder you in your daily tasks?

Trust

- Do you trust your supply chain partners in doing their job well?
  - If yes, which qualities make that happen?
  - If no, what might cause this?

- To what extent is the client willing to listen to your advice?
- Does the lack of trust have influence on the way/frequency of communication with the client?

Organizational Fragmentation

- Do you think the client understands what consequences their actions have on the other actors in the supply chain?
- How do you think the client gets a better understanding of consequences of their actions?

Interview Logistics Controller

The Logistics Controller is the bridge between the client and the distributor. It's most important job is to proactively ensure the timeliness of available materials. The Logistics Controller has direct contact with Program Management to coordinate expected and planned demand. Therefore this person was the ideal start for the interviews, as he gives more insight into his role in the system and what problem he encountered. This helped me massively with validating the quantitative model as it gave me better insight into how the system exactly works.

The Logistics Controller is formally located at the work location of the client. However, this particular Logistics Controller also had experience as an employee from the distributor's side. Therefore, he understands the interests and worries from the distributor's side as well as from the client's side. He immediately recognised the problems when I presented my research approach, which confirms that the problem is not one-sided. To provide me with some additional context about the role of the different actors, we explained what other actors are present at the work location and how they are related.

Interview head of LSE

The LSE is a binding gear between the different processes within the operations of the air force. LSE employees are responsible for the (administrative) support of material management. The head of each LSE is responsible for the daily course of events and coordination of LSE staff. For this thesis, it's most important to know that the LSE is the party that files in the ATBs to the LCW.

Critical conclusions from the interviews are the fact that this head of LSE has never heard of an ATB with a delivery date in the past. This implies that the communication between PM and the head of LSE is therefore so poor that these problems are never mentioned. The head of LSE also mentions that the relationship between their side and LCW is perfect, and there are hardly any problems. This is mainly due to the fact that the LSE have little to no direct contact with the asset managers at PM. Rather, they reach out to the front office at LCW, which is the link between the asset managers and the LSE. If there are any needs for the asset managers to be heard, it is the logistics controller who is the bridge between the LSE and the asset managers at PM to address the problems.

A.O.G. does rarely happen and adjustments in the ATB are made by the LSE, but are mainly minor adjustments. The head of LSE deems LCW a very reliable supplier, and there is an understanding for the hard work at PM when things go wrong. Communication mostly through phone, priorities in topdesk. The head of LSE stresses the importance of having a good relationship and understanding of all players in the supply chain. Most ATB's are a matter of a quick check whether the dates are correct and then it is a matter of forwarding to LCW.

Interview Material Planner

The job of the Material Planner is a relatively new one, around 4-5 years old. This request was made by the BB due to the wish of having a person with logistic expertise at the location of the client. The current Material Planner is the first official Material Planner after the first pilot. Daily tasks include being prepared for support to the BB and reach out to LCW when there is a case of A.O.G. and priorities. Planned ATB's are noted regularly by the Material Planner. These are ATB's with articles with are not in stock yet or with delivery dates far ahead.

Communication with LCW is with PM. Articles regarding a replacement is through IPC whether the replacement is legitimately used. If articles are needed which are not in stock, contact is reached with PM. IPC are mostly experienced mechanics who have the knowledge about materials. Problems occur when articles are not in stock and have a relatively short expected delivery date. Then the ATB is not fixated quick enough which leads to a red light. However there is no knowledge of what the root causes are for problems at PM. As long as materials are delivered, we are happy. Often the delivery date is set to two days in advance when materials are not in stock. The client is happy with LCW as a reliable supplier since the LCW makes effort to complete priorities requests in top desk.

Complaints are always present from the technicians, but there is the realisation that they rely on PM. A.O.G. might happen due to materials with short expiry dates, such as a battery which is usable only for 6 months. Together with Logistics Controller the Material Planner has the most contact with PM from the client side. Contact with PM goes via email, since it is easier to present data on screen rather than via the phone. The Material Planner does not receive requests from PM to change ATB to another date.

Interview Assortment Manager PM

The assortment managers at PM are responsible for the logistic processes regarding their assortment. These assortments are either specific for a type of aircraft, or specific to what type of system they support.

The asset manager does not check ATB, because the assumption is already made that something is not right. The technical vs the logistics world are completely different. The technician solely cares about his product, and wants it rather yesterday than today at their location. The logistics side has to take every aspect of the supply chain into account, and might therefore not always meet the desires of the technician. Asset manager does not give feedback to the client anymore about changing the dates of their ATB's, since it has happened too often and takes too much time to handle each incorrect ATB with the help of the client. The client is however informed about eventual delays.

A way of coping with this is the use of so-called “zero-lists”. There lists are formulated by the different players in the supply chain to put down their priorities of what materials are needed. This “solution” shows that SAP is not used correctly, and actually leads to supply chain inefficiencies. Frequent communication though email with Logistics Controller about delivery lead times and replaceable articles. However once or twice a week face-to-face meetings regarding zero-lists.

If everything is correct in SAP, there is no need for extra work. Priorities are not visible in SAP, therefore the “zero-lists” are used. Delays from the external supplier are manually processed by the asset manager in SAP. This shows that not all ATB’s are deemed as important as they make them to be. It is a case of always ask more than what you need. If the client has for example found a replacement article, they leave the ATB in SAP, which becomes red while it actually could just be removed. In the ideal situation you want every material in stock, however this is not realistic. Even though it is the responsibility of PM to make sure the inventories are designed to meet the expected needs of their clients based on historical data.

Asset managers deem themselves not as reliable as they want to be, due to uncertainties regarding the external supplier. It is hard to measure their performance, because you are only satisfied with completely delivery reliability. There is no analysis method to test how many ATB’s are fulfilled without issues and how many ATB’s turn into a red light.

This project what you are working on is an issue which exists for many years. Even though it seems like something very easy, somehow we still have not found the solution. It helps to be more in touch with each other. Sit for a day next to a logistics person and the other way around. However, the job rotation system makes it difficult to keep a certain level of KSA intact. We take effort in making sure materials arrive at their destination, but we don’t take the effort to changes other people’s behaviour. Another problem is also that we don’t know the other people in the supply chain by face.

The client does not see the problems, since they simply take from our inventory.

Conclusions

The interviews with both the several actors working at the location of the client and the asset managers at PM have shown me how fragmented the supply chain is and that there is little to no trust in the way orders are being filed by the client to the asset managers at PM. Which I found most critical is that PM has launched a program called “Planinngsgedrag in de keten” (EN: Scheduling behaviour in the supply chain) which emphasizes on the problems encountered at PM regarding ATB’s with unrealistic delivery dates, and that the head of LSE has never heard about such a thing. This showed me that the contact between PM and the client is very poor.

The interview with the asset managers at PM confirmed this lack of trust and communication. Because of so many mistakes made by the client, the asset managers have decided to stop correcting the behaviour of the client and rather handle it the way they see fit. This results in behaviour by the asset managers based on experience rather than meeting the demand of the client. This perfectly represents the organizational fragmentation present at the Ministry of Defence, where rather than to cooperate every team handles their own desk.

The interviews have also shown that there are in fact no problems regarding the process design of filing orders in SAP. Rather, it is the human behaviour of employees at the Ministry of Defence on how well the process design is followed. A solution now being used is the so called “zero-list”. However, this solution shows perfectly how wrong the actual system is being used. This solution would not be necessary if the process of filing orders was performed in the correct way.