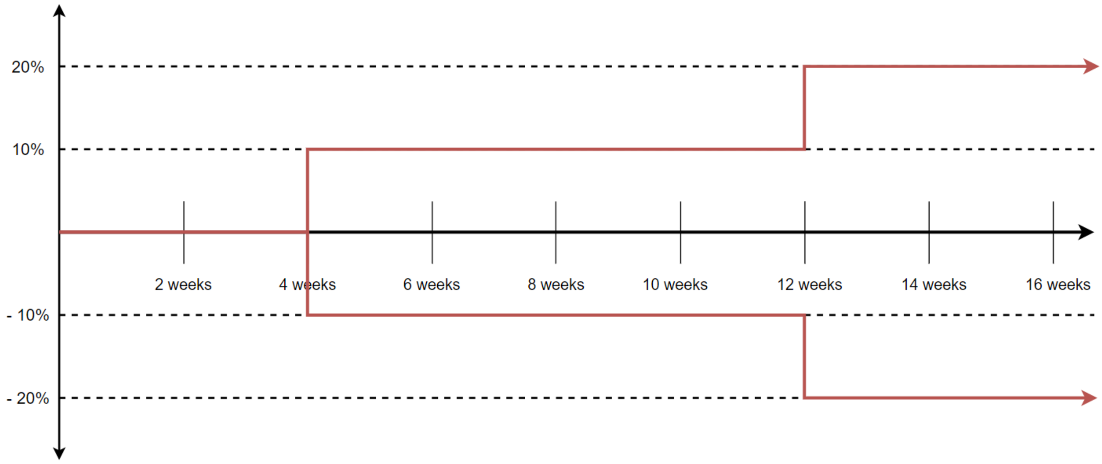

HANDLING VOLATILITY IN DELIVERY PLANS BY IMPLEMENTING FREEZE TIMES

A Case Study of a Supplier in The Automotive Industry

Master's Thesis in Production Engineering

Edvin Johansson
Karl Westmark

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT
CHALMERS UNIVERSITY OF TECHNOLOGY
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Examiner and Supervisor: Patrik Jonsson, Department of Technology Management and Economics

Report no. E2021:032
Department of Technology Management and Economics
Division of Supply and Operations Management
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Deviation model of the case companies implemented new freeze periods.

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Karl Westmark
Edvin Johansson

Department of Technology Management and Economics
Chalmers University of Technology

Abstract

The studied case company has like many other companies within the automotive industry problems regarding delivery plans. Plans are getting changed close to delivery and this creates a hard-to-handle planning environment. The poor planning environment causes issues internally in the information and material flow. Therefore is the aim of this study to reduce the volatility in delivery plans, by designing and implementing a new order handling process and new freeze periods. The freeze periods disables customers from making changes in delivery plans freely, and thereby is the case company taking control of the planning process.

The methods used for implementing the new process were dispatched via a test with four pilot customers. Data was gathered during the pilot, and the pilot was performed in five weeks. After the pilot and the data were gathered, patterns that indicated a reduction in variation in delivery plans were shown. To make a change towards customers is communication very important. Initially were the pilot customers noticed via an information mail it was proven not to be a sufficient method for making the customer realize what was supposed to happen and/or what was expected from them. Meetings and continuous communication were in this case key.

By implementing the new process towards customers, a reduced number of changes in delivery plans were shown. It was possible by using a clear order handling process and transparency towards customers. This specific study and pilot did not reduce the total amount of volatility in delivery plans. Due to the sample size being small. It is thereby hard to say that other processes were improved. It is, however, possible to conclude that if the case company continues to implement the new process and freeze time towards more customers it will reduce the total volatility and thereby also improve other processes.

