Master's degree thesis

LOG950 Logistics

The effects of mismatched Cultural Dimensions on Supply Chain Flexibility - A case study of TOMRA Collection Solutions

Martin Bentzen Schive

Randi Marie Skarset Hjertvik

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Preface

This master thesis constitutes the final mandatory section in order to obtain a MSc degree for the program “Master of Science in Logistics” at Molde University College – Specialized University in Logistics. The thesis was written in the timespan of January 2017 – May 2017 and is the result of the collaboration between TOMRA Systems ASA and Molde University College.

An immeasurable amount of thanks goes to our two supervisors for this thesis, Berit I. Helgheim and Ida K. Aspenes, for their knowledge, invaluable help and support as well as their kind reassuring words in times of stress and panic. This thesis would not be possible without them. Thank you, to Associate Professor Halvard Arntzen for his insights and help provided to two frustrated students battling their dataset and its significance. A further thank you to Even Rekdal, Bente Traa and Ellen Sæther for their continued support and interest in seeing this thesis through, their provision of help, answers, tips and vast amount of knowledge.

Last, but not least…

All those interviewed and further personnel at TOMRA Collection Solutions who showed us kindness and interest during our visits and made us feel at home. Thank you, to our student focus group: Torkil Rasmussen, Francisca Johnsen and Andrea Isaksen Schmidt.

Your support, criticism, questions and valuable input has shaped this thesis into what it is today.

Molde, May 2017

Martin Bentzen Schive

Randi Marie Skarset Hjertvik

Summary

Title of thesis: The effects of mismatched Cultural Dimensions on Supply Chain Flexibility - A case study of TOMRA Collection Solutions

Authors of thesis: Martin Bentzen Schive and Randi Marie Skarset Hjertvik

Supervisors: Berit I. Helgheim (HiMolde) and Ida K. Aspenes (TOMRA)

Case company: TOMRA Collection Solutions (Collection)

Background: As a result of the shifts that have occurred in the competitive landscapes with regards to supply chains, more and more companies are realizing the need to become more flexible in order to retain their competitive advantage. To retain this advantage there has been an added emphasis over the later years on further globalization of the supply chain.

Following the added globalization, cultural differences between supply chain partners have become an increasingly important factor to consider, both internally and externally in the supply chain relationship. Failing to consider and address these differences can lead to decreased flexibility and performance, within and throughout the supply chain.

Purpose of the thesis: The purpose of this thesis is to contribute to the knowledge on how mismatches in perception of cultural dimensions affect supply chain flexibility in an internal global supply chain.

Objectives of the thesis: Providing a theoretical link between the theories of supply chain flexibility and cultural dimensions.

Providing an overview of the challenges faced by Collection in retaining flexibility by analysing their TOMRA Xiamen facility in China, establishing how differences in perception of cultural dimensions can be seen as a driver for the experienced challenges.

Presenting options for adaptation that may be taken to overcome the identified challenges, using the established theories mentioned in (1). Using a combination of theory and collected data will form the basis for developing supply chain scenarios. These scenarios will detail several different adaptation strategies that can be chosen, outlining their strengths and weaknesses.

Research method: Theoretical connections and development of models for use in active case study. Single embedded case design of TOMRA Collection Solutions in connection to their subsidiary TOMRA Xiamen, China.

Short description: This thesis details how mismatched perceptions of cultural dimensions stand to impact current and achievable supply chain flexibility in an internal global supply chain. The thesis makes use of theory, models and scenario analysis in order to determine this relationship on a theoretical and practical level. As a mean to test the theoretical foundations, a case study was conducted at TOMRA Collection Solutions AS. The study finds that such differences in perception has a genuine impact on the current and achievable flexibility for TOMRA Collection Solutions and their subsidiary TOMRA Xiamen China. Further findings suggest that there are several different trade-offs in adaptation towards matching perceptions and concludes that a mixed adaptation strategy is seen as the most beneficial for both parties.

Key words: Supply chain flexibility, cultural dimensions, supply chain, supply chain management, TOMRA Collection Solutions.

Contents

Abbreviations and terms commonly used in this thesis:

C	Cost
Collection	TOMRA Collection Solutions
Corr.	Corrected for manual data entry
IhPLT	In-house Production Lead Time
KPI	Key Performance Indicator
OEM	Original Equipment Manufacturer
P	Performance
PCBA	Printed Circuit Board Assembly
PCBA Supplier	Generic term for the main supplier to TCN
PCC	Parent Company Coordination
PLT	Production Lead Time
Q	Quality
RQ	Research Question
RVM	Reverse Vending Machine
SCF	Supply Chain Flexibility
T	Time
TCN	TOMRA Xiamen China
TOMRA	TOMRA Systems ASA
TPAS	TOMRA Productions AS

A point of clarification: Differences in perception of cultural dimensions and mismatched perceptions of cultural dimensions are to be understood as the same phenomenon.

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1.0 Introduction

As a result of the shifts that have occurred in the competitive landscapes with regards to supply chains, more and more companies are realizing the need to become more flexible in order to retain their competitive advantage. To retain this advantage there has been an added emphasis over the later years on further globalization of the supply chain. As supply chains become more global in nature they also become more complex and will inherently involve different cultures on both sides of the relationship. Acting and interacting within and between these cultures is to be considered a key aspect of modern supply chains and has a potential effect within and throughout the chain itself. Seeing as most countries have their own unique way of expressing their culture, both as part of daily life and in aspects of work, such interaction can be made both challenging and rewarding at the same time.

In meeting these challenges, firms and organizations cannot remain solely focused on the aspects of lower cost and higher quality, but must turn to strategies aimed at creating supply chain flexibility. These strategies cannot be restricted to the company or firm alone, but must be part of a larger network across the supply chain.

As stated by Duclos et al. (2003, *p.455*): *"As supply chains compete with supply chains in the future, companies must understand that flexible supply chains will outperform those that are less agile."*

Cultural differences between supply chain partners have therefore become an increasingly important factor to consider, both internally and externally in the supply chain relationship. Failing to consider and address these differences can lead to decreased flexibility and performance, within and throughout the supply chain. To further develop flexibility, firms must look at their supply chain from a holistic perspective, securing optimization and avoiding sub-optimization. During the optimization process it is imperative to realize that the ripple-effects of changes in A can also affect B and so forth (Simchi-Levi et al. 2008). Our case company, TOMRA Collection Solutions (Henceforth; Collection) have realized the need for retaining flexibility, while controlling how time, cost and quality is impacted throughout their supply chain. Special emphasis for this thesis is here placed on their TOMRA facility in Xiamen, China (Henceforth; TCN).

1.1 Purpose of and objectives of this thesis

The purpose of this thesis is to contribute to the knowledge on how mismatches in perception of cultural dimensions affect supply chain flexibility in an internal supply chain on a global level. This purpose is divided into three objectives that are linked to the presented case study:

1. Providing a theoretical link between the theories of supply chain flexibility and cultural dimensions.

2. Providing an overview of the challenges faced by Collection in retaining flexibility by analysing their subsidiary TOMRA Xiamen facility in China, establishing how mismatches in perception of cultural dimensions can be seen as a driver for the experienced challenges.

3. Presenting options for adaptation that may be taken to overcome the identified challenges, using the established theories mentioned in (1). Using a combination of theory and collected data will form the basis for developing supply chain scenarios. These scenarios will detail several different adaptation strategies that can be chosen, outlining their strengths and weaknesses.

The main problem statement for this thesis is:

In what way does mismatched perceptions of Cultural Dimensions impact Supply Chain Flexibility, and what can Collection do to lessen this impact at their Xiamen facility?

In answering this main problem statement, several Research Questions (RQs) were developed:

Research Question 1 (RQ1): What are the connections between the theories of cultural dimensions and supply chain flexibility? How does these theories affect each-other?

Research Question 2 (RQ2): Which current practices are seen as a negative impact to flexibility for TCN and Collection?

Research Question 3 (RQ3): Which mismatched cultural dimensions are the greatest drivers for lowered flexibility within TCN and Collection?

Research Question 4 (RQ4): Which strategy for adaptation is the most rewarding for Collection and TCN?

1.2 Why this thesis?

This thesis is the result of a request from Collection, a sub-division of TOMRA Systems ASA (TOMRA) to Molde University College, where it was asked for assistance in analysing the possibilities for supply chain optimization on a global scale. The thesis was chosen freely by both authors as the subject was of both practical and theoretical interest. From the perspective of our case company it is so that our results, analysis and conclusion *may* be included in the TOMRA SC2020 project. This project is aimed at setting goals and establishing challenges in the supply chain, with implementation of countermeasures in 2020 at the latest. Our sub-section of this project is limited to the Xiamen, China part of the supply chain, while similar sub-projects are performed in parallel, elsewhere.

1.3 Scope and limitations

The scope of this thesis is that of analysing in what way cultural adaptation can be used to manage time, costs and quality, while strengthening flexibility in a select internal upstream part of the supply chain. As a limitation of the upstream supply chain, only the operations in Xiamen, China have been chosen as the unit of analysis. This entails the supply chain as seen from the furthest sub-supplier, until the goods are ready to be shipped to Xiamen Port (see part 4 for more information). However, the thesis does not aim at providing direct methods for change in supplier or sub-supplier routines nor methods but simply to analyse and suggest implications to their behaviour as a mean to better define current practices at TCN. Further limitations made can be found at the beginning of each specific part and section, if present.

1.4 Intended audience

This thesis is intended for an academic audience, as well as for anyone with an interest in supply chain flexibility and cultural relationships in global supply chains. Furthermore, the thesis is aimed at providing a new angle on the upstream supply chain for the employees of our case company, Collection. As it is an academic paper, the thesis may inspire further research and use of specific findings presented within. The authors presume a basic knowledge level of logistics and supply chain management, as well as terms used in both disciplines in outlining this intended audience.

2.0 Theory and Literature Review

This part of the thesis is concerned with the gathering of theories and available literature relevant for this thesis. As a main limitation, two theories were chosen, 1) Cultural theory with emphasis on two main schools of cultural dimensions and 2) Supply Chain Flexibility theory. Within this part the reader will also find a collection of available pre-existing models (2.2.7), the perceivable connections between the chosen theories (2.3) as well as the models developed specifically for this thesis (2.4).

2.1 Culture

2.1.1 What is culture?

Culture is a complex term, with several definitions, for this thesis we support our understanding of the term culture on the following definition:

> *Culture is a learned, shared, compelling and interrelated set of symbols whose meaning provides a set of orientations for members of a society. These orientations, taken together, provide solutions to problems that all societies must solve if they are to remain viable.*
>
> *(Terpstra and David 1985, p.5)*

Merriam-Webster (n.d.-b) defines culture as *"the integrated pattern of human knowledge, belief, and behaviour that depends upon the capacity for learning and transmitting knowledge to succeeding generations".* Culture starts out in the social environment where one is raised, and the family is the first influence on ones culture. Further on, we are affected by different cultures in our community, education, social groups and work life. Our culture define how we eat, greet each other, how we show emotions, the level of physical distance towards others, or our attitude towards personal hygiene. Culture is usually a shared phenomenon, due to the fact that it is at least to some extent shared with people coming from the same surrounding as us. Culture is something we learn, not something we inherit and should be seen separate from our human nature or our personality, though it can be difficult to draw distinct lines where the three differs (Hofstede et al. 2010).

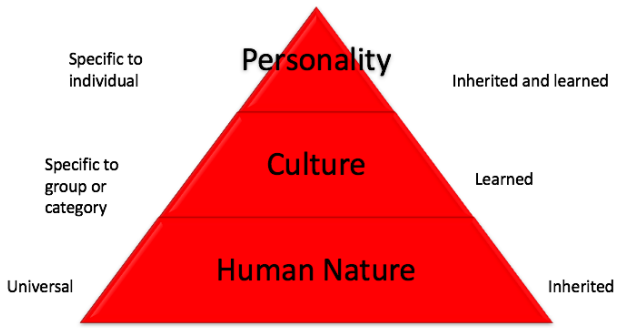


Figure 1 - The three levels of uniqueness in culture (Hofstede 1994 p.8, as referenced in Hartl 2014)

The triangle above illustrates the three layers or levels that compose an individual's behavioural pattern. *Human nature* is the bottom level that all humans have in common, regardless of who they are and where they come from. This is an inherited trait and includes an individual's ability to feel e.g. joy, anger, sadness or love, as well as the wish and ability to talk and connect with others. The *personality* is the unique part of whom we are, and is not shared with any other individual, regardless of their connection. This is composed of traits that are both inherited and learned through association with others. *Culture* is learned, either formally or informally. In this we can find knowledge, beliefs, morals, laws and norms, which can be collected into sub-categories like cultural knowledge, social skill or cultural skill. All individuals belongs to several cultural groups, as we can see culture on a national level, regional/ethnical/religious/linguistic level, gender level, generation level, social class level, and organisational (work) level (Hofstede et al. 2010).

2.1.2 Cultural Dimensions

Hofstede et al. (2010) conducted research in global companies in order to identify the differences between cultures, even though they were employed by the same corporation. From this research they developed four main cultural dimensions:

- Power distance
- Collectivism vs. individualism
- Femininity vs. masculinity
- Uncertainty avoidance

These dimensions gather several phenomena based on statistical ties, measuring the trends for the phenomena to happen in mix. In later years, a fifth dimension was added; long-term vs. short-term orientation (alt; orientation towards time).

Power distance illustrates the extent to which a society is inclined to accept an unequal distribution of power in organisations and/or institutions (Hofstede et al. 2010).

Individualism and collectivism mirrors the extent of which individuals prefer to care for their immediate family and themselves, retaining emotional independency from e.g. social groups and organisations (Ibid).

Masculinity and femininity refers to the revealing a bias of either feminine values like nurturing societies, improving quality of life and retaining relationships, or more masculine values like assertiveness, competitiveness and materialism (Ibid).

Uncertainty avoidance states the tolerance for uncertainty in the society, if predictability and stability is preferred or some risk is accepted (Ibid).

Long-term and short-term orientation relates to the aspect of "quick wins", or if patience and insisting on reaching long term goals is in focus. In the long-term orientation one is typically focused on the greater good, opposite to where ones own face is important in the short-term orientation (Ibid).

All of the five dimensions above can be illustrated on a collective scale as shown in the figure below:

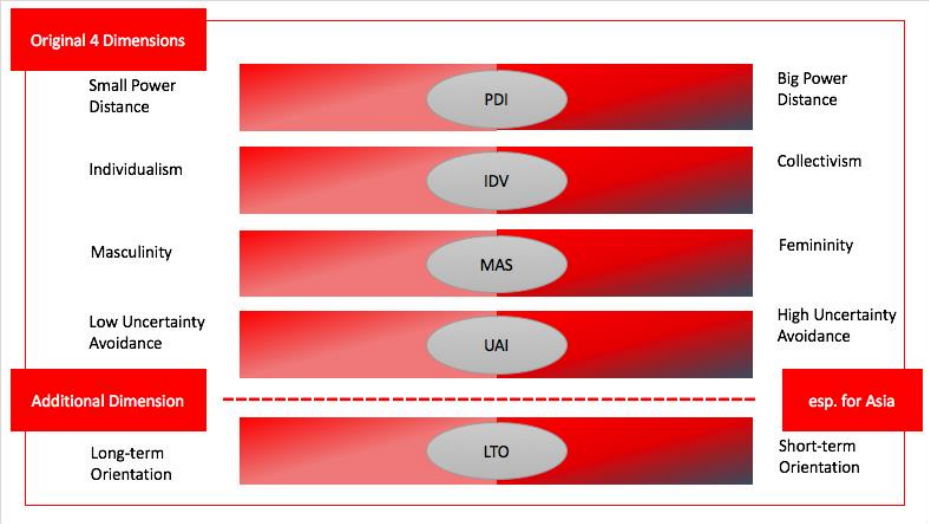


Figure 2 - Illustration of Hofstede's five cultural dimensions (based on Hartl 2016)

Like Hofstede, Trompenaars and Hampden-Turner (2012) developed a set of dimensions called "The Six Dimensions of Cultural Diversity". Many of these dimensions resemble the ones developed by Hofstede, such as the ones that deal with *Individualism vs. Communitarianism* and *Inner vs. Outer direction*. The remaining dimensions are *Universalism vs. Particularism, Specificity vs. Diffusion, Achieved vs. Ascribed Status and Sequential vs. Synchronous Time.*

The one dimension that can be qualified as significantly different from Hofstede's dimensions is the one of Achieved vs. Ascribed status. This dimension deals with the aspect of status in life and how it is achieved, status can here be a result of what one has done previously (earned) or by virtue of your social status or connections (given) (Trompenaars and Hampden-Turner 2012).

When dealing with a different culture than our own, several challenges may occur with regards to both personal and professional culture. In order to be able to conduct business in a professional environment successfully, these differences in culture needs to be acknowledged and taken into account when planning and organizing professional dealings or production. China has here been a sought-after location due to the low labour costs in addition to lower general costs for land and storage, even though the cost levels have risen in later years (The Economist 2012).

2.1.3 Cultural Dimensions in Eastern and Western cultures

If we go further into the dimensions set by Hofstede et al. (2010) and Trompenaars and Hampden-Turner (2012) we can get a clear overview of where different cultures are located within the framework. For the sake of simplicity, we will here illustrate the differences between a generalized Eastern and Western culture for each of the dimensions using China and Norway as the main means of comparison.

When looking at power distance it is so that the Norwegian culture is a good example of lower power distance, where individuals are seen as equals regardless of background and education. This is practically observable as it is not uncommon that floor workers and managers make decisions in e.g. work environments together as a group. Parents raise their children as equals, students are expected to take initiative in the classroom, and the perfect boss is seen as someone who behaves in a democratic manner. The use of higher power distance is an example of a generalized Chinese culture, where parents expect their children to be obedient, employees receive their instructions in a structured and detailed manner, students are expected to follow the teacher initiatives and the ideal boss should be seen as a "gracious father figure" (Hartl 2016).

With regards to individualism vs. collectivism in Europe and particularly Norway each individual is responsible for taking care of one self and ones immediate family, identity is established in the self and it is common to defend ones own opinions. The main goal of education is to "learn how to learn" and advancements in the work environment are an outcome of earlier accomplishments. Tasks are usually more important than relationships in business. In collectivistic cultures such as China, children are born into larger families who expect 100% loyalty from them, and ones relationships and social networks define the individual identity. Conflicts are to be avoided, as harmony is one of the core values in collectivism. In education, the main goal is to learn how to do things, and in business life ones relationships or memberships in certain groups is helpful in getting employment or reaching a certain position in a company. Relationships are considered more important than business tasks (Ibid).

In the dimension of masculinity vs. femininity, China is to be considered a typical masculine culture where predominant values are job advancements and economic success; acquisition of money and other materialistic aspects. Women are expected to stay at home and care for the family, while men are the ones who are to provide for their families. Decisions in business environments are to be made by the boss, and the employees live for their work. In China masculinity in work is often stated trough assertion, with lower tolerances for doubt towards decisions made by management. In feministic cultures such as Norway the predominant values are to take care of other people and existing resources, where individuals and mutual relationships are important. Both men and women are allowed to consider the other individuals feelings and in business the boss is expected to use his or her intuition in addition to look for consensual solutions (Ibid).

China, under the practice of lower uncertainty avoidance considers uncertainty and risk as a normal thing that is a part of life, and it is therefore dealt with in an easy-going manner. Time is viewed as a framework, and hard work is only done when deemed necessary, as there is focus on that each day should be enjoyed. This construct states that punctuality and precision can be learned and it is tolerant towards innovative thinking. In Norway, where the level of uncertainty avoidance is high, uncertainty is viewed as a potential trigger leading to uncomfortable situations and events and therefore it has to be avoided. The view on time is strict, as time is money, and workers are usually emotional towards hard work. Being punctual and precise are values that describe an individual, and in this setting it is preferred to keep things the way they are if change is not strictly necessary (Ibid).

The last of Hofstede's dimensions is the one of long-term vs. short-term orientation. In long-term orientated cultures such as China, the conservation of money is important, as this will be a buffer for future investments. Patience and insistence is predominant in reaching goals, and sometimes it is deemed necessary to take on a subordinate role in dealings both in private and business life if it benefits the long-term result profit from it. China is above all an example of this culture. In short-term oriented cultures such as Norway, the level of savings are usually lower, as future investments are given little acknowledgment in the present on a personal level with focus on quick wins (Ibid).

Under Trompenaars and Hampden-Turners dimension of achieved vs. ascribed status, we see that in cultures such as Norway individuals are judged by past performances, both in personal and professional life, whilst in ascription oriented cultures such as China status is credited to you by birth, heritage, gender, age, or by having the proper connections/acquaintances (Ibid).

Rahman et al. (2012) has examined the differences between Japanese and Western approaches with regards to manufacturing strategy. As several parallels can be drawn between Japanese and Chinese culture, they can be generalized into a single term, Asian culture. Bolwijn and Brinkman (1978, as referred to in Rahman et al. 2012) has compared the Japanese and Western attitude towards manufacturing through examining culture, personnel, organization, management, simplified these aspects into the following table:

Japanese	Western
▪ Adaption to the outside world	▪ Confrontation with the outside world
▪ Buddhism and Shinto aimed at avoiding worries and anxieties	▪ Christianity concerned with absolute moral values, good and evil, and redemption of the soul
▪ How to live	▪ What to live for
▪ Present and tangible	▪ Future and abstract
▪ Man makes 'The Way' great	▪ God makes man great
▪ Society is built on direct personal relationships	▪ Society is built on legalistic contractual relationships
▪ Group orientation, group egoism	▪ Individualistic orientation
▪ Behaviour controlled by group adaption	▪ Behaviour controlled by rules, punishment and rewards
▪ Frame groups are important (neighbourhood, department, company, nation)	▪ Attribution groups are important (family, class, occupation)
▪ Strong hierarchical structure and direct personal relationships	▪ Weak hierarchical structure and contractual relationships
▪ Personal relationships based on mutual obligations and mutual dependence	▪ Contractual relationships based on rights and duties
▪ Education aimed at cooperation and dependence	▪ Education aimed at personal development and independence

Figure 3 - Comparison of Japanese (Asian) and Western cultures (Bolwijn and Brinkman 1978, as referred to in Rahman et al. 2012 p.40)

From the figure above, we see that there is a great similarity between the research performed by Hofstede (1983; 2010) and Bolwijn and Brinkman (1987, as referred to in Rahman et al. 2012). The aspects of personal relationships, group orientation, hierarchy and dependency are the ones that are the most similar to what Hofstede et al. (2010) has highlighted regarding Asian culture. For the western culture the aspects of contractual relationships, individualism, low degree of hierarchy and independence are the most

prominent similarities. Schwartz (1999, as referenced in Siu 2003) states that China among others strongly emphasizes hierarchy in both private and business settings, and that work is central in the individual life. This confirms the aspects that are mentioned by both Hofstede (1983; 2010) and Brinkman (1987, as referred to in Rahman et al. 2012).

When western companies deal with businesses or partners from China, the employee's behaviour needs to be taken into account regarding cultural aspects and the influence from Confucianism when trying to embed ethical values. There are large differences between what is ethically correct in eastern and western cultures, as the core principles are different in the different cultures, for example regarding monetary gifts (Irwin 2012). Like Hofstede, Irwin (2012) states that Chinese individuals are taught to respect authority without questions as group loyalty and relationships are important. When dealing with employees, one might experience reluctances regarding voicing disagreement towards colleagues, which relates to the aspect of "face-saving" which is important in the Chinese culture. The aspect of hierarchy is important to take into account also in staff training, here it can be favourable to keep training groups small and consisting of employees that have the same rank, especially due to the fact that it can inhibit open discussions in the group if higher ranking individuals are present.

Global companies doing business in other countries and cultures, particularly China need to understand the importance of relationships (guanxi) and "face-saving" (mianzi). Taking these two aspects into consideration will enhance the understanding of the employees in the management of business relationships, especially when trying to enforce changes that can be on the verge of controversy, compared to what is deemed normal in the Chinese culture. Proper management of cultural challenges can be crucial for the success of doing business in foreign cultures, as this will have direct impact on the effectiveness of the operations, whether it is a new entry or a reconfiguration of existing business dealings (Johnson and Tellis 2008).

2.1.3.1 Summary

The table below details the relationships between the cultural dimensions set by Hofstede et al. (2010) and Trompenaars and Hampden-Turner (2012) for eastern and western cultures as they are described in theory. Values does not imply absolute highest and lowest in their position, but rather signifies their general orientation towards this end of the scale:

East	Cultural Dimensions	West
High	Power Distance	Low
Masculine	Masculinity vs Femininity	Feminine
Low	Uncertainty Avoidance	High
Collectivistic	Individualism vs Collectivism	Individualistic
Long-term	Long-term vs short-term orientation	Short-term
Ascribed	Ascribed vs Achieved status	Achieved

Table 1 - Cultural dimensions as perceived by eastern and western cultures

2.2 Supply Chain Flexibility

2.2.1 What is Supply Chain Flexibility?

In recent years, there has been a realization towards the fact that there is no longer enough to be flexible in a standalone situation, but that there is a genuine need to be flexible throughout the entire supply chain in order to deal with various forms of uncertainty. Supply chain flexibility is therefore linked between and within the chain, adding itself and its needs to the traditional view of supply chain management (Duclos et al. 2003). In this setting Supply Chain Flexibility (SCF), aka. flexible supply chains have become increasingly important over the last two decades. According to Aprile et al. (2005) it is so that the flexible supply chain came about as a result of rapid changes in market demand, increased or decreased lead time, quality and delay of information. Over the years, Supply Chain Flexibility has been described in many ways, one example is the description by Viswanadham and Raghavan (1997) stating that the flexible supply chain has the ability to react to changes in an effective way with low penalty towards cost, time, performance or quality.

There are numerous definitions of the term Supply Chain Flexibility, but as the subject is still considered to be in a state of infancy there are no commonly unified definitions, or theoretical frameworks to adhere to (De Toni & Tonchia 1998; Fayezi et al. 2015; 2016). For this thesis we support our understanding of Supply Chain Flexibility on the following base definitions:

“Flexibility is the organization’s ability to meet an increasing variety of customer expectations without excessive costs, time, organizational disruptions, or performance losses.” (*Zhang et al. 2003 p.173)*

"Supply chain flexibility: An operational ability that assists organisations to efficiently change internally and/or across their key partners in response to internal and external uncertainties via effective integration of supply chain relationships." *(Fayezi et al. 2016 p.4)*

In the literature on flexibility there has traditionally been a distinction between the constructs of internal flexibility and external flexibility (supply chain flexibility). While internal flexibility has traditionally been seen in the context of a single firm and its performance, supply chain flexibility has been seen as an external measure for the entire chain. Several authors such as Zhang et al. (2003), Zhang (2011) and Suarez et al. (1996) argue that internal flexibility traditionally has been seen as a segmented phenomenon, having little to no chance of becoming external, while Swafford et al. (2006) and Duclos et al. (2003) argue that the integration of internal supply chain flexibility may help and strengthen the further integration of supply chain flexibility at an external level.

In the early 2000s, Lee (2004) proposed that Supply Chain Flexibility had three major components that all contributed in some way or another to the supply chain. This has become known as the "triple A supply chain" consisting of adaptability, alignment and agility. The concept of adaptability is that of making sure your supply chain is equipped to change when dealing with structural changes in the market, by changing strategies or technology. Alignment refers to the concept of making incentives along the supply chain, increasing chances of overall better performance. Lastly, there is the concept of agility, being able to deal with disruptions and short-term changes.

There exists an overall agreement that Supply Chain Flexibility consists of three main aspects, the consensus is that these three aspects are: 1) the buyer-supplier relationship 2) demand and the role of marketing 3) production and/or manufacturing. Gaining flexibility in the buyer-supplier relationship is dependent on being able to choose the supplier that is best suited for sourcing or integration. Good choices with regards to this aspect is seen as a primary driver for relinquishing some degree of Parent Company Coordination (PCC) upon a supplier or subsidiary. In a practical use, PCC is seen as the necessary exercised level of communication and information exchange, as well as governance required to maintain flexibility by the Parent Company over their supplier or subsidiary (Wadhwa et al. 2008).

Focus is here set at the supplier’s ability to be more responsive and frequently being able to change scheduling procedures as mentioned by Krajewski et al. (2005), while Fisher et al. (2009) emphasizes the ability to produce smaller quantities in an efficient manner. Trust is

also a driving force in this relationship as explained by Wadhwa et al. (2008), creating opportunities for unified responsiveness and communication in order to become more flexible as a result.

The second aspect is the use of marketing as a mean to achieve customer value creation and perception is an integral part of the flexible supply chain (Rainbird 2004). Jüttner et al. (2004) states that marketing and Supply Chain Management are the processes that links those who create demand with those who fulfil it. In order to create the best value one must incorporate the basic need(s) into all activities and create something new, namely Demand Chain Management. This combines the advantages of marketing and Supply Chain Management, keeping focus on the customer. Lastly, when it comes to flexibility in manufacturing it is no longer limited to machines alone, but extended to the company as a whole, where changes in products and environments must be met with speed and efficiency in planning and scheduling (Viswanadham and Raghavan 1997; Mentzer 2004).

