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Demand Management for Highly Seasonal Products

A case study at Avero AB

Master's thesis in Supply Chain Management

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Abstract

The purpose of this thesis project is to offer solutions to manage the demand of highly seasonal products effectively. The areas researched are the upstream part of the supply chain, the forecasting process and the planning operations on a tactical and operational level.

Relevant literature and frameworks concerning supply chain forecasting and planning have been reviewed in order to determine the best approach in this context. A case study from the company Avero AB was analysed in the research and several actions have been proposed to address the issue the company was facing regarding the management of the demand.

The demand management in the context of highly seasonal products is extremely challenging and the forecast accuracy could never achieve optimal performance when elaborating the tactical plan. Therefore the supply chain needs to be flexible and responsive in order to be able to face unforeseen events and act promptly on the operational level.

Although a structured approach to forecast is important to improve the accuracy of the outcome, this findings entail that the tactical plan is not reliable enough to allow a completely efficient supply chain in this context. Hence the management team needs to improve the forecasting and planning processes, but always keeping in mind that deviations to the plan will happen during the season. A planning tool to keep track of the deviations, together with a responsive supply chain, allow an effective management approach in this environment.

Keywords: supply chain, forecast, seasonality, demand management, forecast accuracy, supply flexibility

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Anna Németh, Michele Gobbo, Gothenburg, June 2020

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1 Introduction

This Master's thesis research is focused on studying the tactical and operational demand planning and forecasting of highly seasonal products, analysing the case study performed in a company, Avero AB, which sells trampolines. The purpose is to find ways which would improve the planning process and propose solutions to be able to fulfill effectively the demand during the season, without losing sales or creating excess inventory hence too much tied up capital. To achieve that, looking into the supply side of the chain and the present forecasting method and its accuracy had to be done to realize where the weak spots lie. Researching existing literature on the topic helped to discover ways to create a more agile supply chain that is able to react quicker to uncertainties and with several simulations a more accurate forecasting method had to be identified. To be able to conduct our research the company Avero AB's business was analysed, which sells premium quality trampolines mainly in the Scandinavian and Northern European markets with initiatives to expand their reach. In this chapter the underlying issue is introduced and later with the research questions being formulated the aim is presented. At the end of this chapter some limitations to this thesis are highlighted and more deeply elaborated. Finally, the reader will be introduced to the content of the following chapters.

1.1 Background

The purpose of supply chain planning is to balance supply and demand. According to Syntetos, Babai, Boylan, Kolassa, and Nikolopoulos (2016), all actions regarding supply chain planning is originated from the final customer's demand. The decision on which actions to take could be demonstrated with the well known Newsvendor model (DeMarle, 2019). Every morning the newsvendor has to determine how much from the today's paper to buy from the printer. Depending on their decision, two possible outcomes can happen:

1. they buy too much and the copies unsold will end up in the bin
2. they buy too little, and they will lose sales.

Translated this to an environment where the demand is stochastic, meaning very unknown, this two outcomes would result in shortage cost (losing sales) or overage cost (excess inventory after the season) and the planning has to be extensive to avoid any of the options above (Lee, 2019). This planning includes both volume and variant planning (Kaipia and Holmström, 2007).

Using Make-to-Order (MTO) manufacturing strategy, where the manufacturing is initiated at the moment demand arises, would prevent the uncertainty. This is a pull strategy, where the end-consumer sets the whole chain in motion. This strategy is mostly for customer-specific goods, where the volumes are low or where storage cost is unusually high. It is important to understand that in such environment, where production is MTO, the delivery time to the customer is equal to the lead time including production, transit and delivery. Adding to the challenge of uncertain demand, trampoline business is also highly seasonal. The high seasonality shortens the period where the sales happen, thus the whole season has to be planned very thoroughly. At Avero the lead time is, in principle, around 105 days which accounts almost for the half of the whole season. This makes it impossible to use the MTO strategy, since products have to be available right away for the customers.

The season for trampoline sales is around 6 months, moreover 80% of the sales happen in no more then 15 weeks, which is not much longer than the frozen period itself, hence it is very difficult to make changes during the season according to how the sales go. According to Fisher, 1997, the characteristics of a seasonal product are long lead time (105 days), short sales period (less than 6 months) and high uncertainty of market demand. When the season is ongoing, high sales can occur, but during off-season the company might suffer financially when the planning is not effective enough (Gao, Demirag, and Chen, 2012). Other possibility would be to introduce new products that sell during the trampolines off-season, to secure continuous cash-flow. Avero is dedicated to only focus on trampolines (and accessories, spare parts and merchandise) thus this is not a viable option in this study.

1.2 The issue under investigation

The company is undergoing significant changes in the management of the supply chain in order to face the declining sales volumes experienced in the last 2 years. Avero started to focus on its own products from 2020 and is expanding to new markets with the goal to grow and become a more global company in the next few years. The company offers premium category trampolines, which are highly seasonal, have a short season but a long lead time.

To avoid high inventory costs and tied up capital or lost sales which are all the result of an inaccurate planning process, Avero wanted to implement a tool that could forecast demand with a high accuracy. After getting familiar with the processes and operations at the company, it was identified that data recording was done inadequately in the past. Furthermore, it is very difficult to forecast demand since historical data about actual demand is never available only about actual sales, which could be assumed to approximately reflect a share of the actual demand. Additionally, monitoring lost sales would give a more precise understanding of actual demand, but this is not available at Avero.

This tool should help with a planning process that includes demand and supply planning, sales forecasting and to help avoid excess inventory or on the contrary stock-outs. Examining historical sales it turned out that planning has to take place a long time earlier than the demand arises, lead time is almost as long as the period were 80% of the sales happen, hence the chain is very inflexible and there is no possibility to change the initial plan during the season. Considering the high demand uncertainty, the forecast will never be 100% accurate, therefore the whole chain has to be able to react and be more flexible.

To identify possible improvement areas, the planning horizon, the frozen period and different supply chain characteristics have to be examined. After effectively recognizing the areas, various development possibilities have to be analyzed to be able to propose advantageous solutions. Only then it is valuable to have a tool that helps not only the forecasting process but also the follow-up planning during the season.

1.3 Research questions and expected outcome

To successfully conclude this thesis project, the following research questions have to be addressed:

1. *What is the right supply chain for Avero AB and how to achieve it?*
2. *How to build and implement a tool for forecasting and planning, that increases tactical and operational excellence?*

Expected outcome of this case study is a thorough examination of the whole supply chain of the company, Avero, and numerous proposals of improvement areas and specific improvements as well. After getting familiar with the environment, a tool will be developed. The tool needs to be easy to understand, suitable for this setting and helpful when forecasting future demand. Furthermore, it should be able to provide useful information about inventory throughout the season.

1.4 Limitations

Some limitations have to be brought to light before moving forward with the research. The scope of this thesis was only trampolines, hence the accessories and spare parts will left out of the investigation throughout the whole research. The choice was made mainly due to time constraints. Nevertheless improvements regarding the supply chain itself will influence the planning of those items as well. Since partnering up with resellers and B2B is a new area for the company, that only started as of 2020, it was impossible to examine this field comprehensively and for this reason also not included in the research.

Chen and Boylan (2008) argue that when using two or even less years of data, the seasonal indices would make the forecast less accurate compared to not even considering them. Therefore every calculation was based on numbers and figures from the years 2017, 2018 and 2019. The company went through big changes in 2017 both operations wise and personnel wise thus all data from that year and earlier are not to be trusted and were not considered in this research. Since the thesis was conducted in the spring of 2020, data from that year is not complete and therefore not examined.

In addition, the company was selling Berg trampolines during the examined period as well but from this year they removed that part of their business. The question is left open, if this will result in higher North Trampoline sales or the customers will look for the specific brand hence loose a share of the sales in the future. Considering this research we assumed neither would happen exactly and analyzed only North Trampoline volumes with disregards on the effects this change would generate.

The weather factor was mostly ignored in this study since there are no data about promotions and other important factors that were influencing the sales in the past. Only focusing on historical weather and not considering other factors mentioned above would also result in not being able to draw significant conclusions since some of the employees in the marketing team argue that sometimes bad weather makes it possible for customers to thoroughly do their research and decide on buying a trampoline. Others thought too warm or too cold temperatures also worsens the sales regardless if it is sunny or not. Keeping that in mind, it was only suggested to the company that recording data throughout the season about the weather, promotions, events or other factors would make it possible in the future to investigate this issue more in detail.

The time to invest into this research was limited hence the main focus is directed towards finding solutions on improving the as-is situation. Since improving means moving forward into the future, some speculations had to be made, but these are not connected to different expanding strategies. Though entering new markets could take off some weight of the supply chain, e.g. when the new market has different seasons than the ones in Europe, providing the company with a continuous flow and balance in the seasonality, it is worth a whole separate research for finding the most effective approach for each new market.

1.5 Structure of the thesis

The outline of the thesis is presented here to give the reader a guideline and an overview about each chapter and its content.

Chapter 2 - Theoretical Framework

A literature review was conducted and then a theoretical framework established to describe and understand why the investigated problem exists and how it should be dealt with. The framework is based on three topics:

1. The first part presents a framework that supports the designing process of the supply chain in accordance to the product assortment.

2. The second part investigates the supply side of the chain, options to add more flexibility are examined.
3. The third part focuses on forecasting the demand, where different methods, approaches and strategies are defined.

Chapter 3 - Methodology

In this chapter the research design is described and the objective specified. Furthermore, different ways and approaches of data collection used for this thesis are introduced and the process of analysing them described in more detail. Later, the way the verification and validation of the results were done are stated to ensure the quality of the data.

Chapter 4 - Company Background and Current Situation Analysis

In chapter 4 the analysed company's history, their operations and processes are described. Since the focus of this thesis is on the supply chain and the forecasting performance, an overview was given regarding the material and information flow and the performance of as-is forecasting methods were analysed. Then, product and demand characteristics were specified to explore and understand the underlying issues and the difficulties the planning process bears.

Chapter 5 - Results and Discussion

Chapter 5 describes the results of comparing the theoretical framework with the findings from the previous chapter. For a smooth reading experience this chapter is divided into two parts. First, different improvement areas throughout the supply chain are explored and solutions proposed. The areas addressed are the design of the supply chain, supplier collaboration, transportation and scheduling of inbound deliveries and warehouse strategies. The second part explores the possible methods and approaches that help to create a forecasting model. Furthermore a tool is introduced which provides an aid in the planning process before and during the season.

Chapter 6 - Answering the Research Questions

In the sixth chapter of the thesis, all the proposed improvements are outlined, while addressing the research questions and elaborating on the answers that can be found throughout the whole report.

Chapter 7 - Conclusion

In the final chapter of the thesis an overview of the addressed issue is given and the work to reach the outcome outlined. Finally, further research areas are highlighted.

2 Theoretical Framework

In this chapter literature is reviewed to understand the underlying theory within demand management. A conceptual framework was constructed to be able to study the problem and interpret collected data in an effective way. It also helps to set the scope of the thesis. The reviewed articles are of quantitative and qualitative nature and the goal was to make an exploratory review of the existing literature. The aim of this chapter is mainly to fill the gap between the research questions and the findings (Adams, Khan, and Raeside, 2014).

2.1 Designing the supply chain

Fisher (1997) developed a framework for companies to understand what is the right supply chain for their products. According to Fisher (1997), the supply chain of a company performs two functions: physical and market mediation. The former is the production and the transportation of the products while the latter refers to the actions required in order to meet the customer needs with the products offered in the marketplace.

Fisher (1997) states that there are different supply chain costs related to these functions. The physical ones are the manufacturing costs, inventory management and transportation whereas the costs related to the second function are of two types: one is faced in case of a shortage of products and the results are lost sales and dissatisfied customers; the second is related to mark downs or discounts that need to be applied when the company is facing overstock problems.

In order to design the supply chain that best suits the context in which the company operates it is necessary to investigate what type of product it is offering to the market. Fisher (1997) identifies two types of products: functional and innovative products, the first type is characterized by a predictable demand whereas the demand of innovative products is mostly unpredictable.

Table 1 presents the differences in the demand for different type of products, according to Fisher (1997) definition.

Differences in demand		
Aspects	**Functional Products**	**Innovative Products**
Product life cycle	More than 2 years	3 months to 1 year
Contribution margin	5% to 20%	20% to 60%
Product variety	low	high
Average forecast error when production is committed	10%	40% to 100%
Average stock-out rate	1% to 2%	10% to 40%
Average forced end-of-season markdown	0%	10% to 25%
Lead time required for made-to-order products	6 months to 1 year	1 day to 2 weeks

Table 1: Functional versus innovative products: differences in demand (Fisher, 1997)

Considering these definitions, companies that deal with functional products need to focus on minimizing the physical costs since the market will be very price sensitive (Fisher, 1997). On the other hand, innovative products require a different approach: the market reaction is very unpredictable and the risk of stock-out or overstock is very high. For this reason companies need to focus on the market mediation costs, the critical decisions about the inventory and the capacity should be taken with the goal to hedge against uncertain demand (Fisher, 1997). Creating flexibility in the chain, defining the right location to store the inventory, selecting the suppliers that can grant the flexibility needed are the most important focuses to devise the right supply chain in these kind of contexts (Fisher, 1997).

In the article, Fisher (1997) presents the example of Sport Obermeyer and Campbell Soup Company. The first company produces fashion ski wear, a market characterized with high uncertainty, seasonality and random variation of the demand which leads the forecast error to as much as 200%, an example of innovative product. The second company is operating in the processed food market, characterized by a highly predictable demand which allows Campbell to fulfill 98% of the demand, a perfect example of a functional product. The cases presented are very different from each other: Campbell Soup Company needs to focus on a physically efficient supply chain, minimizing the inventory, choosing the suppliers based primarily on cost and maintaining high utilization rate for the manufacturing; Sport Obermeyer primary effort is to create a market-responsive process in order to be able to react quickly to the market unforeseeable variations and trends (Fisher, 1997).

Speed and flexibility are the key to success for a company dealing with innovative products: the main focuses when designing the supply chain should be to invest aggressively to cut the lead time, create buffers along the chain, select suppliers for speed and flexibility, use modular design to postpone differentiation as much as possible. Sport Obermeyer found that the advantage of being able to respond quickly to emerging trends more than offsets the disadvantage of high labor cost, leading to a better result (Fisher, 1997).

According to Fisher (1997), many companies find themselves with a supply chain that is not ideal for the product they offer to the market, creating a mismatch that is harmful to the company performance. The framework elaborated by Fisher (1997) gives guidelines for developing the right strategy for a company, presented in table 2.

Matching Supply Chains with Products		
	Functional Products	Innovative Products
Efficient Supply Chain	Match	Mismatch
Responsive Supply Chain	Mismatch	Match

Table 2: Framework to match the supply chain with the product (Fisher, 1997)

According to Fisher (1997), several companies find themselves in the upper right corner after trying to innovate their products to increase profit margins threatened by the competitors in the market. For this reason, many companies supply innovative products with a chain that is focusing on physical efficiency and therefore using an unresponsive supply chain that is not appropriate to match the demand requirements. Kaipia and Holmström (2007) propose various actions that can be taken in order to address this issue and help companies moving to the upper left or to the lower right corners of Fisher's framework. Two options are presented to deal with the situation: implement changes in order to have a functional product that will be properly supplied by an efficient supply chain or modify the supply chain in order to increase its responsiveness (Kaipia and Holmström, 2007). The first result can be achieved by working on the product offering: simplify the assortment, reduce innovation and the variants of the products to facilitate the planning process (Kaipia and Holmström, 2007). On the other hand, to move to the bottom right corner a company needs to ensure flexibility along the supply chain, reducing the lead times and creating inventory buffers, that can be achieved through supplier collaboration that can increase the agility of the planning process. However, this plan requires a rigorous follow-up process supported by accurate demand information that provide the basis for regular updates of plans so companies are able to build promptly a reaction plan whenever it is needed (Kaipia and Holmström, 2007).

One significant example among the case studies presented by Kaipia and Holmström (2007) is Zara's strategy: the company operating in the fashion business was able to divide the demand in two components, the certain demand and the uncertain demand, and dealt with them in different ways. Nearly half of the seasonal demand is produced and delivered in advance based on the forecast of the certain part of the demand, so it can be fulfilled with an efficient supply chain that takes advantage of low-cost solutions along the supply chain. The second part of the production happens during the season based on the sales trends and the variations in customer taste and it is supported by a responsive supply chain that can react fast and with flexibility to the most recent data, fulfilling the unpredictable part of the demand (Kaipia and Holmström, 2007).

2.2 Adding supply flexibility

In this section the available literature was investigated to find different solutions on how to add flexibility to the supply chain. Theory about the management of suppliers, means of transportation and warehouse distribution will be described more extensively.

2.2.1 Supplier management

The characteristics of a seasonal product can easily lead to stock-outs, overstocking or any kind of inadequate inventory levels (Li, Zhou, and Huang, 2017). Hence the authors suggest to work closely with production and focus on the relationship between retailer and supplier since the efficiency can be more easily increased than by trying to predict such uncertain demand. This relationships can mostly be secured by different contracts between the parties. The most common contract is the commitment-option where the buyer can modify its order, ergo accordingly increase or decrease the volumes with a quantity that was previously agreed on. The price of the extra units and the cancellation is also fixed within a set time frame (Zhao, Ma, Xie, and Cheng, 2013). The advantage of arranging these type of contracts between supplier and buyer make the related additional costs, which is bound to the option of modification of the orders, negligible. The aforementioned advantage is adding more flexibility to the supply chain by allowing adjustments in the orders thus accommodating uncertain demand (Li et al., 2017). The goal should be to have a bidirectional contract which involves the call option and the put option as well. The former means the ordered quantity can be increased which adds more flexibility to market variations (Zhao et al., 2013). Related to this option Hazra and Mahadevan (2009) suggest to use a capacity reservation model, where the supplier and the buyer agree on a certain maximum volume, which the supplier has to be able to deliver in case of increasing the orders. The put option corresponds to the possibility of decreasing the order volume. Zhao et al. (2013) mention the buyback contract as an example for put option, where the supplier retrieves the leftover items for a settled price. Milner and Rosenblatt (2002) propose a two-period supply contract where the volume is fixed for the two periods but after the demand is visible for the first period, adjustments are allowed for the second both up and down from the settled volume, for an additional cost per unit. The initial order quantity and the purchasing quantity can be calculated with a formula demonstrated by Zhao et al. (2013) taken the wholesale price and the price set for the adjustment into account.

When selecting the suppliers that take care of the manufacturing processes a relevant aspect to take into consideration is the labour cost in the country where the producer is situated. A country that has been historically competitive in this aspect is China, in fact in the past few decades it has grown significantly relying on labour-intensive products export (Yuming and Changrong, 2018). However, according to Yuming and Changrong (2018), the continuous growth of the country's economy led to an increase in the labour costs that is reducing its competitiveness compared to other developing countries. Another factor that is playing a role in the competitiveness loss of China is the currency revaluation that determined an increase in prices for the export, consequently reducing its attractiveness for companies looking for the cheapest solutions (Yuming and Changrong, 2018). Analysing as well the most recent data published in 2020, even though the minimum wage differs in different regions of China, the average minimum wage keeps increasing (Chipman Koty and Zhou, 2020). Despite a possible slow down in this increase during 2020 due to the Covid-19 pandemic, it seems reasonable to assume that the growing trend will persist in the upcoming years.

2.2.2 Characteristics of transportation modes

If production takes place in a different country than where the demand arises, choosing the right means of transportation is crucial to secure that raw materials or finished goods are available on time (Crainic, 2003). The different modes are pipes (which will not be further discussed, since it is not relevant to the researched products), road, sea, rail and air and the decision on which one to use could be cost, speed, emission, capacity, etc. In principle, transportation cost has a high share in the supply chain hence choosing the most effective and efficient mode that fits the expectations is a very important task (Ghiani, Laporta, and Musmanno, 2013). SteadiSeifi, Dellaert, Nuijten, Van Woensel, and Raoufi (2014) state that the transportation chain can be divided into three parts: pre-haul, long-haul and end-haul. The first and the latter can be called first-mile and last-mile transportation and are most of the times carried out on road. The long-haul on the other hand can be via air, sea, rail or road depending on which characteristics are of bigger importance. In this work the focus will only be on the long-haul.

According to Fulzele, Shankar, and Choudhary (2019), each mode has strengths in some of the characteristics but also some weaknesses in other. An article from Carnarius (2018) compares the different means as follows: maritime transportation can handle big volumes, is the most environmental friendly option, but requires a lot longer lead time as the other options. Air freight is quick, needs less documentation and handling and the cargo has enhanced security. However, it is the most expensive one due to the fuel it requires, which is also accountable for it being the least environmental friendly option. Rail is said to be the second most environmental friendly option after sea, is fast and cost-effective and has a good reputation when talking about safety. One train can carry an equivalent amount of containers as more than 400 trucks. Nonetheless road transportation also has its advantages. It is the only option viable for door-to-door delivery, is cost-effective, quick, traceable and flexible.

In a report by the International Chamber of Shipping (2020) it is highlighted that the CO2 emission per tonne of cargo among the three compared means, road, air and sea, shipping is the most efficient form. In that report, air freight has an emission of 435 grams per tonne-km, a truck that is heavier than 40 tonnes is responsible for an emission of around 80 grams per tonne-km and a container vessel for only 3 grams per tonne-km. Trains supposedly emit 6 grams per tonne-km (Government of the United Kingdom, 2019).

The most used transportation mode from China to Europe is sea. Land transport options are rail and road whereas the latter is not developed enough for now (The Chamber of Commerce of the United States, 2006). In September, 2018 the border at Khorgos was opened by Kazakhstan and China and made it possible to use road transportation between Asia and Europe in a very effective way (IRU, 2018). After the border was opened, only pilot trucks were sent to improve the cost and time efficiency of road transportation between China and Europe. IRU (2018) state that this would also simplify the whole transportation process, since the pre-, long- and end-haul could be carried out by the same means of transportation. It is estimated to be 50% cheaper than air transport and 10 days faster than rail, altogether around 2 weeks (Ying, 2019). In 2019, Ying (2019) reports of the first successful real-life case, where a truck has been sent from Germany to China, and managed to finish its 11.000 km journey in less than two weeks. Carnarius (2018) recalls the first train in 2015 from China to Rotterdam took 18 days instead of the 44 days spent on the ocean.

2.2.3 Warehouse locations and customer deliveries

According to Cooper (1991), there is a trend for internationalization in Europe since retailers are increasingly operating to identify opportunities in other countries in order to expand their market presence and this trend requires increasing focus in logistics management. There are considerable implications of having a distribution system with a limited number of warehouses, such as a reduced costs of the physical distribution, less expenses for warehouse operations and decreased tied up capital (Cooper, 1991).