Keywords: Freeze times, Volatility, Order handling, Delivery schedules, MAPE, FAI and WTS

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Edvin Johansson and Karl Westmark, Gothenburg, May 2021

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1 Introduction

Companies within the automotive industry constantly strive for better and more efficient ways of producing and handling their supply chain. Implementing Lean management, lower buffers, and lower inventories are necessary to have a competitive edge. Many companies have thereby shifted from build to stock (BTS) to build to order (BTO). BTO can, however, cause some issues and puts pressure on the supply chain (Meyr, 2004; Gunasekaran & Ngai, 2009). Parts of the original equipment manufacturers (OEM) are mostly produced by external suppliers. Communication and collaboration across the supply chain and companies are thereby very important (Sako, 2005). Communication, collaboration, and transparency is a way to tackle volatility caused by forecasts (Wang, Lu, Feng, Ma, & Liang, 2014). Customer orders are sent via delivery schedules, and they are often used in the planning processes in the automotive industry. Delivery schedules are however to a certain degree forecast based which can cause large variations. Thereby are different safety mechanisms often used at suppliers, to guarantee product availability and thereby a high service level. This creates further disturbances and variations further down the supply chain (Martinsson & Sjöqvist, 2019; Schwede & Thissen, 2014). High volatility can be connected to e.g bad precision in performance, extra expenses, imbalance in inventory, and quality issues (Dai, Peng, & Li, 2017; Wang et al., 2014). It is essential to have reliable forecasts, to create a reliable environment where forecasts can support planning and decision making. (Abolghasemi, Gerlach, Tarr, & Beh, 2019) High volatility will make the planning and decision making hard (Syntetos, Babai, Boylan, Kolassa, & Nikolopoulos, 2016).

This project was performed at a company that operates as a supplier within the automotive industry. The company is producing active safety products for autonomous driving and advanced driving assistance systems. The company has experienced customer demand as volatile with big fluctuations close to delivery date ever since they were founded. The delivery schedules are often inaccurate, and the company does not have a structured and developed method of handling variations in delivery plans.

The customer delivery plans are represented in form of customer orders that are sent via EDI messages. They are received once a week to once a day depending on the customer. The case company's current ERP system does not have sufficient methods or tools for visualizing and helping planners to keep track of the variations. There is no standardized process to deal with delivery plan variations. It leads to lots of extra costs both from suppliers and for customers, such as express deliveries, lots of re-planning, unnecessary setups, and stoppages in production, etcetera.

To decrease unnecessary extra expenses there is currently a suggestion of new freeze periods from the case company's side. This would lower the allowed perceptual changes in delivery plans, which would reduce the amount of volatility in the delivery plans. To realize this aim there is a need to design and implement a new order handling process, and to evaluate the new order handling process it will be tested with four customers.

1.1 Aim

This project aims to investigate how a new order handling process and freeze periods can be designed and implemented in the case company. The freeze time determines which changes that are allowed and not allowed in delivery schedules. The intention is that this work should lower the variations, help the case company to handle variations better, and make their customers understand which variations are manageable and which are not.

Further, the new process and freeze times will be evaluated by piloting the proposal towards four of the company's customers. To understand the effects of implementing freeze times the current forecast accuracy will be measured. Another measurement will be made after the pilot is performed. The measurements will be compared and analyzed to understand what impact the new process has on volatility in delivery schedules and also what the effect can be on other processes.

1.2 Research Questions

Three research questions were created, and the questions were formulated in a way that, when answered, would assist in reaching the aim.

To aid the case company in handling and reducing the variations in delivery plans it is essential to know how much volatility the case company currently has. This was necessary to be able to reduce the variations in delivery plans. Thereby was the first question formulated.

Research question 1 - *How much volatility is there currently in the pilot customers delivery schedules?*

It was clear early on that the case company's current order handling process was not sufficient when it came to handling delivery plan variations. It was thereby important to formulate and implement a new order handling process. The second research question is concerning how to create and implement a better order handling process.

Research question 2 - *How should the new planning- and communication process be designed? And how can it be implemented?*

How a new order handling process affects other processes, and how reducing variations with new freeze periods can improve conditions such as e.g quality and flexibility, was an interesting next step to investigate. Thereby was the third question formulated regarding how reducing variation affects other processes.

Research question 3 - *How can the new planning- and communication process with the new freeze times affect other processes within production and supply chain?*

1.3 Delimitations

The work is limited to the case company and its specific plant in Sweden and to develop their planning process. No other companies will be involved in the study the object is, however, that achieved results can be useful across the automotive industry.