2.2.2 Dimensions of Supply Chain Flexibility

Without a consensus definition there has in recent years been made efforts in order to define the different dimensions of Supply Chain Flexibility. These dimensions include several key abilities, such as the ability of the supply chain to be reconfigured, known as supply- and reconfiguration flexibility (for this thesis the two have been combined to form reconfiguration- and supply flexibility). This reconfiguration is tied to the ability to find new sources of supply and/or new suppliers entirely. As an overall structure to the flexibility dimensions is the concept of active flexibility, high degrees of active flexibility enables the chain to respond better to changes, or to better plan ahead in anticipation (Stevenson & Spring 2007; Sánchez & Pérez 2005; Mattsson 2002). In addition to the dimension of Reconfiguration- and Supply Flexibility outlined above this thesis makes use of the following flexibility dimensions presented below, as outlined by Mattsson (2002):

Product Flexibility

Product Flexibility is the ability to create and shape products in accordance with market needs. This dimension of flexibility is highly reliant on collaboration, both within and throughout the supply chain, where several departments, such as marketing may become

involved on a frequent basis. As product lifecycles are decreased further there is an emphasis on being able to bring new products to market in an efficient manner, making increased Product Flexibility a source for an increased competitive advantage.

Product Mix Flexibility

Product Mix Flexibility is the ability to adapt material supply in a situation where there have been variations in the demand for certain products or certain product variations. Having a high degree of Product Mix Flexibility enables the chain to change priorities on the spot, being able to produce less than expected of product A and more of product B, utilising the same capacity.

Volume Flexibility

Volume Flexibility is the ability to adjust production and delivery routines in accordance with market demand and needs. Adjusting production in this manner makes the coordination between manufacturer and supplier crucial. Using Volume Flexibility in a strategic way one may avoid situations such as stock-outs or over-stocking for products that are volatile to shifts in demand. Good use of this flexibility dimension requires a simultaneous ability to adjust planning and scheduling in accordance with production and delivery.

Delivery Flexibility

Delivery Flexibility is the ability to adapt to changes in open orders in an efficient manner. Traditionally, changes can be seen as a disturbance in the supply chain and as such many companies do not allow for changes to be made in open orders, as there is a wish to decrease variability. In recent years this reluctance to undertake changes has been seen as a competitive weakness as changes are part of the shifting market conditions of modern society and an effort should be made to embrace these changes, rather than to discard them.

According to Mattsson (2002) the dimensions of Product Mix-, Volume- and Delivery flexibility are the most relevant in a supply chain management setting. As supply chains become more global in nature there is an added emphasis on mutual dependency, where suppliers are expected to be flexible, especially in areas such as Product Mix- and Delivery

Flexibility. Overall, all flexibility dimensions are subject to the present lead time, delays and the flow of information, as well as communication and coordination between actors in the supply chain. Longer supply links and chains with low degrees of communication and information exchange are seen as less suitable for sustaining their flexibility. Lead times in making administrative decisions and deliberation are here seen as drivers for all of the above factors, making them detrimental to the ability for quick adjustments.

2.2.3 Sources of Flexibility

Suarez et al. (1996) argues that the primary sources for flexibility within a company or firm can be divided into 6 different factors. If managed properly these factors can become a helpful tool, but managed poorly they may become a hindrance:

1. Production technology
2. Management of production and production techniques
3. Supplier relations (including sub-suppliers and distributors)
4. The training and ability of the workers
5. Design of products
6. Systems for information exchange and accounting

With regards to types and dimensions of flexibility it is stated that different types of flexibility are in existence and that they all have a time and place, dependent on the current market situation. It is further argued that there are several ways to achieve the same type of flexibility and that the dimensions of flexibility should be contained to include mix, volume, new-product (product) and delivery flexibility, as these would seem the most prudent (Ibid).

In discussing (2) and (6) Naylor et al. (1999) states that forecasting is imperative to create flow and predictability in the supply chain. This form of flow is usually derived from the principles of lean operations and the agile supply chain, but are easily transferrable to the flexible supply chain. The main purpose when dealing with forecasts and accuracy is to create stability and to become sufficiently predictable in operations. Forecasting is however a subjective form of measurement and can in some cases be described as qualified guesswork, as shown in the figure below:

Forecast accuracy from a group of experts in the electronics product industry [7]

Future prediction	Forecast accuracy
1 month	± 5%
2 months	± 20%
3 months	± 50%
Beyond	Toss a coin

Figure 4 - Forecasting accuracy (Naylor et al. 1999 p.108)

Predictions made for periods further than 3 months out are described as the "toss of a coin", providing ample description to the margin of error. As this is the case one may argue that the use of forecasting techniques is best used in short-term planning.

2.2.4 Measuring Supply Chain Flexibility

Measuring Supply Chain Flexibility is still in a state of infancy when it comes to research, as there are no collective definitions or dimensions to adhere to. Due to this fact, there is a need for a generalized measurement tool. Lacking a general tool for measurement has resulted in subjective and often circumstantial methods and results. The numerous dimensions of Supply Chain Flexibility makes it harder and harder to measure its effects accurately as having flexibility in one of the dimensions is no guarantee of flexibility when looking at another (De Toni & Tonchia 1998; Fayezi et al. 2015; 2016).

Due to these limitations, Stevenson and Spring (2007) suggests that several different forms of supply chains can be seen as equals, even though they are flexible in different dimensions. Following this possibility, models and measurements are considered highly specific/subjective and giving a hard value to the current state of flexibility and improvements made can therefore be seen as objectively difficult (Sánchez & Pérez 2005). It is suggested further that in order to be less circumstantial and more precise in measuring, one should use factors that are common to the general supply chain, as an example these factors can be levels of inventory or the presence of lead time and costs (Stevenson and Spring 2007).

In order to create an accurate measurement, one should keep the number of parameters low, as to not skewer the results (Stevenson and Spring 2007). The TCQ triangle can here be used to make a relatable measurement towards the supply chain, this method is a basic function of three constructs:

1. Time (T)
2. Cost (C)
3. Quality (Q)

In this relationship it is so that:

1. Time is relative to the cost input and the quality output
2. Cost is relative to the time input and the quality output
3. Quality is relative to the cost and time inputs

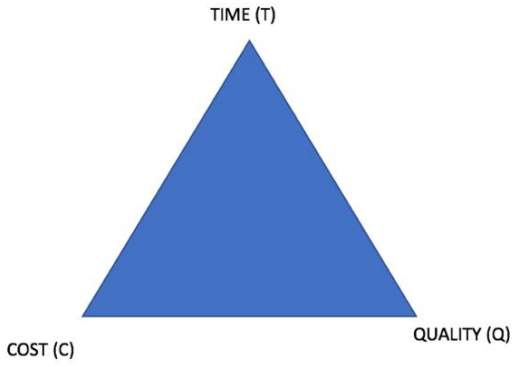


Figure 5 - The TCQ Triangle

This relationship is also held true in the Supply Chain Flexibility literature, supported by Viswanadham and Raghavan (1997) stating that the flexible supply chain has the ability to react to changes in an effective way with little penalty towards cost, time, performance or quality. It is also supported by Zhang et al. (2003) and the definition of flexibility given as:

"Flexibility is the organization's ability to meet an increasing variety of customer expectations without excessive costs, time, organizational disruptions, or performance losses." (Zhang et al. 2003 p.173)

In the above description and definition of the flexibility term there is another construct added to the relationship, that of performance;

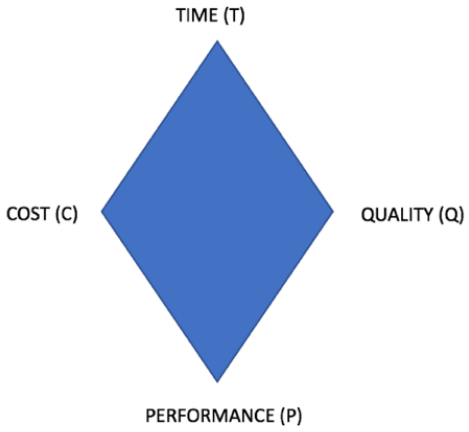


Figure 6 - Extended TCQ Triangle

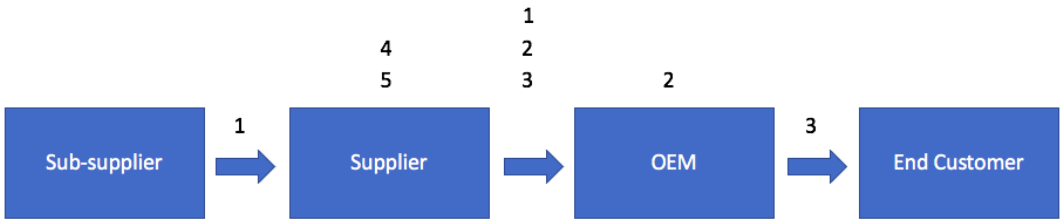
For the purposes of simplicity one may argue that Performance (P) is measured as the collective output of T, C and Q and that whichever construct is deemed most crucial is the one to measure P after. As an example, if P is connected to the delivery of orders, the construct of T would be most crucial, as such the P of the supply chain should be assessed using T as the main Key Performance Indicator (KPI). Following this logic one may freely use the simplified triangle of TCQ to assess and judge current Supply Chain Flexibility without the need to expand the consideration to performance.

2.2.5 The illusion of Supply Chain Flexibility

Mattsson (2000;2002) argues that one of the easiest ways to seemingly increase Supply Chain Flexibility is to increase the perceived flexibility, usually by adding more resources in order to temporarily become more flexible and gain more options. This is however not feasible in the long run, as the costs that emerges from this practice cannot be upheld and in most cases, justified over longer periods of time. As this is the case there is little use in increasing the perceived flexibility and efforts should be made to increase real flexibility. Furthermore, it is no longer enough to just be able to quickly adjust and adapt, this speed should be combined with the ability of limited use of resources. It is this combination of quick adaptation and the limited use of resources that signifies a truly flexible supply chain, without these factors one may say that all supply chains are flexible to some extent.

2.2.6 The strategic points of flexibility in the supply chain

Given the nature of modern supply chains it has become increasingly important to recognize the strategic importance of having different types of flexibility at different points in the supply chain. From a theoretical perspective we can see that multiple types of flexibility are present throughout and within the individual links, but as a simplified view one can look at a generic supply chain in the following manner:



1. Reconfiguration- and supply flexibility
2. Volume Flexibility
3. Delivery Flexibility
4. Product Flexibility
5. Product-Mix Flexibility

Figure 7 - Strategic points of flexibility in the supply chain

From the figure above one may see that there is strategic importance to all of Mattssons (2002) 4 dimensions, including the construct of reconfiguration- and supply flexibility as outlined by Stevenson and Spring (2007) as well as Sànchez and Pèrez (2005). Starting from the point of origin at the sub-supplier, there is an inherit need for reconfiguration- and supply flexibility, as situations may arise where the need for acquiring new suppliers of raw materials or new sources of supply. This is also true for the main supplier, as being able to find temporary sources of supply in times of shortage or entirely new suppliers are crucial in order to keep an adequate level of supply chain flexibility. There should also be elements of delivery- and volume flexibility from the main supplier to the Original Equipment Manufacturer (OEM) as to provide alternatives and solution to smooth production and delivery flows. Mattsson (2002) argues that product- and product mix flexibility capabilities are of equal importance in this link. Within the OEM there should be high levels of volume flexibility in order to adjust and adapt production and delivery in a timely manner.

Having this form of flexibility present is highly dependent on good communication between the OEM and their suppliers, who in turn must have a good link of communication with their sub-suppliers (Ibid). Towards delivery of finished goods to the end customer it is so that there should be a level of delivery flexibility present, as open orders may change in priority or volume. This form of flexibility is closely linked to that of volume flexibility, however they are not the same entirely.

2.2.7 Models for flexibility measurement, impact and increase

Throughout the last 20 years there have been made efforts in order to develop models that can measure and increase Supply Chain Flexibility, while also stating the impact of different flexibility dimensions upon each other. A greater share of these models are however very specific and often only structured in a mathematical fashion. As explained by Fayezi et al. (2015; 2016) there is an essential gap in the flexibility literature regarding relationships related to suppliers and their characteristics both on an internal and external level, where further exploration and research is needed. For this thesis these characteristics are heavily based on their perception of cultural dimensions. As a mean to delve into this proposed gap we have here collected some of the more reasonable models designed for this purpose, detailing their function, strengths and weaknesses:

The partnership model by Lambert et al. (1996) is by the authors´ account one of the earliest models to tackle the issue on partnerships/relationships and how they are beneficial to the supply chain in a meaningful way. The main emphasis is set on when it is beneficial to create or adjust a partnership, as well as on the governance of overall supplier partnerships. The goal of the creation or adjustment is a realization of the mutual gains that can be gleamed from this practice.

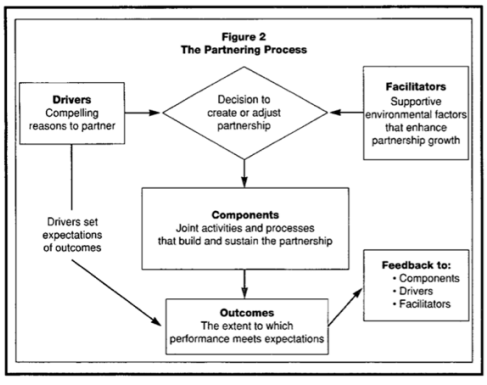


Figure 8 - The Partnership Model, Lambert et al. (1996 p.4)

The strength of this model can be seen in the general fashion in which it can be used, being both suitable for implementing new partnerships, as well as diagnosing and evaluating existing ones. As a negative, this model does not move in-depth on Supply Chain Flexibility, nor the cultural aspects of the drivers that may be involved in the partnership, as such the model is a good basis for evaluation, but will be limited when considering cultural barriers. As a final remark, the authors consider this model as applicable to the issue of cultural adaptation in Supply Chain Flexibility, but are also aware of the minor limitations, as such this model will be used as inspiration.

Sharifi and Zhang (2000) developed a model for agility implementation in the early 2000s with the purpose of determining the best way an organization can consider and implement Agile practices:

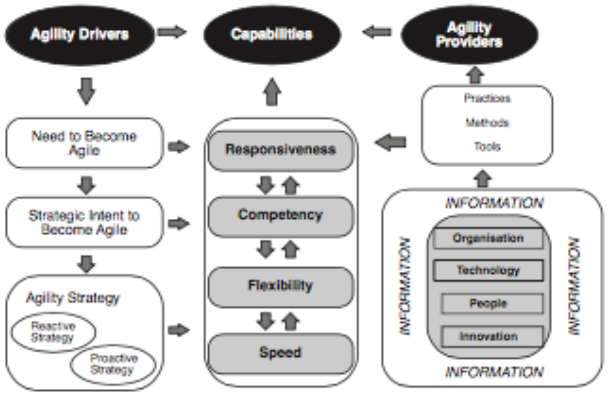


Figure 9 - Model for Agility implementation, Sharifi and Zhang (2000 p.498)

The first consideration is that of agility drivers, seen as the pressure applied on a company, forcing it to evaluate the need for retaining competitive advantage. The second consideration is that of capabilities, where the essential base knowledge for positive response and implementation is located. The third and final construct is that of providers, where the integration and cross functional aspects needed for successful implementation and continuation are considered. In short it is so that the identified capabilities needs to be acquired and further enhanced in order to sustain competitive advantage under changing conditions (Sharifi and Zhang 2000). This model is closely related to the issue of implementing a successful Agile strategy for manufacturing, but does not relate directly to the constructs of culture. However, the model is seen as a good blueprint for the identification of the need to change and how to consider change across the supply chain.

Duclos et al. (2003) – A new framework for Supply Chain Flexibility is considered one of the most applicable models in the Supply Chain Flexibility literature, outlining a model for integrating Supply Chain Flexibility across the entire supply chain, moving from internal to external flexibility. Heavy emphasis is placed on the components of Supply Chain Flexibility and their effect on each-other.

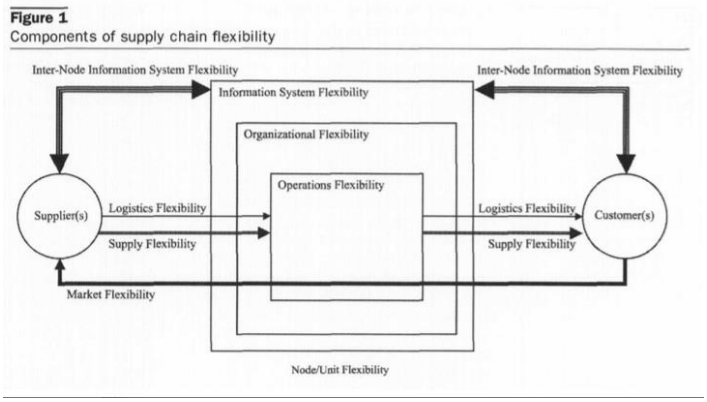


Figure 10 - A new framework for Supply Chain Flexibility, Duclos et al. (2003, p.451)

While the model is a good measure of how integration can be used to expand flexibility, it does not consider direct measures, nor what barriers may be in place in order to address integration or Supply Chain Flexibility in itself. The model is however considered reliable proof that different types of flexibility has an impact across several dimensions and that they must all be considered in the buyer-supplier- and inter-partner relationships, as well as on an internal level.

Rahman et al. (2012) and their model on manufacturing strategy details the impact of environmental factors on the manufacturing strategy of a company. Their studies on the different approaches of Western vs Eastern (particularly Japanese) practices to this phenomenon has concluded in the following model:

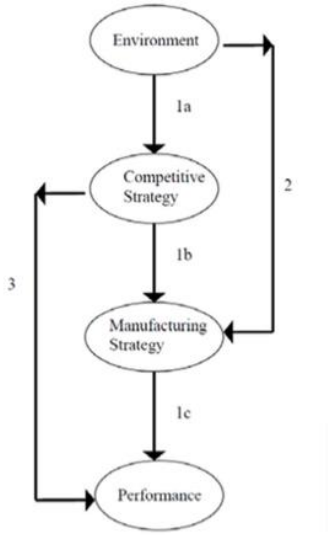


Figure 11 - Manufacturing strategy, Rahman et al. (2012 p.38)

The model is considered comprehensive in the way it explains the relationship between environmental factors and the overall competitive strategy of a company. Emphasis is also placed on the fact that the competitive strategy is a main driver and will influence manufacturing strategy, affecting performance measurements. The model is a good fit for awareness when dealing with general uncertainty as well as environmental uncertainty. One weakness of the model is that it does not consider the close environment on a company level, such as cultural differences on an internal level, but rather emphasises the more complex environments, such as war. This model is considered to be a good fit by the authors and its only major weakness is considered to be the lesser emphasis on close proximity environmental factors.

2.2.7.1 Summary

In the table below several aspects that are considered important to the flexible supply chain structure have been identified. In constructing these flexibility aspects, details from interviews with Collection have been used, alongside the authors understanding of the theory provided. Following this identification and construction, a comparison of their interpretation in eastern and western cultures was constructed:

East	Flexibility Aspect	West
Strict	Planning	Fluid
Relational	Contracting	Contractual
Less important	Quality of products	Important
Important	Quality of process	Important
High Emphasis	Relationships	Lower Emphasis
Stability	Production Techniques	Options
Clear (Non-implicit)	Communication	Abstract (Implicit)
Less frequent (More direct)	Information Exchange	More frequent (Less direct)
In relationships	Trust	In contracts
Low (Unless specified)	Level of employee involvement	High
Hard orders (Pre-set)	Order preferences	Soft orders (Forecasts)

Table 2 - Flexibility aspects as perceived by eastern and western culture

2.3 Theoretical Connections

The following section is included as a summarized connection on how flexibility aspects and cultural dimensions are seen by eastern and western cultures and as a general connection between the theories themselves. While there are no absolutes with regards to culture and their differences it is considered appropriate that a general sense of their relationships is in place for this thesis. The view on eastern cultures is here heavily emphasized on the Chinese way of thinking, while the western views are heavily emphasized on the Norwegian way. This emphasis is predominant in all further parts of this thesis.

2.3.1 Cultural Dimensions

From Table 1 (p.25) one can clearly see a difference towards the dimensions and their significance in eastern and western cultures. None of the dimensions are equal for both cultures, signifying that a method of adaptation is needed in order to create meaningful collaboration. Further details can be found in the summary of the Cultural theory (2.1.3.1) section above.

2.3.2 Flexibility Aspects

From Table 2 (p.39) above one can see that there are several aspects that differ between the two cultures and that only one aspect is considered of equal importance, namely quality of process. With regards to the first aspect of *planning* it is so that the eastern cultures prefer a stricter planning method than the western cultures. While western cultures desire options and choice, eastern cultures can be considered more rigid, having preference for the absolute. *Contracting* is another aspect to consider, where eastern cultures relies on the personal relationship, western cultures rely highly on lawfully binding contracts and agreements in order to establish connections. When it comes to *quality of products and processes* one can see that product quality can be considered less important in the eastern cultures and particularly China. *Product quality* is subject to interpretation and without thorough specifications, a product may end up very differently from the imagined state.

However, the *quality of processes* is highly regarded for both cultures, where faults and errors are subject to "losing face" and as such being a burden to the relationship in eastern culture. This is also true for western culture in terms of reputation, where reliability is appreciated in all parts of the supply chain and faults may jeopardize this reputation or trust. *Relationships* are closely linked to the *trust* and *contracting* processes in each culture, in the east there is a higher emphasis on the relationship between individuals than in the west. In eastern business settings no contracts are made without a personal connection and trust involved, as this is the case, contracts are often subject to heavy investments in time and effort.

Communication is subject to different practices in both cultures, eastern cultures favouring clear and concise instructions, whilst the western cultures rely on implicit information in communication. It can from this be interpreted that western cultures are seen as more analytical and eastern are seen as more practical. The degree to which *information* is exchanged is also subject to this way of thinking. Whereas western cultures may communicate openly across the organization on a frequent basis, eastern cultures are subject to a stricter structure related to hierarchy and positions, due to higher power distance.

In a practical sense one might see that eastern cultures have a top down communication strategy, compared to the more open western structure which often postpones decisions pending input and confirmation. The hierarchical structure of the Chinese work culture is seen as a main driver for lower *employee involvement* in much the same way as information exchange, engaging in training and improvement discussions is subject to rank and status (unless otherwise specified), supported by the dimensions of power distance and masculinity in decision-making. For western cultures this inequality is seen as less predominant as employees are encouraged and expected to involve themselves in a meaningful way.

2.3.3 Cultural dimensions and their impact on flexibility

How the cultural dimensions are interpreted, shared and practiced have an underlying impact on the potential and realized supply chain flexibility. Below, these impacts have been detailed for each of the cultural dimensions relevant to this thesis:

Power Distance

The dimension of power distance is connected to several aspects of the flexibility way of thinking. In cultures of lower power distance there is less impact on the aspects, whist in cultures of higher power distance, the impact will be more significant. The power distance experienced is first and foremost connected to communication and the ability to relay information across the supply chain. In cultures with higher power distances it is so that communication is a top to bottom experience, with little focus on the opposite way of thinking. Leaders are expected to make decisions with little to no employee involvement unless specified and are not to be challenged in their decisions. When planning and scheduling this can become a problem, as the point of determination is far from the actual point of work, this may lead to poor production management.

Another aspect to consider is the training and cooperation of workers, in cultures with high power distances workers are expected to be organized by station or rank (several stations or ranks may here be of relevance) with groups consisting of equals and none of lower or higher station than oneself. A final aspect connected to the dimension of power distance is that of quality through employee involvement, this is closely connected to the aspect of mianzi, where "saving face" is considered important.

Having a low degree of employee involvement, combined with a high power distance may result in decreased quality of processes and products, as workers are not to challenge information or take actions that may cause mianzi, unless instructed otherwise. As a whole, the challenges presented by the dimension of power distance will impact volume- and delivery flexibility, as adjustments in production, delivery and open orders are made challenging without proper communication.

Uncertainty Avoidance

With regards to uncertainty avoidance it is so that cultures with a lower degree of avoidance are more tolerant and susceptible towards the aspect of risk. Other aspects such as time, coordination, planning and production management are shaped by this way of thinking. Taking risks with regards to time may involve at what pace one is to complete production, order raw materials or deliver goods. Parent Company Coordination may be particularly

strained if there is a large discrepancy in the level of avoidance between the two partners, one partner accepting that risk is a natural part of life and the other not being comfortable with risk-taking endeavours. Differences in the perception of this dimension may present challenges with regards to volume flexibility and can by the nature of the risks it represents ultimately impact delivery flexibility.

Masculine vs Feminine

The masculine and feminine attributes of the business relationship is another aspect that may affect in what way the company is able to be flexible. Highly masculine countries are often dominated by the same way of thinking as those with high power distance. In business this is usually characterized by the nature of which decisions are made. These decisions have the potential to impact coordination, planning and scheduling, as well as how the production management should be undertaken. As such, differences in opinion regarding this dimension may impact the volume flexibility of the firm, making for challenges in adjusting production and communicating changes for open orders, affecting delivery flexibility.

Individualism vs Collectivism

Whether the culture is considered individualistic or collectivistic may have a significant impact on the supply- and reconfiguration flexibility, by having supplier considerations being made not for individual gains, but for the "greater good". This can be considered as both a strength and weakness depending on the decision made. The ability for reconfiguration- and supply flexibility will in turn impact alignment, where an established mutual trust and dependence is important. As reconfiguration- and supply flexibility is closely linked to the aspect of volume flexibility it will in turn impact in what way production can be planned and managed. Without a secure source of supply, planning is made exceptionally difficult and presents greater risk to time, costs and quality with widespread reach towards the possibilities of adaptation to open orders, thus impacting volume- and delivery flexibility.

Long-term vs Short-term orientation

Orientation towards time has not only an effect on time itself, but also on several other aspects of flexibility. As an example, being short-term oriented as opposed to long-term can make for decisions that seem worthwhile in the shorter run, but may not be as worthwhile if

the duration is subject to change. Long-term oriented cultures are often more open to the fact that in order to make things work over a longer period of time, it is necessary to undertake some positions or decisions that does not instantly benefit the current situation. Being long-term oriented can have a profound effect on the buyer-supplier relationship as there can be a considerable effort in order to secure the relationship. In cultures based on relational contracts it can be challenging to establish relationships in a shorter timeframe. Uncertainty in the buyer-supplier relationship is a driver for further uncertainty in coordination, as well as in production management and planning. In turn, this uncertainty may affect the reconfiguration- and supply flexibility, leading to further challenges with volume- and delivery flexibility.

Achieved vs Ascribed status

The dimension of achieved vs ascribed status can have a great effect inwards in the supply chain, but has limited effect outwards. Cultures that favour ascription over achievements may present a challenge to the buyer supplier-relationship as there may arise volatile shifts in power and dependency, subject to management views. Western parent companies working with eastern subsidiaries favouring ascription may here find that the level of parent company coordination needed is high, as the management is based on social status, as opposed to skill or achievement. As a result it presents much of the same challenges as the dimension of long-term vs. short-term orientation, impacting both reconfiguration- and supply flexibility, as well as volume- and delivery flexibility.

2.3.4 The impact of Flexibility Dimensions upon each other

Different dimensions of flexibility will not only have an impact on time, cost and quality, but will also impact each other. This relationship is detailed in the figure below:

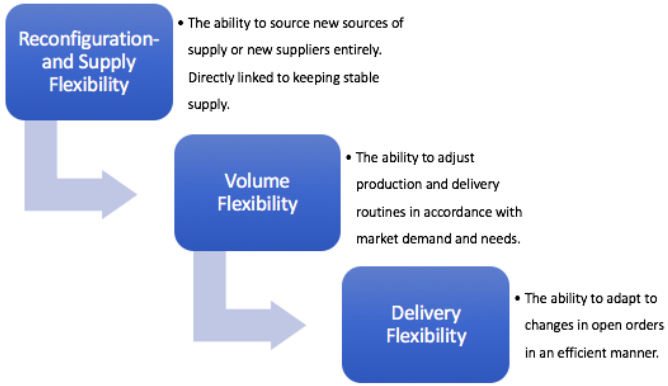


Figure 12 - Impact of different flexibility dimensions upon each-other

As illustrated above, the direct loss of steady supply would make meaningful adjustment in delivery and production routines challenging, if not impossible, impacting the ability for good volume flexibility. The loss of this ability would greatly reduce the way in which open orders could be adapted or changed in order to satisfy customer needs, challenging meaningful delivery flexibility.

2.3.5 The Triple A Supply Chain and its impact on Flexibility Dimensions

Taken further, one will find that the Triple A Supply Chain has a similar impact on the dimensions discussed above, this relationships is illustrated below:

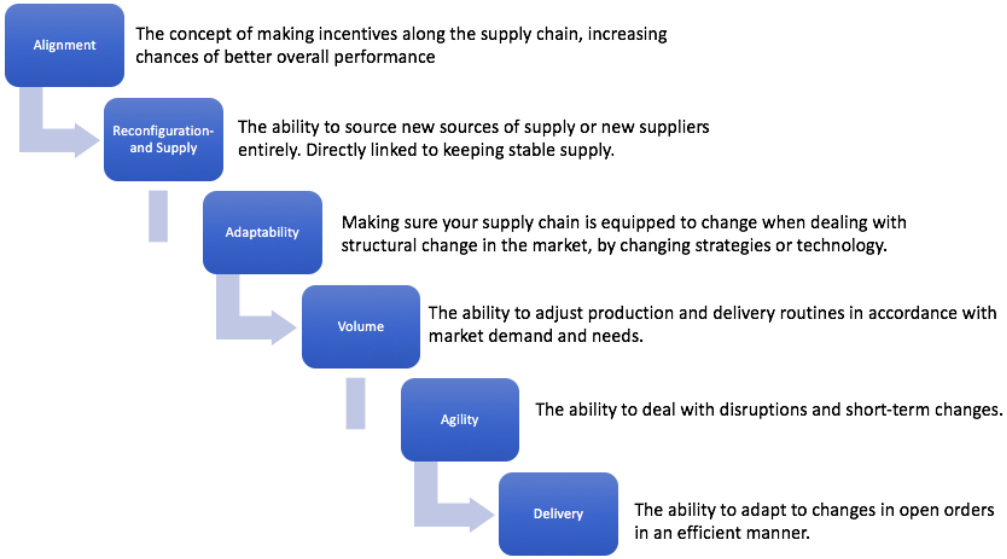


Figure 13 - The impact of the Triple A Supply Chain on Supply Chain Flexibility Dimensions

As suggested by the relationship above, there is a strong connection between the Triple A Supply Chain and the select flexibility dimensions set for this thesis. Practicing good alignment will strengthen the overall supplier relationship, increasing the chance of retaining strong reconfiguration- and supply flexibility. Similarly, having a good understanding of the adaptability concept increases the possibility for strong volume flexibility. Lastly, capability in the practice of agility enables the supply chain to swiftly deal with disruption and short-term changes (such as open orders) improving delivery flexibility.