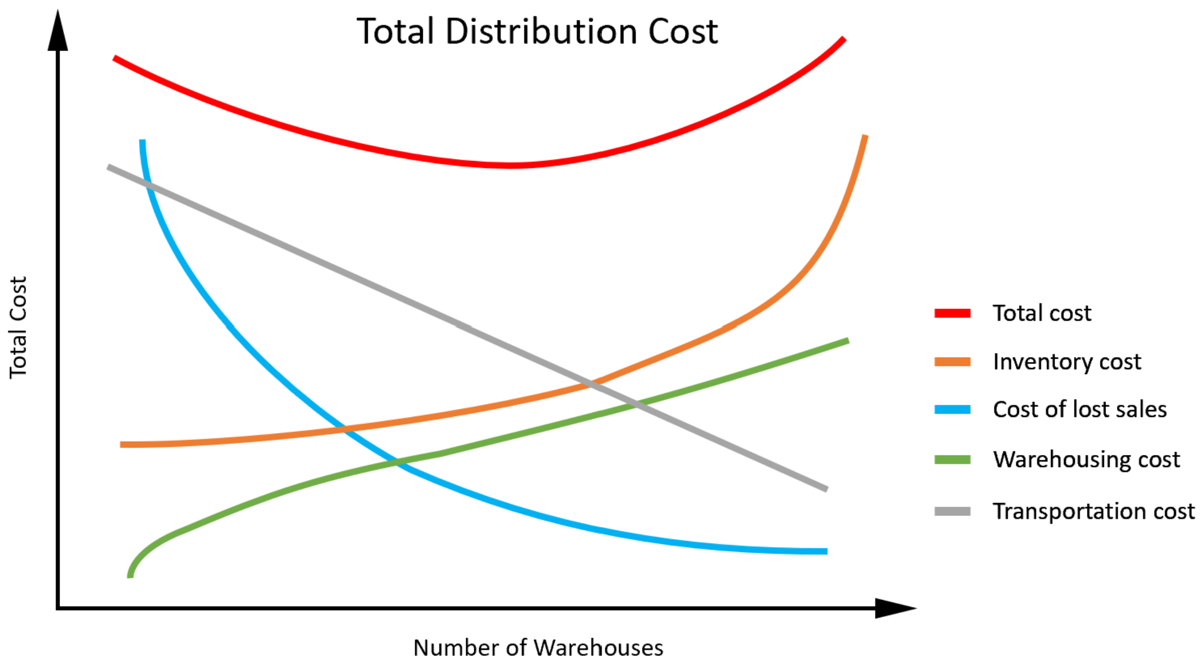

Figure 1: Total distribution cost model according to traditional theories

Abrahamsson (1993), discusses the advantages of introducing new concepts to the traditional theories that have been used to design the distribution systems in the past. Frequently, companies are trying to be geographically closer to the final customers setting a decentralized distribution structure, unaware of the effect that a change of the system would bring in terms of cost savings and customer service (Abrahamsson, 1993). The conventional theories advocate the need of disperse geographical presence in order to close the gaps between the manufacturer and the customers: matching the time and place of the production with the time and place of demand is one of the most important challenges when devising the distribution system (Abrahamsson, 1993). There are several factors influencing the number of warehouses of a distribution channel, both marketing and logistics related, that lead to a total cost analysis that considers inventory, warehouse, transportation and lost sales costs (Abrahamsson, 1993). The geographical distance is an important factor considered by the marketing and logistics theories: if the customer base is disperse, the orders are typically characterized by small volumes and they are hard to predict, then another warehouse in a close location to the customer is recommended to be able to fulfill the demand with a short lead time (Abrahamsson, 1993). Figure 1 represents the total distribution cost in function of the number of warehouses according to the traditional models of marketing and logistics channels (Abrahamsson, 1993).

Abrahamsson (1993) introduces the new theories based on the "Time Based Direct Distribution", which is a system that considers more important to deliver the orders within a fixed time frame than to have warehouses close to the customers. Abrahamsson (1993) reports the results of three Swedish international companies that have implemented a new distribution system based on the time based strategy. The shift from a decentralized system to the centralized warehouse structure brought several improvements to the companies (Abrahamsson, 1993):

- reduced tied-up capital: with a great number of warehouses the number of items stored was significantly higher due to the safety stock and because the companies were trying to have a complete assortment in every warehouse;
- increased delivery performance: the central warehouse allowed a complete assortment in stock, which was problematic to achieve with a decentralized structure, it reduced the number of stock-outs and allowed a direct delivery to be processed as soon as the order was received. The result was a shorter and more reliable lead time, with the possibility to deliver directly from the central warehouse without waiting for the replenishment in the local warehouse that was geographically close to the final customer;
- constant transportation costs: according to the traditional theories the transportation costs should have increased, however the examples studied showed that it did not happen in any of the cases. Increasing the outbound volumes from the warehouse, full truck loads could be used to the local break points in different locations, allowing a smoother flow of goods that combined with the complete assortment in stock resulted in a better stock and availability management and prevented the transportation cost from increasing.

The results of the changes in the cases studied showed a reduction of the total distribution costs due to a reduction in the inventory, the warehousing and the lost sales costs whereas a stable outcome regarding transportation cost has been observed. Figure 2 shows the changes in the total distribution costs model according to the new theories presented by Abrahamsson (1993).

Furthermore, an important aspect to consider when making decisions regarding the warehousing strategy is the location. The cost of warehouse activities are in fact influenced by several factors: warehouse rent, rent per square meter per day, storage period, cost of labour (Lin, Hjelle, and Bergqvist, 2020). According to Lin et al. (2020), warehouse activities are labour intensive, therefore the minimum wage in the country where the warehouse is located is an aspect to consider to reduce the supply chain costs.

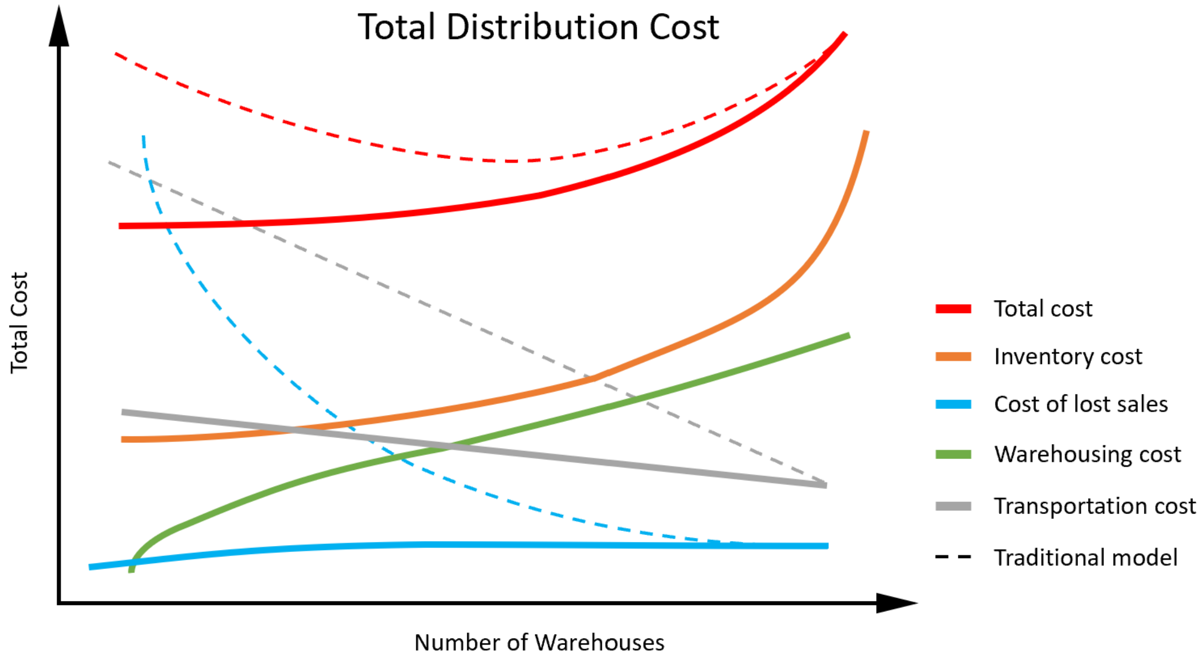

Figure 2: Total distribution cost model according to the Time Based Distribution system

2.3 Forecasting demand

Every company needs to have plans for the future in order for it to be able to function properly, have the right amount of resources and items at the right place, at the right time. A Sales plan, which shows the volumes planned to be sold, a Production plan, stating the volumes planned to be manufactured and a Budget, a plan expressed in monetary terms are ought to be prepared (Jonsson and Mattsson, 2009). These plans do not necessarily align with the forecast but the aim is for them to correlate. According to Jonsson and Mattsson (2009), when the time for a product to be manufactured (or acquired) takes longer then the desired delivery to the customer after the demand arises, then that product needs to be forecasted. A forecast is an estimation of future demand for the products of a company. This demand can be affected by different marketing campaigns and pricing strategies (Jonsson and Mattsson, 2009). Since the market is constantly shaped by different factors, thus always changing, and the product life-cycle is getting shorter and shorter with time there is a high demand uncertainty which requires a faster reaction throughout the chain which can be done by a higher level of collaboration between departments and combination of resources and processes from different functions and organisations (Jonsson and Mattsson, 2009).

There are different qualities that need to be examined first to be able to set up an adequate forecast. Firstly, the time series, which is according to Jonsson and Mattsson (2009) *"a sequence of chronologically ordered data with constant periodicity"*. These time series can highlight different demand patterns. The most common are random variations, trend changes and seasonal variations. Random variations may occur in a basically stable demand. If the periods are long, random variations are more difficult to spot because the demand is more smooth. Trend changes are related to a periodical increase or decrease in demand (Jonsson and Mattsson, 2009). Finally, seasonal variations occur when the demand changes according to what time of the year it is. The last two will be examined more thoroughly later. The basis of a forecast has to be a historical data of e.g. order entries, delivery statistics or invoicing statistics (Jonsson and Mattsson, 2009). This data does not exactly show actual demand since there is always e.g. the possibility of a stock-out but it is the closest to resemble past demand. The length of a forecast period also needs to be fixed according to what the forecast is aimed at. It can be a week, a month or even a year. Jonsson and Mattsson (2009) specify that the length should be selected in regards of the delivery frequency. The higher the frequency, the shorter should a forecasting period be. The appropriate length of a forecast horizon depends on what it is aimed at. The horizon can be one or several years if it is generated for production plans, three to six months if the reason for forecasting is operative material supply and call-offs (Jonsson and Mattsson, 2009). If aiming for a rather errorless estimation, the forecast horizon should be kept short. Additionally, the forecast frequency also needs to be set. Which should, according to Jonsson and Mattsson (2009), be at the same extent as the planning. It is also important, to state in what units the forecast will be produced, e.g pieces, metres, etc. To have a proper forecast random variations should not divert the stability and being able to react, as well as quickly react to systematic changes are the most important requirements (Jonsson and Mattsson, 2009).

Since a forecast is an assumption or calculation of future demand, it is inevitable to have some amount of error. According to Jonsson and Mattsson (2009) these are the most frequent reasons:

- inadequate forecasting methods
- not trustworthy forecast data
- poor combination of judgemental and quantitative forecasts
- unrealistic expectations
- lack of forecast responsibility and forecast follow-up, etc.

The aim is to minimize the influence these reasons have on the forecast to gain a more accurate forecast at the end.

2.3.1 Forecast performance

Measuring the performance of the forecast is extremely important. According to C. W. J. Chase (2013), the measurements are used to identify and solve problems or to assign rewards, if no measurements to evaluate the forecast accuracy are in place the process will never be improved. Therefore the performance measurement serve two important aims, according to C. W. J. Chase (2013):

1. evaluate the accuracy of the prediction, how precise was the forecast compared to the actual outcome, in order to give important indications for future business decisions;
2. compare various statistical models in order to identify the one that suits best the specific customer demand features so it creates more accurate forecasts.

Measuring the forecast accuracy not only compares the actual outcome to the predictions, but it is an important process to increase the knowledge on the demand: in order to understand why a specific outcome has deviated from the prediction entails a thorough analysis of the historical data and the factors that may have influenced the actual sales (C. W. J. Chase, 2013). Several companies fail to keep track of the forecast performance and often, even when some measurements are used for this purpose, they overlook important details due to the level of aggregation of data: the accuracy can vary significantly if calculated for the combined volumes or for the single stock-keeping unit, from now on mentioned SKU (C. W. J. Chase, 2013). A common problem when measuring the forecast performance, according to C. W. J. Chase (2013), is that companies do not use absolute values in the calculations and when aggregating the error of various items the different signs reduce the magnitude of the error, showing a lower error compared to the separated values.

When calculating the error of a forecast the basic formula can be defined as:

$$\text{Error} = e_t = A_t - F_t$$

where e_t is the error of the forecast, A_t is the actual sales and F_t is the predicted quantity, all of them regarding the period t. According to C. W. J. Chase (2013), the formula to calculate the error has been investigated in recent years because another formula gained popularity, which is the following:

$$\text{Error} = e_t = F_t - A_t$$

Although it may seem just formality, comparing the forecast to the actual sales or comparing the sales to the forecast have important implications (C. W. J. Chase, 2013). First of all, the second formula gives a more intuitive outcome when analysing the measurements on a business perspective since a positive result would mean that the budget exceeds the sales and a negative value indicates that the forecast underestimated the actual demand. Nevertheless, when considering a percentage error the implications become more significant, in fact the two formulas can be written as:

$$(1)\ \text{Percentage Error} = PE_t = \frac{(A_t - F_t)}{A_t} \cdot 100$$

$$(2)\ \text{Percentage Error} = PE_t = \frac{(F_t - A_t)}{F_t} \cdot 100$$

In this case, comparing the forecast to the sales, as in the first formula, the error will be higher in case of a higher forecast compared to the actual sales, therefore a bias toward underforecasting can be generated by the departments involved in the forecasting process in order to have an outcome that is safer against possible errors, resulting in a higher risk of stock-out. On the other hand, comparing the actual sales to the forecast creates a bias toward overforecasting because a high forecast would decrease the percentage error but it would have dangerous repercussions on the inventory levels (C. W. J. Chase, 2013).

Following the most common practices to calculate the error are presented (C. W. J. Chase, 2013).

Mean error: it calculates the average error for n SKU in a given time frame t, plus and minus signs can balance each other and reduce the magnitude of the error.

$$\text{ME} = \frac{1}{n}\sum_{t=1}^{n}(A_t - F_t)$$

Mean absolute error: calculating the average absolute deviations gives importance to both a higher or lower error.

$$\text{MAE} = \frac{1}{n}\sum_{t=1}^{n} \mid A_t - F_t \mid$$

Mean Percentage Error: calculates the average of all the percentage errors for all the items in a given period. This method creates a measurement that is better comparable within different products since it expresses the deviation as a percentage of the sales for the item.

$$\text{MPE} = \frac{1}{n}\sum_{t=1}^{n}\frac{(A_t - F_t)}{A_t} \cdot 100$$

Mean Absolute Percentage Error: most companies use this measure to evaluate the accuracy of the forecast because the outcome is a relative amount and it considers the error both when the predictions are higher or lower than the actual sales.

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\frac{\mid A_t - F_t \mid}{A_t} \cdot 100$$

According to C. W. Chase (2016), despite being the preferred forecast accuracy measure, MAPE has some drawbacks that may be criticized in certain situations. As the error is calculated comparing the forecast to the actual sales it appears to be biased towards underestimated predictions: the error for a low forecast will never exceed 100% while there is no upper limit for the error when the predicted outcome is larger than the actual sales (C. W. Chase, 2016). Furthermore, if the values of the demand are very low, the error can rise indefinitely and the final result would give a distorted interpretation of the actual accuracy of the forecast (C. W. Chase, 2016). To solve this problem C. W. Chase (2016) introduces a method that gives a proportional weight to the total: it is called weighted absolute percentage error (WAPE), frequently called also weighted MAPE (WMAPE). This method is particularly suitable when calculating the average error for different items that have diverse sales outcome so every SKU affects the accuracy measurement based on the contribution to the total volume, as in the formula presented below:

$$\text{WMAPE} = \frac{\sum_{t=1}^{n} \mid A_t - F_t \mid}{\sum_{t=1}^{n} A_t} \cdot 100$$

2.3.2 Forecasting methods

The different forecasting methods can be divided into quantitative and qualitative methods. The former is based on historical data and more advanced calculations, the latter is made by experts in the field based on their experience of previous sales and the market's reaction on different factors.

Qualitative forecasting methods

The following forecasting methods, also known as judgemental forecasting methods, are done by experts who have an explicit knowledge of the markets behaviour gained by experience. According to Jonsson and Mattsson (2009), these estimates about the future demand are subjective. Only using this type of methods are most useful when the product range is small. Sanders and Ritzman (2004) state that most commonly the marketing department considers these methods since they have knowledge of market conditions, actions of the competitors and rumors that could be of use. Jonsson and Mattsson (2009) differentiates between three methods:

1. Sales Management approach: people from the management level sit together and they come up with the forecast together. This method is in principle quick and straight-forward. Although everyone who is participating have their own input in the forecast, there is a chance that employees who are more dominant can shape the forecast to their liking. Since this assessment is done during meetings there is also a risk of creating an unrealistic, desired outcome as a forecast. This approach can be done in two ways, first if the whole management group is present and the forecast is created during a meeting. Second if only the leaders of the marketing and sales department sit together. This is more advantageous for short- and medium-term, the former fits rather with long-term and overall sales and business plans (Jonsson and Mattsson, 2009).

2. Grassroots approach: the departments directly linked to the market are creating their own forecast and later these different forecasts are combined and merged into one final forecast. This approach is beneficial since the personnel with most knowledge about the market are responsible for the forecast and not the ones with greater authority. On the other hand compiling the different forecasts and then creating a final one takes more time than the previously mentioned approach.

3. Pyramid forecasting: a combination of the above mentioned two. The numbers predicted by the management personnel are thought to be the most respectable.

The strengths in qualitative forecasting lies in the awareness of present changes and events which would not affect the quantitative forecasts based only on historical data. One important weakness is, as Sanders and Ritzman (2004) point out, that bias can lead to large forecast errors which bring severe problems for customer service or stock planning.

Quantitative forecasting methods

The base of these methods are in depth calculations. According to Sanders and Ritzman (2004), traditionally operations use these approaches since it is more adequate for planning the volumes on SKU level, therefore planning production, stock levels and other related issues. There are two groups that can be distinguished, extrinsic and intrinsic forecasting. The former uses another variable that is easier to forecast and which the examined variable is highly dependent on (Jonsson and Mattsson, 2009). The connection between those two variables have to be settled, generally with regression analysis. This type of quantitative forecasting method needs more data to work with and broader calculations (Jonsson and Mattsson, 2009). An example for highly seasonal products which demand is dependent on the weather could be working with future weather forecasts.

The focus for intrinsic methods is only the variable that is required to be forecasted. Here historical sales data is analysed (Jonsson and Mattsson, 2009). Jonsson and Mattsson (2009) describe moving average and exponential smoothing as follows:

1. Moving average: is a very simple method, where the future demand is considered to be the same as it was in the previous period. This assessment has the disadvantage of being too responsive towards random variations. Determining how many periods the forecast has to consist depends on the individual case. The calculation is done with the help of the following formula:

   $$F(t+1) = \frac{D(t) + D(t-1) + ... + D(t-n+1)}{n}$$

   where *F(t+1)* stands for the forecast demand for period *(t+1)*, *D(t)* stands for the actual demand during period t and n for the number of periods involved in the moving average forecast.

   Choosing the right value of n is essential. Small n means that the forecast will easily be influenced by random variations and the realization of systematic changes in demand will happen quite fast. Large n will show exactly the opposite characteristics. This method surmises that systematic trends in demand are not to be perceived.

2. Exponential smoothing: is a time series forecasting method with rectangular distributed weighting of demand values. It is very similar to the above mentioned method, the difference is that the values are weighted before calculating the result. This approach typically gives a higher weighting to recent demand data with a triangular distribution (Jonsson and Mattsson, 2009). Jonsson and Mattsson (2009) suggest two ways to use the triangular distribution:

   (a) triangularly distributed weighting, which means that there is the same difference between two consecutive weights;

   (b) exponential distribution, similar to the previous principle but instead of a constant difference it uses a constant relationship between consecutive weights.

   Although this method may seem more complex due to the amount of data needed, virtually unlimited, according to Jonsson and Mattsson (2009) it is possible to demonstrate that applying the following formula to calculate the forecast produces the same result as the exponential weighting:

   $$F(t+1) = \alpha \cdot D(t) + (1-\alpha) \cdot F(t)$$

where *F(t+1)* is the forecast value for period *(t+1)*, *D(t)* the actual demand for t and α the smoothing factor.

Once initiated, this method only requires the newest actual demand and the previous forecast in order to update the values according to the latest data thus it can be more favourable than moving average. The value of α has to be less than or equal to 1. A low α is more ignorant to systematic changes in demand but is stable towards random variations.

Sanders and Ritzman (2004) explain that the strengths of this methods are their objectivity, consistency and capability of working with numerous data. One must not forget that the data is not always flawless and could influence the forecast to the wrong direction.

Combining qualitative and quantitative forecasting methods

The above mentioned two different types of methods are mostly used combined to reach a higher accuracy since both of them have their disadvantages which can be repelled by the other form's advantages. There are different ways of how to combine them, but one must make sure that the forecasts are absolutely based on different information and not the same data. Sanders and Ritzman (2004) suggest four ways of combining qualitative and quantitative forecasts.

The first one is *judgemental adjustment of quantitative forecasts.* In this case, the quantitative forecast is prepared first and to get to the final forecast adjustments to it are made based on the judgemental forecast, as seen in figure 3. The strengths of this method is that at the time of reception of new information it can easily be added to the forecast but this could also be a weakness since rapid, irrational changes or bias could destroy a stable forecast. Another problem is that the combination of the forecast is rather subjective. This method fits best in the environments where forecaster and user are the same, have high confidence in contextual information and understand what is behind the factors (Sanders and Ritzman, 2004).

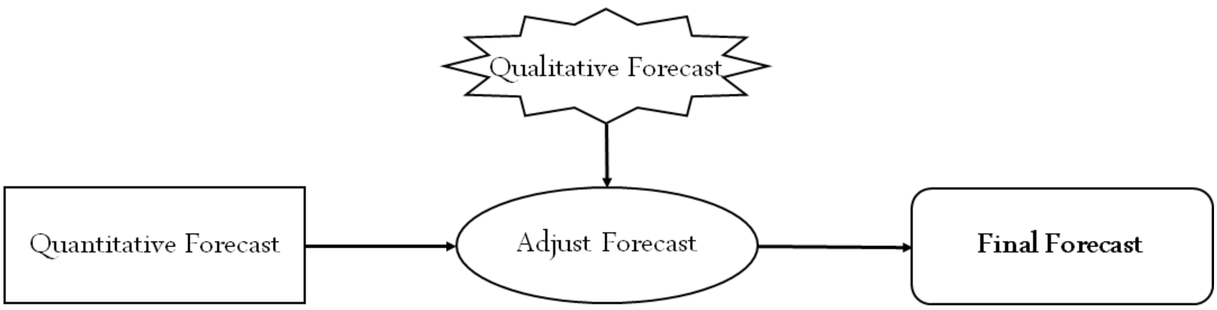

Figure 3: Judgemental adjustment of quantitative forecasts (Sanders and Ritzman, 2004)

The second method is *quantitative correction of judgemental forecasts.* As figure 4 shows, the base of the forecast is a judgemental approach. To avoid bias and all the weakness the qualitative method carries, the forecast then will be adjusted by calculations. According to Sanders and Ritzman (2004), this method is best used when there is insufficient data available and bias is a big concern. To avoid it, forecaster and user should be different people. One weakness of this method is the low sense of ownership, since the person responsible for the forecast will not be the one having to deal with its inaccuracy.