The focus of this thesis work is on developing the order handling of the case company by improving the process and using an existing, already developed application (Qlik), and integrating this with the process. The application is going to be used as an analytic tool. Therefore will, no technical improvements with the application be made. Further, no technical work will be made with the ERP system currently used due to a lack of time. However, if potential improvements are found, this will be recommended for future work. The study focuses on an operational level - supply and operations execution (SOE). No proposals regarding higher strategic levels will be suggested.

2
Theory

A theoretical study was performed to create an understanding of the subject and it is presented in this section to give the reader a adequate background.

2.1 The Supply Chain Planning Process in the automotive industry

Generally, the planning process consists of two or more parts, that are hierarchically divided and differs in terms of time horizon and level of detail Jonsson and Mattsson (2009). are dividing the planning process into four different steps, namely sales and operations planning (S&OP), master production scheduling, order planning, and execution and control. Sales and operations planning has a long time horizon and a small level of detail and further down in the hierarchy the time horizon gets shorter and shorter whereas the level of detail gets higher and higher. However, the planning process can of course vary from company to company and several different variables affect how it is structured. The different steps in the process and their relationship to each other are described in table 2.1.

Table 2.1: Sales and Operations table (Jonsson and Matsson, 2009), the table describes the planning process functions planning object, horizon, period length and planning frequency.

Function	**Planning object**	**Horizon**	**Period length**	**Planning frequency**
Sales and operations planning	Product group	1-2 years	Month	Monthly
Master production scheduling	Product	0.5-1 year	Week	Weekly
Order planning	Item	1-6 months	Week/day	Weekly/ daily
Production activity control/ execution & control	Operation	1-4 weeks	Day/hr	Daily

2.1.1 Sales and operations planning

Sales and operations planning is at the top of the hierarchical structure which means that planning in this stage is made on a long term horizon(1-2 years), with a frequency of one month and with a small level of detail(product group level)(Jonsson & Mattsson, 2009). The aim of the planning at this stage is to level the predicted demand with capacity and material supply. The predicted demand is based on forecasts which normally reaches between one to two years and is made on a product group level.

Within the automotive industry, the OEMs base their forecasts on historical data of sales and already confirmed customer orders, and based on this knowledge production plans are set. These production plans are then sent upstream in the supply chain in form of delivery plans, i.e the first tier supplier base their forecasts on the OEM's production plan and so on (Meyr, 2004). From these forecasts delivery- and production plans are set to reach a balance between demand and supply.

2.1.2 Master production scheduling

The next step in the hierarchical planning structure is master production scheduling (Jonsson & Mattsson, 2009). In this step are production and delivery plans set on the product level, i.e. a higher level of detail than in the S&OP, and often has a time horizon of three months to one year. The steps within the master production schedule are quite similar to the steps in S&OP and also vary depending on the manufacturing strategy (make-to-stock, assemble-to-order or make/engineer-to-order).

The first step is to forecast future demand. The second step is to generate a preliminary delivery plan, which in the automotive industry often is based on delivery schedules sent via EDI from the customers(Meyr, 2004). From this delivery plan, a preliminary production plan is set with the aim to follow the delivery plan while having a balanced stock, if in a make-to-stock environment. The next step is to check if the made-up plans are feasible in terms of capacity and material supply and if OK the final step is to settle the plans (Jonsson & Mattsson, 2009). Figure 2.2 shows an example of a master production schedule.

Table 2.2: Master production schedule (MPS) (Jonsson and Mattsson, 2009), with fabricated numbers that exemplify a MPS. The table specify the needs for the products and weeks

Week	**1**	**2**	**3**	**4**	**5**	**6**
Product A	200	200	200	200	240	240
Product B	120	120	120	120	120	120
Product C	40	40	40	40	40	40

2.1.3 Order Planning

As already briefly described, the customer orders serve an important role when balancing the supply and demand, since they give a good representation of the demand and thereby give good input to the material- and capacity planning processes. The customer order process varies depending on the manufacturing strategy of a company. For example, the process generally is different in a make-to-stock environment and a make-to-delivery schedule environment(Jonsson & Mattsson, 2009). The case company is working in a make-to-delivery schedule environment, and how this process works will be described further.