2.4 A model for increased supply chain flexibility through cultural adaptation

The main models for this thesis were constructed as a mean to provide a visual representation to the phenomenon on how differences in perception of cultural dimensions have a potential impact on supply chain flexibility. As the base for the models, inspiration was drawn from the currently existing research models presented in Part 2.2.7 as well as from the theory and theoretical connections presented in Part 2.3.

The specific purpose of the models are to detail how supply chain flexibility is affected by the *mismatched perception* on cultural dimensions as seen by western parent companies and their eastern subsidiaries. The differences in how companies perceive cultural dimensions have a direct effect on their internal as well as their external potential for supply chain flexibility. This is further enforced by the direct effect these different perceptions have on essential aspects such as communication and information exchange.

The simplest way to explain this phenomenon is through the following model (Full scale can be found as Appendix 1):

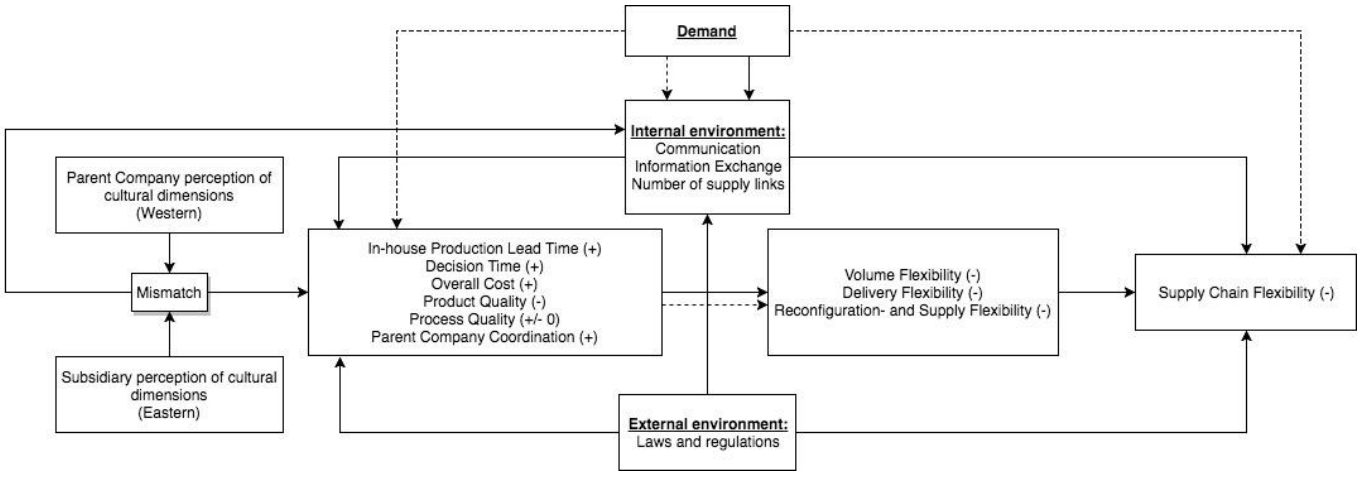


Figure 14 - Simplified model of the effect on mismatched perception of cultural dimensions on supply chain flexibility.

+ : General increase, +/- 0 : Sustained (No general increase or decrease from base conditions), - : General decrease

----: Indirect effect, _____: Direct effect

Within the model it is so that the collective situation of the flexibility aspects are seen as a further driver for the impact on the flexibility dimensions. E.g. Under these specific outcomes to the flexibility aspects, a specified effect is believed to ensue within the flexibility dimensions.

Under the simplified conditions of mismatched perception of cultural dimensions it is so that the time spent, both as part of in-house production lead time and decision time stands to increase. The increased decision time can be seen as a consequence of the parent company wanting to safeguard production, while the increased in-house production lead time can be seen as a consequence of the decreased product quality experienced. As process quality is deemed of equal importance by both cultures, even under mismatched perceptions, this aspect is deemed to remain unchanged. Overall costs will here be increasing as more time is spent in production, decision-making and correction of defects. Under the decreased product quality, the need for parent company coordination is seen as increased due to the expected levels of safeguarding. More overall time spent on decisions signifies a direct decrease to the achievable delivery flexibility, as changes to open orders will take longer to implement. Having to spend more time on safeguarding with regards to product quality, the time for planning and added opportunity for volume flexibility is expected to decrease as well. Lastly, due to the relational contracting practices of the eastern cultures, volatility is still expected to be present, thereby decreasing the ability for strong reconfiguration- and supply flexibility. Demand is here seen as a driver for magnitude of the constructs where an increase would heighten the possibility for the specified outcomes. As a whole, these outcomes are seen as a general decrease to overall supply chain flexibility.

2.4.1 Limitations of the model

As a limitation, the model is reliant on four main flexibility constructs; *time, cost, quality* and *parent company coordination*, these constructs are seen as the *collective primary drivers* for the included flexibility dimensions. Impacts on *time* are viewed as separate impacts to *(1) In-house Production Lead Time* (lead time spent within the subsidiary) and *(2) Decision time* (time spent in implementing decisions and changes) respectively. As time is considered a primary driver for *cost*, it was chosen to include the impact presented to *overall costs* for the selected segment of the supply chain. The model further considers the construct of *quality* on two different tiers, as *(1) product quality* (the amount of units subject to being defect and subsequent re-testing or scrapping) and (2) as *process quality,* (time taken to receive final approval in the event of re-testing) both aspects stands to be affected given their close relationship to each-other. Lastly, the effects on the required level of *Parent Company Coordination* were included.

Further, the model is limited to only include three core flexibility dimensions, as these were seen as the most crucial determinants for overall supply chain flexibility. These are *limited to* Volume-, Delivery- as well as Reconfiguration- and Supply Flexibility. Within these models it is so that the internal and external environments of the supply chain play a critical role in determining the overall supply chain impact. Current demand can here be seen as a driver for the internal environment, as increased demand can have a direct or indirect impact to time, costs and quality experienced. As impacts to these constructs are the basis for all following actions, these environmental factors are considered to also directly affect the overall supply chain flexibility.

2.4.2 Extending the model

Taking the model one step further provides a suitable basis for scenario analysis, where the outcomes of several different adaptation strategies can be considered and discussed. As before, the mismatch in perception on cultural dimensions as seen by the different parties forms the basis for the choice of adaptation strategy. The strategy chosen will firstly impact the flexibility constructs, which in turn will impact the possibility for good practice of the flexibility dimensions, determining the final effect on overall supply chain flexibility.

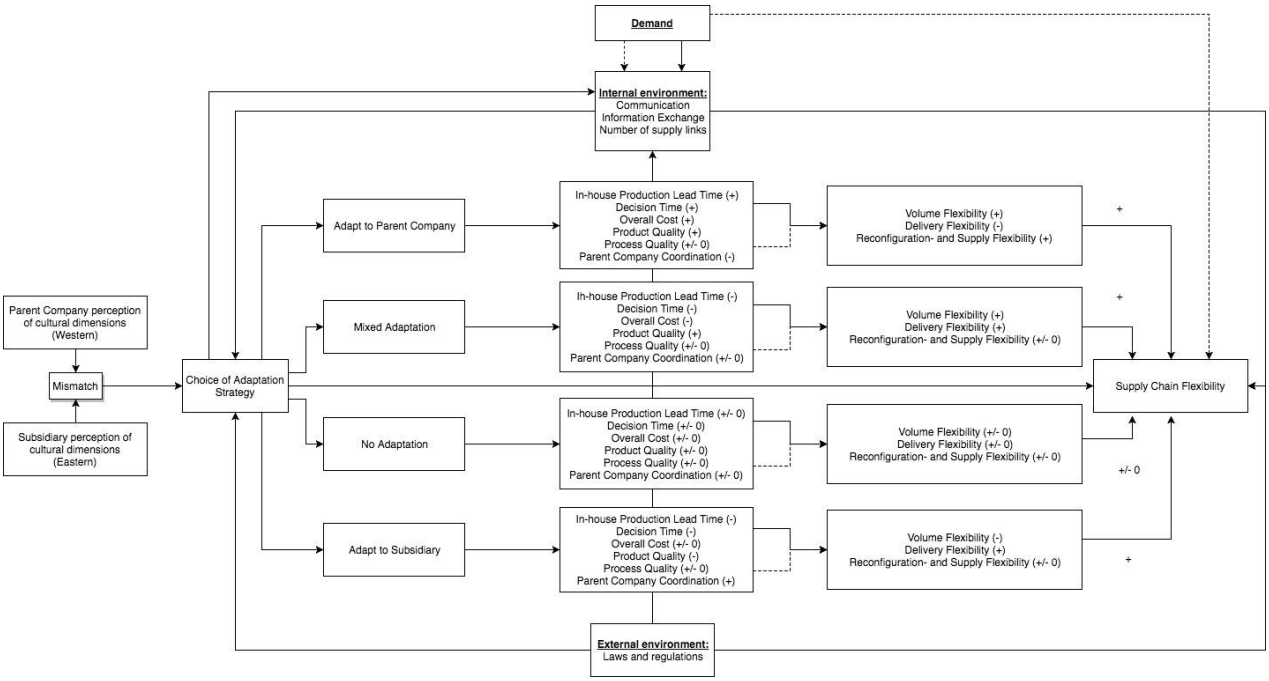


Figure 15 - Extended scenario model (Full scale model can be found as cont. appendix 1)

+ : General increase, +/- 0 : Sustained (No general increase or decrease from base conditions), - : General decrease

----: Indirect effect, _____: Direct effect

The above scenario model has 4 main outcomes:

1. **Adaptation towards the parent company**

   In this setting, the perception of cultural dimensions as seen by the parent company will be the common goal. Due to the how the concept of time is viewed in western cultures and the need for safeguarding and confirmation, in-house production lead time, as well as decision time stands to increase through this choice of adaptation. As a direct consequence of the added time, costs will increase in relation to the time spent. Spending more time on decisions and on general production has the unfortunate drawback of decreasing the ability to make quick changes in open orders, thereby decreasing the delivery flexibility. Given that western companies are more prone to higher product quality than eastern companies it is likely that this aspect will increase, while process quality will remain close to the base conditions. Having more time and better quality, combined with several sources of input can increase volume flexibility, as the capacity for planning increases. Under western conditions to contracting, supply sources are seen as less volatile, thereby increasing the achievable reconfiguration- and supply flexibility. Lastly, as the new adaptation is angled towards the already established practices of the parent company, the need for coordination is seen as less required.

2. **Adaptation towards the subsidiary**

   In this setting, the perception of cultural dimensions as seen by the subsidiary will be the common goal. Under eastern views on decisions and lead time there is a high likelihood that the in-house production lead time as well as the decision time will decrease as the communication is more direct and less subject to confirmation from multiple sources. On a positive note, this will severely decrease overall costs and particularly costs associated with decision making and time itself. A drawback of this adaptation strategy is the fact that the view on product quality enforced by the eastern cultures would decrease this aspect and could therefore increase costs. As a combined consequence of the likely decrease to costs under less time spent and possible increase due to lower quality, this aspect remains unchanged.

Process quality is also expected to remain unchanged, unless the effects of lower product quality has significant impact. As the practices are now heavily angled on the subsidiary and therefore unfamiliar to the parent company, a general increase is likely seen in the need for coordination. The lowered decision time and in-house production lead time is seen as an increase to the available delivery flexibility as changes can be executed in a faster manner. Under the same conditions the achievable volume flexibility would stand to decrease as planning would be less subject to input. As the relationship based model for contracting would still be in place, reconfiguration- and supply flexibility is deemed to remain unchanged.

3. **Mixed adaptation**

In this setting, the most suitable common perception of cultural dimensions as seen by both the parent company and the subsidiary will be the common goal. Under a mixed adaptation strategy there is high likelihood that the decision- and in-house production lead time will decrease as compared to base conditions. This under the assumption that the view on time is favouring the parent company, but with influences of the subsidiary decision mechanisms. Product quality is here likely to increase, as the common perception of this aspect will be easier enforced. As before, process quality will likely remain unchanged and subject to the changes in product quality. Costs will therefore remain relative as a consequence of the time spent, but as the time spent is decreasing and as the product quality is perceived as increasing, this aspect is seen to overall decrease. Under this mixed view across the cultural dimensions, the need for coordination is seen to remain unchanged, as there is no clear advantage of comfort to either party. Under the decreased time and as the product quality is now much higher, the response can be more effective with less defects, as such delivery flexibility is likely to increase. Under the same assumption, more input would be available in planning, thereby increasing the possibilities for better volume flexibility. Given that relationships with suppliers would be volatile under eastern perception and that there is no guarantee that contracts are accepted under western perception, the reconfiguration- and supply flexibility is seen as unchanged.

4. **No adaptation**

   In this setting, the perception of cultural dimensions will remain unchanged for both parent company and subsidiary. Outcomes will in all likelihood be similar to those outlined in the simplified model.

3.0 Methodology

This section contains the methods and methodology used for this thesis, detailing their use and suitability.

3.1 Choice of Research Design

One of the main objectives of this thesis as outlined in the introduction was to provide a theoretical link between the theories of supply chain flexibility and cultural dimensions and to further state this relationship through the provided case study. As a mean to fulfil this purpose, a systems approach was used. The systems approach states that the result as a whole is to be seen as greater than the sum of its parts (Arbnor and Bjerke 2009). In using this approach all internal and external processes, relationships and collaborations that were present in the supply chain and shared by actors were taken into consideration. These connections were then studied in order to provide a holistic view on the supply chain.

The case study method was chosen as the main method for this thesis, especially as the thesis is based on the questions of how to improve and why improvement is needed. For these questions the case study method has been deemed the best choice, as outlined by Yin (2014). Our case study is performed at TOMRA Collection Solutions, a part of TOMRA Systems ASA and is therefore to be considered a single case study. As the focus of the thesis is a sub-unit of TOMRA Systems ASA with some degree of outward analysis, the thesis can be considered an embedded case study with possibilities for expansion to a holistic design, as explained by Yin (2014). In order to conduct the case study, interviews, formal and informal meetings, as well as conversations were conducted with various personnel at TOMRA Collection Solutions.

As the primary interview method, the semi-structured interview was chosen. The semi-structured interview can cover a wider range than the structured method and is considered more general in nature, with an option to vary or change the questions in terms of sequence or content. The general nature of the questions is often a trigger as to follow up with more specific topics in response to the given answers (Bryman and Bell 2015).

Following the approach of deduction and induction, a literature review on the central theories of supply chain flexibility and cultural dimensions were created, along with the two main models. Following this literature review, a study of the interviews and provided data were used to map the past and current state of the supply chain. During the development of the scenario analysis theoretical and empiric findings were used.

3.2 Methods of Research

This thesis is largely based on *qualitative* methods of research and analysis by such means as interviews and the analysis of these. Qualitative analysis can be defined as: *"a process of examining and interpreting data in order to elicit meaning, gain understanding, and develop empirical knowledge" (Corbin and Strauss 2008, p.1)*. Combined with follow-up sessions, the thesis has been further defined, refined and shaped in order to reach a meaningful conclusion. Through analysis and discussion, the available data became easier to structure, this was perceived as a strength to increase the validity and reliability of the data and their results. Some parts of the thesis were however reliant on *quantitative* data, this data has been used in a descriptive manner, detailing the results and implications in the way they are understood by the authors, with less emphasis on heavy mathematics or extensive statistical analysis. Quantitative analysis can be defined as: *"Quantitative research can be characterized as a linear series of steps moving from theory to conclusion"* (Bryman and Bell 2011, *p.170*). From a methodical perspective the thesis has been constructed in a such a way that it is of both a qualitative and quantitative nature. The thesis is based around the use of theory on a specific problem, containing the voices of the authors along their interpretation and findings. As the thesis is further constructed around the principles of scenario analysis it can be seen as a step-by-step process, moving from the use of theory and facts to reach a meaningful conclusion.

3.3 Primary Data collection

"*Primary data are data that are collected for the specific research problem at hand, using procedures that fit the research problem best" (Hox and Boeije 2005, p.593).* For this thesis, primary data has been collected through interviews, formal and informal meetings, conversations per telephone as well as frequent e-mail exchanges. For the first interviews, a qualitative method was chosen, as such the interviews were of a qualitative nature in a

semi-structured setting. In choosing this setting the interviewers were able to control the flow of the interview to a certain degree, without greatly limiting or de-limiting the respondent. The questions set for the interviews were aimed at capturing the general opinion of the respondent within a framed setting. In conducting the interviews, the questions were forwarded in advance to provide adequate time for preparation. All interviews from the first company visit were recorded (if approved) and analysed further to ensure that the data was correctly presented and recalled. In the months following these interviews, the authors used the initial data from the first interviews for extensive follow-up sessions, usually conducted through e-mail or by telephone, due to the nature and structure of these follow-up interviews no recordings were made. Some interviews were used as *general background* for the thesis, while some were used in *specific instances* to prove relation to the data given. All interviews were conducted in Norwegian, as a consequence all questions in the interview guide are in Norwegian as well.

3.4 Secondary Data collection

When primary data is made available to others through e.g. databases, it is transformed into secondary data (Hox and Boeije 2005). Secondary data for this thesis has been provided by the external supervisor, Ida. K Aspenes, alongside other representatives from our case company. These data were mostly raw data, while some data had been constructed in advance and were open for further analysis and interpretation by the authors. All theoretical foundations are part of this secondary data material, comprised of an initial and extended literature search, culminating in a literature review. It was chosen to use a small but varied number of sources for each topic to ensure both width and the presence of different views in the literature, while simultaneously keeping a tidy straightforward structure to the thesis.

3.5 Retaining objectivity, validity and reliability

"Objectivity in social research is the principle drawn from positivism that, as far as is possible, researchers should remain distanced from what they study so findings depend on the nature of what was studied rather than on the personality, beliefs and values of the researcher (an approach not accepted by researchers in the critical, standpoint or interpretivist traditions)" (Payne and Payne 2004, p.152). Objectivity within this thesis is a construct that has closely been taken into consideration, here several separate aspects have been considered. For this

thesis it will be a question on the objectivity of the authors in stating facts and drawing conclusions, as well as the objectivity of the primary sources of information, in this case the employees at Collection. There are few means that could have been taken to ensure and increase the objectivity of this thesis, other than the authors being aware and thorough when analysing and concluding, as outlined by Yin (2014).

Construct validity relates to the aspect of identifying the proper operational measures for the concepts being studied. The main aspects of testing construct validity is to use multiple sources of evidence, to establish a chain of evidence and to have key informants review a draft of the case study report (Yin 2014). *Construct validity* for this thesis is secured through the following safeguards; firstly, questions presented in interviews and further follow-up sessions have been asked multiple times, both in the same and different contexts in order to gather as much and accurate information as possible. As a mean to root out highly subjective opinions and interpretations, as well as false or inaccurate information a cross-check was performed to see if multiple interviews produce the same statements or opinions. Discussions between the authors found that the respondents were largely coherent in their opinions, without being aware of the general consensus or being coloured by the largely subjective opinions of others. By sending the questions in advance the authors could ensure that the questions were answered in a well-thought-out manner. The thesis has been reviewed and approved in its 1st Draft format by both representatives at Collection and the advisor at Molde University College to secure further construct validity. In increasing construct validity for the use of theory and literature, multiple sources have been used to ensure that all theories are considered credible.

Internal validity relates to the aspect of trying to establish causal relationships, defined in part as *"… certain conditions are believed to lead to other conditions, as distinguished from spurious relationships" (Yin 2014, p.46)*. In order to ensure the *internal validity* of the data presented in this thesis causal relationships have been formed by applying a scenario model to the information and data available. By following the method of scenario analysis the thesis has been able to relate aspects on how event *x* can be seen as a driver for outcome *y* and in later stages how potential changes in *x* can impact *y.* In order to provide accurate information to these relationships the authors focused heavily on their interview methods.

External validity relates to the aspect of defining the sphere in which a case study's findings can be generalized. A central challenge here is to recognize if the findings from the conducted study are generalizable to other fields of study (Yin 2014). The future external validity of this thesis it is challenging to determine, as well as the impact the results will have in a generalized setting. However, it is the hope of the authors that the thesis may be used in a general fashion to provide similar results in a company facing identical or relatable challenges to that of our case company.

Reliability relates to the aspect of *"demonstrating that the operation of a study, e.g. data collection procedures, can be repeated with the same results" (Yin 2014, p.46).* To increase the reliability of the thesis, a replication guide was made to prove how data for the first part of the scenario analysis had been constructed and analysed (see appendix 4). This should ensure that the same results are available for replication. As the implications and scenario narratives presented within the later parts of the thesis are experiments of thought they hold less reliability in terms of replication.

3.6 Scenario analysis

"Scenarios are stories about the future, but their purpose is to make better decisions in the present."

Ged Davis (as referenced in Meinert 2014)

A scenario is a representation of a possible futuristic outcome, presented as a narrative. They generally detail causal relationships and are written from the perspective of how the present situation was shaped by the past, and how this again can shape the future. Scenarios are not prognosis as they are not aimed at prediction of the future, in this same way they are not utopias, nor dystopias that sets a desired or feared state with no basis in the present. Scenario analysis is placed somewhere in-between the two aforementioned methods, dealing in somewhere a short distance from today, but still a long distance from the utopic setting (Meinert 2014). This relationship is illustrated in the figure below:

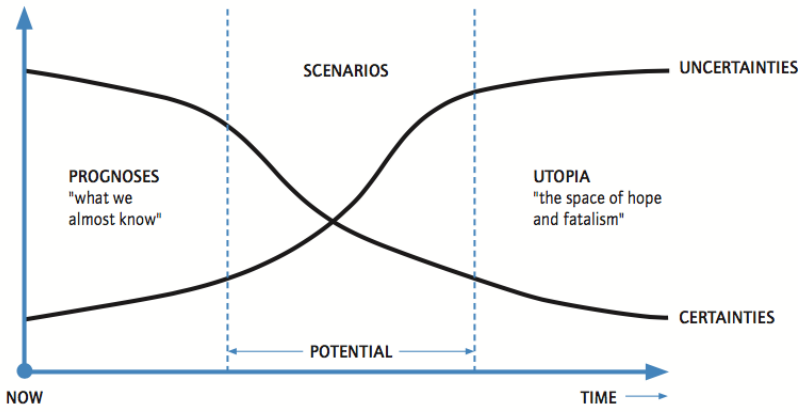


Figure 16 - Use of the scenario model, Meinert (2014, p.8)

3.6.1 The stages of the scenario method

From a theoretical perspective there is an infinite number of possible outcomes and future situations that may arise, practically speaking this is not the case and the window of opportunity is much narrower. This is due to the fact that the future has its basis and root causes in the past behind us, as such we must first turn to the past in order to clarify the present and shape the future. In looking at the history before we may be able to better answer the question of "How did we get here?". Secondly, driving forces behind the factors that shaped the present are crucial to identify, these factors are regarded as "given" when considering the future. Driving factors will be present in all scenarios developed as they are a product of what has and likely will continue to happen. Drivers are not necessarily written in the chronological order that they occurred, but should give an impression as to what has happened, as a whole. Lastly scenarios should contain accounts on the implications to the suggested implementation plan as well as the social and political consequences that may arise (Meinert 2014).

Porter et al. (2011) states a similar view on the scenario construction method, emphasizing five steps, as outlined below:

1. **Identification of variables**

   Variables that are considered meaningful to the analysis should be identified and written down in a suitable format, these variables will be the scenario variables for which to relate to forward.

2. **The development of measurement levels**

   A meaningful level of measurement should be considered for the variables so that they can be equally measured as the results are developed.

3. **Identification of significant variables**

   Following the identification of meaningful variables in step 1, variables that are considered highly significant should be further branched out. Asking which variables will have the largest impact or are most/less certain may help this process. Variables that are determined high impact are always taken further in the analysis, while the lower impact variables are used as explanatory factors.

4. **The creation of the scenario itself**

   The scenario itself should be constructed around the high impact variables, where the impact is used to describe possible outcomes, good or bad. Several variables can be used in combination, or one variable may be discussed as a solo factor. The scenarios should further be classified after their probability and plausibility of being realized.

5. **Developing the accompanying narrative**

   The narrative of the scenarios use details and plausibility in order to provide significant and relatable meaning to the plausible outcomes. Values of significance are here used to provide a frame for the narrative and descriptive details.

3.6.2 Criticism of the scenario method

As stated by Postma and Liebl (2005) it is so that the traditional method has limitations in dealing with paralleled trends, trends that are not defined beforehand and in its need for consistency and causality. Another limitation exists with regards to discussing implications of a certain scenario, where implications or outcomes that are considered unlikely or *"not possible"* are often dismissed or overlooked during the construction phase. As a mean to construct scenarios that are not affected by their limitations Postma and Liebl (2005) states that the approaches of Gregory and Duran (2001), as well as Ringland (2002) should be considered. Gregory and Duran (as referenced in Postma and Liebl 2005) states that one should use concrete examples, representative events as well as easily supported evidence in order to construct better scenarios, along with plausible explanations and causal arguments. An outcome should be considered true if it corresponds with past experiences. Ringland (as

referenced in Postma and Liebl 2005), further suggests that scenarios may not be the only solution and that thorough discussion of past as well as present scenarios along with experience may provide similar answers.

The scenario analysis used for this thesis is primarily based on a mixed interpretation of the methods suggested by Meinert (2014) and Porter (2011), it is divided into three main segments:

Stage 1 – Identification of *challenges through past practices* at TCN (Part 5). An answer to the question "How did we get here?", detailing how the past can be seen as a driver for the current challenges experienced.
Stage 2 – Details on how cultural dimensions *have* an impact on the identified challenges, and overall supply chain flexibility in a present state (Part 6). Identified here are the driving forces for the current challenges experienced, as they are understood by the authors.
Stage 3 – Details on how cultural dimensions *could have* an effect on the identified challenges and supply chain flexibility in the future, given a variety of adaptation strategies (Part 7). This stage outlines the possible implications to the implementation, suggesting positive and negative aspects to each choice of adaptation.

3.6.2.1 Summary

The following summary details the use of methods and methodology through the research performed for this thesis:

Methodology	**Details**
Research objective	Model construction, theory building and fact identification
Research strategy	Mix of qualitative and quantitative research
Research design	Single embedded case-study
Research method	Semi-structured interviews (appendix 3) and scenario analysis
Validity	Secured through multiple sources and review by case company
Reliability	Secured through replication guide (appendix 4)

Table 3 - Summary of methods and methodology

4.0 TOMRA Systems ASA

4.1 Company history

TOMRA Systems ASA is a Norwegian based company, founded by the Planke family in 1972, the goal of the company was to innovate the process of returning empty beverage containers (TOMRA n.d.-b). By the end of their first year of operation, they had already installed 29 machines across Norway, this success quickly triggered interest outside the Norwegian market. In 1973, the first distribution agreements were established within Europe and the US. The growth for TOMRA in the following years can only be described as explosive, with annual revenues in the period 1972-1976 growing from 700.000 NOK to 7.600.000 NOK. A major breakthrough in sales took place in 1974 when the Swedish Systembolaget ordered 100 machines customized to their existing systems. In 1977, TOMRA developed the bottle recognition technology, which led to the continued growth of the company.

The late 1970s also saw the launch of the first self-programmable Reverse Vending Machine (RVM), securing TOMRA a competitive advantage in the market. In 1985, the company went public while also preparing for growth in the US market, this was however not a success due to an overload of aluminium in the international market, causing prices of aluminium to drop drastically. The consequences of this endeavour saw TOMRA choosing to cancel a significant amount of activities in the US. After this incident and throughout the rest of the 1980s, TOMRA chose to focus on their main business areas, securing their position in the European market as well as their position as market leader in product development (TOMRA n.d.-b). In the beginning of the 1990s, TOMRA ventured into new business areas through the acquisition of NEROC. Up until this point, TOMRA had received all their revenues from sales and maintenance of RVMs, but their new business model now included collection, pick-up, material trading, recycling and production of new beverage containers. Through this business model TOMRA became involved in the overall container recycling value chain (TOMRA n.d.-b)

Measures to reduce costs and improve efficiency of production were planned as early as the 1990s, through centralization of production to a single headquarter, as well as making production more efficient through Just-In-Time deliveries of materials and components. Revenue continued to grow steadily throughout the rest of the decade, with an average increase of 46%, mostly due to the fact that the company now had successfully integrated their growth plan in the US, the American market represented approximately 50% of total revenues in 1999. Technological developments in the 90s saw TOMRA succeed in launching new machines, becoming an international company with more than 1700 employees worldwide, in 34 countries and 46 markets. When the company entered the 21st century, they saw the needs to further expand their business model, enter new business areas and markets in order to be able to achieve the desired growth for the future. This was done through projects in Japan and Brazil, but also through a series of acquisitions. This led to more than a doubling of revenues. Strategic actions were also taken with regards to the German market, with an implementation of a new deposit system and in 2006 TOMRA delivered approximately 8.800 machines to Germany. Following this market entry, Germany became their most important market segment (TOMRA n.d.-b).