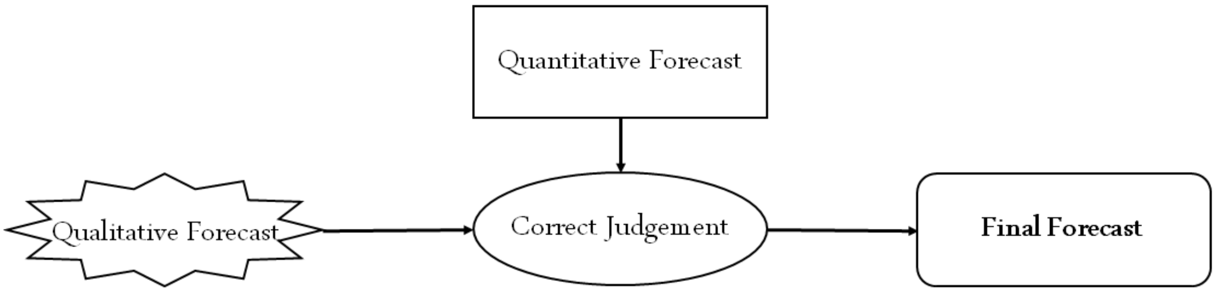

Figure 4: Quantitative correction of judgemental forecasts (Sanders and Ritzman, 2004)

Combining judgemental and quantitative forecasts is the third method and can be seen on figure 5. The judgemental and the qualitative forecasts are prepared separately and then merged mechanically into one final forecast. Sanders and Ritzman (2004) highlight that this method is not so strongly influenced by the judgemental forecasts negative effects. They further mention that the easiest way to combine the two individually generated forecast is to use an equal weighted arithmetic average of both. The strength of this method is its objectivity, but there is a low sense of ownership involved. The best environment to use this method is where the forecaster and the user are different people and when the forecasts come from different sources to achieve an unbiased forecast (Sanders and Ritzman, 2004).

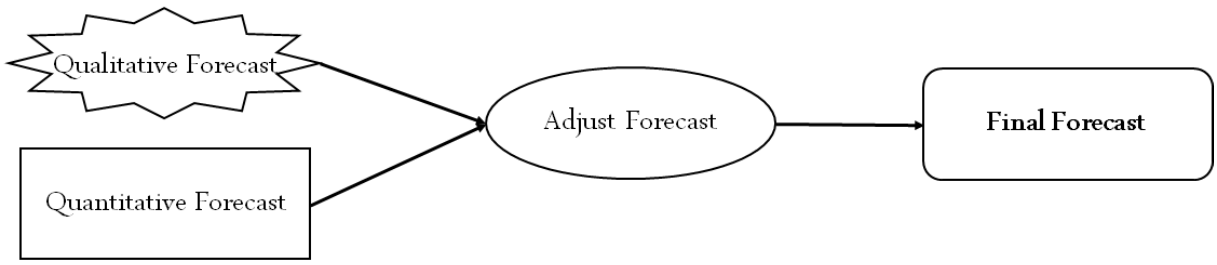

Figure 5: Combining judgemental and quantitative forecasts (Sanders and Ritzman, 2004)

Finally, figure 6 shows the fourth method: *judgement as input to model building.* Here, judgement is used to create a model structure, to set parameters and to select variables (Sanders and Ritzman, 2004). Since after fixing those aforementioned figures only quantitative forecasting takes place, this method is the least opposed to judgemental bias so it can be stated that this is the most objective among the four methods. Weakness of this method includes low sense of ownership over qualitative input and it can not so simply consider the latest information available in the market (Sanders and Ritzman, 2004). The environment where this method is the most suitable is where the forecaster and the user are the same thus understand the complexity of the calculations and high technical knowledge is available.

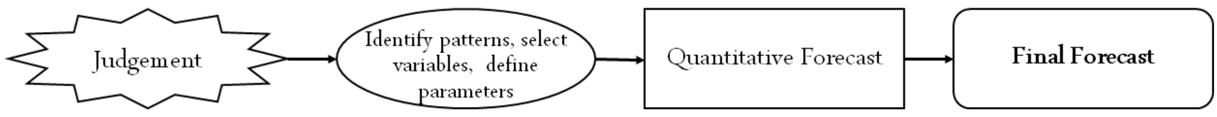

Figure 6: Judgement as input to model building (Sanders and Ritzman, 2004)

2.3.3 Considerations to systematic changes

Trends are easy to spot if qualitative forecasting methods are used, but if they are based on extrinsic or intrinsic methods some additional calculations have to be done (Jonsson and Mattsson, 2009). This is most important when the forecast is not aimed at the near-future but more further. Without adding other calculations, the accuracy will be significantly lower than desired.

If it is possible to identify systematic trends in the demand it is easy to consider them in the forecasting process with a judgemental approach (Jonsson and Mattsson, 2009). However, when using quantitative forecasting methods it is often necessary to analyze the trends and consider them based on calculations on historical data. This approach, according to Jonsson and Mattsson (2009), appears to be useful to correct forecasts that undergo trend-related variations. Working with trends is extremely difficult due to the non-linearity of the real demand of a product that can create irregular fluctuations in the forecasts. In case of low quantities sold, according to Jonsson and Mattsson (2009), the difficulty to forecast is higher because the actual demand can easily deviate to a large extent from the forecast.

In short-term forecasting an additive trend is generally used calculating the variation between the quantities of consecutive periods, however there is a high risk of building a model that is oversensitive to random variations (Jonsson and Mattsson, 2009). To reduce this risk the trend can be determined using exponential smoothing, with the following formulas (Jonsson and Mattsson, 2009):

$$BF(t+1) = \alpha \cdot D(t) + (1-\alpha) \cdot (BF(t) + T(t))$$

$$T(t+1) = \beta \cdot (BF(t+1) - BF(t)) + (1-\beta) \cdot T(t)$$

$$F(t+n) = BF(t+1) + T(t+1) \cdot n$$

where *BF(t)* is the basic forecast for the current period t without considering the trends, *T(t)* is the trend for the current period t, *F(t)* is the forecast demand for current period t, α is the exponential smoothing for basic forecasting, β is the exponential smoothing for the trend and n represents the number of periods considered by the forecast.

Seasonal changes in demand can be neutralized with the help of seasonal index which, according to Jonsson and Mattsson (2009), expresses the magnitude of the seasonal variation. The seasonal index *S(t)* for period t can be expressed with the formula below:

$$S(t) = \frac{D(t)}{D(m)}$$

where *D(t)* stands for the actual demand during period t and *D(m)* for average demand during all periods of the year. The sum of all the indices, which need to be normalised first, has to be equal to the number of periods throughout one year (Jonsson and Mattsson, 2009). The indices can be calculated from historical data and, if required (e.g. to follow the changes in market), they can be adjusted by using moving average or some other complementary approach. One important thing to mention here is that seasonal indices are meant to be calculated for product families and afterwards use the same index for the products in the same group (Jonsson and Mattsson, 2009).

2.3.4 Forecasting strategies

When forecasting, it is important to take into account the different decisions that will be partly or fully based on the forecast (Syntetos et al., 2016). For example, budgeting requires a high level of aggregation of the information while inventory control requires accurate information on the lead time demand regarding each individual SKU. According to Syntetos et al. (2016), the level of aggregation of the forecast output has to be aligned with the decision making that the forecast outcome is supporting. This entails a challenge when forecasting: the output of the forecast could be needed at a higher or lower level than the input data and for this reason the results must be aggregated or disaggregated in order to match the level required by the specific decision the forecast supports (Syntetos et al., 2016). According to Syntetos et al. (2016), there are two approaches that have prevailed in the aggregation methods for the forecast data: bottom-up and top-down.

Bottom-up: this approach uses forecast data at the SKU level and then aggregates the data in order to achieve an estimation at a higher level. According to Syntetos et al. (2016), forecasting on a detailed level ensures a better accuracy since no incorrect assumptions nor macro level mistakes are made when creating a family of products. On the other hand, this approach could overlook some factors such as seasonality or trends. Thereby, reducing its reliability in some cases.

Top-down: this approach entails forecasting at an aggregate level and subsequently disaggregate the output to a lower hierarchical level and obtain an estimation of the individual SKU's requirements. According to Syntetos et al. (2016), the approach ensures that important information is not lost even when the available set of data is not wide enough to identify some trends. Furthermore, using a larger set of data, the forecast outcome could be more reliable at the aggregate level. However, according to Syntetos et al. (2016), a disadvantage of this method could be that some assumption may be wrong when creating a family of products and the outcome could be misleading. For example, a specific product could have a different seasonality trend than other products of the same family even though they share some common characteristics. Therefore, the outcome of the forecast could embed mistakes.

2.3.5 Aggregated forecast for seasonal demand

Traditional forecasting methods that are intended to handle seasonal demand incur in high error in many occasions. The demand for seasonal products, that is often affected by external factors, is characterized by a high degree of unpredictability. Furthermore, short product life cycles in many occasions reduce the data available for the forecast and it hampers the reliability of the outcome, resulting in high forecast error.

A way to overcome this problem in such markets is to use aggregated data as the forecast input. Syntetos et al. (2016) proposes two approaches to obtain aggregated data for the seasonal indices of historical sales:

1. consider the demand of the item groups summing the sales data and determine the seasonal indices from the resulting data;
2. determine the seasonal indices for each product individually, calculate the average for the whole group and use the result obtained as the seasonal index for every product of the group.

Dekker, Van Donselaar, and Ouwehand (2004) studied the differences between the standard seasonal forecasting method and the one using aggregation, applying them to two Dutch wholesalers and comparing the performances of the methods in terms of forecast error.

Dekker et al. (2004) used historical sales data from the selected wholesalers to create different scenarios and compare the outcome. The methods used are:

- Exponential smoothing: only the level of demand is taken into account and no seasonal pattern or trends are used to generate the forecast.
- Holt-Winters' method for seasonal demand. This method considers the level of the demand, the trend and the seasonal pattern. Nevertheless, the products studied by Dekker et al. (2004) are not characterized by a clear trend so they decided to remove the trend factor from the forecast.
- Product-aggregation: in order to overcome the problems related to the demand uncertainty and to smooth random variations in the historical data the demand is aggregated in a

product family. The aggregated demand is used to calculate the seasonal indices that are later used to create the forecast at a non-aggregated level.

- Combining methods with Naïve 1: the goal is to combine different methods, the result would outperform individual methods in terms of accuracy. The Naïve 1 method uses this week's demand as a forecast for next week's demand. Therefore, the combination of methods allows the Holt-Winters' forecast to account for a part of the forecast and the previous week actual sales adjusts the final result. This method helps the forecast to react quickly to unforeseeable changes in the demand: if, for example, the season starts earlier than expected the combination of the methods is able to detect it and to adjust the following weeks' forecast accordingly.

The two companies selected for the study were Schuitema, a large supermarket chain in The Netherlands, and Technische Unie, a wholesaler of electrotechnical products. For the first company the selected products for the project were beers and soft drinks, whose demand is clearly characterized by seasonality with peaks during summer and around Christmas (Dekker et al., 2004). Regarding the second company, the chosen products were plastic tubes, which have a stable demand throughout the year except during the building laborer's summer holiday, that takes place in July and August, and during Christmas and New Year, when the demand drops (Dekker et al., 2004). The experiment consisted in comparing 5 different forecast scenarios:

1. Level only: this method does not take into account the seasonality. However, to make the model reactive and to cope with the changes in the demand, a high smoothing value has been chosen, therefore making it similar to the Naïve 1 method (Dekker et al., 2004).

2. Level and Season: this method is designed for products with highly seasonal demand. According to Dekker et al. (2004), the high uncertainty brought by external factors, e.g. the weather conditions affect beers and soft drinks sales to a large extent, makes the seasonal indices stochastic, therefore the method appears to have a nervous behaviour, characterized by high variations.

3. Level and season with product aggregation: aggregating the demand for different products into product families reduces the variations and make the indices less volatile, with a smoother pattern.

4. Level and season combined with the Naïve 1 method: the forecast combining approach is of great help to improve the performance of the forecasts (Dekker et al., 2004). This method takes into account both the seasonality of the products (on a singular item level) and the recent variations in demand in order to react quickly to the stochastic seasons or to unforeseeable factors.

5. Level and season with product aggregation combined with the Naïve 1 method: this method is similar to the previous one, using the demand data aggregated at a family level in order to identify the seasonal indices.

The study showed that the standard methods failed to provide a good forecast in the situations studied (Dekker et al., 2004). Using product-aggregation the performance of the forecast improve considerably, making the outcome more stable and making it easier to find seasonal indices. Nevertheless, the biggest flaw of this model is that it is not responsive to random variations given by the stochastic seasons. The combination with the Naïve 1 method provides an effective solution to this problem: the model undergoes continuous adjustments so the variations caused by external events are taken into account to correct the future forecast. According to Dekker et al. (2004), methods based on product-aggregation combined with the Naïve 1 method outperform the classical forecasting methods, showing a remarkable increase in the average forecast accuracy.

3 Methodology

The Methodology chapter describes how the problem was investigated. First, the research design is illustrated, followed by the different methods of data gathering and processing. Finally, data verification and validation is discussed.

3.1 Research design

To conduct this thesis work four phases were formulated: preparation, framework, analysis, finalization as shown in figure 7. The phases are described below.

Figure 7: The four phases that led to the final report

Phase 1: Preparation

Before starting working on the thesis, a description from the company of the desired improvement area was given. The goal of the first phase was to get familiar with all the operations within the investigated company and get to know their way of handling the processes better to align our idea of the thesis with all the stakeholders involved. To reach this goal qualitative data was gathered, primary data in form of informal meetings with the company employees and through observations and secondary data from the company website or internal documents. The result of this phase was that the purpose of the thesis was identified and accepted by both the company and the university.

Phase 2: Framework

To build the structure of the thesis, the goal of the second phase was to find connected theory to the identified issues from phase one and decide on the research approach. The method used was qualitative data gathering through literature reviews. The focus of the thesis became clearer after studying relevant literature and several academic papers. As a result a theoretical framework was established. This framework provides the guideline for the analysis.

Phase 3: Analysis

After the framework was established the data gathered was analysed closely with the help of the framework to identify possible improvement areas. Here the emphasis was put on gathering quantitative data, moreover historical data retrieved from the ERP system the company is using and documents received from the personnel. Analysing the data and collecting it was performed simultaneously, to have an idea of which direction to lean towards during the research. The outcome was a current state analysis, various improvement suggestions for different areas and a tool to support different processes: forecasting and supply planning, on the tactical level, and to aid the follow-up and decision making process throughout the season, on the operational level.

Phase 4: Finalization

The goal of the last phase was to conclude all the findings. To achieve this, discussions were led between the authors, some final input was received from the company and guidance from the supervisor. The result of this phase was the discussion and conclusion chapters and with that, the final report.

3.2 Data collection

According to Adams et al. (2014) descriptive research is a research where the situation is described or different facts mentioned and explained. Thus the first two chapters, Empirical Background and Theoretical Background could be categorized as such. Current Situation Analysis and Discussion and Results chapters are based on an explanatory research, hence the collected information is processed in a way from which conclusions can be drawn, explaining the behaviour of the data (Adams et al., 2014).

Both quantitative and qualitative data were gathered to be able to fully understand and identify the problem and to support the proposed solutions that could be implemented in the given environment. Qualitative data were important for identifying the structure of the supply chain, factors or patterns that influence the sales but cannot be properly realized in numbers and connections between the processes and operations. Collecting quantitative data was beneficial to support the assumptions made beforehand and to measure the effectiveness of the current state and realize improvement areas. Spread sheets, such as Excel were used to store the obtained data.

Primary and secondary data were both collected. The latter was the main source. Data missing or not available as secondary were hence attained through experimentation on them, observation, attendance at different meetings and interviews. The interviews were held with the relevant stakeholders, mostly via a face-to-face meeting but also via email or online videocall. In the beginning of the research process the subject of the interviews was decided by the interviewees, who explained everything they thought it could be relevant for the study. After acquiring all applicable secondary data the purpose of the interviews was to complement what was missing.

3.2.1 Primary data

The primary data were collected during several meetings and through email communication with the managers of Avero. The attendance at the weekly meetings of the management team was used to observe the current process of data analysis and decision making during the season. The managers involved in the meetings were:

- O. Eriksson, Chief Executive Officer
- E. Rodhe, Supply Chain Manager
- U. Fredin, Sales Manager
- J. Lyckander, Marketing Manager
- T. Kajerlöv, Customer Experience Manager
- F. Fallegård, E-Commerce Manager
- C. Bröyn, B2B and partnership Manager

Table 3 shows the details regarding the interviews conducted. For all of these interviews one hour was set aside, but sometimes they were finished earlier.

Date	Interviewee	Content of the interview	Type
03/02/2020	Chief Executive Officer, Supply Chain Manager	Introduction to Avero and the business	Face-to-face meeting
04/02/2020	Chief Executive Officer, Supply Chain Manager	Description of the supply chain and the operations of Avero	Face-to-face meeting
11/02/2020	Supply Chain Manager	Historical sales, data handover	Face-to-face meeting
14/02/2020	Supply Chain Manager	Data review and cleaning	Face-to-face meeting
20/02/2020	Supply Chain Manager	Sales forecast, data handover	Face-to-face meeting
26/02/2020	Supply Chain Manager	Historical data analysis review	Face-to-face meeting
02/03/2020	Chief Executive Officer	Thesis scope definition	Face-to-face meeting
04/03/2020	Supply Chain Manager	Transportation modes	Face-to-face meeting
27/03/2020	Chief Executive Officer	Planning cycle	Face-to-face meeting
08/04/2020	Supply Chain Manager	Forecasting process and transportation methods from suppliers to the warehouses	Face-to-face meeting
17/04/2020	Chief Executive Officer	Tool requirements	Virtual meeting
27/04/2020	Supply Chain Manager	Tool requirements, supply chain features	Face-to-face meeting
28/04/2020	R&D Manager	Product characteristics, R&D operations	Virtual meeting
05/05/2020	Chief Executive Officer	Cost breakdown, planning process	Virtual meeting

Table 3: Interviews conducted

3.2.2 Secondary data

The secondary data used for the analysis were existing literature regarding the topic researched and specific data received from the company. The sources of the literature review were different articles retrieved from the Chalmers University library database, other university library databases, Google Scholar. Additionally different websites were also used for this purpose. The keywords applied for finding relevant literature were: seasonality, forecasting, demand management. The company website also offered important information about the product characteristics. The data received from the company and used for the analysis are the following:

- company presentation
- organizational chart
- item list
- sales data 2017, 2018 and 2019
- item equivalent list
- sales forecast 2018 and 2019
- figures regarding the cost breakdown of the products
- cost and revenue analysis
- 3 years business plan.

3.3 Data analysis

The data collected were analysed to extract relevant information to fulfill the purpose of the research. From the primary data the context of the company was analysed to suggest the most effective actions and to complement the information gathered as secondary data. The secondary data provided quantitative information and figures that were analysed thoroughly in order to finalise the results.

The company presentation, the organizational chart and the item list presented the information of the background of Avero. The mission, the values, the history, the historical performance of the company, the characteristics of the items and the internal organization of the company were analysed to understand the context of the business, how Avero has operated in the past and what are the future targets.

The sales data were retrieved from different ERP systems that were used in the previous years by the company. The transition started in 2018, therefore the sales data of 2017 were retrieved from the ERP system called *Specter*, the data of 2018 were retrieved from both ERP systems, *Specter* and *NAV*, and the data of 2019 were gathered from *NAV*. The use of different ERP systems and the change of the SKU codes throughout the years caused inconsistency in the data collected. For this reason an extensive work of data cleaning was performed in order to create a reliable data set for further analysis. For the data cleaning the item equivalent list was used, as well as information gathered from the ERP systems. Additionally, a collaboration with the Supply Chain Manager of the company was necessary in order to ensure that the data were interpreted correctly. After this process the data gave detailed information regarding the sales number of each SKU in each country and the volumes sold per week in each country. These data were used to analyse the characteristics of the demand, the seasonality indices and the level of aggregation needed. They served as the basis of the statistical model to forecast the future demand. Moreover, comparing the sales data with the forecast, the accuracy of the previous forecast has been determined and analysed, to study the expected improvement of the accuracy provided by the model elaborated in this research. Finally, the analysis of these data was used to create the planning tool, which uses the historical sales data to build future forecast.

The cost breakdown of the products and the cost and revenue analysis were used to analyse the characteristics of the product, to understand the right supply chain that needs to be implemented to operate the business effectively. The information regarding the costs was also analysed to evaluate the supply chain and different solutions regarding the transportation modes and the warehousing activities.

The 3 years business plan was analysed to understand the lead time and the planning process in the company, from the strategic to the tactical and operational plan. The information was used to understand the starting point of the company, to identify improvement areas and to suggest actions to plan effectively in this specific context.

3.4 Verification of results

To verify the results of this research the reliability and the validity was measured. The former means that the instrument used for calculations produces the same results when the same conditions are provided and the subject is also the same (Adams et al., 2014). Having reliable data is an important step but not the only condition it must fulfill to have a valid result. Validity is the extent on how much the conclusions of the research are based on sound reasoning. It also shows the accuracy of the measurements done (Adams et al., 2014).

According to Adams et al. (2014), there are two ways to investigate whether the data are reliable or not. First way is the Test-retest method, which proposes to administer the results at two different dates to prove the stability. To measure internal consistency, Adams et al. (2014) suggest to use the Split-half method, where first one part of the scale items are measured, than the rest. With the final results added together the solution must be the same as when calculating with the full scale items. The program used for all calculations was Microsoft Excel. The tool created for forecasting and planning is connected to another spreadsheet which retrieves data from the company's ERP system. The test-retest but also the split-half method was done continuously during the research phase since the tool was introduced to different members of the staff and run many times at different dates and in addition also separated by warehouse or altogether and the results were always corresponding to what was expected. Hence the results offered by the tool have been proved reliable.