2.1.3.1 Make-to-delivery schedules

In a make-to-delivery schedule environment, the delivery schedules received from the customers serve as the customer orders and the manufactured quantities can either be delivered directly to the customers or delivered from stock. The choice here depends on several factors, for example, if the quantities received in the delivery schedule are of a reasonable size to be manufactured in one batch. If they are the parts can be directly delivered and if not the parts can be stored for the next call-off (Jonsson & Mattsson, 2009). A delivery schedule is typically divided into three different parts; call-offs, scheduled call-offs, and forecasts. The call-offs represent a firm commitment where no changes can be made without a good reason, scheduled call-offs are a commitment for procurement of material and the forecasts have no commitments. The time horizon of these three different parts depends on agreements between customer and supplier. For an example of this kind of delivery, schedule see figure 2.1

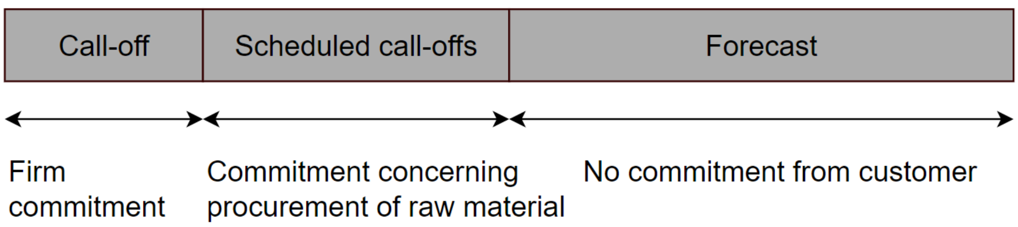

Figure 2.1: Make-to-delivery schedules, the figure shows the commitment connected to the different parts (Jonsson and Mattsson, 2009).

2.2 Forecasting

Making predictions of future demand is called forecasting. This is a very important step in the supply chain planning process as the forecasts serve as input for both sales and operations planning as well as for master production scheduling. Forecasts can be made in several ways and often varies between OEM's and suppliers and it is also made in different ways for different time horizons Jonsson and Mattsson (2009) are roughly dividing the forecasting methods into two different categories, qualitative and quantitative.

2.2.1 Forecast accuracy

Since the forecasts play a major role in the planning process it is important that they are accurate, which is a difficult task because of volatility and varying uncertainties (Abolghasemi et al., 2019). Without accurate forecasts capacity- and material planning will fail which in turn can result in a backlog towards customers or a big finished goods stock depending on if the demand is over or underestimated. However, just as Jonsson and Mattsson (2009) says since the forecast only is an assessment of future demand it will never be 100% accurate with the actual demand.

2.2.1.1 Aggregation level

Products can be clustered in product groups, this can visually display a smooth variation in demand. However, only making assumptions for product groups can cause problems, especially when planning short-term. The variation in demand for specific products can hide when only looking at the group level. It is thereby crucial to decide which aggregation level a forecast should be based on. Figure 2.2 illustrates the variation of demand in specific products against the product group, the figure shows that the demand is less volatile on a higher aggregation level, demand in product groups is thereby easier to predict. This is why the product group aggregation level is more commonly used when planning long term (Jonsson & Mattsson, 2009) (Watts, 2015).