The year of 2009 marked the beginning of the company's strategic choice to move production to China, entering the 2010s TOMRA continued to acquire new companies and to expand their business model. In later years, TOMRA has expanded into a multi-national company and in 2010 it was decided that all the company's activities were to be collected under a common brand "umbrella" - TOMRA. This rebranding process was completed in 2015, with a new vision and mission statement (TOMRA n.d.-b).

4.2 Diversification of core business areas

TOMRA as a company has been diversified into two main business areas, TOMRA Collection Solutions and TOMRA Sorting Solutions, this thesis will focus on TOMRA Collection Solutions alone. The figure below illustrates the two main business areas, their percentages of total revenue in 2015, their customers and relative market shares:

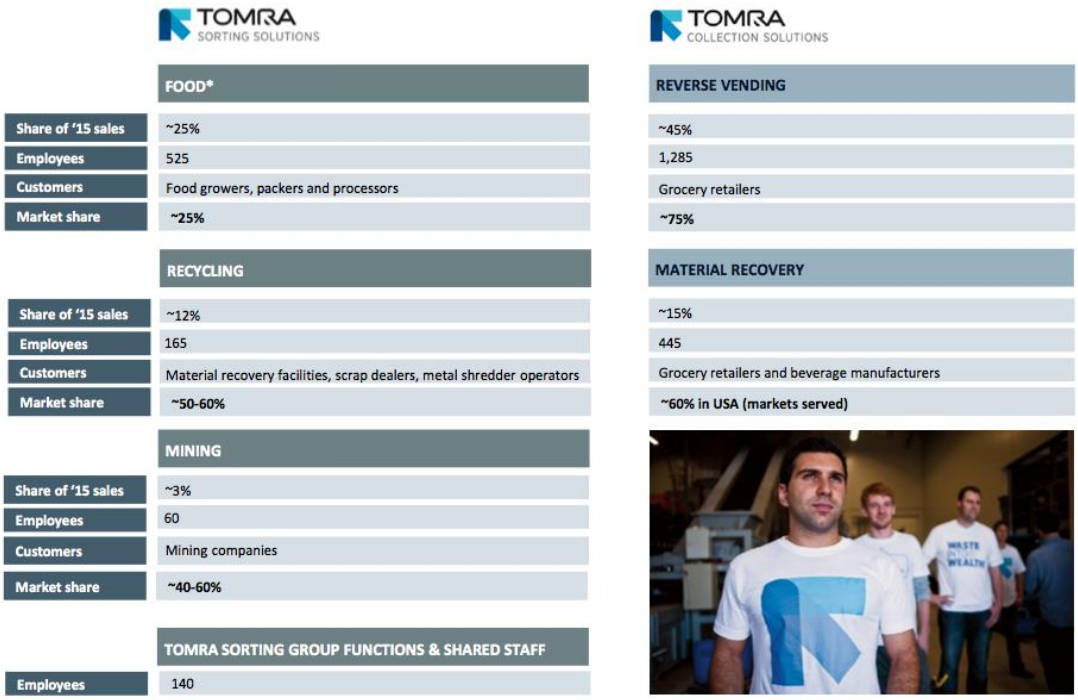


Figure 17 - Diversification of core business areas (TOMRA Investor Presentation 2016)

4.3 TOMRA Collection Solutions

TOMRA Collection Solutions is a world leader in the reverse vendor market of beverages and containers and has gained an estimated 75% market share as part of this. Having solutions that fit almost any thinkable need is a big part in this success. Being part of a highly innovative process enables all parties to benefit, giving an excellent degree of value and operational ease. Container collection in Europe is organized as a cooperation between the beverage industry and the food retailers; this is not the case in the US. TOMRA has made solutions for this and has as a result gained a 60% market share in material recovery services as a provider (TOMRA n.d.-a).

4.3.1 The promise of delivery

One of the most prominent aspects of TOMRA Collection Solutions is their ability to always deliver orders that are part of current forecasting and are placed within acceptable time. Since the early days, Collection has "never" forfeited a delivery and keeping this promise has seen them gain trust and recognition in the global market (Aspenes and Rekdal 2016).

4.4 TOMRA Xiamen - TCN

TOMRA Xiamen is responsible for all support in the Chinese business environment and have established several departments in order to support their growth; such as R&D, production, sales and service, and sourcing in order to be better able to respond to the local market conditions. The facility in Xiamen assembles and tests 27 different modules in total, which are then shipped to either TOMRA Productions AS (TPAS) in Lier, Norway, or Scanfil in Myslowice, Poland.

4.5 Supply Chain Overview

The figure below illustrates the overall supply chain from raw material/component supplier to market/end customers:

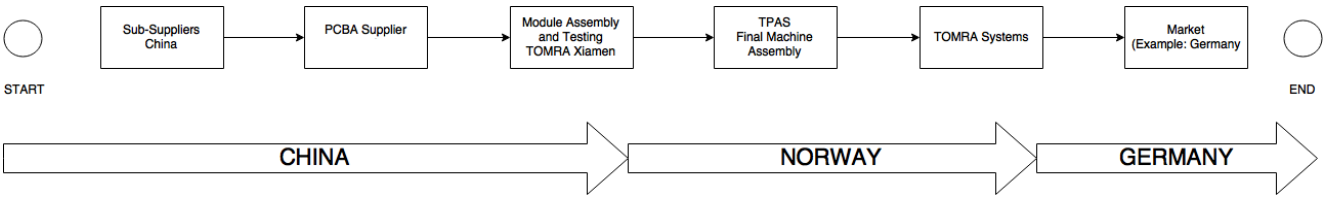


Figure 18 - Illustrative overall supply chain to the German market

The component sourcing mainly takes place in Asia, more specifically China, the components are then assembled at TOMRA Xiamen China, before they are shipped by sea to Norway. When the modules are received at TPAS in Lier, they undergo final assembly and are configured to customer requirements. The backroom extensions are manufactured in Myslowice, Poland and when complete, the products are shipped to subsidiaries in the individual markets, before they are delivered and fitted at the customer's locations (Aspenes and Rekdal 2016; Aspenes 2017).

4.5.1 TCN Supply Chain

For this thesis, primary focus is only on the part of the supply chain that takes place in China. This involves a detailed overview of the processes at the Xiamen facility, where the main camera modules are assembled and tested before shipment. This supply chain is illustrated in the figure below:

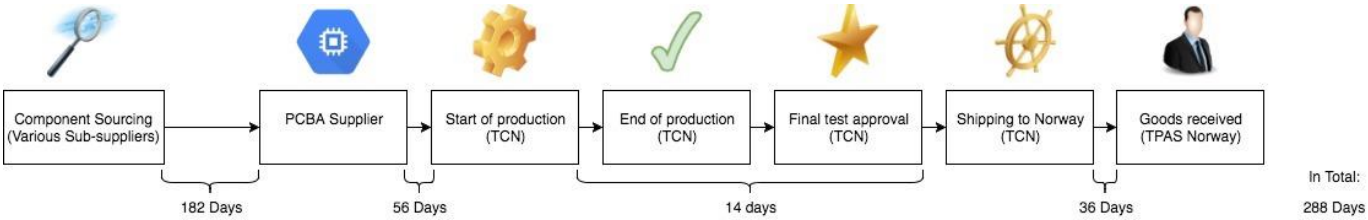


Figure 19 - TCN Supply Chain

In the figure above the authors have illustrated the lead times and process times between the different steps of the supply chain for normal production flow. Times have been calculated and deduced from interviews, data collection and email exchanges with Collection. Below, the reader will find an overview of the components, modules and machines relevant to this thesis:

Figure 20 - Overview of components, modules and machines (Aspenes 2016; Aspenes 2017)

In the top left corner is the PCBA (Printed Circuit Board Assembly) which is a part of all main camera modules. The main camera module is part of the crate module illustrated in the T9 RVM, the purpose of the main camera module is to take pictures of inserted bottle crates in order to identify the shape of the crate and the number of bottles. The T9 reverse vending machine is the newest addition to TOMRAs product portfolio of front-end machines and is accompanied by a backroom extension when installed at the customer´s location. An example of a total solution is shown to the right in the figure. The T9 was launched in 2013 and is the key product for replacements in the German market as the new technology in these machines makes it faster and cleaner than its predecessors, in addition to accepting all types of beverage containers (Aspenes 2017; Hanevold 2017; TOMRA Investor Presentation 2016).

4.5.2 Why the main camera module?

The main camera module, which is the main focus of this thesis, represented 2304/36185 modules assembled and tested at TCN, equal to 6,4% of the total modules. While this may be seen as a relatively low percentage isolated to quantity it is so that the impact on labour hours is greater. The labour hours per main camera module is equal to 0,5hr/module making the share 11,25% of the total labour hours for 2016, 4th largest in this group (Aspenes and Sæther 2017). From these numbers alone one might argue that the main camera module is a substantial part of the assembly. In addition to this, the module is part of the bottle recognition technology in the T9 RVMs, a central piece in their largest market, Germany. Assembly is done manually, while the testing is done automatically. TCN is located in close proximity to the main harbour in Xiamen, for easy shipment to Lier and Myslowice. The estimated shipment time from Xiamen to Lier is 6 weeks, on arrival the modules are ready be assembled as part of the front-end module in the final assembly (Sæther 2017).

4.6 Market challenges

The market has changed for TOMRA during the last two decades, as it has become increasingly challenging to gain and maintain competitive advantages. The 1970s and 1990s saw TOMRA in a perceived monopoly with few to none competitors (Hanevold 2017).
One of the main reasons for this perception was that TOMRA has always been and still is to some extent seen as a step ahead of their competition regarding R&D. This has made them able to offer products and solutions that the competitors cannot match, delivering more value for money to the end customers. TOMRA Collection Solutions is the global market leader in RVMs, with a total market share of 75%, leaving TOMRA in a strong position compared to their competitors. Retaining market share is challenging as competitors are quicker to catch up now than what they did a few decades ago and as customer requirements change continuously with regards to price and quality (TOMRA n.d.-a). The changes in market conditions were one of the main reasons for the offshoring process to China and the establishment of TCN in 2009.

Customer requirements have in later years been subject to continuous changes, as a consequence Collection must once more find new ways to reduce costs throughout their supply chain in order to deliver at the required price and quality.

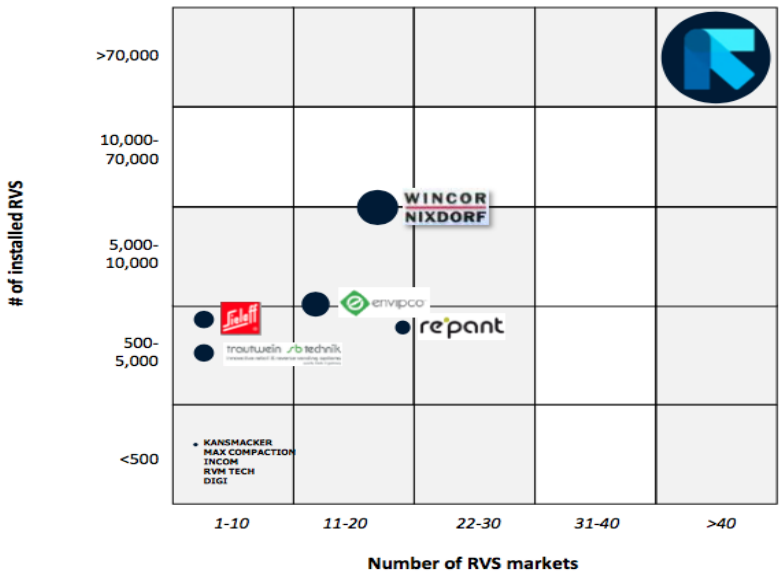


Figure 21 - Illustration of market conditions (TOMRA Investor Presentation 2016)

The figure above is a representation of the competition TOMRA faces in the RVM segment, showing TOMRA as the largest representative, both in number of machines installed and number of markets entered, with emerging competition from Wincor Nixdorf. This shows the importance for TOMRA to continue their work in maintaining their competitive advantage as well as their key markets and customers. As an example, losing the German market could prove a major disadvantage for TOMRA.

5.0 Main Challenges faced by TCN and Collection

This section of the thesis contains the results of the provided raw data when constructed into a meaningful manner for the case. The results are here commented upon as a mean to clarify their significance and meaning, however no further analysis will be performed to discuss the implications between theory and results at this stage. The purpose of this section is only to define what challenges can be seen in the past and is the first stage of the scenario analysis for this thesis. Using these data will form the basis for further analysis and discussion for the remaining stages of the scenario analysis.

5.1 Primary Work Processes

The primary work processes performed at TCN are those of module assembly and testing, for this thesis both areas are in focus. As a mean of visualizing the challenges faced at TCN and as a mean to back up statements about current practices, several graphs and tables were designed.

5.2 Details on the dataset

The dataset for this thesis contains the following variables; Production Date (the *production date for the PCBA* at PCBA Supplier) for 2012 – 2016 as well as the Testing Date (the day the *assembled module* was tested at TCN) for 2015 and 2016. Time taken between these two variables is considered Production Lead Time (PLT) involved as a module moves from completed *component production* to final *module approval*. It is here important to note that modules can be re-tested if found faulty and therefore the same module may occur one or more times in the dataset. An overview covering the number of modules sent for re-testing is also included in this section. All data is based on modules tested in 2015 and 2016.

5.2.1 Unstructured raw data

Our initial raw data was provided in the following format:

Manufacture	Part type	Serial	Test date	Name	Value
Tomra China	Module CamCrate Main	50152124-06433	15-01-06 11:58	hw tags:FUNTEST_C503	141208 191240
Tomra China	Module CamCrate Main	50152124-06434	15-01-06 12:06	hw tags:FUNTEST_C503	141209 191025

Figure 22 - Unstructured Raw Data

Unstructured data like the example above needs processing in order to be useful for analysis. As a mean of re-creating the same results as detailed in this section a replication guide was constructed, this can be found in the appendices, results of the processing can be found below.

5.2.2 Structured raw data

This is what the data looks like in a structured format. As an example, the first unit below contains a PCBA produced on December 8th, 2014 and was given final approval on January 6th, 2015, making the Production Lead Time for this particular unit 29 days.

Manufacturer	Part type	Serial	Name	Prod Date	Test date	PLT
Tomra China	Module CamCrate Main	50152124-06433	hw tags:FUNTEST_C503	08.12.2014	06.01.2015	29
Tomra China	Module CamCrate Main	50152124-06436	hw tags:FUNTEST_C503	09.12.2014	06.01.2015	28
Tomra China	Module CamCrate Main	50152124-06437	hw tags:FUNTEST_C503	08.12.2014	06.01.2015	29

Figure 23 - Structured Raw Data

5.2.3 Reliability of the dataset

In order to increase reliability, obviously duplicated values and triple registries of the serial numbers have been set aside and analysed separately, as to not give a false impression to normal production flow. As a result, the dataset was trimmed from 7216 lines (100%), down to 5593 lines (77,5%) in setting aside 1623 instances of duplicates or triple registries. Non-obvious duplicated values have been used to form the basis for the calculations on the re-testing of modules. All calculations and measurements regarding time are made in the format of days, except for the calculation on value adding time which also makes use of minutes as a point of clarification.

Overall Assumptions: Production dates in the dataset are assumed to be the production of ONE *specific* PCBA at PCBA Supplier, all instances of PCBA production within the dataset are assumed to be specifically designated for TCN. As the main camera module consists of only one PCBA it is assumed that the number of units produced by PCBA Supplier in a given year is roughly equal to the number purchased as well as modules assembled and tested by TCN. In this context, if 800 units are produced by PCBA Supplier, TCN are assumed to have purchased, assembled and tested 800 units in the same year, given normal production flow.

5.3 Base conditions

Collection have stated that they now experience a longer lead time as a direct consequence of their offshoring process. The supply chain as it was provided to the authors by Collection can be found below, this estimate is to be considered base conditions for this results section:

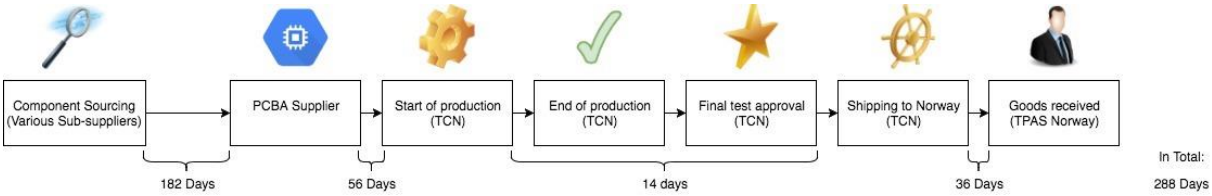


Figure 24 - TCN Supply chain with provided lead time considerations by Collection

The above statement on lead time can be somewhat proved true, as the current supply chain has an estimated total lead time of 41 weeks. Main drivers of this lead time include their component sourcing, PCBA delivery time and shipping links, where roughly 63%, 19% and 13% of time is spent respectively. Time spent outside TCN is an average of 274 days of 288 days in total, equivalent to 95% of total lead time. Lead time for component sourcing is here detailed as the provided time between order placement and reception of goods. Times between PCBA Supplier and TCN is the mean delivery lead time between these two links. The days within TCN is the provided time of which a module spends at the facility while the days of shipment is the estimated time at sea for goods. Results of the analysis below seek to examine these base conditions.

5.4 Production Lead Time

Below, Production Lead Time has been mapped for the TCN section of the supply chain, this lead time is the total time taken between the *production date of the PCBA* at PCBA Supplier and *the date of final module approval at TCN*. Production Lead Time is here an indication as to the relative age of the PCBA at the time of final approval for the module.

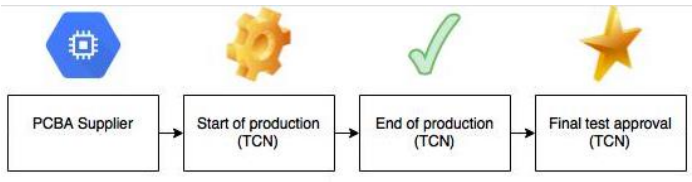


Figure 25 - Segmented part of the TCN supply chain for calculations on PLT

The distribution of Production Lead Time for modules tested in 2015 – 2016 as viewed per month is detailed in the graph below:

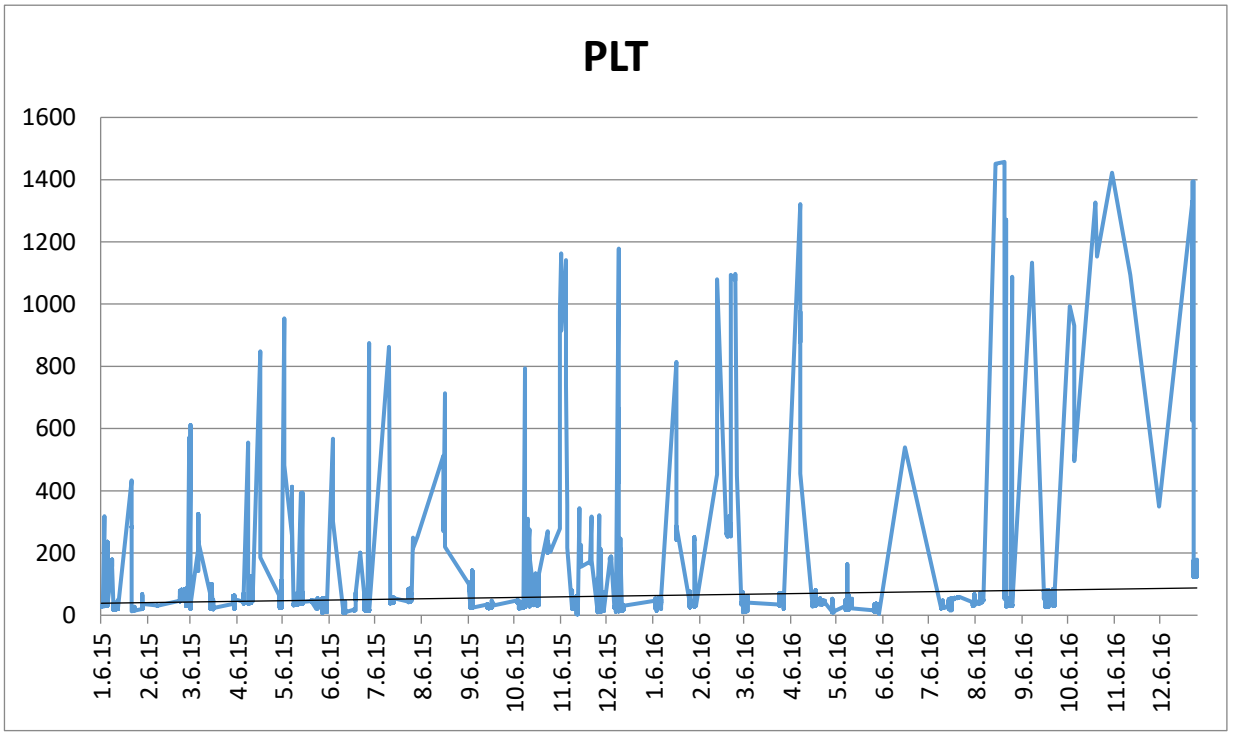


Figure 26 - Production Lead Time for modules tested in 2015 – 2016.

There is a high degree of variation and fluctuation in the Production Lead Times for modules tested in 2015 and 2016, looking at the trend-line one may see that there has been a general increase in time throughout the years. Below, the reader will find the accompanying table detailing factors such as mean, standard deviation and minimum and maximum time spent in this state:

RESULTS PLT	
MEAN	58,95
MEDIAN	36,00
MIN	3,00
MAX	1457,00
STD.DEV	121,46

Table 4 - Results – Production Lead Time

The data above indicates that the average age of a PCBA is 58,95 ≈ 59 days at the point of final approval for the module at TCN.

5.5 In-house Production Lead Time

In-house Production Lead Time (IhPLT) was mapped in order to determine how much of the PLT was spent at TCN. As there was no available information to the authors as to the total exact time a module spends in storage, assembly and testing the provided value is to be considered a best guess estimate.

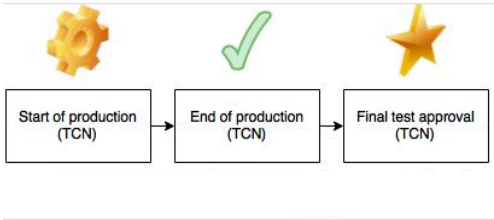


Figure 27 - In-house section of the TCN supply chain

As an initial assumption, the authors used the provided mean of 56 days of delivery as a tool to map In-house Production Lead Time as suggested by Collection, where In-house Production Lead Time was equal to Production Lead Time – 56 days. However, the dataset show that roughly 80% of all PCBAs from PCBA Supplier were delivered early (less than 56 days), this would indicate that the remaining Production Lead Time was spent at TCN. In-house Production Lead Time is here an indicator for the *relative age of the module* as it is ready to be shipped. As a mean to calculate the actual time of delivery, the authors chose to base their calculations on PCBAs that were delivered early as these represented the greatest portion of deliveries made.

Most PCBAs were delivered with 25 days of the original estimate to spare, meaning the delivery was made in (56 – 25 = 30,8 ≈ 31 days on average) Removing these days from the PLT (58,95 – 30,8) provides an IhPLT of 28,15 ≈ 28 days. As a result, modules are considered to have an average IhPLT of 28 days. This would make the average age of a module 28 days when it is subject to final approval.

PCBA SUPPLIER --> TCN DELIVERY TIME & IHPLT AS SUGGESTED BY THE AUTHORS

ESTIMATED AVERAGE DELIVERY TIME FOR PCBAS SUGGESTED BY COLLECTION	56	
AVERAGE NUMBER OF DAYS TO SPARE ON PCBA DELIVERY (80%)	25,2	
ACTUAL AVERAGE DELIVERY TIME FOR 80% OF PCBA	30,8	31
DELIVERY TIME PCBA SUPPLIER --> TCN	31	
PLT	58,95	
IHPLT	28,15	

Table 5 - PCBA Supplier -> TCN: Delivery Times and IhPLT as suggested by the Authors

PCBA DELIVERY

LESS THAN 56 DAYS	4462	79,80 %
MORE THAN 56 DAYS	1130	20,20 %
PCBA IN TOTAL	5592	100,00 %

Table 6 - Proportion of PCBAs delivered earlier than estimate

The average Value Adding Time to a module in itself is less than 0,5% given an 8 hour work day (28 work days x 8 work hours = 224 available hours of work), as the module has a 50 minute assembly and test time combined. Converted to minutes the modules spends an average of 13 440 minutes at TCN, where value is added for 50 minutes on average. The time it takes for one module to receive final approval is equal to the assembly and test time of 269 modules of the same type, this is more than the total amount for an average shipment. It is here important to note that the level of variation and fluctuation in the IhPLT is equal to the variation in the Production Lead Time, as delivery time between PCBA Supplier and TCN are currently to be considered a constant.

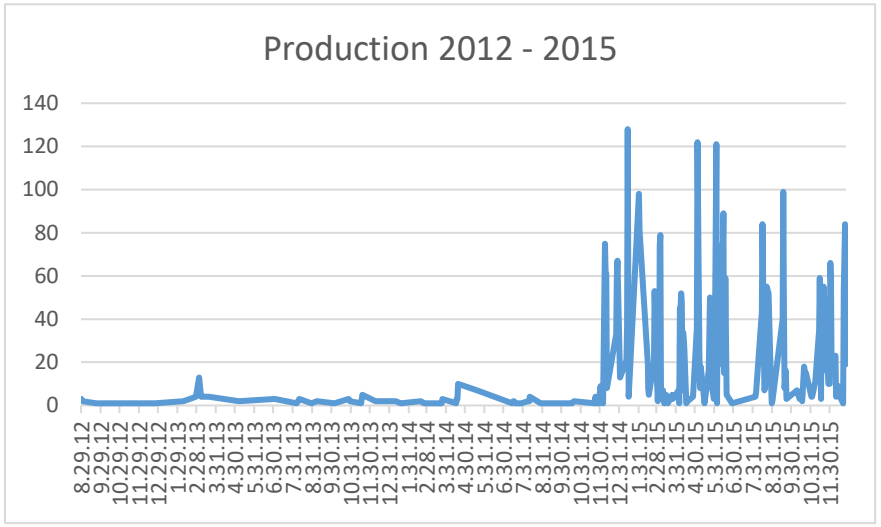
5.6 Production planning and method

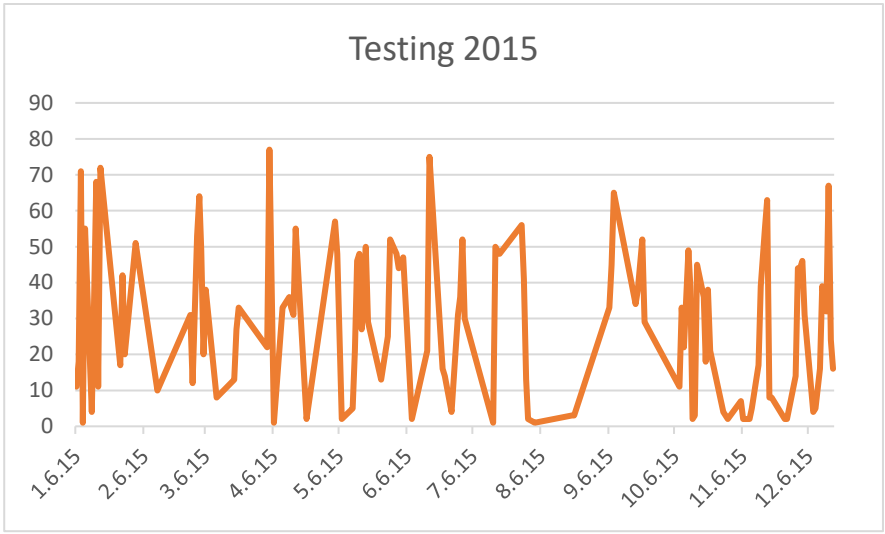
The module assembly and testing department (Production department) at TCN is newly implemented (est. 2009) and as such it has had little time to evolve and adapt itself to the new reality that comes with it. Consisting of 5 to 6 employees and a small production space there has been little focus on Lean production or any form of production philosophy.
As a result, there is little to no observable pattern or trend in the provided data from this facility, where modules are assembled and tested in a seemingly random fashion. With no set plan of production, other than delivery and shipment dates, assembly is largely based on the perceived availability of resources. Modules that should be prepared in March may be prepared ahead as early as January, given available time and resources. In times of perceived availability, where this is not the case, extra manpower must be contracted as a mean to cope with the sudden workload. On the other hand, in times of perceived non-availability workers may go idle for longer periods of time (Sæther 2017).