Validity shows on what degree are the results connected to what it was supposed to be measured in the first place (Adams et al., 2014). It is very important to validate data to make sure that it can be trusted and the solutions proposed will be effective also in practice. Golicic, Davis, and McCarthy (2005) suggest that in order to gain both external and internal validity, qualitative research (maximizes realism) and quantitative research (optimizes control and generalizability) have to be conducted.

In order to validate the data we used different sources to retrieve the same information. Some employees at Avero raised their concerns about the data from 2016 and earlier so we have not considered anything from that period. After having a discussion with the sales manager, it turned out that data from 2018 were not trustworthy enough since that was the year when the company changed their ERP system and during that year, both systems were used parallel (U. Fredin, personal communication, March 28, 2020). This resulted in overlapping information in some cases but also in incongruent set of data. To be able to work with historical data from that year the data were compiled, monitored, inspected with the help of other internal spreadsheets from that year and verified by the Supply Chain Manager himself.

Towards the end of the research process the company asked us to present them our findings during a meeting and there was a discussion afterwards where satisfaction was highlighted from the present stakeholders. Some additional input was also added which were later implemented in the tool. This helped with the verification.

4 Company Background and Current Situation Analysis

This chapter introduces the reader to the company Avero and the brand North Trampoline. The current state of relevant processes are described to have a picture of the challenges that are identified and the issues that needed to be addressed for the aim of this thesis project.

To understand the environment in which the demand management was executed first it must be stated that the company was overlooking some important data that would have been helpful for the decision making when designing the future plans. It is necessary to highlight, for instance, the lack of measurements of some costs for the company such as the stock-out cost and the related lost sales, the lack of a systematic way of gathering data, that are stored in different ERPs. Furthermore, the company made limited use of historical data when creating new plans, which were based only on the events of the current year, losing the overall perspective due to a lack of general confidence on the data gathered during the previous years.

4.1 Description of Avero

Avero started off as an e-commercial retailer with the name Studsexperten in 2003. From 2004 it quickly became the leading retailer in the Nordic countries for trampolines hence Avero was founded in 2005. While selling different brands the owner grew to the realization that it is crucial to have different shapes and sizes in the market. While continuously developing new ideas and improvements to a trampoline the first North Trampoline was designed in 2012 and sold the following year. The aim was to create innovative products with high quality and safety. The assortment grew from year to year and the brand quickly got recognition in the region. From 2013 the company acted as an e-commerce retailer for other trampoline brands while focusing on designing and building their own products. The decision of only selling North Trampoline products was made in 2019, starting from 2020. Their mission is to bring joy and increase physical activity and social interaction among children and adults while focusing on safety standards and lead the market of trampolines in sustainability and innovation. Their core values are the following (North Trampoline, 2020):

Love – help make this world a better and more loving place
Quality – develop and promote products of the highest quality
Pioneering Spirit – be creative in all aspects of the business operation

For now Avero's assortment of trampolines consists of six product families with a wide selection of shapes, colors and sizes. They also offer different accessories for the trampolines but also some clothing and spare parts. Avero is a B2C company but from 2019 on, they also started to do B2B. The main channel to purchase their products is their own website, accessible in multiple languages. In addition, a purchase can be done through Amazon (in Germany, United Kingdom, Spain and Italy), through their initial retailer websites and with the help of wholesalers in the UK and in the US. Their aim is to grow 15-20% annually but not by expanding their assortment to other products as well which have probably a different seasonality but by opening up to new markets.

Avero puts very big emphasis on being sustainable. Above creating durable, high quality trampolines, they also focus on having less impact on the resources of our planet. From 2020 on, they introduced a recycled EPE material for the padding foam. and the materials used are 100% recyclable. The packaging is also done in a way to use the least amount of plastic and recycled paper in it. They offer an environmental friendly delivery option too. Avero participated in projects such as *Re-use Re-Invent Re-market* with the University of Gävle, Sweden and *CIRCit – Scandinavian Sustainability Project.* On top of these measures they also propose three ways for the customer to be more sustainable, namely, how to take care, how to prolong the life of the products and, after being done with the trampoline (when i.e. the children grow up and do not use it anymore), resell it.

Another very important quality that has a priority when designing and developing the trampolines is safety. They have a collective name for all the features that are built in the products, the North Safety Systems. The aim is to minimize possible hazards and ensure safety and confident use. Some of the features are spring protection, zero gap safety net zippers or safety belt.

4.2 Operations at Avero

At Avero there are 7 different departments, namely Finance, Human Resources, R&D, Sales, Marketing, Supply Chain and Customer Experience (figure 8). All employees in the different departments are working from the HQ in Gothenburg except for the R&D, whose work is located in the same city but further away. Altogether around 30 people are employed by the company and during the season a seasonal staff is added to the Customer Experience team to be able to answer all inquiries. In 2017, there was a reorganization taking place, where some roles have been specified and responsibilities changed.

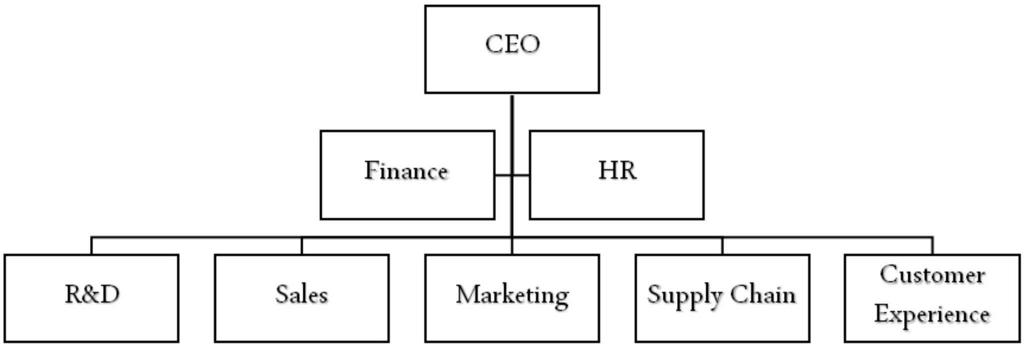

Figure 8: Organisation chart of Avero

Finance supports the area of Business Control. Its responsibilities are planning and controlling the company's finances. HR, Human Resources, is responsible for recruiting, handling employees' relations, payrolls and well-being.

The research and development department is designing the trampolines. They are working closely with the suppliers in order to please the preferences of both sides, the production and the customers. To introduce a totally new product to the market they usually need around five years. The first years consist of discussion and brainstorming. This phase is not considered while creating the business plan, since it is an on-going, never-ending phase. This is followed by a concept-phase, where understanding the customer-base plays a high role. The product is then developed in-house so they can apply for patents to protect their original developments from the competitors. Then it is brought to the supplier to prepare the production. Continuous development on already existing products is on-going through the whole year in case they feel like there is a need for it.

The marketing team is responsible for exploring new markets and channels, continually develop the customer facing channels and its content, create advertising materials, brand identity and development, marketing plans and campaign strategies. Another responsibility of the marketing team is to follow-up with the competitors. Having exact plans for promotions and campaigns is crucial from a planning point of view. Throughout the season a lot of such are running and these can drive the sales up or down. Some of the campaigns go live only when there is a deviation in sales from the plan to reach the target but some are planned based on different events during a year (e.g. Easter Holidays). Since marketing team has a high involvement in driving the sales and smoothing demand variations, a strong communication between them and the supply chain department is required.

Customer Experience has a high importance in the company since that is the only customer facing function. During the season additional employees are added to bear the workload. Avero puts high emphasis on treating customers right and aims for only highly pleased customers. Employees in this team are very diverse and speak a wide range of languages. Since a lot of NT products have warranty on different parts, having knowledge on what is available at that moment is crucial as is being aware of when to expect inbound deliveries and stock shortages. This information is available from the Supply Chain team therefore a close cooperation is a must.

The sales department is responsible for the sales forecast accuracy of the full assortment (incl. spare parts), revenue, customer price and margin. Together with the marketing team, they are executing the full assortment strategy for in-house and sourced products. The focus of this department is selling, growing and expanding.

Finally, the supply chain team is responsible for dealing with suppliers, organizing the inbound deliveries, making agreements with third party logistics for outbound deliveries, managing the relationship with the warehouses and keeping the inventory at reasonable levels. Since the focus of the thesis is on this department and the aim of the research is to make the work of the team easier, the supply chain and the challenges will be described in more detail in one of the following sections.

The management team has a meeting every Monday during the selling season, called the Monday Action Meeting. They walk through the actions of the previous week's meeting, compare the sales figures with the budget and the last year's sales, talk about ongoing or starting campaigns, discuss the stock levels in all the warehouses, summarize the actions of the competitors, check the weather forecast and mention customer input, if any. The same day but in the afternoon there is another meeting regarding the actions to take. Outcome could be, for instance, moving stock or adding campaigns. On Tuesdays, a Marketing Meeting is being held where only the marketing team and the lead of the finance department is present. They review the actions agreed on Monday and decide on the plan. Another task here is to check the conversion rates and discuss it more thoroughly. On Fridays the management team have a Stand Up meeting, where they discuss the indications from that week.

Additionally there is a monthly meeting for the whole company, where they discourse about the past events happened during that month and discuss the plans for the following month. To keep everyone updated about sales situation, stock-outs, or anything in particular there is also a weekly email elaborating on those sent by the CEO. During the season this emails are sent even more often to communicate any occurred situations and changes.

4.3 Planning process

The strategic plan sets the goals of the company on the long-term, with a time horizon of three years. It starts with the market and assortment planning, which determines the product plan for the next three years and gives input to new product development and operations.

According to the leader of the R&D team, the outcome of the product plan starts the R&D operations, that take approximately 2 years from the start of the process to the start of production (T. Hagel, personal communication, April 28, 2020). The process involves different phases:

- 6 months of concept elaboration, study of the market and the needs of the customer base;
- 9 months of product development, technical elaboration conducted in-house in order to be able to file new patents;

- 4-6 months of collaboration with the manufacturer in order to complete the new products and to conduct the tests;
- 6 months of preparation for the production.

After one year a revision of the market and assortment plan is made, based on the actual sales of the current year and considering the deviations from the initial plan. The revised plan is the basis of the sales and cost budget, which defines the sales budget per channel, split per country and the cost budget in order to meet the revenue and profit targets.

The marketing plan is elaborated on a tactical level, with a time horizon of one year. The plan involves the creation of marketing material for B2B and B2C and the campaign planning for the season, which lasts two months and it occurs in the months preceding the selling period.

The tactical plan to manage the demand starts in June of the previous year, when the sales department develops the first sales plan draft based on the sales of the current year. The outcome of the sales plan is the total amount of items that will be sold in the following year, the planning process ends in August. A detailed description of the forecasting process will be presented in section 4.7.

The sales forecast is the basis for the supply planning that takes place in August and September. The process, according to the supply chain manager, includes the following operations (E. Rodhe, personal communication, April 27, 2020):

- the forecast is compared to the total inventory in order to know how much is needed from the suppliers,
- the quantities that are expected to be sold are spread on a weekly plan based on the respective weekly share of sales of the current year and the deliveries are planned accordingly,
- the deliveries are split between the warehouses according to the cumulative sales share that occurred in the regions served by the warehouse during the current year.

The supply planning process includes also the negotiation of the terms of the contract with the suppliers, which ultimately result in the production order, that is committed typically at the end of September. The order includes 90% of the needed quantities and a 20% extra purchase for the safety stock, small adjustments are possible during the month of October.

In December the supply chain department elaborates the delivery plan for each warehouse in Europe. The deliveries are scheduled to arrive three weeks before the sales forecast in order to reduce the risk of lost sales in case of delays and to be prepared in case of unexpected variations of the demand, e.g. early start of the season. The deliveries are spread during the selling season to avoid overloading the regional warehouses with the unloading operations that would hinder the performance of the order processing operations during the peak workload (E. Rodhe, April 8, 2020). The first containers are delivered in February and other 5-6 shipments are planned throughout the season, with the last delivery scheduled in June.

According to the supply chain manager, issuing a new order during the season entails some capacity issues for the suppliers who can only fulfill the order in 30 days, best case scenario (E. Rodhe, personal communication, April 8, 2020). Therefore an order placed during the season would result in available products at the warehouses in no less than 10 weeks and this is the reason for such a rigid plan, in which approximately 110% of the quantities (90% of the forecast and 20% as safety stock) are fixed four months before the selling season.

Figure 9 shows the operations and planning of the peak season, with a particular focus on the sales and supply chain operations that lead to the supply plan for the season, important milestones of the supply plan are highlighted in the figure.

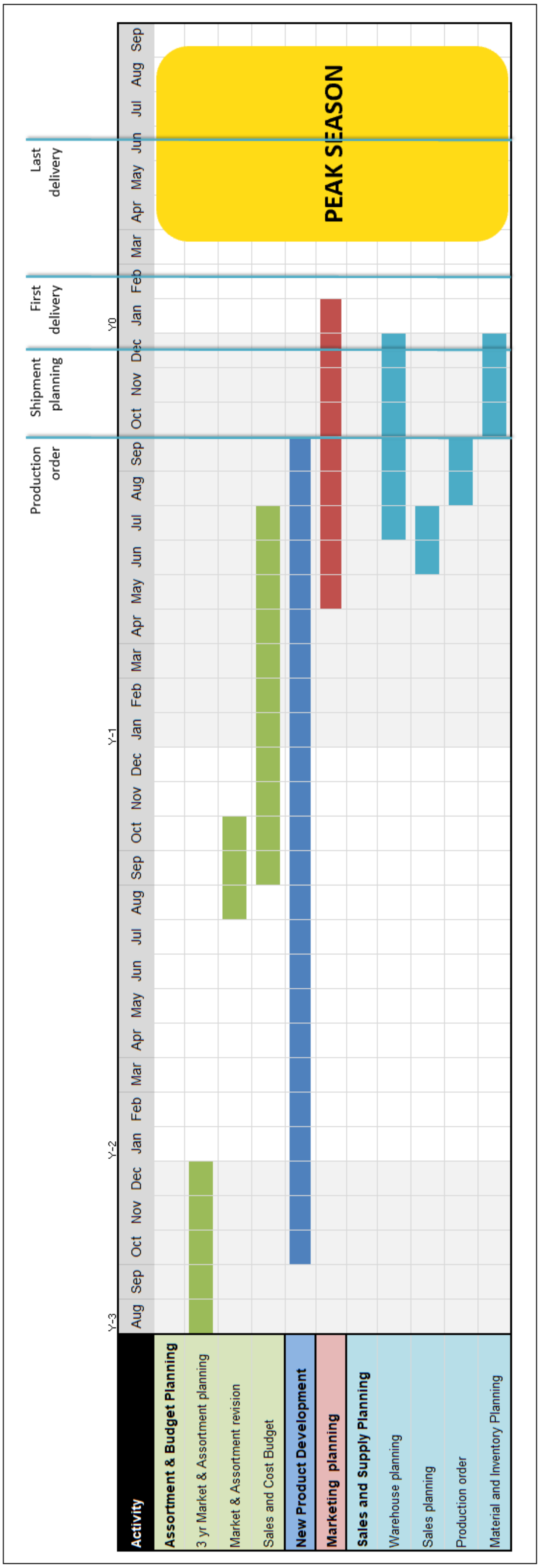

Figure 9: Planning process

4.4 Supply chain

In the two following sections the structure of the supply chain will be described in more detail and then the processes involved with supply chain planning analysed.

4.4.1 Overview of the structure of the supply chain

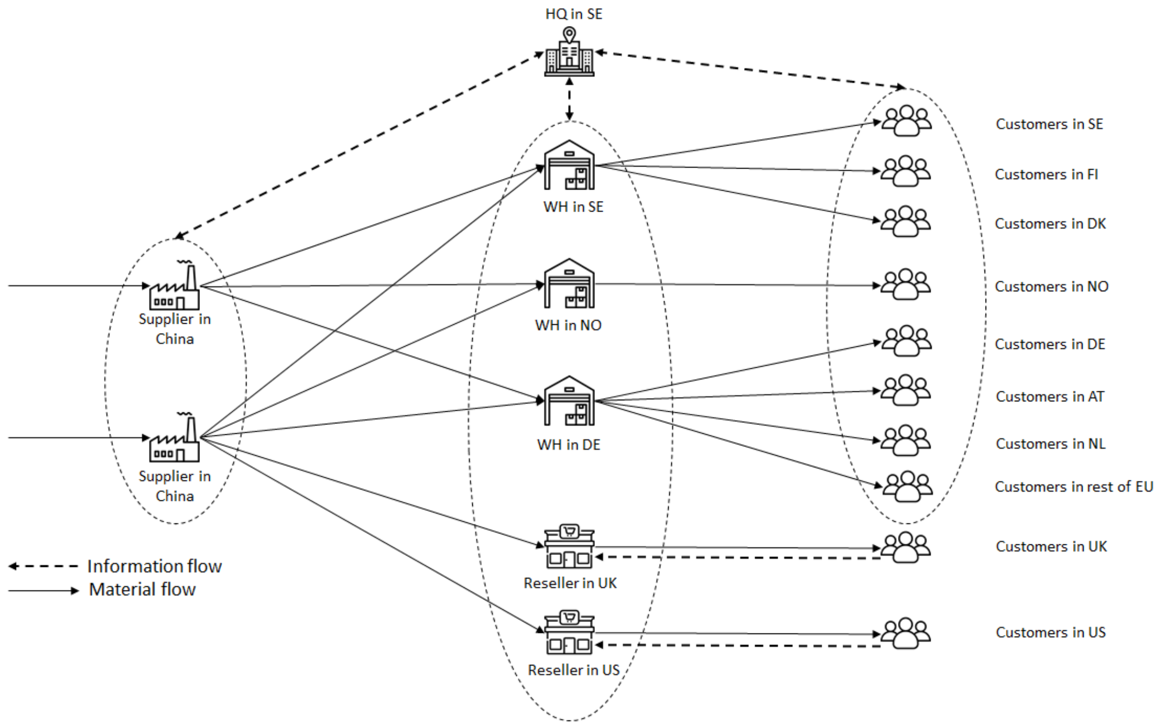

Figure 10: Supply chain of Avero

Avero has a simple supply chain structure, comprising of two suppliers, 3 warehouses and 2 resellers (figure 10). The suppliers are both in China and are responsible for the procurement of the raw materials and the production of the trampolines, accessories and spare parts. Avero has a good and tight relationship with both of them. The two suppliers are manufacturing different products so it is essential to have both and in case of an unforeseen event the production can not go on in the other facility. They are the biggest trampoline producing companies in China and, according to the supply chain manager, 65% of the products are delivered from one and 35% from the other one (E. Rodhe, personal communication, February 5, 2020). The finished goods from the supplier are then sent to one of the warehouses in Norway, Sweden or Germany or to one of the resellers in the UK or the US. According to the supply chain manager, the transit time from the supplier to the Port of Gothenburg is about 45 days via sea and one week less to Rotterdam (E. Rodhe, personal communication, February 5, 2020). Due to the long inbound delivery time Avero is considering to move the production closer to Europe. The items are shipped in a container, the cost for shipping depends on different factors but is on average EUR 3.000/container, and the containers are unloaded at the warehouses (E. Rodhe, personal communication, February 5, 2020). The resellers are only supplied from one supplier which results in a smaller assortment of products.

The three warehouses where the finished products are stored until they are sold are in Norway serving Norwegian customers, in Sweden serving Danish, Swedish and Finnish customers and in Germany for German, Austrian, Dutch and other European customers. The warehouses are not owned by Avero, they are rented according to the volumes planned at each one. Handling of goods are done by the warehouse employees with whom Avero has a good relationship. The goods are being unloaded from the arriving container at the warehouses. The company has different deals with a third party arranging the outbound deliveries to the customers. The deliveries can take up to 7 working days depending on the location of the customer. Avero promises to process and ship an order the same day if the products are available and the order comes in before 10 in the morning. In case of a stock-out the products are shipped right after they arrive to the warehouse.

The headquarter in Gothenburg is where the orders come in from end-consumers through a platform. After processing the orders, the warehouses are being notified through the same platform and start the picking activities accordingly. All communication is received or sent from the headquarter therefore the suppliers, warehouses, and customers have no direct connection with each other. The structure is slightly different with the resellers since they manage all the communication with their customers.

4.4.2 Analysis of the supply chain

The Supply Chain of the company is characterized by a long lead time, from the moment an order is placed to the suppliers, to the time the product is available to be shipped to the customers. According to the supply chain manager, when an order of new products is issued to the suppliers, it takes 45 days to procure the safety net and 30 days for the other materials of the trampoline (E. Rodhe, personal communication, March 4, 2020). The manufacturing time to produce the trampolines is generally 15 days. When the products are ready to be shipped to Europe they are sent from China via sea in containers, reaching the warehouses in Europe in approximately 45 days, when the weather is favourable, but this could also easily increase with bad weather. The total lead time is 105 days, as shown in figure 11.

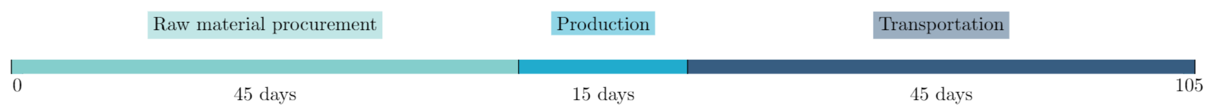

Figure 11: Lead time from order placed to products delivered to the warehouse

According to the supply chain manager, when an order of products already in assortment is placed to the suppliers the products are usually ready to be shipped in 30 days due to production capacity, assuming the raw materials are already in stock (E. Rodhe, personal communication, March 4, 2020).

Considering the length of the season, a crucial challenge for the supply chain is to plan the production and the replenishment in order to be able to meet the customer demand. With the current supply chain, if more products are needed during the season the warehouses can be replenished in no less than 10 weeks, leaving hardly any possibility to make changes to the initial plan. As a consequence, 110% of the quantities, including the extra purchase for the safety stock, require to be decided in advance, resulting in the need to have a final forecast and sales plan in October of the previous year, according to the supply chain manager (E. Rodhe, Personal communication, March 4, 2020). The uncertainty related to the demand creates a difficult environment to forecast future sales and combined with a long lead time it represents one of the biggest challenges for the demand management of North Trampoline.

An example of a difficult situation caused by these factors occurred during 2019 season: the sales started to increase earlier than the previous year and the management team considered it a sign that the forecast was underestimating that year's sales. Due to the long lead time, the decision of ordering more products was taken at the beginning of the season in order to be able to meet the expected demand avoiding stock-outs. Unfortunately, the sales dropped after the first peak and the promotions could not change the declining trend of the sales. This issue led to excessive inventory at the end of the season, when the sales are close to zero, except for the black Friday week, in which occurs a small peak that accounts for approximately 3% of the yearly sales, but was not enough to reduce the stock levels.