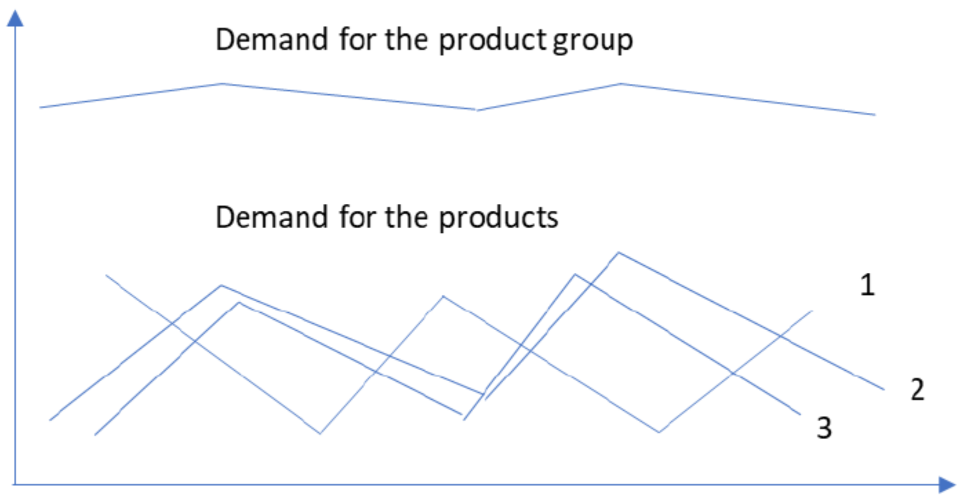

Figure 2.2: Aggregation level for specific products and for the product group, demand for specific products are more volatile than product groups (Jonsson and Mattsson, 2009).

2.2.1.2 MAPE, FAI and WTS

Because of prior mentioned problems regarding forecast accuracy, it is very important to measure and monitor the accuracy of the forecasts and there are several ways of doing this. Between 2010 and 2014 Odette developed an industry standard for automotive supply chains for measuring forecast accuracy in delivery schedules.

This standard consists of two different measurement indexes, forecast accuracy index (FAI) and weighted tracking signal (WTS)(Odette, 2012).

Mean absolute percentage error (MAPE) can be used to display and measure deviations and random variation (Chase, 2016). It can also be used to monitor the number of changes in delivery plans. The values of MAPE can be visualized into a graph that displays variations. This method is used in the industry due to it being intuitive and easy to understand. There are some issues regarding the MAPE method. When calculating the MAPE the actual demand is divided by the predicted demand, which means that it can not be used when the actual demand is zero. For low forecasts, the error can not exceed one hundred percent, and when forecasts are high there is no upper limit to the error. And finally, when there are decreases in plans there is a higher penalty than when there are increases. It is important to consider these issues when using this method (Tofallis, 2015).

FAI is found by calculating the MAPE for several time lags (weeks) where the actual demand is compared to the forecasted demand and then an average of these are calculated. This gives a good indication of how accurate the forecasts are. Alpha values can also be used to weigh the importance of specific lags. WTS on the other hand shows bias if historical delivery schedules are over-or underestimated compared with the actual demand. Figure 2.3 shows how customers need to change their orders considering their bias (Ekberg, Raju, Bahsson, & Jirholm, 2019). The mathematical definitions of MAPE, FAI, and WTS are in the methods part.

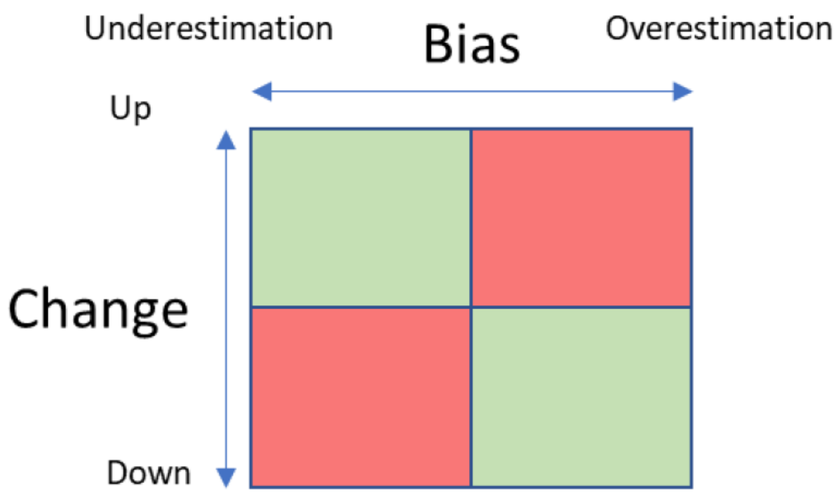

Figure 2.3: Customer bias, a model that visualise how customers bias affect how they make changes in delivery plans (Ekberg et. al, 2019).