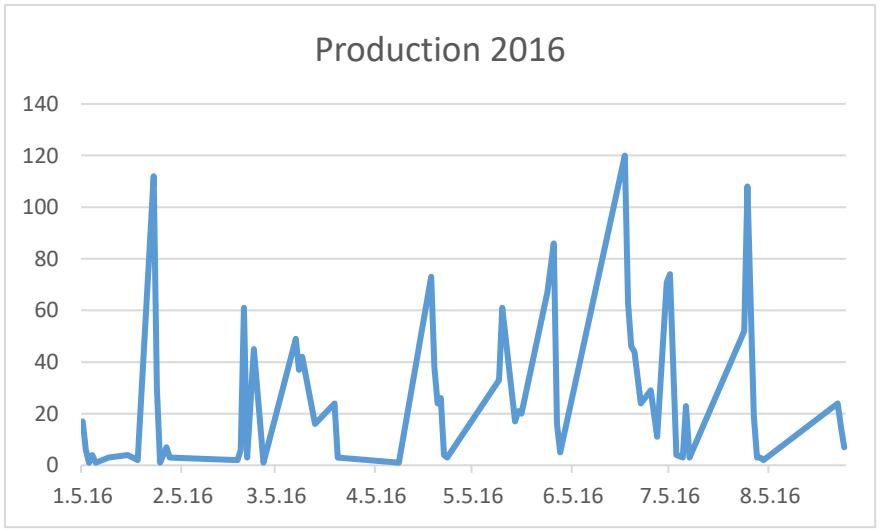
The comparison below detail the periods in which PCBAs were produced vs periods of assembly and testing for TCN in 2015 and 2016. Production dates for the PCBAs are here used as far back as 2012 as some modules tested in 2015 and 2016 contains PCBAs produced in the period of 2012 -2015. Any prolonged period of assembly and testing after production was over for the year is deemed to indicate re-testing of modules, or first time tests for older modules. The development and activity for modules *tested* in the years 2015 and 2016 can be seen as follows:

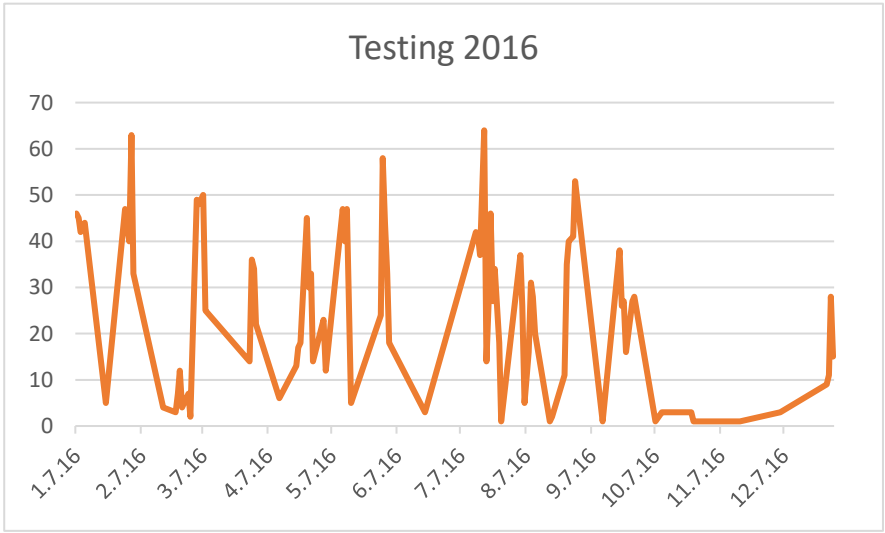
Figures presented below:

Top-left: Production of PCBAs 2012 - 2015
Top-right: Testing of Modules 2015
Bottom-left: Production of PCBAs 2016
Bottom-right: Testing of Modules 2016


Production 2012 - 2015
140
120
100
80
60
40
20
0
8.29.12
9.29.12
10.29.12
11.29.12
12.29.12
1.29.13
2.28.13
3.31.13
4.30.13
5.31.13
6.30.13
7.31.13
8.31.13
9.30.13
10.31.13
11.30.13
12.31.13
1.31.14
2.28.14
3.31.14
4.30.14
5.31.14
6.30.14
7.31.14
8.31.14
9.30.14
10.31.14
11.30.14
12.31.14
1.31.15
2.28.15
3.31.15
4.30.15
5.31.15
6.30.15
7.31.15
8.31.15
9.30.15
10.31.15
11.30.15


Testing 2015
90
80
70
60
50
40
30
20
10
0
1.6.15
2.6.15
3.6.15
4.6.15
5.6.15
6.6.15
7.6.15
8.6.15
9.6.15
10.6.15
11.6.15
12.6.15


Production 2016
140
120
100
80
60
40
20
0
1.5.16
2.5.16
3.5.16
4.5.16
5.5.16
6.5.16
7.5.16
8.5.16


Testing 2016
70
60
50
40
30
20
10
0
1.7.16
2.7.16
3.7.16
4.7.16
5.7.16
6.7.16
7.7.16
8.7.16
9.7.16
10.7.16
11.7.16
12.7.16

In 2015 there was a slightly extended testing period in terms of date, this trend was also the case in 2016, but the testing period was here greatly extended. The reason for this extensive increase can be clearly seen, as the production of PCBAs designated for TCN were stopped at the 28th of August 2016. There is further considered to be a low degree of flow in the way testing is performed as can be seen from the pattern of the graphs above, this would also indicate that module assembly follow a similar pattern, as no test or re-test can be performed before assembly is finished.

5.7 Number of modules sent for re-testing

As a mean to see how many modules were tested more than once to receive final approval modules with the same *unique serial number* and *identical production dates* with multiple *dates of testing* were identified. The authors chose these variables as they were considered the best indicators to argue that it is the same module in question. Same production date signifies that it is the same unique PCBA within the module, while the serial number adds to the traceability throughout TCN. Modules with the same serial number, but different production dates are assumed to be separately unique module in all instances.

Manufacturer	Part type	Serial	Name	Prod date	Test date
Tomra China	Module CamCrate Main	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	19.08.2016
Tomra China	Module CamCrate Main	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	19.08.2016
Tomra China	Module CamCrate Main	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	25.08.2016
Tomra China	Module CamCrate Main	50152124-01888	hw tags:FUNTEST_C503	30.08.2012	06.11.2015
Tomra China	Module CamCrate Main	50152124-01888	hw tags:FUNTEST_C503	30.08.2012	12.04.2016

Figure 28 - Structured data for number of re-tests

As a practical example: The reader will notice that two unique modules, 50152124-01572 and 50152124-01888 are occurring more than once in the *Test Date* column of the dataset, this would indicate that the module was re-tested. For this specific example, we can see that the module bearing the serial number 50152124-01572 has been tested both on the 19th and the 25th of August, 2016. August 25th would in this case be the date the module received final approval.

All entries in the Duplicated Serials sheet (the basis for this calculation) was hand-checked by both authors, as described in the Replication Guide (Appendix 4). As there is a relative chance of error in manual data entry the authors have relied on a corrective percentage of 1,5%. This corrective percentage was chosen as there is between 1 – 2% error margin for:

"Students performing calculator tasks and table lookup tasks. Per multipart calculation. Per table lookup. Etc." as suggested by Panko (n.d.) of Shidler College of Business, Hawaii. Manual estimates have been corrected in the analysis performed, this is with special attention towards the mean number of tests per module. The full results of modules sent for re-testing are detailed in the table below:

RESULTS: RE-TESTING		**CORRECTED (1,5%)**
MEAN NUMBER OF TESTS OBSERVED PER MODULE	2,73	2,68
MIN NUMBER OF TESTS OBSERVED PER MODULE	2	
MAX NUMBER OF TESTS OBSERVED PER MODULE	13	
NUMBER OF UNIQUE MODULES IN DATASET	5592	
SUM OF TESTS ON DUPLICATED MODULES	2341	
NUMBER OF UNIQUE MODULES RE-TESTED	859	
% OF TOTAL UNIQUE MODULES	15,36%	
NUMBER OF AVERAGE MODULES IN NEED OF RE-TESTING	7,00	

Table 7 - Results for calculations on re-testing

From the table above we see that the average re-tested module undergoes 2,73 (corr. 2,68) ≈ 3 tests before receiving final approval. While some modules were approved on their first re-test (2nd overall test), others were subject to as many as their 13th test before being approved. Results show that 15,36% (1 in 6,5 ≈ 7) of all modules were subject to re-testing on average. A standard shipment contains 192 modules, signifying that as many as 28 modules per shipment could be subject to re-testing on average. Details from the graphs in the "Production planning and method" section above indicates that testing was still done long after production was finished, this would indicate that a portion of all tests performed are to be considered re-tests. Of the 7074 tests performed throughout 2015 and 2016, 2341 were re-tests of modules, this is equal to 33,09% of the total number of tests performed. This is illustrated in the chart and table below:

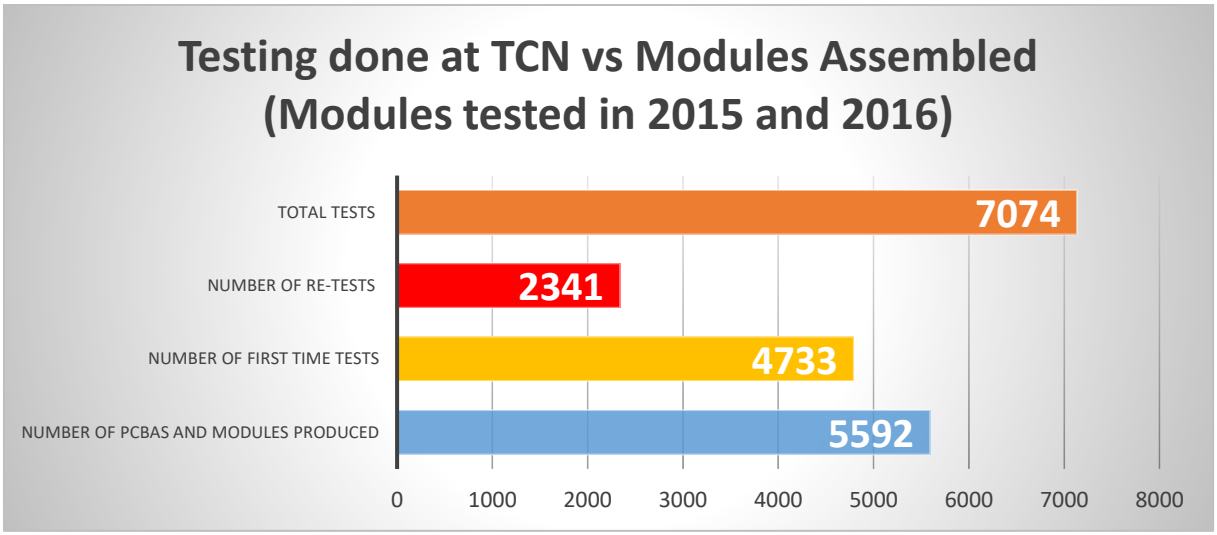


Figure 29 - Number of tests performed at TCN vs modules assembled for modules tested in 2015 and 2016

NUMBER OF PCBAS AND MODULES PRODUCED	5592	
NUMBER OF FIRST TIME TESTS	4733	
NUMBER OF RE-TESTS	2341	33,09 %
TOTAL TESTS	7074	

Table 8 - Proportion of tests proven to be re-tests

The extended testing periods as seen in the "Production planning and method" section above combined with the number of tests performed could signify that a larger number of modules were still pending final approval at any given time and that they are likely to be tested or re-tested at later dates in the year. PCBAs within these modules would here be of a greater age than average, this is proven by the table below:

AVERAGE AGE OF PCBA (DECEMBER 8 - DECEMBER 18, 2015)	70,12
AVERAGE AGE OF PCBA (AUGUST 29 - DECEMBER 30, 2016)	139,93
AVERAGE AGE OF PCBA OVER THE FULL DATASET	58,95

Table 9 - Age of PCBAs tested late 2015 and 2016

5.9 Time between first and final test

The re-testing data has been further used as a resource to determine the average time between the first and final test. In order to determine this time, the first and final testing dates for a portion of re-tested module were identified, measuring the time in days between these dates for a smaller population of the dataset:

MODULES CONTAINING PCBAS PRODUCED BEFORE 2015	70,64
MODULES CONTAINING PCBAS PRODUCED IN 2015	44,06
MODULES CONTAINING PCBAS PRODUCED IN 2016	102,76

Table 10 - Results from calculations on time between first and final test

Results on the number of days between the first and final test for re-tested modules show that there are some differences when looking at mean times. For modules with PCBAs produced before 2015 the re-test time is relatively high across all observations, for PCBAs in 2015 one may see that while *most* modules are re-tested within a day, *some* are seen as drivers for the mean value. Within this setting it is so that *some select modules* are greater drivers than others for the mean value observed. All modules found to be drivers are varied in both the amount of time between their first and final test, as well as the number of tests they were subjected to. For 2016 the re-test time was seen as increasing, with several modules being the cause for the large observed mean value.

5.10 New overall lead time as a result of this analysis

Below, the reader will find the complete TCN supply chain as it was perceived by the authors, after conducting their calculations. It remains very much unchanged from the original provided supply chain, however, some adjustments have been made. The time taken between PCBA Supplier and TCN has been adjusted to account for the large number of deliveries that were made earlier than expected by Collection. In the same manner, the time for assembly and testing at TCN has been adjusted to reflect the results above. Component sourcing is here unchanged as the authors have no available information to challenge this claim, this is also the case for the shipping time.

Results find that Collections overall current supply chain model (as of January/February 2017) is very similar to the one presented below and that the time taken between PCBA Supplier and TCN is currently overestimated, while the time spent at TCN is currently underestimated. The overall lead time for this new supply chain is 40 weeks, as before a significant portion of time (90%) is spent outside TCN.

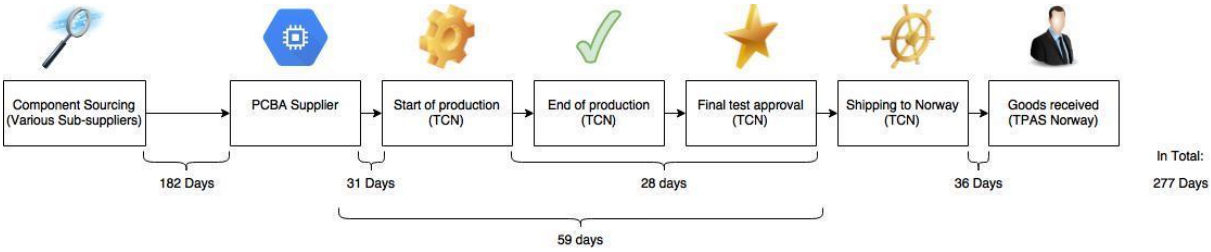


Figure 30 - New supply chain as perceived by the authors

5.11 Use of Rush orders

Another challenge identified by the authors is that of rush orders, their use and their significance. As there is currently no method for tracking the amount of or assessing the cost of rush orders, their scope is unknown to Collection and the authors. From the interviews the authors were told that Rush orders are usually triggered by events in the supply chain where the goal of delivery on time is threatened and involves transport by air. This method is considered more convenient, but is also more expensive.

5.12 Keeping suppliers engaged and retaining access to steady supply

One of the main challenges as stated by Aspenes and Sæther (2017) was on dependency, buyer- and supplier power. This is combined in a market where cultures, norms and business practices are largely different from those already known to Collection. The main consequences of these differences is the elusive and uncertain nature of suppliers, where suppliers may be available one day and gone the next. Change of industries or management are stated as possible reasons for this elusiveness, where new management can impose new contracting measures, or evict customers from established contracts. Alternatively, suppliers may change industries completely, now making iron cast parts and not plastic. In this setting, TCN is considered a smaller customer to their main supplier PCBA Supplier and towards their other sub-suppliers, with few to none alternative sources of supply.

5.13 Forecasting

This section is included as a base of discussion to a deeper challenge faced by Collection, that of accurate forecasting. The purpose is to illustrate the fluctuations that must be accounted for by TCN in the ordering of PCBAs, assembly and testing of modules, as well as how availability of resources must be considered and managed.

Below, the reader will find the results of forecasting in two instances:

1. From TCN to PCBA Supplier (PCBAs)
2. From TPAS to TCN (Modules)

Both sets of forecasts are constructed in such a manner that they detail the best guess estimate at one point in time for a specified period, e.g. "In July 2014; What do we believe we will order in January 2015?", based on a 12-month rolling forecast.

5.13.1 TCN to PCBA Supplier

Forecast from TCN to for 35150503 - C503												
	2015											
Info.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C503 orders	0	0	250	230	320	432	0	200	460	70	330	290
Ordered qty.	288	96	288	256	288	288	192	96	384	192	384	384
Forcast qty. 2014 - 7	70	150	160	70								
Forcast qty. 2014 - 8	150	130	160	200	180	70						
Forcast qty. 2014 - 9	Didn't provide forecast due to not received forecast from TPAS											
Forcast qty. 2014 - 10	190	120	200	210	180	190	90					
Forcast qty. 2014 - 11	355	150	150	180	190	190	190	100				
Forcast qty. 2014 - 12	140	300	110	200	220	190	190	320	64			

Figure 31 - Forecasts of PCBAs for January 2015 as seen throughout 2014

As seen in the example above, the row marked “C503 orders to PCBA Supplier” is the actual ordered quantity for the module PCBAs (35150503 – C503). The row below details the orders from TPAS to TCN. The rows marked “Forecast qty. 2014-X” are the points in time in which the estimates were set, this seen up against the month and year detailed in the “Info” rows. As a practical example; It was forecasted in July 2014 (Forecast qty. 2014-7) that there would be a need for 70 PCBAs in January 2015. At the maximum it was believed that there would be a need for 355 PCBAs (Forecast qty. 2014-11), but the actual quantity ordered was 0.

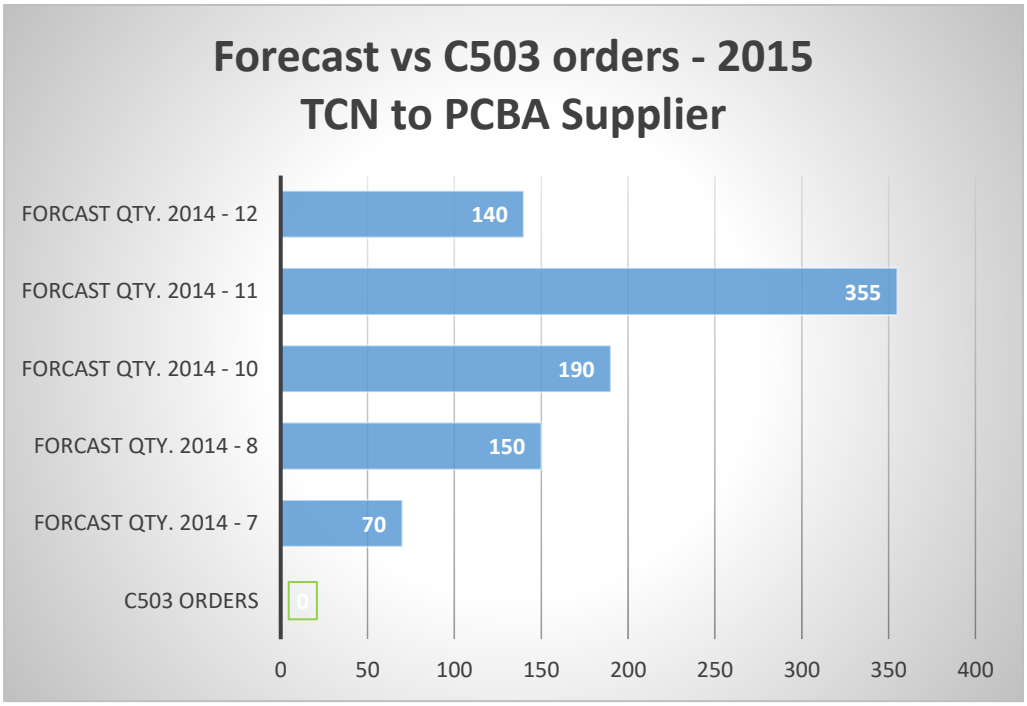


Figure 32 - Forecasts PCBAs for January 2015 as seen throughout 2014

5.13.2 TPAS to TCN

Forecast from TPAS to TCN for 50152124

	2015											
Info.	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
C503 orders	**0**	**0**	**250**	**230**	**320**	**432**	**0**	**200**	**460**	**70**	**330**	**290**
Ordered qty.	**288**	**96**	**288**	**256**	**288**	**288**	**192**	**96**	**384**	**192**	**384**	**384**
Forcast qty. 2014 - 7	132	132	165	66								
Forcast qty. 2014 - 8	165	132	165	231	165	66						
Forcast qty. 2014 - 9	192	128	224	192	192	192	64					
Forcast qty. 2014 - 10		64	224	224	192	192	192	96				
Forcast qty. 2014 - 11				32	224	192	192	320	64	32		
Forcast qty. 2014 - 12					224	192	192	288	256	64		

Figure 33 - Forecasts of modules for January 2015 as seen throughout 2014

The forecasting from TPAS to TCN works in the same manner as the one above, with the exception that the row marked “Ordered qty.” is the actual number of modules ordered. In July 2014 it was believed that there would be a need for 132 modules for January 2015, at the maximum it was believed that it would be need for 192. The actual number of modules ordered was 288.

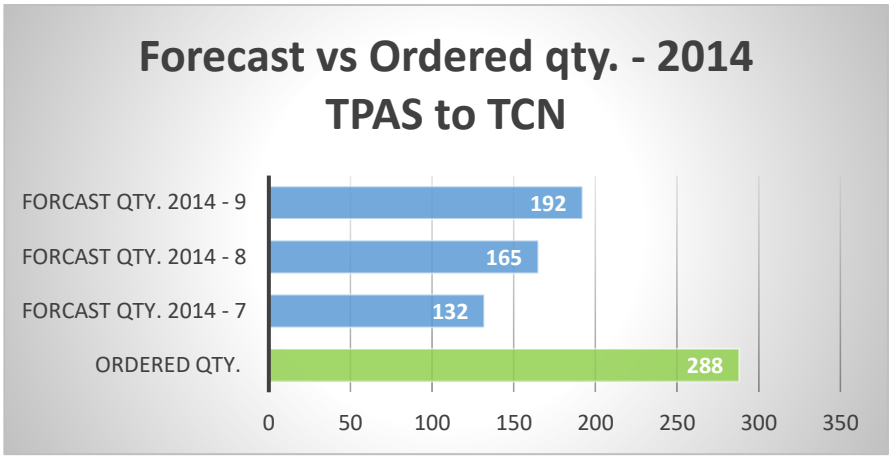


Figure 34 - Forecasts of modules for January 2015 as seen throughout 2014

Below are the order patterns for modules and PCBAs for the years 2015 and 2016, the graphs are included as a mean to visualize the number of PCBAs ordered in comparison to the demand of modules set by TPAS:

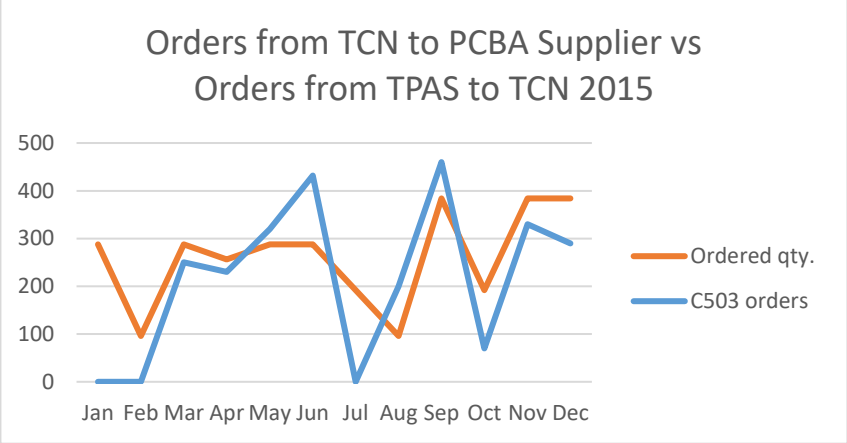


Figure 35 - Orders from TCN to PCBA Supplier vs Orders from TPAS to TCN 2015

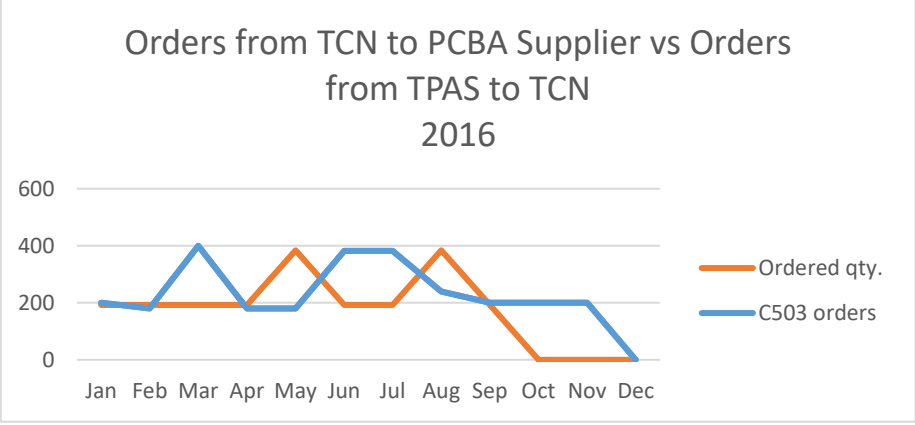


Figure 36 - Orders from TCN to PCBA Supplier vs Orders from TPAS to TCN

6.0 Present impact of cultural dimensions

This section of the thesis contains the links between the available theory and the practical case study. The goal of the analysis is to provide meaningful connections of how mismatched cultural dimensions may be of impact to the current supply chain flexibility of TCN and Collection. This is the middle stage of the scenario analysis method, detailing the present-day impact of mismatched cultural dimensions on supply chain flexibility.

Current differences in perception of cultural dimensions are believed to have a strong impact on the potential for TCN and Collection to retain and practice strong supply chain flexibility. How different cultural dimensions are currently perceived by the different parties based on the authors understanding are illustrated below:

TCN	**Cultural Dimensions**	**Collection**
High	Power Distance	Low
Masculine	Masculinity vs Femininity	Feminine
Low	Uncertainty Avoidance	High
Collectivism	Individualism vs Collectivism	Individualism
Long-term	Long-term vs short-term orientation	Short-term
Ascribed	Ascribed vs Achieved status	Achieved

Table 11 - Cultural Dimensions as seen by Collection and TCN

As a limitation of the analysis, only the flexibility dimensions of reconfiguration- and supply-, volume- and delivery flexibility have been included. This choice was made as the further dimensions of product- and product mix flexibility were seen to have little impact on the standardized nature of products at TCN. As the perception on individualism and collectivism are seen to be of little consequence over the dimensions of long- and short-term orientation, as well as achieved vs ascribed status the authors have chosen to place less emphasis on this dimension at this stage. Following the overall KPI set by Collection; on time delivery, the analysis will heavily emphasize factors that may threaten this goal.

6.1 Lead time and number of links in the supply chain

Increased lead time and number of links in the supply chain has been a growing phenomenon for Collection in later years, as the introduction of their new Xiamen facility has increased the supply chain complexity. The present number of links and overall time spent in the TCN supply chain represents a potential risk towards the preservation of quality in both products and processes as a module is constantly moving, or being kept as stock. As a direct consequence of the time spent in motion and stasis, the risk for damages, changes in scheduling or obsolescence become increasingly likely. Of these three main factors, damaged goods and re-scheduling are seen as the most impactful events to the continued flexibility of the supply chain, as modules are seldom unusable if out-dated. At present time there is however a high risk of damage to the modules, as they spend very little time in a value-adding state and have severely volatile components that are susceptible to breakage.

Current practices within TCN and the previous links of the supply chain enforcing this risk can be tied to the cultural dimension of uncertainty avoidance. As TCN is considered more risk comfortable than Collection this perception may be a potential driver for lowered volume- and delivery flexibility, should modules be subject breakage or schedules be changed. Such events would have significant impact on the time, cost and quality aspects of the supply chain. From Part 5 of this thesis there is clear evidence that the average module currently spends as little as 50 minutes in a value-adding state, while the remaining 28 days of which an average module is kept at TCN is in stasis, presumably in larger bulks. Breakage of one or more modules could here actively disrupt the flow of production and as an ultimate consequence threaten on-time delivery. If this is the case, rush-orders would have to be initiated, extending and/or shifting the number of links in the supply chain, alongside contracting of extra manpower as to not incur any further delays. In such a situation, the possibilities for maintaining efficient volume- and delivery flexibility would be considered a challenge.

Current differences in perception of risk has a potential further impact on coordination, as well as information exchange. Both of these aspects are vital in order to keep flexibility at an accepted and desirable level, finding balance in the way risk is handled and tolerated is

imperative for Collection in order to coordinate with TCN. As TCN is a directly owned subsidiary that is an offshored part of Collection and not an outsourced partner it should prove easier to implement shared goals and practices that can benefit both parties in the long run. A challenge for Collection may here be to surpass their short-term goals in favour of more long-term goals, as this is more beneficial to the Chinese way of thinking.

6.2 Production planning and method

As stated in part 5 of this thesis there is currently no specific production philosophy at TCN when it comes to assembly and testing of modules. There seems to be a rather free hand with regards to planning, with emphasis on predicted level of available resources, making a steady work flow challenging on a per module basis. This practice is seen as highly influenced by the cultural dimensions of power distance, uncertainty avoidance, long-term orientation and masculinity. This can clearly be seen by the nature of which current production methods are executed and the acceptance towards the fact that production is based on delivery, not flow. There seems to be of little consequence at what time a module is finished in comparison to when it is supposed to be shipped and delivered. This is enforced by the statements of Aspenes and Sæther (2017), stating that modules intended for shipment in March, *may* be assembled as early as January.

As with the above risk towards quality of products spending large amounts of time in stasis, current production practices further magnify this risk. While stocking up products for anticipated changes in demand are considered a wise choice in most situations, there is an element of risk if the modules are kept too long in storage. Storage of products may be considered cheaper in the East than in the West, but should be considered as a cost regardless, if the storage is also unnecessary it should be considered an unnecessary cost.