Reducing the stock, especially during the off-season, is one of the aim of the company. The boxes in which trampolines are stored in the warehouse are heavy and large therefore having excess stock is very costly. During the sales season there is a need for safety stock and, according to the supply chain manager, the inventory costs are higher in order to be well prepared before the start of the season to avoid stock-outs due to the unpredictable demand (E. Rodhe, personal communication, March 4, 2020). Nevertheless, the planning errors create an overstock situation during the off-season that leads to higher inventory costs and tied-up capital, reducing the cash flow of the company during the period in which it is needed to invest for next year's production.

Furthermore, it is relevant to analyse the current inventory approach. Until 2019 the company was delivering the products to the customers from four regional warehouses:

- warehouse in Sweden, serving the customers in Sweden and Finland
- warehouse in Norway
- warehouse in Denmark
- warehouse in Germany, serving the customers in Germany and in other EU countries.

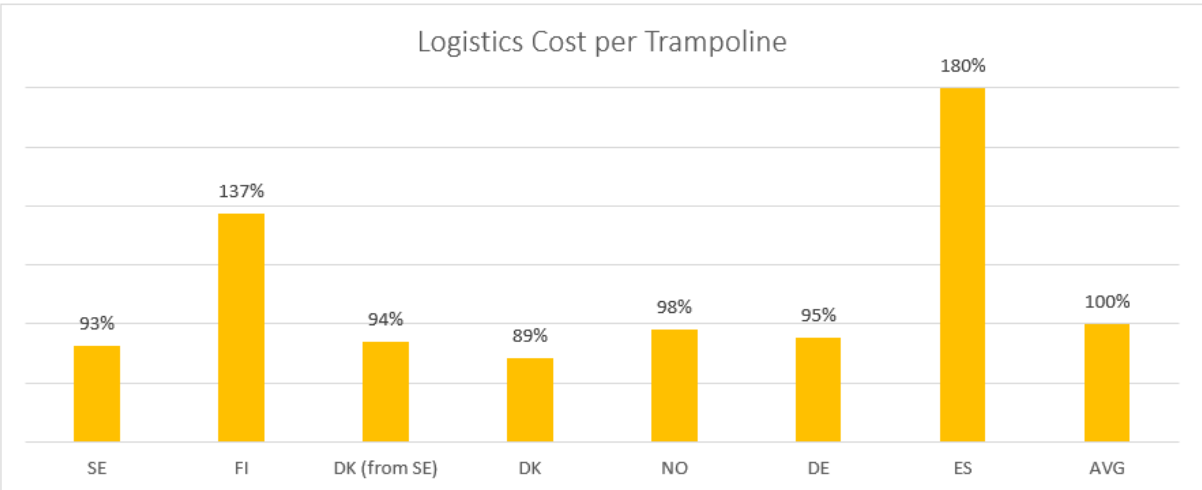

Figure 12: Logistics cost comparison

Due to the reduced volumes of the previous years and due to the decision to discontinue the partnership with Berg, whose trampolines counted for the majority of sales on the Danish market, the company decided to serve the customers in Denmark from the Swedish warehouse, therefore reducing the number of warehouses to 3 in 2020. Despite this decision, the approach of the company in terms of inventory management is to have decentralized warehouses that are geographically close to the markets served. According to the CEO of the company, as soon as they have significant sales in a specific country the idea of having an additional warehouse is discussed, considering the reduced delivery time and transportation costs from the warehouse to the final customer (O. Eriksson, personal communication, February 4, 2020). In order to understand the reasons behind this approach it is relevant to analyse the logistics costs per trampoline in different markets, figure 12 shows the logistics costs per trampoline in some of the markets served by Avero, using the average cost as the benchmark value for the comparison.

It is important to observe that all the countries in which a warehouse is present the logistics costs are lower than the average. Therefore, provided that the market is big enough, the consequence is that a decentralized distribution system is built to avoid excessive extra costs for the transportation, as the examples of Finland and Spain. However, it is relevant to examine the Danish example more in detail: as the decision to serve the market from the warehouse in Sweden was recently made, an analysis of the logistics cost of the two scenarios is provided. The geographical proximity and the size of the market prevent the logistics costs from rising excessively even though the Danish customers are served from Sweden.

During the selling period, it is common to witness shortages of products in a warehouse and overstock in other warehouses so it is not unusual for the supply chain manager to take the decision to rearrange the stock among the warehouses, entailing additional transportation costs (E. Rodhe, personal communication, March 4, 2020). For this reason it is important to analyse the regional demand in order to have a better planning perspective. As a consequence of the demand uncertainty and the random variations that can be caused by local factors (e.g. weather conditions), the regional demand appears more irregular compared to the aggregated quantities, leading to a more challenging planning environment. Figure 13 shows the regional demand in 2019, considering as regions the areas served by a single warehouse during the year in exam.

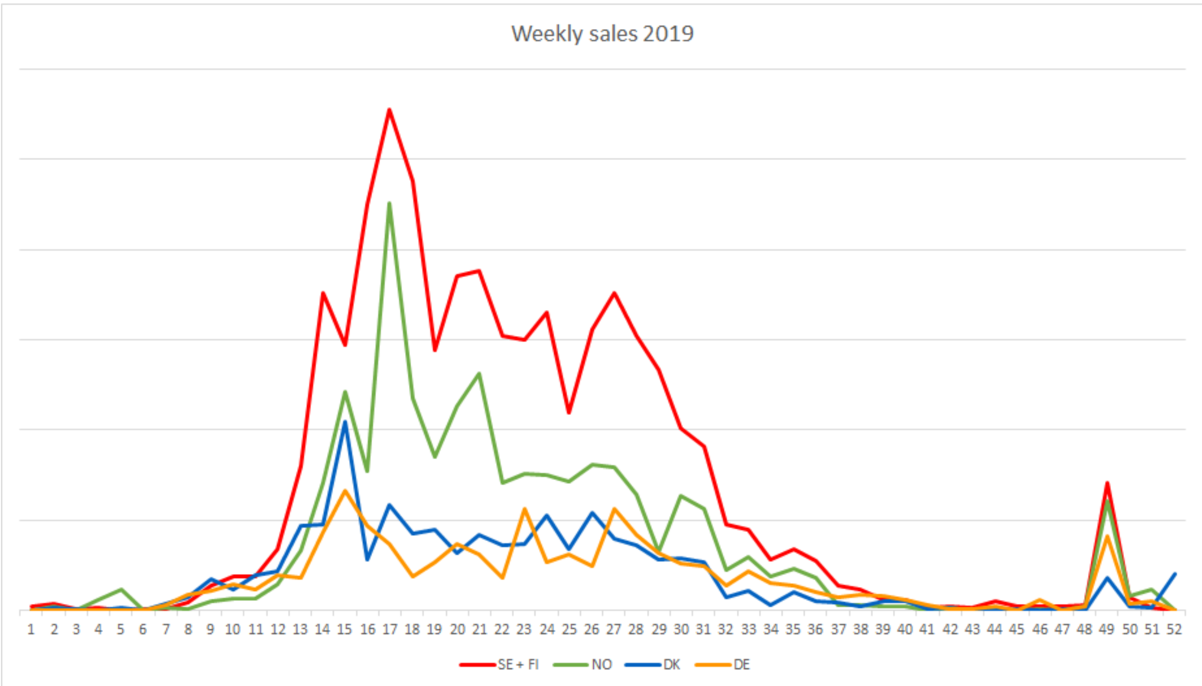

Figure 13: Regional sales in 2019

The high unpredictability of the demand increases significantly the risk of stock-outs. To date, the company is not collecting data about the stock-outs, it is an issue addressed during the season when the stock levels become critical but no historical data is available for the analysis. Moreover, in case of stock-out the website shows the date in which the product will be back in stock, giving the possibility to place the order with a longer delivery time due to the shortage. However, no historical data are stored about the customer behaviour in case of stock-outs. During the first weeks of the season in 2020, when the demand had a considerable increase, customers were ordering products regardless of the stock-out to the point that the majority of the products in transit from China were already sold, according to the supply chain manager (E. Rodhe, personal communication, April 27, 2020). Nevertheless, it is important to mention that the general situation of shortage was a common issue for the competitors during the same period, therefore the extent of lost sales in case of stock-outs cannot be assumed by this example. The lost sales due to shortages is very costly for the company, considering the relatively low quantities and the high average contribution margin of the products. For this reason, it is necessary to avoid shortages to the greatest extent possible, which means that not only the quantities sold need to be in the right place at the right moment, but also the right item needs to be in stock in the right warehouse at the right moment. As a consequence, the forecast needs to be detailed to the single SKU and the region in which it is predicted to be sold.

4.5 Product characteristics

Avero is offering different trampolines, spare parts, accessories and customer service as their profile. Their products are characterized by high quality so they position themselves as a premium category brand. From the year 2020 their focus is only directed towards products from the North Trampoline brand but they still offer different brands they started to resell in previous years. Their plan is to stop reselling other brands after the stock runs out.

The brand North Trampoline offers consumer goods with only a very little assembly needed from the user after receiving it and all without bolts or nuts. The company's aim for being as sustainable as possible also shows the way they provide the instructions which are not paper based but the manual is showed on a video. The accessories can be divided into clothing (shirts, caps and hoodies) and products directly connected to the trampolines, such as ladders, basketball hoops, weather cover, etc. The brand encompasses six product families among the trampolines: Pioneer, Challenger, Explorer, Performer, Adventurer and Athlete. The latter, the Athlete comes in the official competition size (5,4x3,2 m), is both for indoor and outdoor use. The target audience for this product are professionals or jumping arenas hence this is the most expensive trampoline with a price of EUR 4.499 (North Trampoline, 2020). The other trampolines are for children, families or anyone in the mood for jumping, recommended from the age of 3 but with all the inbuilt safety features younger children can also bounce around in them. The performance trampoline is aimed more for teenagers since it is easier to jump higher on them thus do more tricks and flips. The price of the other trampolines range from EUR 549 to 2.149 depending on the size and shape of the trampoline (North Trampoline, 2020). There is one particular style, the Explorer Planet which is made of recycled materials.

Most of the products were black but from the year of 2020 the frame pad can be ordered in petrol, maroon or coral. The Explorer Planet is wood green. There is also one product which is not from the latest edition and will be running out this year, the Adventurer Oval 500 which can be chosen in aqua, i.e. light blue. There is also a wide selection of shapes, namely rectangular, oval and round. All three shapes can be purchased as a mounted trampoline but the latter two are also offered as inground models. There are also different sizes for each product family with a jumping area ranging from 3,5 metres to 8,9 metres (North Trampoline, 2020).

The trampolines can be classified as durable products and the company also provides a warranty for the most important parts of a trampoline, i.e. the jump mat and springs for 5 years, safety net and frame pad for 2 years and the frame for 7 to 10 years depending on the type (North Trampoline, 2020). The accessories directly related to the trampolines also have a one year warranty. The lifespan for a trampoline is yet unknown but for safety reasons it is recommended to change the safety net every two years since it is heavily exposed to ultraviolet light, being an outdoor product. For the same reason the materials are developed so it can withstand bad weather, such as rain or frost.

From a logistics point of view, the trampolines are delivered in boxes where there are no unnecessary plastics only the packaging material itself to be as sustainable as possible in packing as well. Depending on the size and shape of the trampoline the boxes can weight from 35 up to 89 kg, have a length up to to 190 cm, and a width to 60 cm (North Trampoline, 2020). Most of the trampolines are delivered in two boxes but there are exceptions, e.g. the smallest Pioneer where one box is already sufficient or the Performer, which is packed in 6 individual boxes. The Athlete, the biggest trampoline from NT, is packed in 7 big boxes with a max weight of 95,5 kg, and 5 additional small packages are included that are only 28x19x15 cm and 8 kg (E. Rodhe, personal communication May 13, 2020). The home delivery, as an offered service has an additional cost which varies depending on which country the order was placed from. For now, 28 countries are in the scope but the plan is to grow even further. The deliveries are taken care of by a third party or by regular mail when the order consists only of small pieces.

4.6 Demand characteristics

Trampolines are a leisure and sport equipment that is mainly used outdoor, for this reason the seasons and the weather conditions affect the demand heavily. During spring and summer, when the temperature and the weather favour outdoor activities, the trampolines are sold in high quantities, while during the off-season period the demand is minimal. Being an expensive product, the demand is higher at the beginning of the season so that the customers are able to take the most advantage from the product during the current season. Figure 14 shows the sales of trampolines per week, comparing the volumes sold by the company in 2017, 2018 and 2019.

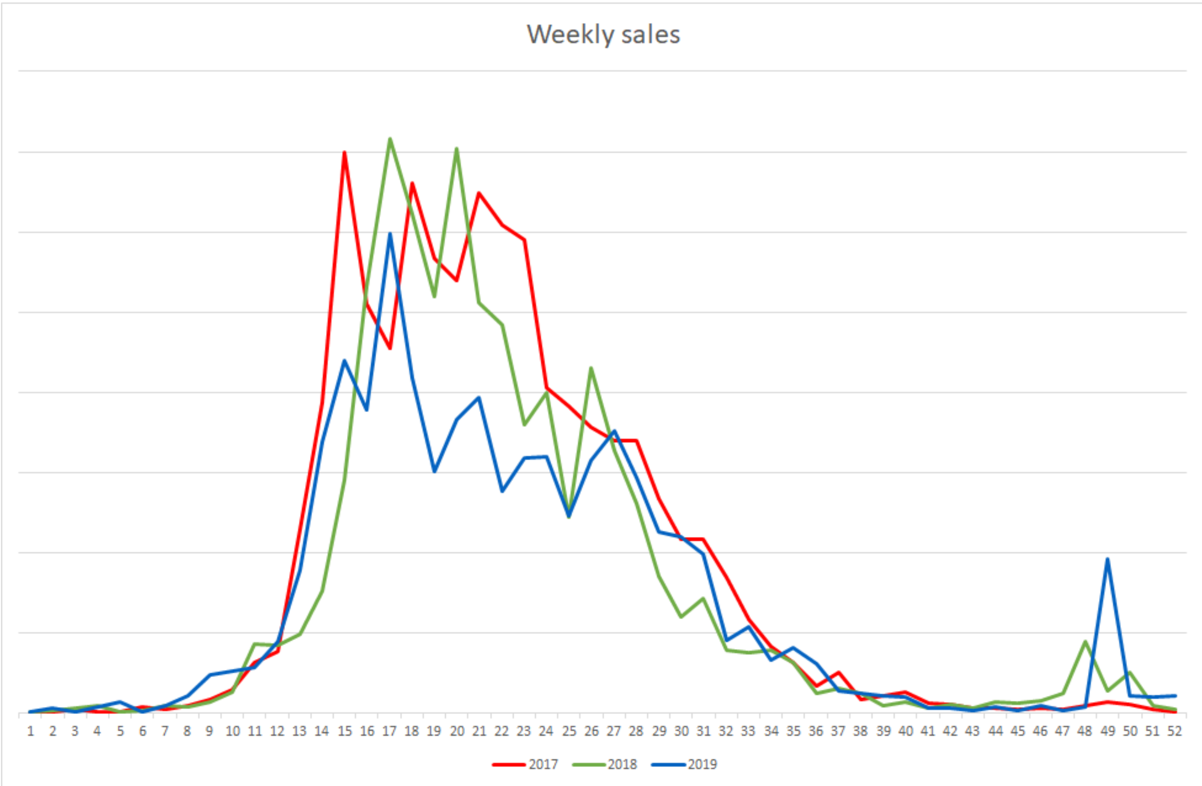

Figure 14: Total sales of trampolines

Analysing the weekly sales during these three years it is possible to determine some of the characteristics of the demand:

- **seasonality**: the curves show that during the off-season the demand is approximately zero, while the majority of sales take place during spring and summer and with a small peak at the end of the year due to black Friday;
- **short sales period**: approximately 80% of sales occur in a 15 weeks period (from week 14 to week 28), which is less than 30% of the year;
- **uncertainty**: the demand is characterized by high levels of uncertainty, in fact it is possible to see that for example in 2018 the season started later compared to the other years and it relevant to notice that the peaks happen at different times and with different volumes;
- **random variations**: the curves are sharp and with several peaks during the season that appear to be unforeseeable.

These aspects of the demand create a challenging environment when it comes to forecast the future demand. According to the sales and the supply chain managers, the demand is heavily affected by several factors that are predictable only partially or in a short term horizon or not at all (U. Fredin and E. Rodhe, personal communication, March 23, 2020).

The most important factor is the weather condition. As the season affect the demand of trampolines, the weather can be responsible for an early or late start of the sales peak. If the weather conditions are favourable during the spring, with warm temperatures and several sunny days, the sales rise and there is a general boost of the demand of equipment such as barbeques or outdoor furniture, which are products that share a similar seasonality pattern as trampolines. However, bad weather conditions during spring can lead to a delay of the sales peak and even to some lost sales. The weather forecast, although improving over the years, is not reliable on a long term horizon, therefore it can influence the demand in an unforeseen way. For this reason the majority of the sales occur during spring and summer, when the temperature rises and there are more sunny days. Nevertheless, the weather is very unpredictable and the forecast is reliable only on a short time frame. For this reason it is not possible to include the weather conditions during the forecast process for the following year but it can only be taken into account during the season when it comes to forecast the expected deviations from the initial plan. For example, according to the CEO of the company, the belief in the company is that sales during 2018 dropped halfway through the season because of the weather conditions: the temperature was very high and people preferred to do other outdoor activities like swimming (O. Eriksson, personal communication, February 4, 2020). On the other hand, in 2019 the company faced the opposite situation: the weather was not good, with a lot of rainy days and low average temperatures, so after the first peak the sales never got to the levels they were expecting.

Another factor that is influencing the demand and is strongly related to the weather is the characteristic of the product. It is an expensive outdoor leisure equipment for kids so families consider it as an investment. As a result, it is possible to see that the sales peaks are higher during the first part of the season and a slow decline in sales is visible in the second part, when the remaining time of the outdoor season is shorter. According to the CEO of the company, the bad weather conditions during the first part of the season are likely to affect the performance of the whole year since the customers will tend to postpone the investment to another year when they will be able to maximise the use of the product (O. Eriksson, personal communication, February 4, 2020). This effect can be clearly identified in 2019, when the weather conditions were not favourable, the season started with a relatively low peak and after the decrease they never reached the plan.

Similarly to other products that share some common demand features, trampolines are bought mainly during the weekend or during holidays, when the families have more time to browse the websites and place orders. When it comes to planning it is necessary to keep in mind that some holidays, paired with the weather conditions, can affect sales in different ways: a peak could be shifted, amplified or reduced due to the influence of these circumstances. According to the sales manager, Easter is a very important holiday for the trampoline market (U. Fredin, personal communication, March 23, 2020). However, being on a different date each year the forecast needs to take into account this variability, therefore it is important to consider that the seasonal indices might be inconsistent due to the Easter effect.

Another important element that must be considered regarding the trampoline demand is the competition in the market. promotions and campaigns both from the company and from the competitors affect heavily the sales and the market is very competitive. Campaigns and promotions are important measures that can push sales and the competitors' actions can introduce variations by capturing a bigger market share. The competitors act on their own interests, which means that specific promotions can be put in place to reduce excessive stock in the warehouse or to push sales in case of bad performances. These actions affect the sales and generate unpredictable variations in the demand. The effect of promotions can be seen for example in the sales figures of 2019, due to the low sales and high inventory the company introduced several promotions to push the sales after the demand dropped. As a result, it is possible to identify at least three peaks during the second part of the season. Even though the effect of these actions is clearly noticeable in figure 14, the campaigns did not succeed in pushing the sales to the expected levels and the company ended the season with excess stock.

Unforeseeable events are external factors that cannot be predicted but can affect the demand of the market extremely. For example, during spring 2020 the Covid-19 outbreak in Europe created a highly exceptional situation for the trampoline market. The lock-down measures taken by several governments in Europe created an exceptional increase of the demand due to the decision of closing schools, due to the application of remote working policies and due to a reduction of travels and recommendations to stay at home. Families, looking for ways to entertain kids within the boundaries of their household, found the trampolines very convenient for the purpose and during this period sales increased greatly, causing a shortage of products in the market.

4.7 Forecast

According to the supply chain manager, the sales forecast for the following year is elaborated by the sales department, it indicates the total amount of expected sales in the year of the single SKU in each country, taking into account the data of the current year and the sales growth objectives (E. Rodhe, personal communication, March 4, 2020). According to the sales manager, previous years historical sales data are not considered in the forecast process due to a lack of a quantitative forecasting method to support the process and due to a lack of confidence in the data collected in the previous years (U. Fredin, personal communication, March 23, 2020). The transition to a new ERP system, started in 2018, improved the data storage and availability, making it easier to access and gather historical data. However, the new system was completely functioning from 2019, after a transitional period in 2018, therefore the sales data prior to 2019 required additional effort to be retrieved and the sales department do not consider them reliable (U. Fredin, personal communication, March 23, 2020). Furthermore, no other departments are involved in the forecasting process so the outcome is mainly influenced by the ideas and targets of the sales department, starting from the current year sales data. According to the CEO of the company, the forecast accuracy is not measured, no indicators have been used to monitor the error nor to evaluate the performance of the forecast throughout the years (O. Eriksson, personal communication, February 4, 2020).

As part of the analysis of this project, the sales data from 2017 to date have been retrieved from the ERP systems and compared with the forecast elaborated by the sales department in order to evaluate the accuracy of the forecasting method used by the company. To perform the evaluation of the forecast accuracy several measurements have been considered: the mean error

(ME), the mean percentage error (MPE), the mean absolute error (MAE), the mean absolute percentage error (MAPE) and the weighted absolute percentage error (WMAPE). The first two methods have been considered inadequate for the purpose due to the characteristics of the demand: the frequent variations of the demand create a sharp curve with unpredictable up and downs, therefore the forecast has the same likelihood of being higher or lower than the actual sales. Consequently, the ME or MPE would not be able to capture the magnitude of the error, since the plus and minus signs could outweigh each other (C. W. J. Chase, 2013). According to C. W. J. Chase (2013), the MAE, although calculating the error in both directions, gives a measurement that is difficult to interpret and it may vary considerable throughout the years but it would bring a different information because it is not presented in relation to the actual data. The MAPE, on the other hand, gives a relative amount that is easily comparable and it considers the errors in both cases, over or under predictions (C. W. J. Chase, 2013). However, some products with very low sales quantities can easily present high percentage errors in spite of a small deviation that has a lower impact on the planning performances. For this reason, it is useful to weigh the results based on the sales volumes in order to have an indicator that considers more the error related to the best selling products (C. W. Chase, 2016). Hence the WMAPE has been chosen to evaluate the forecast accuracy, with the following formula (C. W. Chase, 2016):

$$\text{WMAPE} = \frac{\sum_{t=1}^{n} \mid A_t - F_t \mid}{\sum_{t=1}^{n} A_t} \cdot 100$$

The choice of comparing the forecast to the actual sales, that could result in biased predictions toward underestimation, is taken considering the context of the company. In fact, according to the CEO of the company, the lack of incentives in case of overachievements for the sales department prevents the bias towards underestimated forecast, therefore it is reasonable to compare the forecast to the actual sales data (O. Eriksson, personal communication, April 17, 2020). Table 4 shows the results obtained by the analysis of these data, only considering the products of North Trampoline brand. The information regarding the forecast for 2017 was not possible to retrieve due to the lack of data storing that was in place before the reorganization that occurred in 2017, according to the CEO of the company (O. Eriksson, March 2, 2020). Hence the forecast accuracy measurement has been performed for the years 2018 and 2019.