Other ways to measure accuracy in delivery plans are used in the industry. One measurement is established by Verband der Automobilindustrie (VDA, 2008). VDA (2008) has classified whats good, medium, and poor performance regarding delivery accuracy. VDAs measurement was converted and adapted into a corresponding FAI value. VDAs FAI value classification is shown in table 2.3.

Table 2.3: FAI performance classification table, created by VDA (2019).

Time horizon	Demand Period	Forecast Period	FAI	Classification
Short	Days	Weeks 0 to -2	>97%	Good
			92-97%	Medium
			<92%	Poor
Medium	Weeks	Weeks -3 to -8	>95%	Good
			90-95%	Medium
			<95%	Poor
Long	Months	Weeks -9 to -x	>90%	Good
			85-90%	Medium
			<85%	Poor

2.3 Demand Planning and Control

Manning (2021) is emphasizing the importance of demand planning and differentiates it from forecasting. Forecasts will always be wrong and if relying on them too much, companies will always act reactive and spend too much time on firefighting. His solution to this problem is demand planning, which is a more advanced type of forecasting where more factors are taken into account.

When making demand plans, the focus should not be solely on the forecast numbers, instead, the focus should be on the assumptions behind the numbers to understand why the forecast was wrong (Manning, 2021). Only when this is achieved in combination with well-structured demand control companies can start acting more proactively.

Furthermore, Hower (2018) is talking about demand control which is described as a necessary part of the earlier described S&OP process, but yet it is still rarely talked about. Demand control is about continuously reviewing the S&OP plan and adapt it to sudden, unforeseen, changes. This often occurs on a daily or a weekly basis. Hower (2018) lists several examples of when the demand control process is being used and one of these examples is inaccurate forecasts. Then the S&OP plan has to be reviewed and revised to match the new demand. This is an important part of the supply chain planning process.

2.4 Variations in delivery schedules

Volatility and big variations in delivery schedules are a rather common problem in automotive supply chains. There can be several reasons behind the variation, and one of the reasons is called the bullwhip effect (Jonsson & Mattsson, 2009). The so-called bullwhip effect is a common phenomenon in supply chains. It is caused by a skewed information order transition upstream. The information gap is caused by fluctuations in demand. The impact of the bullwhip effect gets larger further down in the supply chain. The result of the bullwhip effect is shown by big variations in customers ordering stock. The bullwhip effect makes the market demands hard to determine, interpreted, and grasp. Causes of the bullwhip effect can be things as e.g., fluctuations in prices, shortages, imbalance in inventory, lead time, and/or order quantity decisions (Dai et al., 2017). See figure 2.4 for an illustration of the bullwhip effect.

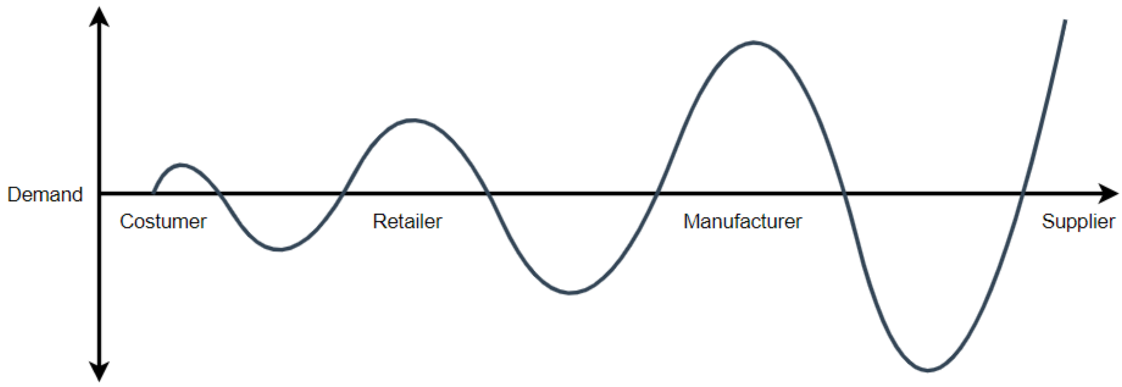

Figure 2.4: Illustration of the bullwhip effect, volatility increases further down the supply chain.