Current stocking of products is seen as highly beneficial towards increasing volume and-delivery flexibility in the long run, but can quickly become a liability towards the same flexibilities should breakage occur. Current lack of a steady production philosophy at TCN is considered an extreme element of risk to both delivery, time spent, quality of products and processes, as well as the costs that may arise from the above factors. More time spent means less margin for error, less margin to finish on time and can involve a significant

increase in costs to make good on promised delivery. Rush orders are here to be considered part of this risk, but can also be seen as an element of disturbance, as they are costly for all parts of the supply chain and require a fair amount of restructuring backwards in the pipeline. Once again it is so that differences in perception of cultural dimensions may affect supply chain flexibility, here the risk comfortable nature of TCN may impede on the lower risk attitude of Collection, making coordination, production management, alignment, training and predictability uncertain moments in the overall supply chain.

6.3 Production Lead Time and In-house Production Lead Time

Production Lead Time is for this thesis considered to be highly connected to the concepts above on supply chain links and overall lead time. As an added point of analysis it is so that most of the links and lead times in the pipeline for TCN and their suppliers are component sourcing and delivery times, which are highly subject to variation. This is proven by the fact that the stated average lead time for components from PCBA Supplier to TCN were estimated at 56 days, this same time is estimated at 31 days by the authors as data provided by Collection indicates that 80% of deliveries are performed below the original estimate. Given the high variation in the dataset and the estimates there is little to say as to the nature of causes to the variation itself, but the higher estimate of lead-time in the supply chain from Collection is a clear proof of their higher position on the uncertainty avoidance scale. Being less comfortable with the elements of risk and disturbances, Collection has allowed themselves some room to breathe in their calculations, making room for unexpected events. When it comes to the In-house Production Lead Time it is so that it is also highly subjected to variation, as can be seen from Part 5 of this thesis.

Given that our dataset is for only 1 out of 27 modules tested and assembled at TCN, the authors have made the assumption that the current level of variation is constant across all modules present. From the results of our data analysis it is seen that the average value adding time for each module is below 0,5 percent of PLT and that the remaining time of which the module is being kept at TCN is to be considered stationary time where the module is at risk.

6.4 Number of modules sent for re-testing and time between tests

The current number of modules that are being sent for re-testing are to be considered a large amount, both by its quantity, as well as by the share of an average shipment. The sheer number of tests performed at TCN presents a potential impact to time, costs and quality of products, while simultaneously impacting volume- and delivery flexibility. Another impact in this setting is the strain on process quality that is exerted through the number of days between the first and final test for the module. In themselves, defects are to be considered "time-thieves" and in so being they also represent a significant source as a cost driver, given that time is to be considered a cost. The number of re-tests are also a measurable KPI for the quality of the products and the processes performed at TCN and should as such be closely monitored and evaluated.

The current differences in perception of the cultural dimensions of Power Distance and Masculinity at TCN will undoubtedly make it more difficult for employees to have an active participation in the optimization of assembly or testing. This is seen as impacts to both communication and information exchange, as well as the level of employee involvement possible. Given these differences perceptions there is a considerable chance that the number of defects are persistent through "cultural blindness". In this sense we can see that the attributes of culture in itself can be considered detrimental to the goal of process quality, decreasing product quality and forcing time and costs to increase. It should also be noted that the current time for re-testing and approval for some modules is of such a length that it is highly unlikely that the same module will reach its originally intended shipment, rather being replaced by a new "healthy" module, possibly forcing overproduction. Modules that were replaced due to longer wait-times may here be the main cause for the prolonged testing periods experienced in 2015 and 2016.

From Part 5 of this thesis there is clear evidence that a great number of older modules were tested at the end of both 2015 and 2016. It is the belief of the authors that these modules were all set aside as defects and that some were replaced by healthy modules, being re-tested at a later date, in times of low production volumes. Comfort with the risks of possible overproduction or stalling over repair is a clear example of the contrasting position TCN has

taken with regards to uncertainty avoidance over Collection. Possible overproduction is in this case to be considered a driver for time, cost and quality, as there is no guarantee to the product, nor process quality of the new module produced. There is however a guarantee to that the overproduction means more time spent than initial planning accounted for, further increasing costs.

Currently, 1 in 7 modules are on average sent for re-testing, some more than once and with varying time between the first and final test, implying that re-testing of as many as 28 modules per shipment may occur. While defects are a natural part of any manufacturing process, active measures should be taken in order to prevent both existing and further defects from occurring. This may present a challenge at TCN, as the active Power Distance is higher than what is considered normal at Collection, making it difficult to voice ones opinion upwards in the system. Causes for defects may be understood and acknowledged by the workforce on a manufacturing level, but due to the concept of Power Distance and the Masculine nature of Chinese culture, complaints and worries may never reach those who can influence it. As such, defects may continue to occur, without the knowledge of those who have an actual possibility of contributing to awareness and change. Defects are not only subjects to cultural aspects, but also have a fair impact on the flexibility of the company. Not being able to reduce defects means that time and money is being spent in a system that is not willing to admit problems due to “face-saving”, or willingness to communicate problems due to Power Distance and Masculinity. Should this prove to be the case one may see that the interpretation of Power Distance and Masculinity at TCN is directly connected to the quality of products and processes.

6.5 Keeping suppliers engaged and retaining access to steady supply

Keeping ones suppliers engaged and in a state of fruitful collaboration is essential to the flexible supply chain. From a cultural perspective in a global supply chain the challenges are greater and more volatile, this can especially be seen where there are differences in how to approach and maintain the buyer-supplier relationship. Aspenes and Sæther (2017) stated that Collection in recent years have experienced uncertainty as part of the volatile supplier situation, not being able to secure footholds and being unsure of their position within these relationships.

Loss of steady supply would directly impact the level of reconfiguration- and supply flexibility at TCN, seeing as a steady supply is crucial towards being able to adjust planning and production, as well as being able to cope with changes in forecast or open orders, volume- and delivery flexibility would here be threatened as well. The potential loss of supply and current volatility of the suppliers would further be considered an increased strain to parent company coordination for Collection towards TCN. The situation currently experienced by TCN and Collection can in this regard be considered a monumental risk towards keeping a steady supply of raw materials and retaining exchange of competence. Without supplier's expertise and effort, many of the core values that make up the flexibility concept may become threatened. The cultural dimensions responsible for the current supplier behaviour towards TCN can be found in their long-term orientation, combined with their collectivistic nature and affinity for ascribed over achieved status.

TCN is situated in a country where contracts are relied upon based on relationships, as such there is a considerable investment in time and money towards effective partnerships. Time and costs can here be seen as a potential penalty as losing suppliers will entail a considerable time of recovery. Searching for new suppliers or sources of supply within the supplier network may subject TCN to lower performance, increased costs and constricted use of time, impacting their reconfiguration- and supply flexibility. The influence of the ascribed vs. achieved status is here seen as an active driver for the volatility of the supplier relationships experienced.

6.6 Use of Rush orders

When it comes to the use of rush orders there is not much to be analysed, as the availability of data is low or non-existing. However, it must be noted that the use of rush orders on a frequent basis is a strong driver for the perceived flexibility of a company. While perceived flexibility makes for more options in a shorter timeframe it is not something to adhere to as standard practice and is in all essence a Band-Aid for a deeper root cause. This challenge is tied directly to the financial solidity of the TCN operations and the perceived flexibility of Collection in making good on their delivery promise.

In addition, there is an established understanding that rush orders are expensive, but fast, thus increasing costs and reducing time, however they are also to be seen as an added element of risk towards the quality of the product. A shipment under rush order conditions is here to be considered of greater importance than a regular shipment, making the unlikely event of damages or failure to deliver more crucial towards the delivery guarantee practiced at Collection. As the use of rush orders are dependent on meaningful exchange of information, power distance and masculinity at TCN may become a hindrance towards the exchange in itself.

Use of rush orders in themselves can be seen as a consequence of the higher uncertainty avoidance practiced at Collection, favouring less risk towards the time of delivery. Defects may here be considered a source towards potential failure to deliver as defect modules need to be either repaired or re-produced, if either of these processes take too long, delivery can become threatened. If this risk becomes too great, Collection will make use of rush orders to safeguard and secure their delivery. In this case we can see that the contrasting views on risk and uncertainty may prompt more rush orders than necessary, due to Collection not being as risk comfortable as TCN. Additionally, Collection has placed a risk upon themselves by guaranteeing delivery, seemingly at any cost. Low comfort with risks and unexpected events would signify that the choice of this promise might be unsuited for Collection in the long run under current conditions. Differences in the perception of risk may here strain the parent company coordination to a level that creates additional costs and time spent at Collection.

6.7 Forecasting

The use of forecasting is a core pillar to TCN and Collections operations in order to predict and fulfil the perceived and realized needs of the market. This is a prominent feature in their relationship and as such it has a clear potential impact on flexibility. Collection is highly reliant on this forecasting in order to plan production, and have implemented a 12-month rolling forecast policy in order to create stability for themselves and their customers. From a purely cultural perspective one may see that there are significant differences in the way TCN and Collection treat their orientation towards time, and as such their planning accordingly. Forecasting is by most considered to be a short-term tool for demand management, and as such it is considered to be suitable for predictions in the immediate to near future.

This coincides well with the practices at hand in Collection; being a typical western company they are subject to the same short-term mind-set that is part of their culture. TCN are however not inclined to the same way of thinking, being situated in a long-term oriented culture where there is little room for quick wins or short gains. As a consequence, short-term tools such as forecasting reports are believed to be of lesser value to TCN where long-term pre-set “hard orders” are preferred. Given the inaccuracy and volatile nature of the forecasts, there is an inherit risk towards how TCN may plan their production, seeing as it is primarily based on perceived availability of resources. In considering these differences there is a clear discrepancy between how the two companies relate to time and that it may impact the predictability of the supply chain, thereby directly impacting flexibility.

The Chinese attitude towards production tends to be of a more rigid nature than what is found in European production, where everything can be subject to change right up to the last moments of production, through such means as postponement. This is however not a strategy that is well aligned with TCN, as there is a tendency for wanting non-implicit information and predetermined quantities to adhere to. Current cultural differences towards order types and communication is seen as a potential key driver towards loss of flexibility at TCN, impacting their ability to be agile, adaptive and create predictability. Furthermore, the current uncertainty regarding forecasts can be seen as a challenge for TCN is establishing their need for manpower as there are specific costs connected to both having too much and to little manpower available.

Example: Under current conditions TCN may receive a forecasting report for March and see that expected production is well suited to available manpower and make the necessary arrangements. However, expected production may change several times before March, now requiring less or more manpower than initially foreseen. If there is too much manpower at hand, employees are possibly forced to go idle, or working a module of which design they have little to no knowledge of. If there is however too little manpower, extra resources must be brought in to cope with the reality of production.

Had expectations been more aligned, these costs could have been reduced and allocated to a more "correct" time and place when needed. In a situation where workers may be prompted to work with modules they are not specialized on, product and process quality may be compromised, this could in the long-run impact both time and cost in recovery. In such situations the ability for exercising volume flexibility becomes greatly reduced, as adjustments are continuously subject to change. Changes in open orders may here also be threatened as the sudden nature of changes may collide with the available amount of resources, threatening volume- and delivery flexibility. This can become a challenge to delivery in itself and can be an increased source of rush orders, increasing costs and the risk of unexpected events. The amount of time spent by Collection in securing accuracy and follow-ups towards their forecasts is seen to be a driver for increased parent company coordination. As Collection does not create the forecasts, only adapt them according to market expectations; a considerable amount of time and resources are spent on “correcting” the estimates and making sure that they are as realistic as possible. This makes the forecasting policy as it exists today a major cost driver as it is time consuming and involves a great amount of links to consider.

6.8 Summary

As a summary one may see that TCN and Collection has experienced an increased decision time in the form of forecasting correction and order placements. In addition, there is an increased in-house production lead time experienced as a consequence of the lower product quality and an increased cost aspect as a combined consequence of the above mentioned factors. Under the mismatch in current perception there has also been a significant impact to process quality, as can be seen by the prolonged times in re-testing, which in turn has led to an increase in coordination. As a consequence of the increased in-house production lead time combined with the limited sources of input in decision making and planning under the current mismatch, volume flexibility is seen to be reduced. Under the increased decision time the ability for rapid adjustments in open orders is seen as a challenge, lowering delivery flexibility. This is a good fit to several of the outcomes presented within the simplified model in chapter 2.4 of this thesis. Of the cultural dimensions discussed above the authors would place the current differences in perception of Power Distance, Masculinity and Uncertainty Avoidance as the primary drivers for the lowered flexibility.

While orientation towards time and ascribed vs achieved status are considered to be strong influences to the current challenges met by TCN and Collection they are seen as lesser drivers. How changes in perception of these drivers may impact supply chain flexibility is discussed in the last part of the scenario analysis.

7.0 Scenario model for TOMRA Collection Solutions

This part of the thesis is concerned with outlining the possible effects on supply chain flexibility that may arise from the different choices in adaptation strategy. It is the final part of the scenario analysis, stating the *possible* implications and outcomes to each choice in adaptation. The final scenario model for Collection and TCN is presented below:

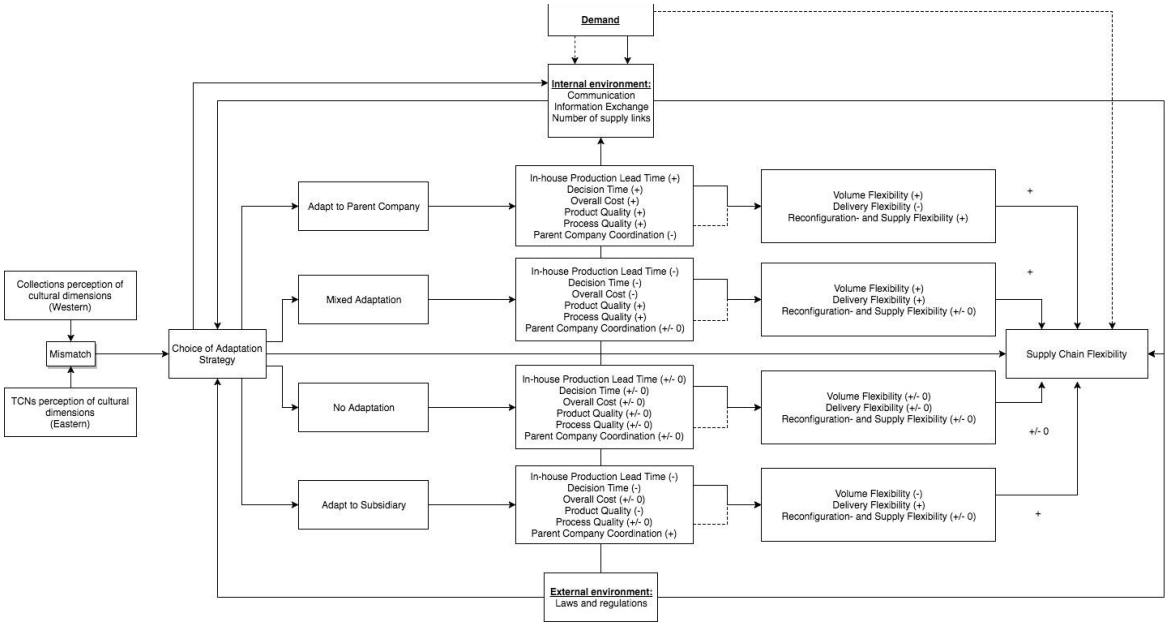


Figure 37 - Scenario model for TOMRA Collection Solutions and TCN (Full scale can be found as appendix 2)

+ : General increase, +/- 0 : Sustained (No general increase or decrease from base conditions), - : General decrease

----: Indirect effect, _____: Direct effect

For this case there are four main adaptation strategies to consider:

1. **TCN adapts towards Collection**

   In this setting, the perception of cultural dimensions as seen by Collection will be the common goal.

2. **Collection adapts towards TCN**

   In this setting, the perception of cultural dimensions as seen by TCN will be the common goal.

3. **Mixed adaptation**

   In this setting, the most suitable common perception of cultural dimensions as seen by the authors for both Collection and TCN will be the common goal.

4. **No adaptation**

   In this setting, the perception of cultural dimensions will remain unchanged for both Collection and TCN.

All strategies of adaptation are based on the following differences in cultural dimensions and flexibility aspects for Collection and TCN:

TCN	Cultural Dimensions	Collection
High	Power Distance	Low
Masculine	Masculinity vs Femininity	Feminine
Low	Uncertainty Avoidance	High
Collectivistic	Individualism vs Collectivism	Individualistic
Long-term	Long-term vs short-term orientation	Short-term
Ascribed	Ascribed vs Achieved status	Achieved

Replication of Table 11 - Cultural dimensions in Collection and TCN

TCN	Flexibility Aspect	Collection
Strict	Planning	Fluid
Relational	Contracting	Contractual
Less important	Quality of products	Important
Important	Quality of process	Important
High Emphasis	Relationships	Lower Emphasis
Stability	Production Techniques	Options
Clear (Non-implicit)	Communication	Abstract (Implicit)
Less frequent (More direct)	Information Exchange	More frequent (Less direct)
In relationships	Trust	In contracts
Low (Unless specified)	Level of employee involvement	High
Hard orders (Pre-set)	Order preferences	Soft orders (Forecasts)

Table 12 - Flexibility aspects in Collection and TCN

There is currently no point of numbered summary as the weights of each factor are highly subjective. The authors will therefore only present their assumptions to outcomes and from those give their recommendations, these recommendations are not meant to be the single point of solution, but may serve as a guidance for Collection in implementing real life changes. Outcomes are discussed by first outlining the positive aspects of the adaptation, followed by the conflicts and challenges that are identified. As a primary limitation to the scenario narratives themselves, no impacts on or from the external environment are included.

There is however an understanding that during implementation, all factors are likely to be affected, especially as the adaptation process will likely be one of *learning by doing*. Information regarding the foreseen conflicts and challenges in implementation may here be used as further guidance towards the potential trade-offs. As the perception on individualism vs collectivism are seen to be of little consequence over the dimensions of long- and short-term orientation, as well as achieved vs ascribed status the authors have made the choice to place less emphasis on dimension within the scenario narratives.

7.1 Scenario 1 – TCN adapts to Collection

In a scenario where TCN takes on absolute adaptation towards the western dimensions of culture, several changes may be observed. The cultural dimensions of which TCN would adhere to in this situation are presented below:

Cultural Dimensions	**Collection**
Power Distance	Low
Masculinity vs Femininity	Feminine
Uncertainty Avoidance	High
Individualism vs Collectivism	Individualistic
Long-term vs short-term orientation	Short-term
Ascribed vs Achieved status	Achieved

7.1.1 Positive aspects

Firstly, the lowering of power distance will make more room for greater inter-firm communication and knowledge exchange across departments at TCN, in having this previous barrier removed, volume- and delivery flexibility may be positively impacted. This impact will enable for more dynamic and fluid planning, another recognized aspect of conducting strong volume flexibility. For TCN this may be a tool towards increasing the quality of processes and products, as concerns and flaws may be discussed more openly, thus reaching the correct branch of management. Such an increase in quality may have a directly positive effect on the number of re-tests performed at TCN, as well as the time taken between first and final tests. By removal of "status and rank" (one of the aspects common to power distance) less time and money can be spent on individual groups in training, favouring larger groups. By moving from the masculine to the feminine side of cultural dimensions TCN will be able to strengthen their inter-coordinative relationship in much the same way as the shift from high to low power distance. As this dimension has effect on both planning and scheduling as well as coordination it is strongly connected to volume- and delivery flexibility. Strongly masculine cultures have a clearly unilateral view on decision making and control, by shifting towards the more feminine aspects of culture TCN may become more open to indirect decision-making, favouring input from several sources. Successful implementation of lower power distance could further enable TCN to easier identify and correct their modules, thereby decreasing the amount of modules that would need to be re-tested.

Moving from a long-term to a short-term orientation towards time as well as to an individualistic view may prove to be the biggest challenges for TCN. Having cultural roots in Confucianism within these cultural dimensions may present problems with adaptation. As the view on Confucianism and collectivism traditionally may impact the nature of business relationships (buyer-supplier relationships in particular) the shift towards the more individualistic view may change how relationships are conceived and maintained. One of the key flexibility aspects that are affected by this shift is the perception of trust and the grounds for contracting. Where previous contracts would be maintained and determined by relationships and time, new contracts would be governed by the mutual lawfully binding agreements within, where time and relationships are to be established later, not

beforehand. The use of legal contacts over relational contracting would firmly secure the reconfiguration- and supply flexibility for TCN as partners would have greater difficulties in simply disappearing.

In this scenario TCN would be prone to a more fluid work process, where options are favoured over stability. Planning would be more fluid and dynamic and the order preference would shift to a short-term oriented method of forecasting from long term hard orders. Using the same basis for planning through forecasting would enable TCN to better plan their resources, given accurate forecasts from Collection. A shift from low to high uncertainty avoidance may here prove one of the most impactful changes for TCN and the overall supply chain. Current interpretation of this cultural dimension is set at the lower end of the scale, favouring a stronger risk comfortability. As discussed in Part 6, this risk comfort is sharply contrasted with how risk is perceived at Collection. By making the shift from low to high uncertainty avoidance there is an increased chance of planning and production being aimed at flow and not only delivery. Having an expected level of flow to adhere to may help TCN in making better decisions with regards to use of available resources. This stability and foresight in production may enable Collection to decrease their need for coordination and may make the characteristics of rush order situations easier to identify. Having less tolerance for risk may also help with the number of modules being re-tested, as well as with the time taken between the first and final test.

In a situation where TCN is less tolerant of risks, the current possible practice of producing a new "healthy" module in favour of repairs to a defect one would not be tolerated, as there is considerably more risk towards creating a new module that may contain the same defect, than repairing an old one. Under this new perception TCN can reduce the number of modules awaiting test or re-test, as well as reduce their possible overproduction and extended testing periods of older modules. Lastly, the shift from an ascribed to a more achieved state in cooperation with suppliers and within TCN itself would open for greater stability in the buyer-supplier relationship. While TCN may have little power to affect this dimension in a practical manner, one may insist on that the shift should occur internally in the company. Having a deeper connection with supply partners may also favour this way of thinking, e.g. promoting a coordination officer towards TCN that has achieved their position.

As the buyer-supplier relationships impacts the reconfiguration- and supply flexibility with further impacts on the volume- and delivery flexibility, adaptation towards western values may here be challenging, but preferable over the current state. Use of achievement over ascribed status may here also strengthen relationships between Collection and TCN as Collection can be further assured to the competence of their management.

7.1.2 Conflicts and challenges in implementation

The shift of power distance will likely present challenges at TCN as the familiar established chain of command becomes subject to change. Being used to a culture of rules and instructions, having to make analytical decisions and forwarding concerns may prompt silence and discomfort as older cultural values are still not forgotten. The easiest way to decrease this possibility is by having the management enforce this change, catering to some reminiscent of the older practices. If this shift leads to a significant increase time there is a clear risk to the continued delivery flexibility at TCN, as open orders would take longer to change. As a clear negative possibility towards the shift in orientation towards time stands the increased possibility of further volatility in the buyer-supplier relationship. If such increase should occur, the reconfiguration- and supply flexibility would be severely impacted, following a similar impact to volume- and delivery flexibility. As a negative, the shift with regards to uncertainty avoidance could prove detrimental to the quality of work processes at TCN, where the habit and inert affinity for higher risks in production is an integral part of day-to-day operations. Lastly, the concerns present in the shift from ascribed to achieved status could be much the same as the ones experienced under the shift of orientation towards time. As a result of this change, TCN may struggle with keeping the respect of their workers, as the cultural dimension of your status over your achievements is still a part of daily life.

7.2 Scenario 2 – Collection adapts to TCN

In a scenario where Collection takes on absolute adaptation towards the eastern dimensions of culture, several changes may be observed. The cultural dimensions of which Collection would adhere to in this situation are presented below:

TCN	**Cultural Dimensions**
High	Power Distance
Masculine	Masculinity vs Femininity
Low	Uncertainty Avoidance
Collectivistic	Individualism vs Collectivism
Long-term	Long-term vs short-term orientation
Ascribed	Ascribed vs Achieved status

7.2.1 Positive aspects

The shift towards a higher level of power distance would enable Collection to streamline decision-making and communication within the company, transferring more responsibility upon the management. One of the perceived upsides to this change is the potential savings in decision time and money that may be realized from shortening the distance from decision to implementation. Not having to adhere to several opinions and spending time on arguments, meetings and deliberations may here see the cost and time aspects decrease through efficient communication and information exchange.

This change would most likely be combined with a shift towards a more masculine attitude towards decision-making and employee involvement. Upsides to this change can in the long-term be similar to those of the increased power distance, saving time and money, while strengthening the internal delivery flexibility, making for swifter actions in open orders. Towards their interactions with TCN there is a high likelihood that the exchange of information would be more efficient as only a select group of personnel from both sides would be needed in order to make decisions. Having this direct form of communication may here enable TCN to increase their production flow by reducing their In-house Production Lead Time, thereby increasing their potential for added volume- and delivery flexibility.

Moving from a higher degree of uncertainty avoidance toward the more risk comfortable lower levels may cause Collection to spend less time and effort in safeguarding their forecasts and quality processes. From this practice there is a potential increase towards the payoff with regards to time and money spent, further, being more risk comfortable may enable Collection to relinquish some of their coordination efforts, thus saving time and money. Changing their orientation towards time may be as impactful for Collection as it could prove for TCN. Having a basis in short-term orientation with low tolerance of risk is well suited to current use of such tools as forecasting and frequent follow-ups with their market needs. In shifting towards a more long-term oriented stance, Collection could make more long-term decisions, without the disadvantage of effort spent on constant adjustments or changes. In the same manner as TCN would experience a higher degree of volume- and delivery flexibility from clear orders, Collection could here benefit from greater ease in information exchange, given equal assessment of current risks between the two parties. The shift from achieved to ascribed status may here prove the greatest challenge of all for Collection, as the cultural norm of work advancement through achievements runs deep within the western work ethics. In making this change the management of Collection and all future advancements would be based on the ascribed status of personnel. Having similar values in advancements and employment may further strengthen ease of communication and information exchange with TCN, while also lessening the need for Parent Company Coordination.

7.2.2 Conflicts and challenges in implementation

As a negative perspective stands the potential impact the change in power distance would have on autonomy and critical assessment of work-processes at Collection. Not being able to voice ones opinions could lead to neglecting factors that are perceived as damaging by some employees. This negligence could have a potential impact on cost, time spent and the direct quality of products and processes, both within Collection and TCN. While the mutual higher power distance in both companies would be seen as a positive development for communication and stability, this loss of critical assessment may prove damaging to the overall supply chain flexibility. Employees at Collection may by todays practice voice their opinions regarding their own company, as well as the practices of TCN, this resource would disappear in making this shift. A potential trade-off to changing the level of uncertainty

avoidance is the added need for coordination in events of failure, prompting costs and time to increase, while potential quality of processes and products stands to remain unchanged or to decrease under the minimal safeguarding. As a negative outcome to shifts in orientation towards time stands the possibility of increased coordination, time spent, cost and decreased process quality in situations where the long-term plans are subject to unforeseen changes, possibly prompting more rush orders. As markets are mechanisms of constant volatility, this shift would be seen as a severe decrease to the potential delivery- and volume flexibility that Collection could offer to their customers through TCN. Changing from achieved to ascribed status would give a diminished possibility for Collection in choosing the most qualified person for the job, thus affecting trust both within the market and the company itself. Had Collection adopted this cultural dimension before their establishment in China, events might have turned out very differently, as the instigator for the Xiamen project was chosen to lead the project based on achievements and merits. The use of "positioned" leaders may here also affect the level of trust and respect experienced within the company. A company with little to no respect for their management would in all instances cause the combined aspects of time, cost and quality to decrease. As a western company, potential effects may be seen in inefficient work routines as a form of protest, causing costs and overall quality to be compromised.

7.3 Scenario 3 – TCN and Collection adapts in a mixed manner

In a scenario where Collection and TCN takes on a mixed adaptation towards each-others select cultural dimensions, several changes may be observed. The cultural dimensions of which both companies would adhere to in this situation are presented below:

Cultural Dimensions	**Mixed**
Power Distance	Low
Masculinity vs Femininity	Masculine
Uncertainty Avoidance	High
Individualism vs Collectivism	Either or
Long-term vs short-term orientation	Short-term
Ascribed vs Achieved status	Achieved

7.3.1 Positive aspects

Having mutually lower power distance will ensure that inter-firm communication and information exchange have every possibility of being beneficial to both parties in the overall supply chain with minimal barriers. In addition, it could become a mean as to increase the quality of products and processes, increasing the level of employee involvement at TCN, while keeping Collections ability to participate in the exchange in the long run. For TCN this lower and more informal setting may also be a mean to increase their volume- and delivery flexibility, now being able to quickly adjust and adapt to Collections ways of communication. In turn, this may help Collection in their awareness towards current challenges or delays in production, minimizing the need for rush orders, decreasing the need for added coordination, while safeguarding product- and process quality. The increased delivery- and volume flexibility could prove to have a positive effect on the number of defects experienced, severely decreasing the need for overproduction or rush order use. As a slight negative consideration, the shift in power distance may lead to too much leniency in employee involvement, thereby increasing in-house production lead time, the use of masculinity should here be used as mechanism to stabilize possible leniency. For Collection this change can become a tool to achieve less waste of time and money, asserting better decisions with fewer links and considerations. In so doing, time and money saved can be better spent elsewhere.