Forecast error		
Market	**2018**	**2019**
Sweden	40.10%	42.87%
Finland	63.37%	113.42%
Norway	29.51%	52.35%
Denmark	68.14%	76.15%
Germany	39.63%	44.30%
Total	33.98%	43.54%

Table 4: WMAPE comparison during 2018 and 2019

Based on the error it is possible to conclude that the performance of the forecast is not satisfying. Considering the complex demand characteristics, reducing the forecast error is an important challenge that the company need to face in order to be able to manage the demand with an effective and efficient plan. It is worth mentioning that the error of the disaggregated forecast in most cases is significantly higher compared to the aggregated one, especially for the countries in which the company has low sales volumes. Furthermore, the lack of data regarding the previous years leads to a higher error: the company entered the Finnish market in 2018, hence the lack of experience and knowledge of the market is the cause for the poor forecast performance. In the countries with higher market share, such as Sweden and Norway, the error is lower than the total in 2018. The small quantities sold in other countries make the forecast more difficult because of the uncertainty of the demand and the random variations that appear to be amplified in small contexts. However, 2019 was an unfortunate year for the trampoline market in Norway, where the company experienced a decrease in sales of 26% compared to 2018, and the forecast error in that year was close to 53%. It is worth mentioning that the error considering the aggregated quantities only increased slightly, despite Norway being the second most important market for the company. The reason for this result can only partly be identified in a better forecast performance of other countries, like Denmark and Sweden, since the slight improvement in those countries is not enough to outweigh the terrible performance of the forecast in Norway. Therefore it is possible to conclude that the aggregation of the demand decreases the variability and the uncertainty, resulting in a better overall forecast result that outperforms the forecasts on a country level.

4.8 Cost breakdown

In this section a description of the variable costs related to the products is presented. Due to the fact that some prices and costs are considered sensitive information they will be shown as the average percentage of the average selling price and in some cases they will not be presented numerically but just in qualitative terms. Table 5 summarizes the average variable costs related to the logistics activities of the products, as estimated by the company for the year 2020.

Activity	Cost
Transportation from supplier	5%
Handling	2%
Storage	3%
Delivery to final customer	6%

Table 5: Average cost breakdown as percentage of selling price

According to Fisher (1997), the threshold of the contribution margin for a product to be considered innovative is 20%. Although some data regarding the variable costs cannot be presented in detail, such as the purchase price of goods from the suppliers, from the data shown in table 5 and the information gathered in the company, it is possible to state that the products sold are characterized by a high average contribution margin, that exceeds the 20% of the average price. The high contribution margin is necessary to cover the indirect costs such as, among others, the customer service, the marketing costs and the R&D. However, the contribution margin is variable for each product and for some of them it is significantly lower. Furthermore, the margin varies during the selling period due to the marketing promotions that reduce the price. For example, in 2019 several promotions were adopted in order to push the sales that were not at the expected levels, resulting in a reduction of the contribution margin of the sales. Considering the nature of the demand, the products lose value at the end of the season, although they can be kept in stock for the next year it is more convenient for the company to reduce the remaining inventory in order to cut inventory costs during the off-season. For this reason and due to the decreasing trajectory of the curve, trampolines typically undergo a price markdown at the end of the selling season. However, according to the CEO of the company, the strategy pursued is to avoid price markdown to prevent the brand from weakening and to preserve the average contribution margin (O. Eriksson, personal communication, May 8, 2020).

4.9 Looking into the future of Avero

Since the aim of this thesis is to optimize the planning process for the following years it is important to also consider future plans of the company. Taking those into consideration when looking into possible ways of adding more flexibility will make the integration of the solutions easier.

A big initiative the company is taking is expanding to new markets to have a more global reach. In 2020 they already started to be more present in the Netherlands and in Austria in terms of having the company website in the local language and having the local domain extension, to be able to reach more people in those countries. Being present at a country for Avero also means having customer care in the local language. Looking into the following years, expanding further is very much in the scope. One strategy used by the company is offering deliveries in more countries than they are present and thus see which country is interested in their products the most. Countries southern from Germany are all served from the German warehouse at this time, but the company is considering going more decentralized and renting warehouse places in the future where sales are high. This would allow the company to promise shorter delivery times and the transportation cost would decrease. The disadvantage in this situation from the supply chain point of view is that the planning process would be more complex and distribution of products between warehouses more difficult.

Avero is not considering selling other type of products to smoothen out their seasonality but thinking about expanding to markets where the season is during the other half of the year. This would balance the sales throughout the whole year and could result in a more continuous flow of goods. Ordering too many products during one season would not result in having excess stock during the whole off-season since it could be shipped and the products would be right away available in the other market.

The company realized that having the production so far from the end-consumers makes the whole planning process more difficult, is not sustainable in long-term and brings a lot of risks with itself. Especially with unforeseen events such as the Coronavirus Pandemic in 2020, when the deliveries in January arrived with a huge delay. Because of the delays and the Pandemic, the company was forced to look into other means of transportation to be able to have ready stock before the season starts. They managed to arrange transportation with rail which turned out to take 19 days less on average than via sea. Nevertheless the cost of rail was more than double as it would have been with vessels. Furthermore, all inbound deliveries were scheduled 3 weeks in advance than the demand for the products were expected hence it did not result in a big disturbance. Additionally a high stock from last year was also available. Nevertheless in an environment where the season is short and is the only possibility to generate income it is crucial to have accessible products ready to ship to the customers as soon as actual demand arises.

5 Results and Discussion

This chapter is divided into two parts. In the first part possible improvement areas in the supply chain are discussed to better handle uncertain demand and to be able to react to unforeseen events in a more effective way. The aim of this part is to find an adequate answer for the first research question. The second part addresses the second research question and introduces the reader to the tool, created by the authors of the thesis, which generates a forecast and provides help with the planning process pre- but also during the season. The tool can also be used to simulate different sales scenarios and how they effect the stock-levels in the warehouses.

5.1 Proposing a more reactive supply chain

The part one of this chapter is focusing on the supply chain of Avero and the possibility of increasing the agility and reactiveness. Discussion about the right design for this case is led, depending on which category the trampolines fall into, innovative or functional. This is followed by an outline on what factors to consider regarding suppliers and what important agreements should be made with them. In order to reduce the lead time, the transportation mode of the inbound deliveries are thoroughly analysed and a possible approach suggested. To prevent stock-outs different warehousing strategies are also discussed in this part of the thesis. Finally, some factors are outlined that could influence plans for the future and expanding to new markets.

5.1.1 Designing the right supply chain

Designing the right supply chain for the product of the company is essential to perform the functions of the supply chain, which are the market and the physical mediation (Fisher, 1997). Avero's supply chain is currently focusing on efficient performance. The upstream part of the supply chain is setting the constraints, with a long lead time that drives the decisions of the company regarding the sales and supply planning processes. In order to avoid high logistics costs approximately 90% of the quantities that are predicted to be sold during the season are ordered 5 to 6 months before the sales are expected to take place and the transportation method is chosen based on the cost, therefore the maritime transportation is used to ship the products from the manufacturing plants to the warehouses in Europe. The warehouses in Europe are located with a decentralized approach, distributing the inventory in different locations in the attempt of being physically close to the customers and to reduce the cost of transportation to the final customers. Due to the long lead time Avero is not able to react to unexpected changes during the selling season, having the possibility to place one order at the beginning of the season that would be able to cover the last part of the season, which accounts to a maximum of 10% of the volumes sold.

In order to understand if the supply chain settings suit the company's needs it is necessary to analyse the product and demand characteristics according to the framework presented by Fisher (1997) to classify the product as functional or innovative. For this purpose, different aspects of the products are analysed based on Fisher's classification:

- **Product life cycle**: some of the trampolines undergo small changes and updates on a frequent basis but the model itself does not change, hence it has a long life cycle, that lasts longer than 2 years. The target of Avero is to keep the products on the market for 3-5 years without major changes (E. Rodhe, personal communication, March 4, 2020). Therefore the products can be considered functional regarding the life cycle aspect. The life cycle of the products is longer than the peak selling season, which means that the items can be stored to be sold during the following season.
- **Contribution margin**: the contribution margin of the sold products is high, although it varies considerably between different products the average contribution margin is higher

than 20%, which is a typical feature of the innovative products.

- **Product variety**: the assortment of North Trampoline is characterized by low variety, with a few dozens of items. However, the introduction of new colors, sizes and shapes during 2020 season has increased the number of product variants offered which, considering the size of the trampoline market increases significantly the complexity of the sales forecast and supply chain operations.
- **Average forecast error when the production is committed**: As reported in section 4.7, the forecast error is extremely high in all the markets considered, exceeding 50% and in some cases even 100%. Considering the forecast error on an aggregated level the forecast error is above 40%, thus fitting the innovative products criterion for this aspect.
- **Average stock-out rate**: it is complicated to have data regarding the stock-out rate due to the fact that this information is not measured in the company (O. Eriksson, personal communication, February 4, 2020). Although it is possible to extract from the historical data when a specific product was out of stock, there is no data regarding the customer behaviour in that case: how much lost sales did the stock-out situation generate? Before purchasing, the website displays the stock-out information and the date when it is expected to be available in stock. It is also possible to order the trampoline before it is physically in the warehouse, accepting a longer delivery time. In this case it is not possible to measure the amount of lost sales because the reaction of the customer is not tracked, it is unknown the share of customers that order the products regardless of the stock-out situation, the share of those selecting a different item from the same website and the share of customers that give up the purchase, either to wait or to buy from a competitor. With these premises, the stock-out rate is assumed to be low due to the tendency of over-forecasting during the last few years and due to the excessive inventory levels at the end of the season, which is considered as a sign of overdimensioned stock.
- **Average forced end-of-season markdown**: products that have highly seasonal demand are typically sold at a discounted price at the end of the season in order to reduce the slope of the sales curve that is declining. Considering the life cycle of the products, at the end of the season the company has two options: either storing the products for the next season or using promotions and campaigns to reduce the excessive inventory and to reduce warehouse costs during the off-season. During the last few years, discounts have been applied up to a 5-10% markdown. However, the strategy of the company for the upcoming years is to avoid this type of promotions in order to prevent the brand image from weakening and to maintain the customer view on the quality of the products (O. Eriksson, personal communication, May 8, 2020). Therefore the company is willing to face higher inventory costs during the off-season regardless of the characteristics of the market.
- **lead time required for made-to-order products**: the market requirements for a made-to-order trampoline is short. It is a seasonal product that can be used only during a short period of the year, therefore customers that are buying during the season are not willing to accept an excessively long delivery time that would reduce the utilization period and, consequently, its value for the user. An acceptable waiting time is assumed to be 1-2 weeks for the final customers.

Based on the given analysis, the trampolines can be considered hybrid products since they present both characteristics of functional and innovative products. However, the majority of the features are typical of innovative products and the demand characteristics create a particularly challenging forecasting environment, therefore it is reasonable to treat them as innovative products when designing the supply chain. As a consequence, Avero is currently distributing an innovative product with an efficient supply chain, falling in the top right corner of Fisher's framework, which is a situation of mismatch between the supply chain settings and the type of product (Fisher, 1997). According to Fisher (1997), this situation is inappropriate to meet the demand requirements, in fact it will prove to be unresponsive to unexpected changes and the performance regarding the market mediation function will be inadequate. In this situation the company needs to implement several changes in order to shift either to the top left or to the bottom right corners of the framework that will enable the supply chain to match the demand needs (Kaipia and Holmström, 2007). Considering the particular demand and product characteristics, the best option is to move to the bottom right corner, building a responsive supply chain that is able to react faster and fulfill unexpected variations during the peak season. In order to achieve this target the company needs to create more flexibility along the supply chain: working towards a lead time reduction and creating inventory buffers through supplier collaboration (Kaipia and Holmström, 2007). The proposed solution for Avero is to divide the demand and supply planning in two parts and deal with those with a hybrid supply chain, that will be efficient for the first part and responsive for the second one, similarly to Zara case study (Kaipia and Holmström, 2007). The first part of the demand is an estimation of a safe quantity that will be sold during the season, which can be planned with an efficient supply chain. The second part represents the uncertainty of the demand: this part will be more accurately estimated during the season and it needs to be fulfilled with a different supply chain that enables a shorter lead time, therefore giving the possibility to adapt to unforeseen events, both in case of over- or underestimation of the initial plan. In the following sections different actions to achieve more flexibility in the supply chain are discussed in detail.

5.1.2 Supplier collaboration

As already mentioned in chapter 5 the lead time of a trampoline from order placed to products delivered to the warehouse is 105 days. This is a sum of the raw material procurement (45 days), production (15 days) and transportation (45 days). A visual representation is in figure 15 as the first timeline. It is also important to highlight that one of the suppliers is only manufacturing trampolines, which means they are running close to their maximum capacity in the first quarter of the year which is also the time when Avero would expect the production to take place there.

Before revising the different options on how to shorten this lead time, it must be stated that regardless of the placement of orders are taking place at once, having inbound deliveries spread out during the season and not receiving everything at the same time is a good strategy and should be sustained. All our suggestions are based on the idea that deliveries should be planned throughout the whole season, or at least until the penultimate month.

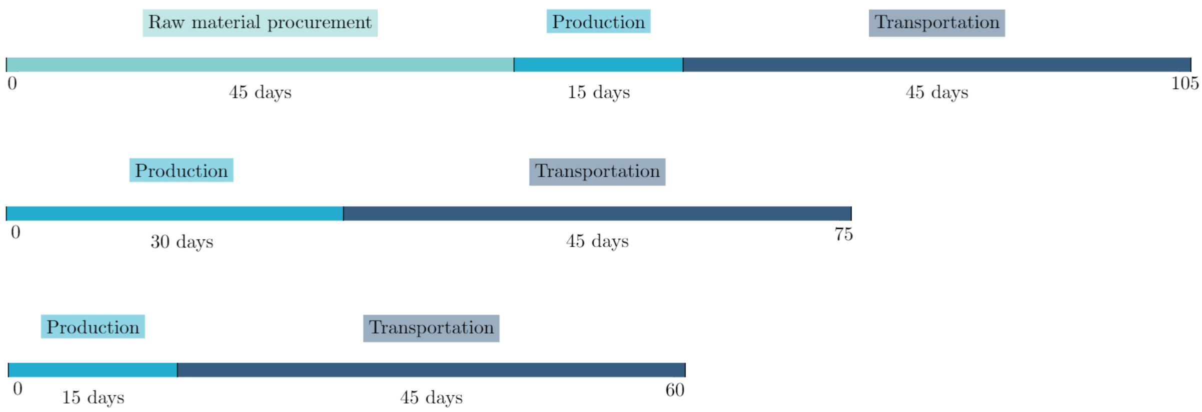

Figure 15: Lead times with the proposed approaches

Since the procurement of raw materials take the most time (tied with transportation, which will be discussed in the section below) improvements in this area should be considered. One suggestion here would be to store some of those materials at the supplier. This would decrease the procurement and production time from 60 days to 30 days, i.e with 4 weeks. There may be a contradiction to what is stated above, about the 15 days production, but there also might be capacity problems. Thus 30 days is promised by the supplier, provided that the raw materials are available right away. This option can be seen as the second timeline in figure 15. Additional two weeks could be saved by making sure there are production slots reserved for Avero's products. This could be achieved by agreeing with the supplier on reserving production slots first and later deciding on the product mix (Kaipia and Holmström, 2007). Result would be that changes are allowed to be made during the season as well since, as mentioned earlier, inbound deliveries are spread out during the season and they do not all arrive at the same time before the sales start to pick up. Having raw materials ready, available production capacity would add up to 15 days instead of 60. This would be a 6 week reduction in the lead time. The three possible lead times are illustrated on figure 15.

In addition, Zhao et al. (2013) suggest to use bidirectional contracts, which allow both the put and the call option. The call option allows to increase the volumes with an agreed quantity, the put option, on the contrary, grants the possibility to decrease the ordered volume according to in-season changes. In that case it would mean that exact volumes do not have to be determined during autumn but only to an extent. It would allow Avero to adjust the deliveries according to how the beginning of the season differentiates from the initial plan. Generally it must be taken into account that these changes would involve additional costs but we assume it would mean less of an expense than the loss on stock-outs and lost sales. This would only become clear when discussion about the contracts would begin. According to Milner and Rosenblatt (2002) the two-period contracts would be of benefit in such case, so the sales in the first period could influence the second period. When such contracts or agreements are in place, the frozen period is more clear and a lot more consistent which makes the planning easier. Compared to the situation there is now, additional orders are always problematic since the time the supplier can provide the products differs from case to case, hence it is not known in advance when the order should be placed at last.

Another interesting field to look into would be the supplier selection. Avero has a good relationship with both their suppliers which are able to supply the products maintaining high quality standards. This is of high importance for the brand, hence the discussions about looking for different suppliers was not taken further. Their location in China was beneficial because of the labour cost. Nowadays the labour cost is increasing, hence it might be the case that moving production closer to Europe would not result in higher expenses for the company (Yuming and Changrong, 2018). Looking at the growing trend of Chinese average minimum wage (Chipman Koty and Zhou, 2020), it can be expected that moving production would be even more appealing. Yuming and Changrong (2018) also highlights that the currency revaluation had a high impact on the prices resulting in a much less attractive solution to leave the production in China.

5.1.3 Organizing inbound deliveries

As mentioned above, the transportation time accounts for more than 40% of the lead time. The best case scenario is 45 days, but depending on the circumstances with the weather there might even be delays in some cases. This more or less 7 weeks is a time frame which can be hardly shortened since it is the time the products are on the sea being transported by vessels. Maritime transportation costs on average around EUR 3000 per container but this can increase and decrease depending on different events as e.g. the Chinese New Year.

The only possibility to shorten the transit time is to change the means of transportation. That said, following Carnarius (2018) description of all the modes, meaning transportation via air, road, rail and sea, should be evaluated. The second least expensive option for Avero would be using train. That option is 19 days faster, which has been proven in this year, 2020, when Avero had to reschedule some of their inbound deliveries because of the delays connected to the Covid-19. As a trade-off this option costs double the price as it would transporting on sea resulting in an average of EUR 6000 per container. The other two options are staying on land and using road transportation or via air. The former would cut 10 additional days from the transit time and has one big advantage, the transportation chain does not have to be divided into three parts, as SteadiSeifi et al. (2014) propose. It would be a door-to-door delivery without needing to go through customs or inspections at the port or the station. The problem with road is that it is not a very developed means for now from China, it still needs some development. It is also highly unsustainable and the price is double than the rail (Ying, 2019). Ying (2019) also mentions that on the other hand the cost is half as much as it would be with air. Therefore to understand the difference we assumed road transportation costs EUR 12.000 and air EUR 24.0000 per container, which is 4 times as rail and 8 times as sea. Transit time is assumed to be around 10 days, since handling takes longer than with road, so only a 6 day decrease. The above mentioned relation of transit times and prices are illustrated on figure 16. The numbers are assumptions, derived from different correlations found in articles as Ying (2019), IRU (2018), Carnarius (2018) and data retrieved from the supply chain manager (E. Rodhe, personal communication, March 5, 2020).

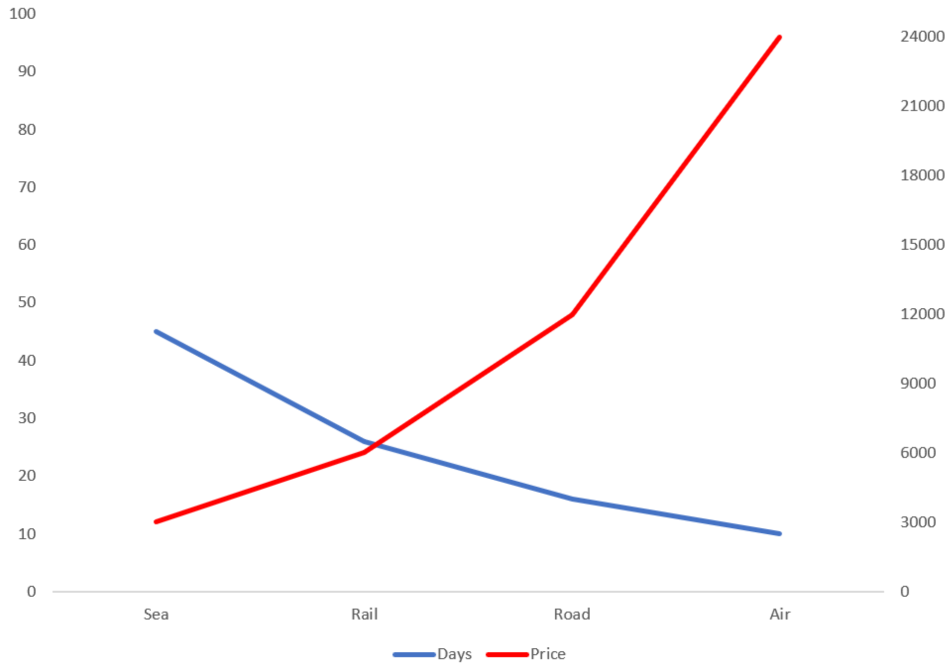

Figure 16: Comparison of the price and days spent in transit for each transportation mode

As seen on figure 16, using air transportation would be too much of an increase in the expense compared to the win on transit time. Its CO2 emission is also terribly high hence we ruled that option out. Shipping products on road would still result in a high additional cost which would probably not pay out, but to have exact numbers, stock-outs and lost sales should be calculated. As mentioned before it is also very unsustainable which goes against the company's policy thus we would not recommend this option either. Nevertheless when it is highly important to get something to Europe on time, e.g. for fairs, exhibitions, etc. trucks would still be a better option than with plane. In the sections above, splitting of the demand quantities is proposed.

The one part is the safe quantity, which deals with certain demand. From a transportation point of view this could be organised with maritime transportation since it would represent a fixed volume known earlier than the demand arises hence long transit time would still be acceptable. The second part, which represents the uncertain part of the demand, needs to be more flexible therefore considering a faster mode is crucial. For the disadvantages mentioned regarding shipping with trucks, the railway transportation is proposed. Cutting 19 days from the transit time is of high importance when the season is so short. Considering the changes proposed in 5.1.2, the lead time of 105 days would be down to 41 days, a decrease of 60%.