Having both parties adapt to a mutual state of uncertainty avoidance, production and delivery could be planned with common goals at hand. Here, understanding risks as the same phenomenon may become a crucial part of determining when rush orders are needed, as with the planning of resource availability at TCN. Being able to foresee the risks as a unit with the added benefits of lower power distance can enable TCN and Collection in making joint plans and decisions, accounting for the risks that may arise in the volatile market experienced. Whether the two companies take on an individualistic or collectivistic stance is to be seen as of little concern to the overall supply chain flexibility, as the dimensions of short-term vs long-term orientation as well as ascribed vs achieved status are seen as stronger determinants to the possible outcome. Mutual adaptation to a more short-term orientation towards time may improve coordination and performance given the current

market characteristics and situation. This change will further enable possibilities for the adjustments and agility needed in order to meet new market demands. Having both companies practicing achievement over ascribed status is seen as a strength to both parties. This would enable the promotion and advancement of individuals with a high degree of skill and specialization, while ensuring the trust of the general workforce. Having the ability to promote the most suitable candidate is seen as a direct increase towards the quality of processes, products, trust and relationships, while also strengthening the ability for inter-firm communication. Using themselves as a model for this change, TCN may inspire other suppliers to promote personnel based on their achievements, making them well suited to act as an intermediary between the companies. For TCN, having someone on the supplier side who truly understands their business, challenges and needs is seen as an increase towards retaining suppliers, thus retaining strong reconfiguration- and supply flexibility.

7.3.2 Conflicts and challenges in implementation

One of the possible downsides to the lowered power distance is that management will have to become more involved in decision-making as a group, increasing costs and decision time spent. For TCN the shift towards a higher uncertainty avoidance could prove challenging in planning and scheduling production, impacting volume- and delivery flexibility in a negative way as decisions will need more thought. For Collection this means that their use of forecasting must become even more accurate, as the flexibility of TCN is still threatened by sudden shifts in the market, even given the change towards a higher uncertainty avoidance and short-term orientation. For TCN this means that the level of planning and adjustment must become more fluid, requiring more time and money spent. While the options and flexibility that may arise from short-term orientation can be seen as obvious gains for Collection through their ability to practice better volume- and delivery flexibility, TCN may experience a decrease in these same dimensions. Loss of flexibility would here be caused by the limited possibility of making long term plans with regards to available resources and capacity. Transitioning from the use of ascribed status to of achieved may cause TCN to experience challenges in internal communication, coordination and information exchange through the loss of trust or respect. If these challenges become great enough, they have the possibility to affect flexibility within and throughout the company, threatening reconfiguration- and supply, as well as volume- and delivery flexibility.

As such it is important that the person chosen for a new position is considered competent and has a level of trust and respect amongst his or her employees.

7.4 Scenario 4 – No Adaptation

In a scenario where Collection and TCN makes no mutual adaptation towards each-others select cultural dimensions the current state of affairs remain unchanged from those outlined in Part 5 and detailed in Part 6 of this thesis.

7.5 Summary and Recommendations for Collection

As a short summary of the section above one may see that there are several up- and downsides to all scenarios presented, some of more or less impactful than others. All scenarios are however considered to be an improvement on the current situation and will regardless through their mutually shared practices have a positive effect on the supply chain flexibility. There is an established understanding that the level of increase may vary, with the goal of increased supply chain flexibility as the overall measurement the authors would rate the scenarios in the following order for recommendation:

1. Mixed adaptation
2. TCN adapts to Collection
3. Collection adapts to TCN

It is the primary recommendation of the authors that Collection and TCN makes joint efforts towards a mixed adaptation strategy in order to increase their overall supply chain flexibility. While the lowered power distance may increase both time and costs at TCN, it is considered vital in order to increase communication, information exchange as well as both process- and product quality. The mutual use of Masculinity is here seen as an opportunity to control the amount of decision time and costs spent, giving management a final say in which further deliberation is unwanted. This should ensure that time spent is still less than under current conditions. Mutual risk adaptation through uncertainty avoidance is here important in order to have the same understanding of the capabilities and limitations of each party, as well as the volatilities that may arise within the market. A common understanding of these phenomena are seen as a direct increase to volume- and delivery flexibility.

The shift towards a more short-term oriented way of thinking is closely linked to the previous section, where TCN must accept that long-term planning is an unwanted element of risk within a volatile market, an unwanted stance with their new perception of risk. Lastly there must be an element of trust between the two parties in matters that require coordination. As a mean to please both parties in this endeavour, achievements should be favoured over ascribed status. This way, both TCN and Collection may place their most competent personnel in strategic positions, increasing the likelihood of meaningful information exchange. Through this change, the added potential for volume- and delivery flexibility will be increased as well.

The scenario model for TCN and Collection is seen to be similar to the extended theoretical scenario model presented in chapter 2.4.2 on several points. However it is so that Process Quality is seen to increase under the choice of Parent Company or Mixed Adaptation, this is simply due to the low base conditions of this aspect, where TCN has *similar views* to Collection on this matter, but currently lacks the *ability* for meaningful increases.

8.0 Conclusion

This thesis finds that there is a theoretically applicable connection to the theories of supply chain flexibility and mismatched cultural dimensions that has previously been missing. These connections have resulted in two models, one simplified and one extended scenario model. From these models one can see that how cultural dimensions are perceived and practiced have a direct impact on the time spent, the costs involved and the achievable quality of products and processes at both the parent company and the subsidiary within a global internal supply chain. The models and theoretical connections within this thesis are seen to close this theoretical gap.

Data analysis has been used in order to determine where and how Collection and TCN are affected by the mismatched perceptions of cultural dimensions. This analysis has revealed several points of weakness and potential improvement that could help Collection and TCN in practicing better supply chain flexibility. The findings are a good fit to several points of the simplified model within the thesis.

The models have further been applied in order to identify how Collection and TCN may use a variety of different cultural adaptation strategies in order to better retain supply chain flexibility. One common trait to all adaptation strategies presented within this thesis is the fact that they are considered to increase supply chain flexibility simply by forcing both parties to adhere to the same conditions. This is proof that the choice of common measures is more impactful than the choice of adaptation strategy in itself. For Collection, the most rewarding choice towards lessening the impacts on supply chain flexibility at their Xiamen facility is seen as a Mixed Adaptation strategy. Use of this strategy will decrease time, costs, and the need for coordination while increasing quality of both products and processes. Following this strategy for adaptation will in turn increase the achievable supply chain flexibility. The practical use of the scenario model on TCN and Collection has proved to be a close match to the initial assumptions, with exception of the aspect of process quality, which is seen to strongly increase when choosing the Parent Company or Mixed Adaptation strategy.

9.0 Further Research and Limitations

As this thesis was limited by time and scope an overview of suggested further research and the limitations of the results within are presented below:

The first point of further research should concentrate on the wide-spread effects of recommendations across the supply chain in connection with all SC2020 projects, this would take the case study from embedded to holistic in design. A second point of interest could here be the following unexplored question: "Are modules found faulty as part of final assembly at TPAS and are they sent back for repairs?". The amount of time spent between first and final test are currently subject to speculation as there is a small possibility that modules are not discovered faulty until they are tested as part of the final machine assembly at TPAS (Aspenes 2017). As both a limitation and point of further research it is so that the authors have fallen in the "trap" outlined by the theory on scenario analysis, in which very unlikely events have been dismissed entirely when dealing with the data and the future outcomes presented in Part 7. The reasoning for this reluctance to discuss such unlikely events were that they could enter the areas of dystopias, removing the basis of facts. An interesting way forward could also be to determine the exact position and relations of TCN and Collection on the scales of cultural dimensions to ease adaptation further and present even more detailed scenarios. Combining this effort with a broader use of both cultural- and flexibility dimensions could here be a tool as to find additional relevant data to consider in further scenario building. As there has been placed less emphasis on the correction of forecasting methods within this thesis, an interesting angle could be to explore in what way a restructured order horizon stands to impact flexibility for both TCN and Collection.

A primary limitation of this thesis is that it only explores data for 1 of 27 modules, expansions to more modules should be done to get a further refined relationship to the presented results in Part 5 and to challenge the assumption of equal variation across all modules assembled. As with all case studies it is so that the results are highly limited to the case company and their conditions, this should be taken into consideration if the methods and models are to be used in other academic circumstances.

10.0 References

Aprile, D., Garavelli, A. C., & Giannoccaro, I. (2005). Operations planning and flexibility in a supply chain. *Production Planning & Control*, *16*(1), 21–31. https://doi.org/10.1080/09537280412331313348

Arbnor, I., & Bjerke, B. (2009). *Methodology for creating business knowledge* (3rd ed). Los Angeles ; London: SAGE.

Aspenes, I. K. (2017, January 10).

Aspenes, I. K. (2017, May 2).

Aspenes, I. K., & Rekdal, E. (2016, October 21).

Aspenes, I. K., & Sæther, E. (2017, February 3).

Aspenes, I. K., & Traa, B. (2017, March 9).

Bryman, A., & Bell, E. (2011). *Business research methods* (3rd ed). Cambridge ; New York, NY: Oxford University Press.

Bryman, A., & Bell, E. (2015). *Business research methods* (Fourth edition). Cambridge, United Kingdom ; New York, NY, United States of America: Oxford University Press.

Corbin, J. M., & Strauss, A. L. (2008). *Basics of qualitative research: techniques and procedures for developing grounded theory* (3rd ed). Los Angeles, Calif: Sage Publications, Inc.

De Toni, A., & Tonchia, S. (1998). Manufacturing flexibility: A literature review. *International Journal of Production Research*, *36*(6), 1587–1617. https://doi.org/10.1080/002075498193183

Duclos, L. K., Vokurka, R. J., & Lummus, R. R. (2003). A conceptual model of supply chain flexibility. *Industrial Management & Data Systems; Wembley*, *103*(5/6), 446–456.

Fayezi, S., Zutshi, A., & O'Loughlin, A. (2015). How Australian manufacturing firms perceive and understand the concepts of agility and flexibility in the supply chain. *International Journal of*

Operations & Production Management, *35*(2), 246–281. https://doi.org/10.1108/IJOPM-12-2012-0546

Fayezi, S., Zutshi, A., & O'Loughlin, A. (2016). Understanding and Development of Supply Chain Agility and Flexibility: A Structured Literature Review: Supply Chain Agility and Flexibility. *International Journal of Management Reviews*, n/a-n/a. https://doi.org/10.1111/ijmr.12096

Fisher, M., Hammond, J., Obermeyer, W., & Raman, A. (2009). Configuring a Supply Chain to Reduce the Cost of Demand Uncertainty. *Production and Operations Management*, *6*(3), 211–225. https://doi.org/10.1111/j.1937-5956.1997.tb00427.x

Foss, E. (2017, January 10).

Hanevold, G. (2017, January 9).

Hartl, B. (2014). Cross Cultural Competence Log 904 – Seminar Series in Logistics 2014 READER.

Hartl, B. (2016). Cross-Cultural Competence.

Hofstede, G. (1983). The cultural relativity of organizational practices and theories. *Journal of International Business Studies (Pre-1986); Atlanta*, *14*(2), 75.

Hofstede, G. H., Hofstede, G. J., & Minkov, M. (2010). *Cultures and organizations: software of the mind: intercultural cooperation and its importance for survival* (3rd ed). New York: McGraw-Hill.

Hox, J. J., & Boeije, H. R. (2005). Data Collection, Primary vs. Secondary. *Encyclopedia of Social Measurement*, 593–599. https://doi.org/10.1016/B0-12-369398-5/00041-4

Irwin, J. (2012). Doing Business in China: An overview of ethical aspects. Retrieved from http://www.ibe.org.uk/userfiles/chinaop.pdf

Johnson, J., & Tellis, G. J. (2008). Drivers of Success for Market Entry into China and India. *AMA American Marketing Association*. Retrieved from http://gtellis.net/Publications/ChinaIndia.pdf

Jüttner, U., Christopher, M., & Baker, S. (2004). *Demand chain management – integrating marketing and supply chain management industrial marketing management, vol.36(3) april 2007, 377-392.* Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=D6FBA19F43F06F051FD8D8123D573D54?doi=10.1.1.129.928&rep=rep1&type=pdf

Krajewski, L., Wei, J. C., & Tang, L.-L. (2005). Responding to schedule changes in build-to-order supply chains. *Journal of Operations Management*, *23*(5), 452–469. https://doi.org/10.1016/j.jom.2004.10.006

Lambert, D. M., Emmelhainz, M. A., & Gardner, J. T. (1996). Developing and Implementing Supply Chain Partnerships. *The International Journal of Logistics Management*, *7*(2), 1–18. https://doi.org/10.1108/09574099610805485

Lee, H. L. (2004, October 1). The Triple-A Supply Chain. Retrieved 21 November 2016, from https://hbr.org/2004/10/the-triple-a-supply-chain

Mathisen, N. (2017, January 9).

Mattsson, S.-A. (2000). *Embracing change: management strategies in the e-economy era*. Danderyd: Intentia Publ.

Mattsson, S.-A. (2002). *Logistik i försörjningskedjor*. Lund: Studentlitteratur.

Meinert, S. (2014). Field manual - Scenario building (p. 32). ETUI. Retrieved from http://www.etui.org/content/download/13953/114820/file/2014_Scenario_Building_DEF.pdf

Mentzer, J. T. (2004). *Fundamentals of supply chain management: twelve drivers of competitive advantage*. Thousand Oaks, Calif: Sage Publications.

Merriam-Webster. (n.d.-b). Definition of CULTURE. Retrieved 7 March 2017, from https://www.merriam-webster.com/dictionary/culture

Naylor, J. B., Naim, M. M., & Berry, D. (1999). Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. *International Journal of Production Economics*, *62*(1–2), 107–118. https://doi.org/10.1016/S0925-5273(98)00223-0

Østby, T. (2017, January 9).

Panko, R. R. (n.d.). Basic Error Rates. Retrieved 2 April 2017, from http://panko.shidler.hawaii.edu/HumanErr/Basic.htm

Paur, J.-H. (2017, January 9).

Payne, G., & Payne, J. (2004). *Key Concepts in Social Research*. SAGE.

Porter, A., Cunningham, S. W., & Banks, J. (2011). *Forecasting and management of technology*. Hoboken, N.J.: Wiley. Retrieved from https://ebookcentral.proquest.com/lib/moldebib-ebooks/reader.action?docID=693201

Postma, T. J. B. M., & Liebl, F. (2005). How to improve scenario analysis as a strategic management tool? *Technological Forecasting and Social Change*, *72*(2), 161–173. https://doi.org/10.1016/j.techfore.2003.11.005

Rahman, A., Nizam, M., Ho, C. K., Jamian, R., Ramli, N. F., & Cherng, N. M. (2012). Comparative Study of Manufacturing Strategy between Japanese and Western Approaches: An Overview. *Jurnal Kejuruteraan*, *24*, 35–43.

Rainbird, M. (2004). Demand and supply chains:the value catalyst. *International Journal of Physical Distribution & Logistics Management*, *34*(3/4), 230–250. https://doi.org/10.1108/09600030410533565

Sæther, E. (2017, January 10).

Sánchez, A., & Pérez, M. (2005). Supply chain flexibility and firm performance: A conceptual model and empirical study in the automotive industry. *International Journal of Operations & Production Management*, *25*(7), 681–700. https://doi.org/10.1108/01443570510605090

Sharifi, H., & Zhang, Z. (2000). A methodology for achieving agility in manufacturing organisations. *International Journal of Operations & Production Management*, *20*(4), 496–513. https://doi.org/10.1108/01443570010314818

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2008). *Designing and managing the supply chain: concepts, strategies, and case studies* (3. ed., internat. student ed). Boston, Mass.: McGraw-Hill/Irwin.

Siu, O. (2003). Job stress and job performance among employees in Hong Kong: The role of Chinese work values and organizational commitment. *International Journal of Psychology*, *38*(6), 337–347. https://doi.org/10.1080/00207590344000024

Stevenson, M., & Spring, M. (2007). Flexibility from a supply chain perspective: definition and review. *International Journal of Operations & Production Management*, *27*(7), 685–713. https://doi.org/10.1108/01443570710756956

Suarez, F. F., Cusumano, M. A., & Fine, C. H. (1996). An empirical study of manufacturing flexibility in printed c. *Operations Research; Linthicum*, *44*(1), 223–240.

Swafford, P., Ghosh, S., & Murthy, N. (2006). The antecedents of supply chain agility of a firm: Scale development and model testing. *Journal of Operations Management*, *24*(2), 170–188. https://doi.org/10.1016/j.jom.2005.05.002

Terpstra, V., & David, K. H. (1985). *The cultural environment of international business* (2nd ed). Cincinnati: South-Western Pub. Co.

The Economist. (2012, March). The end of cheap China. *The Economist*. Retrieved from http://www.economist.com/node/21549956

TOMRA. (n.d.-a). Business Strategy TOMRA. Retrieved 26 October 2016, from https://www.tomra.com/en/about-us/business-strategy/

TOMRA. (n.d.-b). History TOMRA. Retrieved 26 October 2016, from https://www.tomra.com/en/about-us/history/

TOMRA Systems ASA. (2016). *TOMRA Investor Presentation*.

Trompenaars, A., & Hampden-Turner, C. (2012). *Riding the waves of culture: understanding diversity in global business* (Rev and updated 3rd ed). New York: McGraw-Hill.

Viswanadham, N., & Srinivasa Raghavan, N. R. (1997). Flexibility in manufacturing enterprises. *Sadhana*, *22*(2), 135–163. https://doi.org/10.1007/BF02744486

Wadhwa, S., Saxena, A., & Chan, F. T. S. (2008). Framework for flexibility in dynamic supply chain management. *International Journal of Production Research*, *46*(6), 1373–1404. https://doi.org/10.1080/00207540600570432

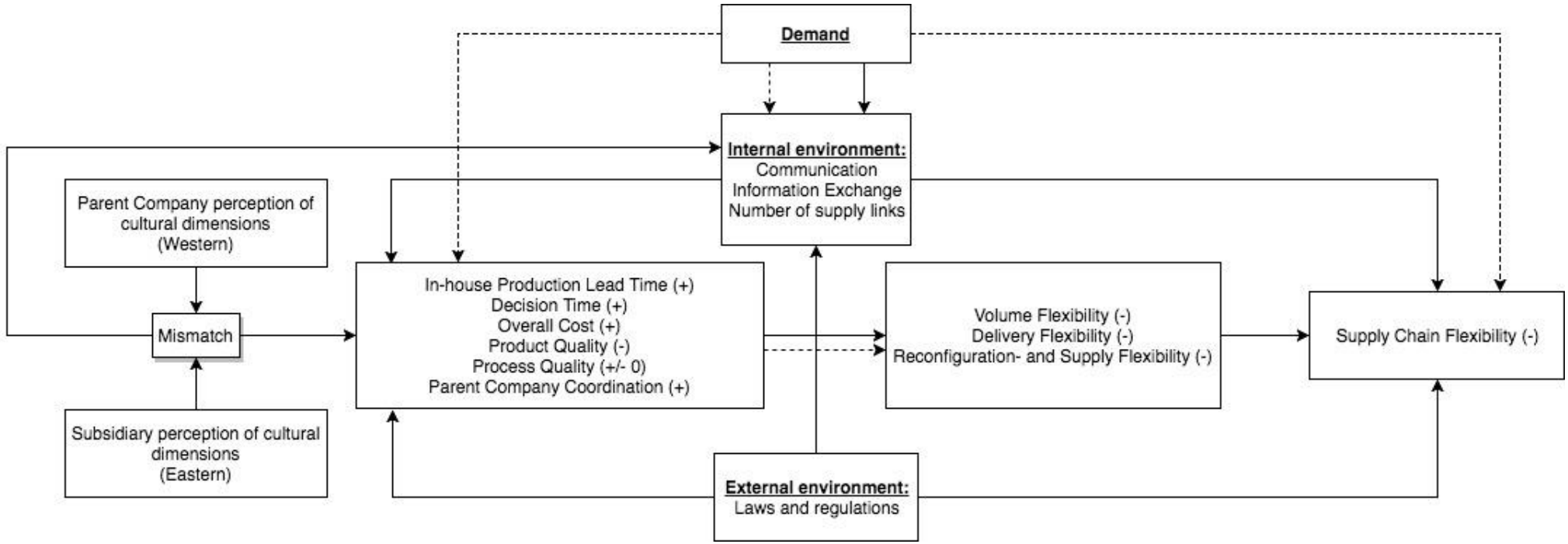
Yin, R. K. (2014). *Case study research: design and methods* (Fifth edition). Los Angeles: SAGE.

Zhang, D. Z. (2011). Towards theory building in agile manufacturing strategies—Case studies of an agility taxonomy. *International Journal of Production Economics*, *131*(1), 303–312. https://doi.org/10.1016/j.ijpe.2010.08.010

Zhang, Q., Vonderembse, M. A., & Lim, J.-S. (2003). Manufacturing flexibility: defining and analyzing relationships among competence, capability, and customer satisfaction. *Journal of Operations Management*, *21*(2), 173–191. https://doi.org/10.1016/S0272-6963(02)00067-0

11.0 Appendices

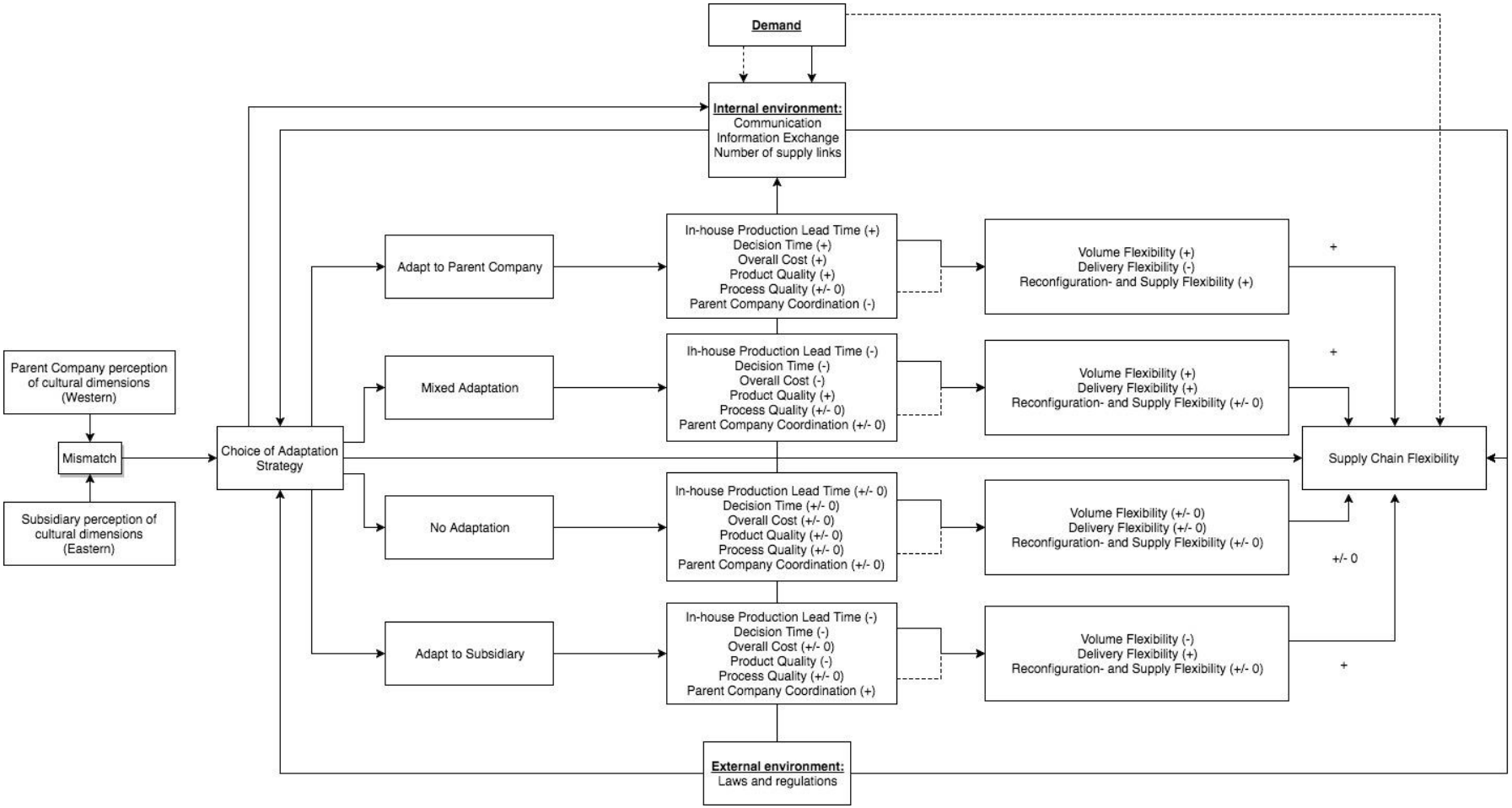
Appendix 1 – Simplified model (Full scale)



+ : General increase, +/- 0 : Sustained (No general increase or decrease from base conditions), - : General decrease

----: Indirect effect, _____: Direct effect

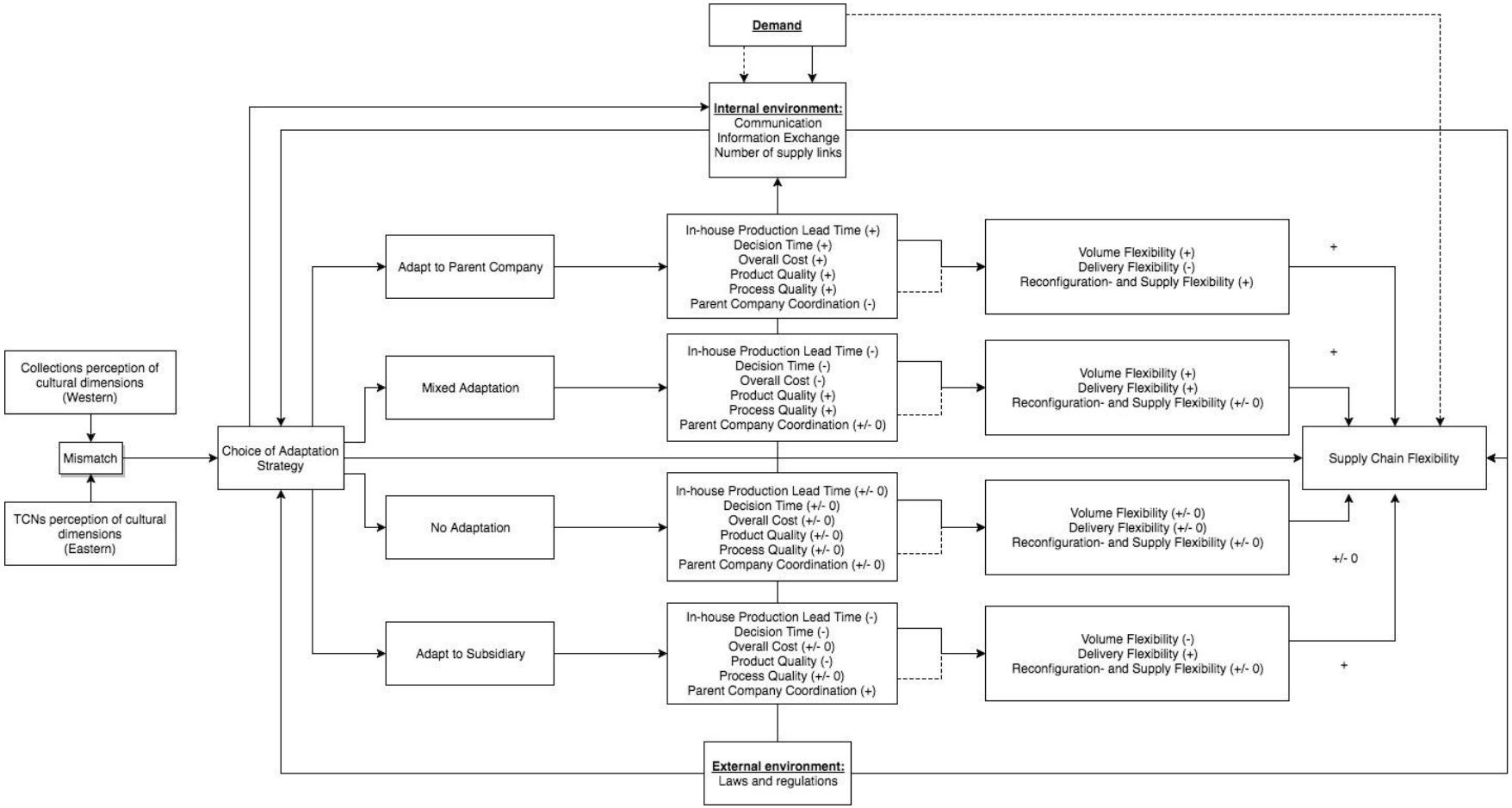
Appendix 1 cont. – Extended scenario model (Full scale)



+ : General increase, +/- 0 : Sustained (No general increase or decrease from base conditions), - : General decrease

----: Indirect effect, _____: Direct effect

Appendix 2 – Scenario Model for TCN and Collection (Full scale)



+ : General increase, +/- 0 : Sustained (No general increase or decrease from base conditions), - : General decrease

----: Indirect effect, _____: Direct effect

Appendix 3 - Interview Guide

Below, the interview guide for this thesis is presented, it details the person(s) to be interviewed, the format of the interview and the questions presented beforehand (if present).