5.1.4 Warehousing strategies

The warehousing strategy needs to support the planning process in order to enable the changes proposed to the supply chain to add more flexibility. Furthermore, the strategy needs to support the long term targets of the company which is focusing on expanding to other European countries, a choice that, according to Cooper (1991), poses increasing challenges regarding the management of the logistics operations. For this reason, one of the solutions suggested by Fisher (1997) is to create buffers along the chain in order to be able to be responsive whenever the demand requires it. A buffer can be added close to the manufacturing plants to store finished goods that will be ready to fulfill the unpredictable part of the demand, the one that is more accurately forecasted during the selling season. Keeping the inventory close to the production allows to postpone the transportation decision, giving the possibility to ship the products directly to the warehouse where it is more needed, reducing the chances of needing extra transportation between the warehouses due to the error of the initial forecast. This solution increases the overall flexibility in the chain since it reduces the lead time for a reorder during the season of 30 days: eliminating the raw material procurement and the production process, the lead time is the transit time for the transportation, which is 45 days in case of sea freight or 26 days in case of rail transportation. Furthermore, postponing these decisions entails a significant cost reduction: warehousing is costly because of the space used and because of the related labour intensive activities, hence keeping the inventory in a country with lower fares for space usage and with lower labour costs is cheaper than having the stock close to the markets in Europe (Lin et al., 2020). Despite the increase of the labour costs in China and the revaluation of the Chinese currency, the country still offers competitive prices compared to the most developed markets in Europe (Yuming and Changrong, 2018). However, according to Chipman Koty and Zhou (2020) these aspects continue to show an increasing trend, therefore it is reasonable to analyse opportunities to move the production closer to the markets in which Avero operates, that would reduce further the lead time allowing a higher degree of flexibility.

Furthermore, it is worth discussing the warehouse distribution settings in Europe. Avero is currently operating with three warehouses:

1. warehouse in Sweden, serving the customers in Sweden, Denmark and Finland
2. warehouse in Norway
3. warehouse in Germany, serving the customers in Germany and in other EU countries.

According to Abrahamsson (1993), implementing changes based on the "Time Based Direct Distribution" would result in a reduction of the total distribution costs. Reducing the number of warehouses in the supply chain would bring several advantages (Abrahamsson, 1993):

- reduce inventory and tied-up capital: the amount of safety stock needed to face unexpected sales decreases with fewer warehouses
- Steady flow of goods: the random variations of different markets partially outweigh each other, increasing the steadiness of the flow.

- Reduced warehouse costs: lower stock levels, reduced space usage, dealing with fewer storage providers, reducing the number of contracts result in lower overall warehouse costs. Furthermore, dealing with fewer providers means committing bigger volumes, therefore a better price can be negotiated and the provider would give more attention to the company since it would be an important customer.
- Increase planning accuracy: as mentioned in section 4, the forecast accuracy increases if considered on an aggregated level, which means that planning for a complete assortment in a central warehouse would result in better forecast performance and better planning, reducing the risk of stock-outs and eliminating the extra transportation between different warehouses.

However, some drawbacks need to be considered in case of implementing a central warehouse strategy:

- increased complexity: dealing with taxes and customs may be more complex due to a lack of presence in the country where the customers are served, especially when an important market of the company is not a member of the European Union.
- Slower deliveries: being farther from the customers in some markets will increase the delivery time.
- Transportation costs: although in the case study presented by Abrahamsson (1993) the transportation costs remained constant, it is important to highlight that the result is obtained by an increased loading rate of trucks through consolidation and with continuous deliveries of products with high turnover. In Avero's case, the transportation between warehouses would be eliminated but the average cost of the single deliveries is expected to increase considerably due to the volumes implicated and the frequency of the sales.

Distribution settings	Markets served	WMAPE 2018	WMAPE 2019	Average Weighted WMAPE 2018	Average Weighted WMAPE 2019
Decentralized (5 warehouses)	SE	40%	43%	40%	53%
	FI	63%	113%		
	NO	30%	52%		
	DK	68%	76%		
	DE	40%	44%		
3 warehouses	SE+FI	37%	44%	36%	47%
	NO	30%	52%		
	DE+DK	47%	46%		
3 warehouses	SE+FI+DK	20%	32%	25%	41%
	NO	30%	52%		
	DE	40%	44%		
2 warehouses	SE+FI+NO	31%	46%	34%	46%
	DE+DK	47%	46%		
2 warehouses	SE+FI+DK+NO	21%	39%	23%	40%
	DE	40%	44%		
Centralized (1 warehouse)	SE+FI+DK+NO+DE	34%	44%	34%	44%

Figure 17: Comparison of hypothetical scenarios with different warehouse distribution

To have a better understanding of the impact of the distributions settings on the planning performance, several distribution strategies have been evaluated conducting an analysis on hypothetical scenarios based on historical data. The scenarios evaluate the performance in case of a different warehouse distribution in the years 2018 and 2019 and they are measured using the weighted average WMAPE, which weighs the forecast error of an area based on the share of contribution to the total sales for the examined year. Figure 17 offers a summary of the distribution settings evaluated. Among the possible combinations the markets have been grouped based on the proximity and the sales volumes. Furthermore, the analysis focuses on the main markets for Avero according to the data available at the current date. Since other markets represents a small share of the sales at this stage it is not relevant to consider placing new warehouses in the system to serve them.

The results obtained show that two scenarios stand out in terms of performances:

- three warehouses: one serving Sweden, Finland and Denmark, one in Norway and one in Germany;
- two warehouses: one serving Sweden, Finland, Denmark and Norway and one in Germany.

In order to choose the best option the benefits and drawbacks mentioned above need a further analysis. The first option could be preferred depending on the influence of customs activities and taxes while the second option is more appealing based on the forecast performances.

Figure 18 shows an example of how the distribution flow would appear after the implementation of the proposed changes: the use of a warehouse close to the supplier location would add more flexibility to the upstream side of the supply chain and use of two warehouses close to the markets served would ensure acceptable delivery times and it would increase the predictability of the demand.

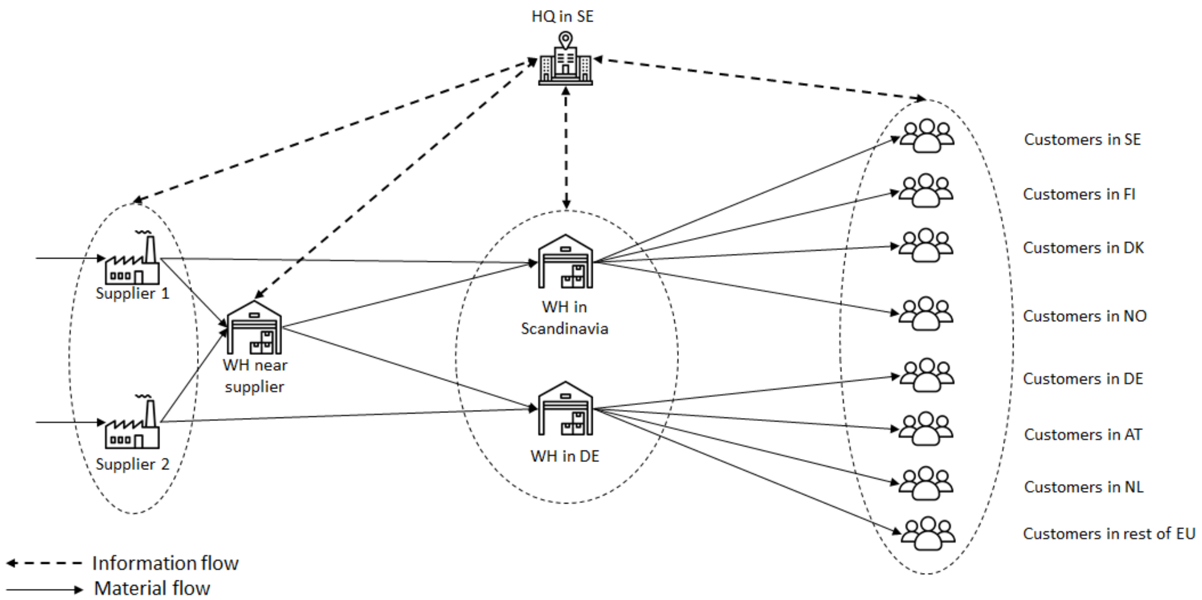

Figure 18: Information and material flow with the new warehouses

The choice of the warehouse locations, furthermore, is strategical to divide the markets in two areas:

- Scandinavian area: it includes the most important markets for the company, with higher sales volumes, therefore this setting would help keeping a strong position in those markets, ensuring fast deliveries and high customer service.

- Central European area: the German market showed a growing sales trend during the last few years. Moreover, the warehouse in Germany can serve a strategic purpose due to its central location in Europe, it can provide fast deliveries to different markets and it is a perfect starting point for the expansion to the rest of Europe that has started successfully to Austria and the Netherlands in 2020. However, as the market share grows in different countries for example in the Southern European area, further analysis regarding the possibility of increasing the warehouse number in other strategic locations needs to be carried out.

5.2 Forecast and planning process

To improve the forecast and planning process a tool that was developed by the authors will be introduced in the second part of this chapter. This tool is an aid for creating quantitative forecast and support the management team in decision making before and throughout the season. It is a statistical model that is supported by historical data. The data were retrieved from the company's ERP systems (the actual one and the old one they used before 2018) and documents were received from employees. Since the company went through a reorganisation in 2017 historical data from earlier than that year is not to be trusted hence they were not considered when building the forecast. Some of the employees doubt the credibility of the newer information provided as well, hence additional verification had to be performed to obtain reliable data for the forecasting model. Lack of data-follow up and information about stock-outs and lost sales made it also more difficult to consider every factor. For future research around improvement areas it is therefore strongly recommended to have a trustworthy data storing system and to measure important KPIs.

To create real value to the company, the tool was presented to the management team during the time the research was conducted. Suggestions were received and implemented to increase the effectiveness.

5.2.1 Choosing the right forecasting approach

Avero was creating demand forecast on a qualitative basis according to the sales plan established by the sales department. This qualitative forecast was biased and mostly focused on the wished growth on the company. Thus it had a very high inaccuracy and resulted in stock-outs during the season and excess inventory after the season.

Jonsson and Mattsson (2009) propose two different methods on how qualitative forecast should be constructed and the combination of those two. The grassroots approach's most valuable feature is that the forecast is created by those departments, who have the most knowledge of the market. It avoids that employees with most authority influence the outcome. For drawbacks of this approach, it has to be mentioned that it takes time to gather the individual forecasts created by the departments and then merge them into one final piece. Since the company puts high emphasis on management meeting we propose to use the Sales Management approach, since it is relatively quick and straight forward. Here, the management team gather for a meeting, where all aspects are talked through and they create the forecast together. It is important that everyone has an input and all factors are considered. After a thorough observation some of the factors identifies are:

- holidays and special events not occurring on a specific date from year to year (e.g. Easter, Black Friday)
- unforeseen external factors (e.g. Covid-19 in 2020)
- specific market related preferences (e.g. in Netherlands people prefer the in-ground trampolines over mounted ones)

- etc.

The aim for campaigns planned for the following year also has to be clarified: scheduled campaigns, such as Easter campaigns, need to be considered when creating the plan, whereas campaigns that will be used when the planned budget is not reached, should not. It is also necessary to focus on possible outcome and not on a desired one. Jonsson and Mattsson (2009) advise that there is a chance that the people with most influence are able to shape the forecast according to their own aspiration. This has to be prevented thus everyone has to participate on the same level.

As it is inevitable to have errors in generating qualitative forecast with such demand uncertainty Sanders and Ritzman (2004) propose to combine it with a selected quantitative method. This would increase accuracy therefore it is crucial to implement. The four methods are (1) Judgemental adjustment of quantitative forecast, (2) Quantitative correction of judgemental forecast, (3) Combining judgemental and quantitative forecasts and (4) Judgement as input to model building. All four methods were examined and considered the environment it has to be implemented, evaluated.

It is essential to understand what perspective the personnel at Avero has over quantitative forecast. Some of the people do not trust historical data hence anything calculated with the help of it is also considered as unreliable for them. Acknowledging this, the last two methods were disregarded, since both suggest that the final forecast will be generated in a way directly from statistical forecast. The first two methods were studied for this environment more in depth. After joining the management meetings during the research phase and realizing what impact a week with extraordinary weather can have it was accounted that being able to adjust the forecast after reception of new information is essential. Taking the suggestions in the first part of this chapter into account, when the demand is divided it is also pressing to have the ability to change plans accordingly. Therefore method 1, judgemental adjustment of quantitative forecast was chosen. As pointed out above, Avero has not worked with quantitative forecast before, so one had to be built from scratch.

5.2.2 Creating quantitative forecast

The aim of the quantitative forecast is to provide a statistical prediction based on in depth calculations that serve as a basis for the planning of production, distribution and other related operations (Sanders and Ritzman, 2004). In order to create a reliable outcome it is important to use an adequate set of data to support the forecast. For these reason the historical sales data have been deeply analysed to build a robust forecasting model using the intrinsic method (Jonsson and Mattsson, 2009). Considering the characteristics of the trampoline demand, the moving average method is not believed to be adequate to create a consistent forecast due to its disadvantage of being too responsive towards random variations (Jonsson and Mattsson, 2009). The exponential smoothing method, despite giving high importance to the most recent data, ensures more stability and it creates a model that is less sensitive to random variations since a large extent of the basic forecast is determined by the combination of older data. In order to initiate the model with the historical data from 2017 to 2019 the exponential distribution has been adopted to generate the forecast for the year 2020. Therefore the factors used to weigh the demand values have been chosen maintaining a constant relationship between consecutive values: 1/2 has been associated with the most recent data, 2019, 1/3 to 2018 and 1/6 to 2017.

Another important factor considered to build the forecasting model is the trend. Since the outcome of the model needs to be used to make decisions for the following year, the forecasting horizon is fairly long hence the trend consideration is rather relevant to achieve a higher degree of accuracy (Jonsson and Mattsson, 2009). Forecasting the trend-related variations is extremely difficult due to the non-linearity of the demand (Jonsson and Mattsson, 2009). Furthermore, the trampoline demand undergoes consistent variations that in some cases deviate to a large extent from the forecast. In this context, it is not recommended to include an additive trend to the forecast because it risks to build an oversensitive model (Jonsson and Mattsson, 2009). The typical choice is to use the exponential smoothing formula to include the trend variations. Given the data availability, only two years trends could be included in the model, selecting 3/5 for the trend variation between 2018 and 2019 and 2/5 to the variation between 2017 and 2018.

Data aggregation

Before getting to the actual outcome of the model it is necessary to analyse the appropriate level of data aggregation in order to obtain a more accurate result. This analysis is key to identify the right approach to predict the future sales: is it appropriate to use a bottom-up approach or does the top-down guarantee a better forecast performance? The first approach creates the forecast at a SKU level and then aggregates the data into the total volumes, reducing the possibility of mistakes related to inaccurate assumptions (Syntetos et al., 2016). According to Syntetos et al. (2016), the top-down approach is suitable for the cases in which the set of data may be insufficient to identify the trend variations, therefore it may be beneficial to create an aggregate forecast and subsequently split the result to the single SKUs. Although the first instinct may suggest a top-down strategy to forecast the trampoline demand due to the limited data and the relatively small volumes, after a thorough analysis it is possible to identify different trends on SKU level that represent a strong point in favour of the bottom-up approach. Figure 19 shows the trend of the total sales during the period 2017-2019, considering the volumes sold in 2017 as the benchmark value. Figure 20 shows the sales trend of a single SKU during the period 2017-2019 in two different markets, considering the volumes sold in each market in 2017 as the benchmark value for the following years.

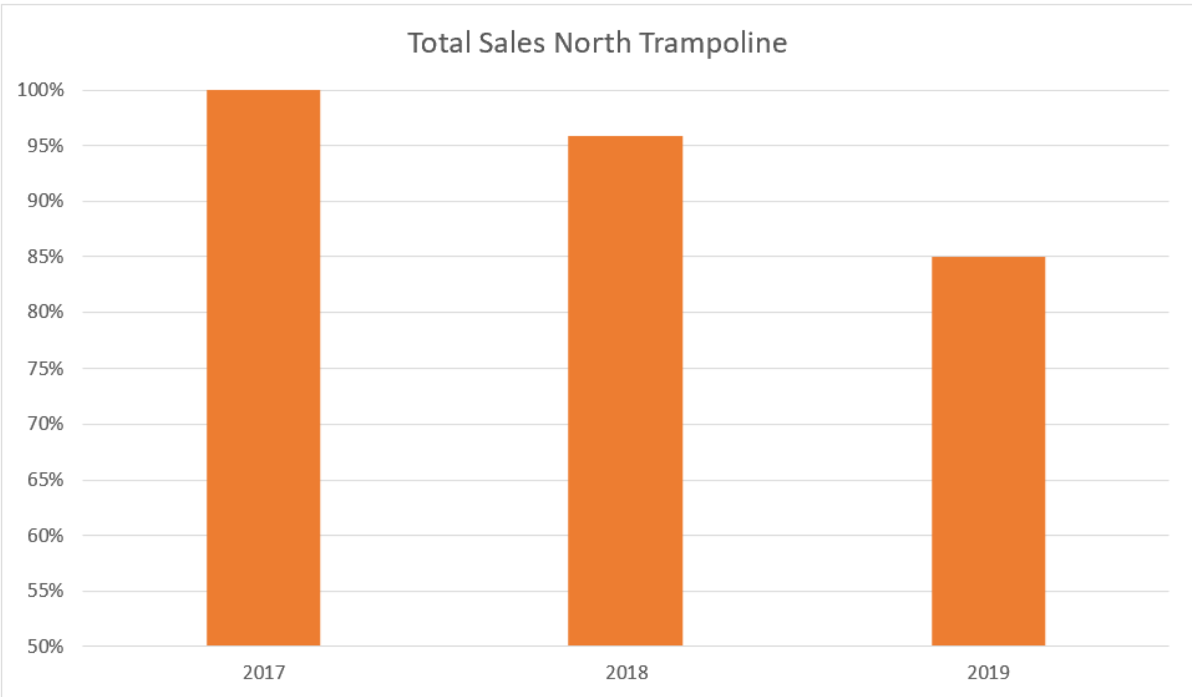

Figure 19: Total sales North Trampoline

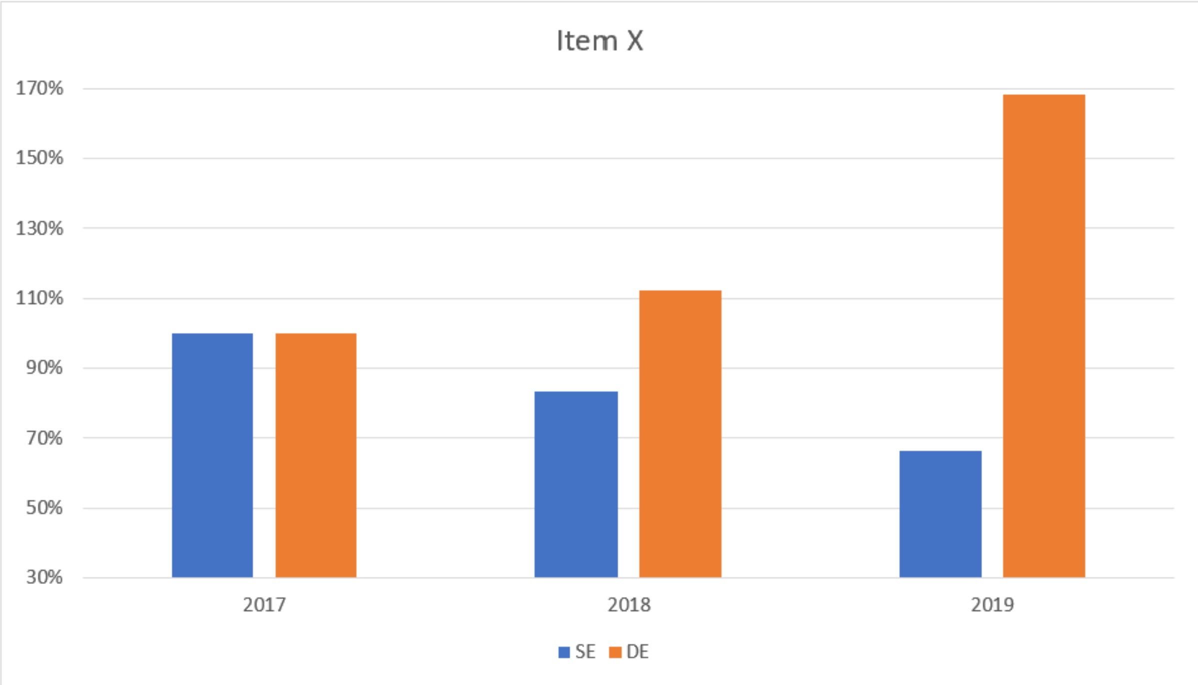

Figure 20: Sales trend comparison for an example item

Pictures 19 and 20 provide an example of the data analysis conducted. It is clear that on a single SKU level in different countries the trends could differ significantly therefore using the aggregation level on total amounts represents an inappropriate choice and it is possible to conclude that the bottom-up approach is a viable option to build the forecasting model for the trampolines future demand.

Simulations and model selection

In order to identify the combination of factors that could create the best forecasting model for the future demand the strategy was to apply the above mentioned approaches to simulate the behaviour of the model when forecasting the sales volumes for the year 2019, using the data from 2017 and 2018, and then compare the outcome with the historical data available. Although the use of a smaller set of data could hinder the outcome of the forecast, it is considered a useful way to conduct an unbiased analysis to compare the accuracy with the forecast created by the company in order to suggest the future actions. The results are evaluated using the WMAPE, which is identified as the best performance indicator for this purpose because it takes into account absolute error values and it gives a relative amount that is weighted on the sales quantities of each SKU (C. W. Chase, 2016). Several simulations were created:

1. Simple additive trend, the sales in year 2018 have been used as the basic forecast with the addition of the trend variation between 2017 and 2018.
2. Exponential smoothing, the exponential smoothing approach was used with a 60% weight to the most recent data and 40% to the sales of 2017.
3. Exponential smoothing and additive trend, the combination of the first two models.
4. Exponential smoothing and family trend, for this model the SKU have been grouped in families based on the shape of the trampolines to calculate the trend variation.
5. Exponential smoothing and size trend, the items have been grouped based on the size of the trampoline to calculate the trend variation.

6. Exponential smoothing and smoothed trend, similar to the model number 3 but with the introduction of a smoothing factor for the trend. Different smoothing factors have been considered, however, in order to limit the sensitivity to random variations the upper limit was set to 0.5:
   (a) 0.2 trend smoothing
   (b) 0.3 trend smoothing
   (c) 0.5 trend smoothing

Table 6 shows the results obtained in the simulations generated compared to the historical data of 2019.

Statistical model	WMAPE
1	18.69%
2	21.50%
3	16.59%
4	20.87%
5	17.35%
6.a	19.09%
6.b	18.10%
6.c	16.52%

Table 6: Evaluation of the different statistical models

Despite the models 3 and 6.c having similar results, it is essential to keep in mind that the demand variability in the business is very high therefore using an additive trend, or an excessively high smoothing factor, would result in an oversensitive model with the risk of reducing the future forecast accuracy (Jonsson and Mattsson, 2009). For this reason the statistical model with the best performance uses the exponential smoothing and a smoothed trend with a moderately high factor (model 6.c). Comparing this simulation with the actual forecast elaborated in the company, which resulted in a WMAPE of 43.54%, the accuracy is improved of 27%.

Based on the results of the simulations the quantitative forecast for 2020 has been built (see Appendix A). This forecast is exclusively created on quantitative calculations, in order to complete the forecasting process the qualitative adjustment needs to be performed, as mentioned above. The judgemental approach will add factors that are unforeseeable from a purely statistic model, e.g. the influence of the coronavirus outbreak on the demand could not have been predicted by the quantitative model but it is an adjustment that can be introduced with the sales management approach, involving different departments with business expertise.

5.2.3 Planning and follow-up

In this section the tool and the steps of its developing process will be described. As the initial objective of the project was to realize a tool to support the planning and follow-up processes both before and throughout the season, to achieve it several aspects need to be addressed:

- the appropriate time bucket within the time horizon of the plan
- the historical weekly sales and the seasonality
- the proper level of data aggregation to ensure the highest accuracy achievable
- a feasible follow-up model with relevant information to support the decision making of the management team.

As mentioned in section 4.6, among the demand characteristics a high degree of seasonality and a short sales period are identified. Therefore, in order to create a detailed supply plan for the following year, the weekly time buckets are considered the most suitable to represent the sales configuration and to support the decisions without overlooking important data, as in a monthly time bucket system, or focusing on irrelevant aspects, as the daily time buckets would provide. For this reason, the weekly sales data in the different markets during the years 2017, 2018 and 2019 have been analysed to extract the seasonality indices. According to Jonsson and Mattsson (2009), the seasonal indices need to be calculated on an aggregated level, therefore the total weekly sales of trampolines have been used for the analysis. However, the separated sales data of different countries have been further analysed due to the factors that can influence the sales. For instance, different national holidays or the different geographical location, which implies different meteorological seasons, can affect the seasonality patterns and consistent discrepancies can be identified between countries. According to Dekker et al. (2004), the product aggregation approach when calculating the seasonality indices represents an effective strategy to overcome the issues related to demand uncertainty and to reduce the influence of random variations. The weekly sales analysis offer evidence of similar patterns between different countries and therefore different groups were created for the seasonal indices calculations, specifically the groups established were:

1. Sweden and Norway
2. Denmark and Germany
3. Finland

The SKU forecast generated according to the steps described in the previous section provides the basis for the supply planning. The approach adopted distributes the total sales forecast per week, based on the seasonal indices previously calculated. The result is useful on an aggregated level to understand the volumes that are expected to be sold during the season in the different markets (see appendix B) and to compare the actual sales with the prediction.

Tactical level

In order to support the tactical supply planning process a warehouse view has been implemented in which the SKU forecast and the weekly forecast are matched to provide a detailed prediction of the week in which the sales of specific items will happen. In order to be relevant for the supply chain decisions that need to be made according to this view, it is necessary to identify the right level of data aggregation, therefore the markets served by the warehouses need to be taken into account and the forecasts need to be aggregated accordingly. The information provided is the following:

- expected sales per item per week in the area served by the warehouse
- stock level, the week when the stock is expected to run out and the extent of the stock-out
- inbound orders in the warehouse.

Figure 21 shows an example, from week 1 to week 12, of the warehouse view for the Swedish warehouse.

SKU	WEEK	1	2	3	4	5	6	7	8	9	10	11	12
A	Sales FC	0	0	0	0	0	0	0	0	0	0	0	0
	Stock		0	0	0	0	0	0	0	0	0	0	0
	Orders												
B	Sales FC	0	0	0	0	0	0	0	0	1	1	2	2
	Stock		0	0	0	0	0	0	0	-1	-2	-4	-6
	Orders												
C	Sales FC	0	0	0	0	0	0	0	1	1	2	3	4
	Stock		0	0	0	0	0	0	-1	-2	-4	-7	-11
	Orders												
D	Sales FC	0	0	0	0	0	0	0	0	0	0	1	1
	Stock		0	0	0	0	0	0	0	0	0	-1	-2
	Orders												
E	Sales FC	0	0	0	1	1	0	0	1	2	2	4	5
	Stock		0	0	-1	-2	-2	-2	-3	-5	-7	-11	-16
	Orders												
F	Sales FC	0	1	1	1	1	0	1	2	4	5	9	12
	Stock	25	24	23	22	21	31	30	28	24	19	10	-2
	Orders						10						

Figure 21: Warehouse view example

A simulation of the behaviour of the tool is presented for SKU F in figure 21, in which the information of the initial stock is filled in and the inventory level decreases week by week as the quantity that is expected to be sold, according to the initial plan. The inbound orders are added to the existing stock and when the forecasted sales exceed the existing stock the stock level is presented with a minus sign, indicating the extent of the stock-out, and with a red cell, serving as an alert of a stock-out situation that needs to be addressed. This tab allows to have a complete overview of the expected sales from a single warehouse, to have control over the inventory level and deal with the stock-out situations with an effective inbound delivery planning. Further implementations could regard the turnover, the financial overview of the stock or the warehouse utilization.

Operational level

The operational plan represents the actions that are taken during the season, to support the decisions a follow-up plan needs to be in place. According to the case studies conducted by Dekker et al. (2004) regarding highly seasonal demand, the method based on product-aggregation combined with the Naïve 1 method outperform the traditional forecasts because they add more responsiveness to stochastic changes. The Naïve 1 method uses the most recent actual data to predict the outcome of the following period, therefore it is responsive to unforeseeable variations (Dekker et al., 2004). For instance, if one year the season starts earlier than expected the classical model would not be able to detect it and adjust the forecast, while the Naïve 1 method would blindly follow the new information. For this reason the combination of the two methods can improve significantly the forecast accuracy: the Naïve 1 method adds responsiveness to the initial plan that is based on a wide set of more consistent data. To implement this approach for the trampoline demand a follow-up view has been included in the tool, in which the initial forecast generated as part of the tactical plan is adjusted on a weekly basis in order to capture the deviations from the plan and consider them in the following weeks plan. The concept is to compare the weekly sales, on a SKU level per warehouse area, with the predicted sales quantities and to include the deviation in the future plan with a smoothing factor that prevents the forecast from diverging excessively from the initial plan. Therefore, as the deviations are included with a smoothing factor, the future forecast will be led back to the initial plan after a few weeks of adjusted values, depending on the magnitude of the unexpected sales. This method is used to rearrange continuously the plan and to give important information based on statistical evidence that can be considered only in the short term plan.

The tab providing the new plan adjusted on the actual sales presents several information useful for the decision to be taken at the operational level:

- actual sales information, on SKU level per warehouse
- outcome of the combination of the forecasting methods based on the actual sales data as the expected sales per SKU per week in the area served by the warehouse
- stock level adjusted to the new plan, the week when the stock is expected to run out and the extent of the stock-out in the warehouse
- aggregated stock level information, including the inventory of all the warehouses in the system
- scheduled inbound orders in the warehouse.

The data need to be updated regularly, on a weekly basis, in order to have a follow-up analysis that is useful during the weekly "Monday Action meeting". Therefore the tool needs to be integrated with the ERP system in order to retrieve every week the required data regarding the actual sales. Figure 22 shows an example, from week 1 to week 6, of the view of the follow-up tab.

The example provided in figure 22 shows a simulation of the behaviour of the model in case of the SKU *F*. It is possible to observe that the unexpected sales during week 1 generate a higher forecast for the following weeks and the stock information is updated accordingly. Furthermore, the data regarding the aggregated stock in the row "*stock EU*" provides the necessary information in order to take action when the stock needs to be rearranged between different warehouses, either redirecting a scheduled shipment from the supplier or issuing an internal transportation between the warehouses in the system. In fact, in the example provided the stock-out of product *F* in week 4 could be avoided knowing that part of the excess stock in the other warehouses can be moved to the first location, covering the expected sales before the replenishment scheduled in week 6 and therefore avoiding lost sales.

SKU	WEEK	1	ACTUAL	2	ACTUAL	3	ACTUAL	4	ACTUAL	5	ACTUAL	6
A	Sales FC	0		0		0		0		0		0
	Stock	0		0		0		0		0		0
	Orders	0		0		0		0		0		0
	Stock EU	0		0		0		0		0		0
B	Sales FC	0		0		0		0		0		0
	Stock	0		0		0		0		0		0
	Orders	0		0		0		0		0		0
	Stock EU	0		0		0		0		0		0
C	Sales FC	0		0		0		0		0		0
	Stock	0		0		0		0		0		0
	Orders	0		0		0		0		0		0
	Stock EU	0		0		0		0		0		0
D	Sales FC	0		0		0		0		0		0
	Stock	0		0		0		0		0		0
	Orders	0		0		0		0		0		0
	Stock EU	0		0		0		0		0		0
E	Sales FC	0		0		0		1		1		0
	Stock	0		0		0		-1		-2		-2
	Orders	0		0		0		0		0		0
	Stock EU	0		-1		-1		-3		-5		-5
F	Sales FC	0	15	6		3		2		1		0
	Stock	25	10	4		1		-1		-2		8
	Orders	0	0	0		0		0		0		10
	Stock EU	225	210	203		199		196		193		203

Figure 22: Follow-up plan example

Dashboard and what-if analysis

Another functionality provided by the tool is the possibility to run simulations to perform what-if analysis during the season. This is a valuable support for further analysis when there is evidence of events affecting the demand on a long term horizon, which the statistical model would not be able to detect and a manual adjustment is required. The functionality is available through a dashboard provided by the tool that gives the possibility to change the plan on different levels:

- monthly variations, it can provide an overview of a scenario in which the season starts or ends earlier or later than expected, or to increase sales for specific reasons;
- weekly variations, it can be used to simulate the effect of promotions or campaigns during specific weeks;
- market variations, particularly useful to analyse the effect of unforeseeable events in specific countries such as the entering of new competitors in a market or particular situations brought by external factors, e.g. the different measures in response to the coronavirus outbreak.

Figure 23 shows the view of the dashboard for the monthly and market variations to illustrate the outlook of the tab, a similar table is provided for the weekly variations with the same functionalities.

DASHBOARD				
MONTH		VARIATION FROM BDG	MARKET	VARIATION FROM BDG
1	JAN	100%	SE	100%
2	FEB	100%	NO	100%
3	MAR	100%	DK	100%
4	APR	100%	DE	100%
5	MAY	100%	FI	100%
6	JUN	100%		
7	JUL	100%		
8	AUG	100%		
9	SEP	100%		
10	OCT	100%		
11	NOV	100%		
12	DEC	100%		

Figure 23: Dashboard view

The variations are expressed as a percentage of the initial plan, giving the possibility to introduce both positive or negative changes. The adjustments made in the dashboard automatically modify the warehouse view and the follow-up plan, giving the possibility to assess the effects in terms of inventory, stock-out and scheduled deliveries.

Furthermore, it is possible to change the parameter of the smoothing factor of the Naïve 1 method. This choice was taken in order to give the possibility to give more consideration to the deviations during different periods of the season. For instance, an unexpected deviation during the off-season could represent an outlier and it should not have repercussion on the future forecast. On the other hand if the sales are particularly driven by a promotion during a specific period it is possible to reduce, or even remove, the effect of the Naïve 1 method when the promotion ends. Therefore it is important to keep in mind that the tool provides useful information that is exclusively based on the data available, nevertheless the constant adjustments based on the external factors and additional insights that can be provided by professionals with a good knowledge of the business are the key to leverage the potential of this resource.

6 Answering the Research Questions

To summarize the previous chapters the authors thought it is necessary to address the research questions in a clear, easy-to-follow way. This chapter elaborates on those questions and the answers given throughout the report.

The first part of this study was to find a way in which the design of the supply chain corresponds to the products offered at Avero. The research question was therefore the following:

1. What is the right supply chain for Avero AB and how to achieve it?

To address this question, first the framework from Fisher (1997) was adopted. After finding that Avero's products are of a hybrid type the decision was made to divide the demand and supply planning in two parts, where the first part, a safe quantity, can be handled with an efficient supply chain (which Avero has today) and the second part, related to demand uncertainty, requires a responsive supply chain. This supply chain has to be able to react faster and fulfill unexpected variations during the peak season. To achieve this the lead time needs to be reduced and inventory buffers have to be placed through supplier collaboration. The idea of managing the second part is that after the season starts, new calculations can be made on how the season will turn out and with a shorter lead time it will be able to easier adapt to over- or underestimation of the initial plan.

To manage a responsive supply chain, changes have to be initiated throughout the whole chain, starting with the supplier. Since the raw material lead times are long, it must be addressed. Creating inventory buffers at the supplier would reduce the time hence be a good solution. Another fault with the supplier is that they do not always have the capacity right away for the products which results in an additional 2 weeks in production. This could be resolved by only reserving production slots in advance and deciding on the product mix at a later date. Two types of contracts were also proposed to create a more agile supply chain. First, bidirectional contracts, where for a settled price, adjustments are allowed regarding the ordered volumes in both directions, meaning increasing or decreasing the quantity. The second type of contract is the two-period contract which aligns with the ideas of the hybrid supply chain. Here the orders are split into two, of which the second order can be adjusted according to how the first period goes. It is also proposed to look into the possibility to select another supplier which is located closer to the targeted markets.

Since the length of the inbound deliveries is responsible for more than 40% of the long lead time this was also recognized as a possible improvement area. As proposed, the first part of the demand can be served with an efficient supply chain, thus choosing the least expensive means of transportation, regardless of the transit time is a good and viable option. Nevertheless the second part, where agility is of high importance, rail is proposed. It is the second cheapest option, but still achieves a decrease of the transportation time by 19 days. Furthermore, it is the second most sustainable mode right after maritime transportation, which aligns with the views of the company. Besides the main volumes having transported via rail and sea, if there is an urgent matter there is a possibility to use trucks, which would still be a better choice regarding the speed-cost relation than via air.

Finally, the possibility of changing the warehousing setup was examined. One proposed option is to have a warehouse close to the suppliers location. This would allow the company to postpone the decision regarding which warehouse in Europe to send the products to. This would be beneficial since the cost for transportation between European warehouses could be avoided and the warehousing prices are still very competitive in China. The biggest advantage is that the procurement and production process could be "eliminated" thus the lead time would be shortened to 45 days when using sea and to 26 days when using rail transportation. In Europe there are two options that would be viable and advantageous, remain with three warehouses, where the customs activities are facilitated or eliminate one and serve the markets from two warehouses. This would increase the forecast performance. Regarding location, one warehouse would serve the most important markets to the company: Norway, Finland, Sweden and Denmark, hence located in Scandinavia, from where fast deliveries and high customer service are ensured. The second warehouse would serve the Central European market. As the location, Germany proves to be the right choice, since it is the perfect starting point for an expansion to the rest of Europe and from where fast deliveries are possible.

The second part of this study was focused on the planning process of the company. Improvements on the tactical and operational level were needed, thus the second research question was the following:

2. How to build and implement a tool for forecasting and planning, that increases tactical and operational excellence?

The first step was increasing forecast accuracy. To do that the demand characteristics were analysed and historical data about the sales figures gathered. The authors suggest to not only use qualitative methods for creating the forecast but combine it with a quantitative one. The combination should be based on the method proposed by Sanders and Ritzman (2004), where to get to the final forecast, the quantitative forecast is adjusted by the qualitative input. The decision about using Sales Management approach for the qualitative adjustment was made since it is vital to be able to react and act quick. The statistical model had to be built first because using one was not a practice at Avero. Carefully considering different methods, the exponential smoothing was chosen. It ensures more stability and is less sensitive to random variations. The model was built with the data from 2017, weighted with 1/6, 2018 with 1/3 and 2019 with 1/2. To gain more accuracy the trend was also recognized and with an exponential smoothing added to the model. In the next step the aggregation approach had to be chosen. Different trends can be identified on SKU level therefore the bottom-up approach was concluded as the right choice. Options for the statistical model were compared and then the chosen one finalized, namely exponential smoothing and smoothed trend with a smoothing factor for the trend set at 0.5.

To enhance the planning process first the time buckets were determined to have them on a weekly basis, to support the decision making without overlooking important data or focusing on irrelevant aspects. To obtain the seasonal indices, weekly historical sales were analysed. After acknowledging different factors that influence the sales in different markets, Sweden and Norway were grouped together and Germany and Denmark for having the same indices. The above mentioned SKU forecast was then distributed weekly according to the seasonal indices. This is then used for the basis for the supply planning.

With the aim to support the tactical supply planning, a warehouse view was implemented in the tool, where the expected sales per item per week are shown with aggregated markets according to where they are served from. Additionally, the stock level, the expected week when a stock-out will occur and its extent and the inbound deliveries to the warehouse are included.

To support decision making on operational level, a follow-up plan is needed. To add more responsiveness to stochastic changes, the Naïve 1 method proposed by Dekker et al. (2004) was implemented. It uses the most recent actual data and adjusts the forecast accordingly. Therefore the tool was extended with a follow-up view, where data about the actual sales have to be integrated to recognize the deviations from the initial plan and include them with a smoothing factor. This view presents actual sales information on SKU level per warehouse, the outcome of the combination of the forecast and the actual sales in previous periods, stock levels adjusted to the new plan, the expected stock-out date and its extent per warehouse, aggregated stock level information on SKU level in the European warehouses and last, the scheduled inbound deliveries per warehouse.

The tool is also capable of running different simulations to perform what-if analysis during the season. This is a valuable feature when it comes to events that can affect the sales on a long term horizon. The simulations can be run through a dashboard where the initial plan can be changed according to three aspects: (1) change the percentage of the volumes planned on a monthly basis, (2) change them on a weekly basis and (3) change the volumes per market. It is also possible, to change the smoothing factor from the Naïve 1 method, which is helpful, when e.g. there is an unexpected deviation during off-season.

The idea with the tool is to connect it with the ERP system Avero uses, to retrieve the actuals, the stock levels and the scheduled inbound deliveries from there, so nothing has to be done manually only the simulations. This would ease the the work of all the stakeholders who are engaged in the planning process and who have the responsibility to take actions during the season if the demand develops differently than expected.

7 Conclusion

The thesis was conducted at Avero AB, a Swedish trampoline selling company. The initial purpose was to create a forecasting model and a planning tool that would result in higher forecasting accuracy and would ease the planning during the sales season.

After getting familiar with the product and demand characteristics it had to be realized that the demand is, in principle, as for every highly seasonal product, stochastic and uncertain. To face the demand uncertainties, corresponding literature had to be studied while getting more involved with the processes of the company, to identify key factors playing a role in realizing demand at an earlier stage and being able to act on it.

To face the uncertain demand, the supply chain had to be reviewed and redesigned according to the expectations of the environment. The framework of Fisher (1997) was used to identify the type of supply chain needed. After agreeing on the type which is the most suitable, its characteristics had to be revisited and solutions for optimizing it had to be found. Both primary and secondary data, that were available to the authors, made it possible to determine improvement areas and propose actions to address them. In the next phase the forecasting performance of the company was analysed to detect if there was room for improvement. After finding a relatively high error when calculating the WMAPE, it was decided that a different method had to be chosen. To find the best method both Jonsson and Mattsson (2009) and Sanders and Ritzman (2004) proposals were studied. For a follow-up tool that helped with the planning of seasonal demand, Dekker et al. (2004) proposed the Naïve 1 method, which was considered the best solution to implement in the context of Avero.

The scope of this thesis was to broadly answer the two research questions while proposing several improvements along with it. Although this was done sufficiently, there are areas that have not been addressed in this study and would require further research. One suggested area would be to optimize the replenishment and improve inventory management. Another interesting field to analyse would be new markets and expansion opportunities or the market saturation. Since the sales are influenced by the weather on a high degree collecting data about that and other factors influencing the sales would be a great base for another research looking for the connections and how they could be exploited to achieve further improvements in the planning process.

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A Appendix - SKU forecast 2020 per market

SKU	SE	FI	DK	NO	DE	TOTAL
A	34	2	10	33	17	96
B	143	9	45	126	65	388
C	293	34	50	215	54	646
D	55	7	15	118	57	252
E	390	48	94	717	241	1490
F	971	146	171	1362	348	2998
G	82	11	12	61	42	208
H	182	27	27	152	36	424
I	696	66	65	383	125	1335
J	680	114	69	354	126	1343
K	102	11	21	53	22	209
L	346	36	39	107	65	593
M	448	74	44	119	75	760
N	4	1	8	1	3	17
O	10	2	43	9	10	74
P	21	7	48	21	12	109
Q	1	2	16	13	8	40
R	17	1	65	48	28	159
S	31	6	76	74	31	218
T	6	2	0	5	4	17
TOTAL	4512	606	918	3971	1369	11376

Figure 24: SKU sales forecast for 2020 per market

B Appendix - Weekly sales forecast 2020 per market

2020	Weekly distribution from SKU forecast					
Week	SE	FI	DK	NO	DE	SUM
1	1	0	0	1	0	2
2	4	0	0	3	1	8
3	2	0	1	2	1	6
4	5	0	1	4	2	12
5	5	0	1	4	2	12
6	1	0	1	1	1	4
7	2	0	3	2	4	11
8	5	0	4	4	7	20
9	11	0	9	10	13	43
10	14	1	11	12	17	55
11	27	1	16	24	24	92
12	36	3	20	31	30	120
13	77	3	30	68	45	223
14	166	3	37	147	55	408
15	228	17	63	201	93	602
16	280	14	43	247	64	648
17	398	30	53	350	78	909
18	343	30	35	302	53	763
19	253	32	36	222	54	597
20	302	58	47	266	70	743
21	296	49	36	260	53	694
22	235	29	40	207	60	571
23	212	27	44	187	65	535
24	209	39	38	184	56	526
25	152	18	32	134	48	384
26	212	36	37	187	55	527
27	190	54	39	167	59	509
28	160	32	37	141	55	425
29	116	35	26	102	39	318
30	110	14	21	97	31	273
31	98	20	26	86	39	269
32	55	9	12	49	18	143
33	52	6	15	46	22	141
34	33	6	15	29	22	105
35	35	7	13	31	19	105
36	24	5	7	21	10	67
37	14	4	6	12	10	46
38	10	0	6	9	9	34
39	6	0	4	6	7	23
40	6	1	5	6	7	25
41	2	0	2	2	3	9
42	4	0	2	4	2	12
43	2	0	1	2	2	7
44	4	0	2	4	3	13
45	3	0	1	3	2	9
46	4	0	3	3	5	15
47	5	0	2	4	4	15
48	16	2	7	14	10	49
49	60	19	15	52	23	169
50	18	1	3	16	5	43
51	8	1	3	7	4	23
52	1	0	5	1	8	15
SUM	4512	606	916	3974	1369	11377

Figure 25: Weekly sales forecast per market

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