Date	Respondent(s)	Position	Interview format
21.10.2016	Aspenes, Ida K. Rekdal, Even	Purchasing Analyst Vice President Supply Chain	Personal attendance at Molde University College by the respondents
09.01.2017	Østby, Thomas	Technical Product Support Director	Personal attendance at TOMRA Productions (TPAS) by the authors
09.01.2017	Hanevold, Geir	Managing Director TPAS	Personal attendance at TOMRA Productions (TPAS) by the authors
09.01.2017	Paur, Jan-Henrik	Purchaser TPAS	Personal attendance at TOMRA Productions (TPAS) by the authors
09.01.2017	Mathisen, Nina	Purchasing Director	Personal attendance at TOMRA Collection Solutions by the authors
10.01.2017	Foss, Eirik	Director Orders and Shipment	Personal attendance at TOMRA Collection Solutions by the authors
10.01.2017	Sæther, Ellen	Manager Strategic Sourcing	Personal attendance at TOMRA Collection Solutions by the authors
10.01.2016	Aspenes, Ida K.	Purchasing Analyst	Personal attendance at TOMRA Collection Solutions by the authors
03.02.2017	Sæther, Ellen Aspenes, Ida K.	Manager Strategic Sourcing Purchasing Analyst	Conference call
09.03.2017	Aspenes, Ida K. Traa, Bente	Purchasing Analyst Project Manager	Conference call
02.05.2017	Aspenes, Ida K.	Purchasing Analyst	Conference call

Friday, October 21 - 2016

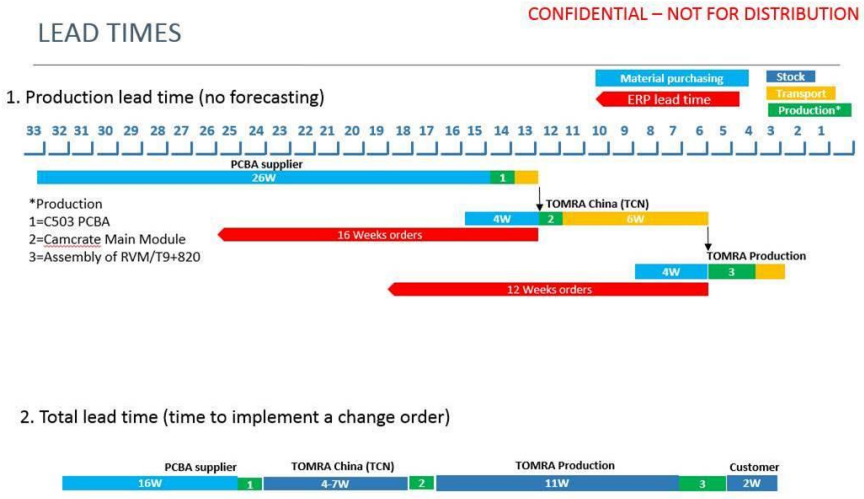
No specific set of questions were produced for this first meeting as its purpose was an initial presentation of Collection and the subject for the thesis. Notes were later used as a base for the first official interviews on January 9 and 10, 2017.

Monday, January 9 and Tuesday, January 10 - 2017

The following set of questions were used in the interviews performed at Collection on Monday 09.01 and Tuesday 10.01. Each respondent was asked the same base questions, while follow-up questions were adapted as the interview progressed.

Intervjuspørsmål TOMRA

1. Hvordan er deres supply chain strukturert?
2. Hvilke utfordringer møter dere i deres supply chain?
3. Hva var bakgrunnen for å outsource produksjonen?

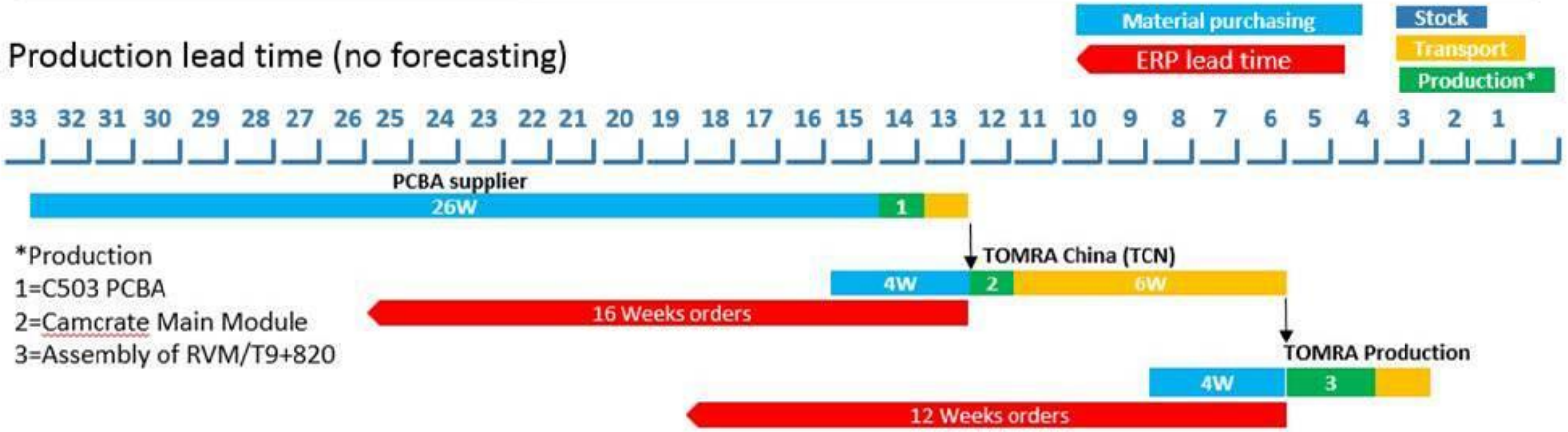


Med fokus på figuren over:

4. Hvordan arbeides det for å kartlegge nødvendig ledetid?
5. Hvilke systemer finnes for utveksling av informasjon mellom partene?
6. Hvilke utfordringer møter dere innenfor ledetid?
7. Hva er den største utfordringen for å gjennomføre endringer i en ordre?
8. Hvordan beregnes kostnaden for èn dag og èn uke utsatt ledetid?

LEAD TIMES

1. Production lead time (no forecasting)



2. Total lead time (time to implement a change order)

Friday, February 03 - 2017

1. Hva er ledetiden fra komponentleverandør inn til PCBA Supplier?
2. Hva er ledetiden fra PCBA Supplier til TCN?
3. Hvilke policyer finnes for sikkerhetslager?
    a. Hvor store er disse lagrene?
    b. Hvor er de lokalisert?
    c. Hvordan reguleres disse lagrene? (bruk og oppbygning)
    d. Hva er kostnaden av disse sikkerhetslagrene?
    e. Angående policyen for sikkerhetslager som er del av risikovurderingen: Slik vi har forstått det gjør denne policyen at både TCN og TPAS har sikkerthetslager i tilfelle dårlige varer eller varer tapt på sjøen. Dersom det kunne utdypes hvordan denne fungerer hadde dette vært til stor hjelp
4. Hva er årlig volum fra komponentleverandør til PCBA Supplier?
5. Hva er årlig volum fra PCBA Supplier til TCN?
6. Hva er MOQ fra komponentleverandør til PCBA Supplier?
7. Hva er MOQ fra PCBA Supplier til TCN?
8. Hvordan fungerer kommunikasjonen mellom partene i Kina, TCN og deres underleverandører?
9. Hvor mange hasteordre håndterer TCN på årlig og månedlig basis?
    a. Hva er beregnet kostnad på disse?
    b. Hvordan holdes det oversikt over antallet ordre?
    c. Hva skal til for å utløse flyfrakt som løsning på en hasteordre?

Friday, February 3 cont.

1. Hva er total produksjonstid for en modul? Fra mottatt råvare til ferdig modul før test. Per dagens dato har vi kun ”dødtiden” en modul tilbringer på gulv i påvente av test.
2. Hva koster modulen i sin helhet? Gjerne også brutt ned i antall komponenter og kost per komponent
3. Hvilket internsystem for ERP benyttes i Kina?
4. Hvor monteres kretskortet i modulen, Lier eller Kina? Dette har vært noe uklart for oss
5. Hvor mye av kapasiteten til produksjon er utnyttet og hvor mye ledig kapasitet finnes?
6. Hvor mye av kapasiteten til testing er utnyttet og hvor mye ledig kapasitet finnes?
7. Hva er normale årsaker til at en modul må testes på nytt?
8. Benyttes produksjonsarbeidere også til testingen slik at de må sette ned tempo på produksjonen for å ha tid til å utføre nok tester for å levere?
9. Hvor mange moduler må være klare per shipment? Et standard antall vil her ansees interessant for utvikling av ulike scenarioer.
10. Finnes det en ordrekostnad? Kostnad for å legge inn ordre
11. Finnes det informasjon på NÅR TCN starter produksjon av modul etter FAKTISK ORDRE er mottatt?

Wednesday, March 9 - 2017

A conference call was here initated in order to clarify direction and scope of the thesis, as well as the *current* progression. Although no formal interview questions were asked, a short summary is here made available:

1. Oppgaven har tatt retning av å se hvordan de kulturelle forskjellene mellom TOMRA (Vestlig) og TCN (Østlig) påvirker fleksibiliteten i TCN

2. Det er tatt en avgjørelse at alle avvik som er del av oppgaven skal ha påvirkning eller innvirkning på ett eller flere av tre områder definert i fleksibilitetsteorien: Tid, Kostnad og Kvalitet.

Avvikene det vil fokuseres på for denne oppgaven spesifikt er de som kan identifiseres fra datagrunnlaget + de som er fortalt oss gjennom intervjuer og oppfølgings-samtaler, per dagens dato er disse:

Ledetiden i SC (Mindre del)
Produksjonsmetoder og planlegging
Antall re-test/defekter + Tiden mellom første og siste test
Forholdet mellom TCN, TOMRA og suppliers (Mindre del)
Hasteordre (Mindre del)
Forecasting

3. Det er fortsatt for tidlig for oss å spekulere på mulige løsninger ettersom analyse av data og implikasjoner av denne er avhengig av de modeller og den teori oppgaven befatter seg med. Det er derfor kun satt en løsnings-modell basert på scenarioanalyse, hvor aspekter vil diskuteres etter «hva hvis» prinsippene.

Eks: «Hva skjer dersom antallet defekter reduseres med 90%?»

4. Veien videre for oss går mot å finne en modell som kan benyttes til å analysere de avvik som er identifisert og betydningen av disse (impact), samt innsamling av teori og videre dataanalyse.

Tuesday, May 2 – 2017

No predetermined questions were set for this conference call as the subject was feedback on the 1st draft of the thesis and the results within. Necessary changes with regards to confidentiality were discussed and approval was given for the thesis.

Appendix 4 - Replication guide for Dataset

This replication guide is meant as a tool for reconstruction of the data-material used in this thesis. Using the guide will help in replication of Part 5 and contains the justifications and decisions made in order to construct the data sources. When done, the document should be identical to that of "Final Results.xlsx", provided as a mean of confirmation.

Final Results.xlsx was constructed from the following documents:

NEWCamcrate vs PCBA 15_16.xlsx

Description of data - SC2020 Tomra.docx

Final Results.xlsx contains the following work sheets:

0. *Report name*
1. *China only*
2. *Duplicated Serials - No removal*
3. *Unique serials*
4. *Duplicated serials*
5. *Re-test*
6. *Production Planning and Method*
7. *Summary*
8. *Flow*

Re-creation of the file Final Results.xlsx is reliant on the following base file:

NEWCamcrate vs PCBA 15_16.xlsx

IMPORTANT: When launching the base- and confirmation files, make sure to <u>IGNORE ALL DATA-CONNECTIONS</u> if prompted.

<u>OBS:</u> All references to number of lines are made in the following format (XXXX – 1) as the top line is the headers. If the guide states that you should have 4000 lines in a column, the entire column will be 4001 lines long, but the top line is here subtracted for clarification.

Stage 0: Making the values meaningful

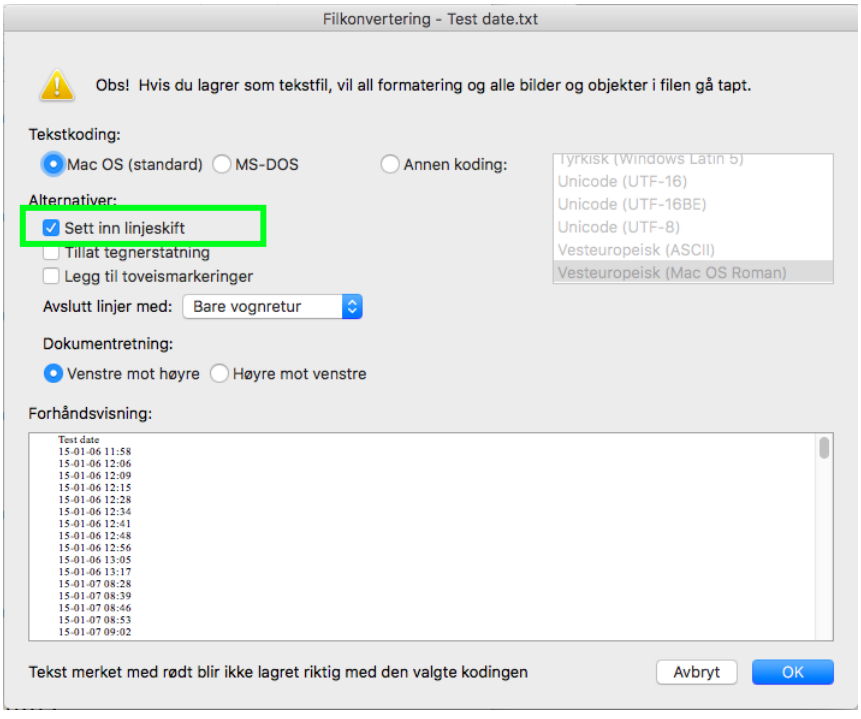
You will notice that the "report" sheet of *NEWCamcrate vs PCBA 15_16.xlsx* contains a different order to the columns than our Final Results.xlsx document.

1. Make sure your document conforms to the following structure

A	B	C	D	E	F	G	H
Manufacturer	**Part type**	**Serial**	**Name**	**Value**		**Test date**	

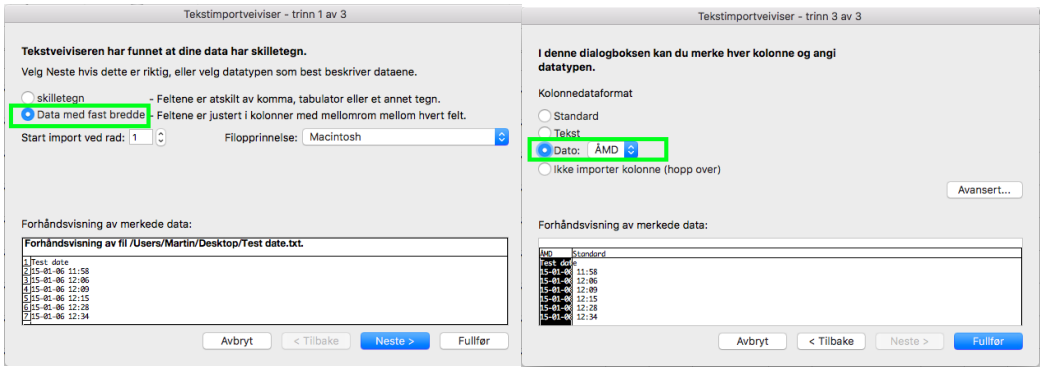
Make sure that columns F and H are blank.

2. Copy the entire E column (value) into a word document and save it in .txt format, with the name "Production Date" making sure to select the LINE SHIFT alternative in saving the document, this will be the base for our Production Date column in the finished file:



3. Do the same for the G column, this will be the base for our Test Date column in the finished file.

4. Delete columns E and G in your sheet, you should now only have values in the A – D columns.
5. In order to separate the time-stamps from the Production Date, import the .txt file in which you saved the data from the E column back into excel using the "From text" function in the "Data" tab.



6. Import Test Date into the G column, time-stamps for both variables should place themselves in columns F and H respectively, these columns may now be deleted so that Production Date can become column E and Test Date become column F. Sort the sheet after Serial.

Your file should now look like the one below and contain 7394 lines (7395 – 1). The file is now ready for Stage 1.

	A	B	C	D	E	F	G
1	**Manufacturer**	**Part type**	**Serial**	**Name**	**Production Date**	**Test date**	
2	Tomra China	Module CamCrate Main	50152124-06433	hw tags:FUNTEST_C503	08.12.2014	06.01.2015	
3	Tomra China	Module CamCrate Main	50152124-06434	hw tags:FUNTEST_C503	09.12.2014	06.01.2015	
4	Tomra China	Module CamCrate Main	50152124-06434	hw tags:FUNTEST_C503	09.12.2014	06.01.2015	
5	Tomra China	Module CamCrate Main	50152124-06435	hw tags:FUNTEST_C503	09.12.2014	06.01.2015	
6	Tomra China	Module CamCrate Main	50152124-06435	hw tags:FUNTEST_C503	09.12.2014	06.01.2015	
7	Tomra China	Module CamCrate Main	50152124-06436	hw tags:FUNTEST_C503	09.12.2014	06.01.2015	
8	Tomra China	Module CamCrate Main	50152124-06437	hw tags:FUNTEST_C503	08.12.2014	06.01.2015	
9	Tomra China	Module CamCrate Main	50152124-06438	hw tags:FUNTEST_C503	08.12.2014	06.01.2015	
10	Tomra China	Module CamCrate Main	50152124-06439	hw tags:FUNTEST_C503	09.12.2014	06.01.2015	
11	Tomra China	Module CamCrate Main	50152124-06440	hw tags:FUNTEST_C503	08.12.2014	06.01.2015	
12	Tomra China	Module CamCrate Main	50152124-06441	hw tags:FUNTEST_C503	08.12.2014	06.01.2015	
13	Tomra China	Module CamCrate Main	50152124-06442	hw tags:FUNTEST_C503	08.12.2014	07.01.2015	
14	Tomra China	Module CamCrate Main	50152124-06443	hw tags:FUNTEST_C503	08.12.2014	07.01.2015	

Stage 1: Removing test series and TOMRA Production (TPAS) from the dataset.

Sort the sheet on the Serial column. Serials ranging from 50152124-00001 to 50152124-01550 should not be considered, as these are part of a test series and can not be accounted for in a safe manner. Serials with values in the range 50152124-00001 to 50152124-01550 (A39:F39) should here be deleted and the Manufacturing tab should be set only to filter "Tomra China", in order to secure the data, copy them into a separate sheet, name this sheet "China only". Successful replication of stage 1 should yield the same results as the "China only" sheet in the file Final Results.xlsx, the sheet should contain 7215 lines (7216 – 1).

Stage 2: Setting aside duplicated values

Your current "China only" sheet will have several duplicated values within and should at this point contain 7215 lines (7216 – 1). In order to remove duplicated values from the dataset, we will use "Conditional Formatting" in the "Home" tab. By using the "Mark cells" and "Duplicated Values" in column C, all duplicated values can be seen as pink cells, sorting these cell at the top of the sheet. Copy all pink cells into a new sheet, name the sheet "Duplicated Serials". Go back to the "China only" sheet and delete all cells that are pink. You should now be left with 4733 (4734 – 1) lines, as an extra precaution, check that no duplicated values are left in the C column by running the "Conditional formatting" check for duplicates once more. You may now copy the remaining lines from "China only" into a new sheet, name this sheet "Unique Serials", this sheet should contain 4733 (4734-1) lines. As a precaution one might want to copy this sheet and name it "Duplicated Serials – No removals" as a mean to have a fresh start, should something unexpected happen.

Stage 3: Removing Dirty Data from the Duplicated Serials sheet

In order to get an as accurate representation of how many times a module has been subject to re-testing, dirty data must be removed from the "Duplicated Serials" sheet. To make the calculations, only multiple instances of modules with the *exact same* serial number and *production date* are to be kept. Modules that do not conform to this description are to be deleted.

A practical example:

As can be seen below, the module with serial 50152124-01572 conforms to the specifications above, this module has been registered 3 times with the same serial number and identical production dates and should be **kept**. Further down the list, module 50152124-02855 has 4 registries, but only 3 conforms to the same production date, as a consequence, the fourth entry is deleted.

A	B	C	D	E	F
Manufacturer	**Part type**	**Serial**	**Name**	**Prod Date**	**Test date**
Tomra China	Module CamCrate Main	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	19.08.2016
Tomra China	Module CamCrate Main	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	19.08.2016
Tomra China	Module CamCrate Main	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	25.08.2016
Tomra China	Module CamCrate Main	50152124-01888	hw tags:FUNTEST_C503	30.08.2012	06.11.2015
Tomra China	Module CamCrate Main	50152124-01888	hw tags:FUNTEST_C503	30.08.2012	12.04.2016
Tomra China	Module CamCrate Main	50152124-02186	hw tags:FUNTEST_C503	07.02.2013	02.07.2015
Tomra China	Module CamCrate Main	50152124-02186	hw tags:FUNTEST_C503	07.02.2013	02.07.2015
Tomra China	Module CamCrate Main	50152124-02489	hw tags:FUNTEST_C503	04.03.2013	25.08.2016
Tomra China	Module CamCrate Main	50152124-02489	hw tags:FUNTEST_C503	04.03.2013	26.08.2016
Tomra China	Module CamCrate Main	50152124-02520	hw tags:FUNTEST_C503	19.03.2013	29.02.2016
Tomra China	Module CamCrate Main	50152124-02520	hw tags:FUNTEST_C503	19.03.2013	29.02.2016
Tomra China	Module CamCrate Main	50152124-02520	hw tags:FUNTEST_C503	19.03.2013	29.02.2016
Tomra China	Module CamCrate Main	50152124-02520	hw tags:FUNTEST_C503	19.03.2013	29.02.2016
Tomra China	Module CamCrate Main	50152124-02855	hw tags:FUNTEST_C503	02.07.2013	06.03.2015
Tomra China	Module CamCrate Main	50152124-02855	hw tags:FUNTEST_C503	02.07.2013	06.03.2015
Tomra China	Module CamCrate Main	50152124-02855	hw tags:FUNTEST_C503	02.07.2013	06.03.2015
Tomra China	Module CamCrate Main	50152124-02855	hw tags:FUNTEST_C503	28.02.2013	06.03.2015
Tomra China	Module CamCrate Main	50152124-03211	hw tags:FUNTEST_C503	10.08.2013	05.03.2015
Tomra China	Module CamCrate Main	50152124-03211	hw tags:FUNTEST_C503	10.08.2013	13.10.2015
Tomra China	Module CamCrate Main	50152124-03211	hw tags:FUNTEST_C503	10.08.2013	12.04.2016
Tomra China	Module CamCrate Main	50152124-03743	hw tags:FUNTEST_C503	27.10.2013	02.07.2015
Tomra China	Module CamCrate Main	50152124-03743	hw tags:FUNTEST_C503	27.10.2013	02.07.2015
Tomra China	Module CamCrate Main	50152124-03937	hw tags:FUNTEST_C503	18.11.2013	08.06.2015
Tomra China	Module CamCrate Main	50152124-03937	hw tags:FUNTEST_C503	18.11.2013	13.10.2015
Tomra China	Module CamCrate Main	50152124-04018	hw tags:FUNTEST_C503	19.11.2013	12.04.2016

If a module has two or more entries with the *same* serial number, but *different* production dates for all entries, the <u>entire</u> modules is removed.

In instances where two identical serial numbers appear multiple times, but has different production dates they are labelled XXXXXXXX-XXXXXa/b/c respectively and treated as separate modules.

				Prod Date
Tomra China	Module CamCrate Main	50152124-05978a	hw tags:FUNTEST_C503	16.07.2014
Tomra China	Module CamCrate Main	50152124-05978a	hw tags:FUNTEST_C503	16.07.2014
Tomra China	Module CamCrate Main	50152124-05978b	hw tags:FUNTEST_C503	04.03.2013
Tomra China	Module CamCrate Main	50152124-05978b	hw tags:FUNTEST_C503	04.03.2013
Tomra China	Module CamCrate Main	50152124-05978b	hw tags:FUNTEST_C503	04.03.2013

The end result for this cross-check for the authors left 2341 (2342 – 1) lines in the "Duplicated Serials" sheet.

Stage 4: Calculating the time between first and final test for a module

Calculation of time between first and final test for modules should be done in the "Duplicated Serials" sheet, after the following criteria. Here, the date of the last test is seen up against the date of the first test for each unique module, measuring the difference. A smaller sample of serial numbers should be focused upon for three main time periods:

1. PCBAs produced before 2015 (Prod date 2012 – 2014)
2. PCBAs produced in 2015 (Prod date 2015)
3. PCBAs produced in 2016 (Prod date 2016)

Manufacturer	Part type	Serial	Name	Prod date	Test date	Days between first and final test
Tomra China	Module CamCrate	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	25.08.2016	
Tomra China	Module CamCrate	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	19.08.2016	
Tomra China	Module CamCrate	50152124-01572	hw tags:FUNTEST_C503	29.08.2012	19.08.2016	6
Tomra China	Module CamCrate	50152124-01888	hw tags:FUNTEST_C503	30.08.2012	12.04.2016	
Tomra China	Module CamCrate	50152124-01888	hw tags:FUNTEST_C503	30.08.2012	06.11.2015	158

As in the example above, module 50152124-01572 has been tested 3 times over a period of 6 days, while module 50152124-01888 has been tested 2 times over a period of 158 days.

Stage 5: Average number of tests per module and proportion of re-test

In order to see how many unique serial numbers are present in the "Duplicated Serials" sheet, a pivot table sorted on the column "Serial" should be constructed, observations should be unfiltered, revealing 859 unique values totalling 2341 observations. The sum of 2341 is the collective number of tests the 859 units have been subject to. Each of the 859 modules will have been tested 2 or more times, this can be confirmed by using the MIN and MAX commands of Excel to find the smallest and largest number of tests a module has been subject to. Minimum should here be 2 tests and maximum should be 13, as 2 tests are an indication of re-testing we can now be sure that all modules present have been tested more than once. If the cell for MIN states less than 2, locate this serial number and delete it from the "Duplicated Serials" sheet, then update the pivot table.

From Stage 2 we have proven that there are 4733 unique modules in the full dataset, as we have now proven that 859 unique modules were re-tested we can calculate the mean number of tests per module, as well as the percentage and average number of modules sent for re-testing based on the collective sum of 4733 + 859 = 5592. As the mean number of tests are based on the previous manual operation of the dataset, a 1,5% correction should be made to this value (aka corr.). Mean number of tests performed should be constructed from the "Average" command in Excel and give the answer of 2,73 (corr. 2,68) ≈ 3, another way to find this average is by dividing the total number of tests on the number of unique modules; 2341 / 859 = 2,73 ≈ 3 tests on average per module. The proportion of modules being tested more than once can be seen as 859 of 5592 modules; 5592 / 859 = 6,5 ≈ 7, this would indicate that every 7th module in the *total* datasheet has been re-tested. Expressed as a percentage of the total number of unique modules, this proportion is equal to 15,36% of all modules. Average number of re-tests for 2015 and 2016 is the average sum of values for test dates for each respective year in the pivot table.

Stage 6: PCBAs and modules produced in relation to number of tests performed

In order to calculate how many tests of the total tests performed that can be considered re-tests, a chart must be made. This chart is based on the following data:

Number of PCBAs and modules produced	5592	
Number of first time tests	4733	
Number of re-tests	2341	33,09 %
Total tests	7074	

Number of PCBAs and modules produced is here the sum of the 859 unique modules found to be re-tested on top of the unique modules that were not re-tested (4733 + 859 = 5592). The number of first time tests is equal to the number of modules that were not part of re-testing (4733) and the number of re-tests is equal to the sum of the pivot table in the "Re-test" sheet. Combining these first time and re-tests gives the total amount of tests performed for 2015 and 2016 (7074). The average age of PCBAs for December 2015 and August to December 2016 is calculated by taking the average of the PLT from the Summary section for the specified time periods, which are made in the 7th step.

Stage 7: Summary

In order to get an accurate estimate to the actual Production Lead Time and In-house Production Lead Time, the following steps should be taken. All values from the sheet "Unique Serials" should be pasted into a new sheet called "Summary". In yet another sheet, all values from the "Duplicated Serials" sheet should be pasted. Using the Remove Duplicates function of Excel in this sheet should enable for removing all duplicated values, leaving only 859 unique serial numbers, these can now be added back to the existing values in the "Summary" sheet. In this fashion the entire production volume is accounted for, the dataset should be 5592 (5593 – 1) lines long. Production Lead Time (PLT) is calculated by measuring the differences of the Test Date and Production Date columns. Subtracting column E from F should here yield the same values as in the G column of the "Summary" sheet in Final Results.xlsx. For In-house Production Lead Time as estimated by Collection (IhPLT), simply take the values of column G and subtract 56. Negative values in these columns will signify that delivery of PCBAs to TCN were made in under 56 days. By using the Excel functions for Mean, Median, Min, Max and Standard Deviation you will be able to construct the same tables for "Results PLT" and "Results IhPLT – Estimate by Collection" as the one in your reference file. The Graph for Production Lead Time (PLT) is made by marking rows F and G, inserting a line graph. The average of the negative values should indicate that most PCBAs (80%) were delivered with an average of 25 days to spare. Using this information in the "IhPLT as suggested by Authors" section will enable you to replicate the table. Counting the number of PCBAs with a negative range will provided information towards the " PCBA Supplier -> TCN: Delivery Times" section. Your excel sheet should now look identical to the "Summary" sheet in Final Results.xlsx.

Stage 8: Flow

The flow sheet contains the pivot-tables for the production date and test date columns in the "Summary" sheet sorted by date. From these tables, several graphs have been designed, outlining the values of the years 2012 – 2016 in production and for the years 2015 – 2016 in testing. It is once again emphasised that PCBAs produced before 2015 must be included as some of these were part of modules tested in 2015.

Forecasting

Forecasting tables can be found in the documents "Forecast - TCN to PCBA Supplier" and "Forecast - TPAS to TCN" and are select months (2014-7 through 12) as described in Part 5 of the thesis.