2.4.1 MRP Nervousness

Another common cause for variations in delivery schedules is MRP nervousness. This can be defined as large changes in MRP plans caused by small changes in higher-level plans such as MPS. I.e. a small change in the OEM's MPS can cause large variations in the delivery schedules for the supplier and related to the bullwhip effect, the variations will be larger further downstream in the supply chain (Zhao & Lam, 1997). Further Blackburn, Kropp, and Millen (1985) is describing how there are two basic causes for MRP system nervousness. Uncertainty in demand (and supply of components) and variation in lot-sizing decisions. Also, they are giving several proposals on how to deal with nervousness. Their top suggestion is to use buffer stocks at the top level of the supply chain. The buffers absorb the fluctuations in demand and thereby the consequences of small changes in the top will not affect the lower levels as much. One problem with higher buffers is that it creates bigger costs.

The bullwhip effect and MRP nervousness create many problems when planning production, determining safety stock, and forecasting. A way to counter this is to share information thru out the supply chain and sharing information between suppliers, manufacturers, and retailers.

2.5 Visibility in Supply Chains

A basis for decision-making in management regarding supply chain is the demand forecast, (Narayanan, Sahin, & Robinson, 2019) thereby is a reliable forecast important for the supply chain managers, in the support of planning and decision making

(Abolghasemi et al., 2019). Uncertainties and volatility will significantly impact the precision in performance when forecasting demand at a high level. Thereby will volatility make the supply planning tough and lead to extra unnecessary expenses (Syntetos et al., 2016), (Abolghasemi et al., 2019).

Increasing the transparency and information sharing in the supply chain can help in decision-making both towards costumers and internally. Increased Information sharing can lead to increased visibility. The increased visibility can give companies a more effective supply chain and thereby give companies a competitive advantage (Barratt & Oke, 2007). Visibility has been proven to have the potential to reduce inventory, reduce quality issues, improve responsiveness, increase flexibility, and increase product availability (Lee & Whang, 2000; Barratt & Oke, 2007). It is also proven that a way to counter volatility and the bullwhip effect, is utilizing the method of sharing information in the supply chain (Wang et al., 2014).

Information sharing is based on both human interaction and technology. Information sharing via technology can be things as a collaborative planning system, which could be an internet-based ERP or EDI:s. Information sharing also occurs for instance via meetings face to face, telephone, etcetera. Continuous contact between employees from the supplier and customer increases visibility. Building trust and a good culture are advantageous for visibility. Having clear visibility in the supply chain can improve performance in the supply chain when using certain resources or mechanisms (Barratt & Oke, 2007).

2.6 Collaborative Planning

Collaborative planning is according to Dudek (2009) a way to plan and to coordinate operational planning tasks between suppliers and manufacturers which are independent but are linked in the same supply chain. Collaborative planning is about creating services and products for the final customers by handling and synchronizing production, storage, and distribution, in the supply chain. Different approaches can be used for collaborative planning such as e.g., having a deciding unit that is centralized. A negative aspect of a centralized deciding unit is that it requires all relevant information, this can be hard to achieve, and it is thereby critical to have well-structured decision-making. Having a higher controlled supply chain may not be possible in every case. Collaborative planning, however, has a huge potential to increase competitiveness, performance and reduce costs.

There are other forms of collaborative planning one of which Dudek (2009) calls "*Collaborative operations planing*", and this differs from the hierarchical collaborative planning which has a centralized controlling unit. The operative planning is controlled by the individual companies across the supply chain. This form of planning is about exchanging relevant data and creating a mutual plan and aligning plans between supply chain members to achieve coordination and common goals. Figure 2.5 shows how the different companies planning domains engage in collaborative planning (Kilger & Reuter, 2005; Stadtler, 2007).

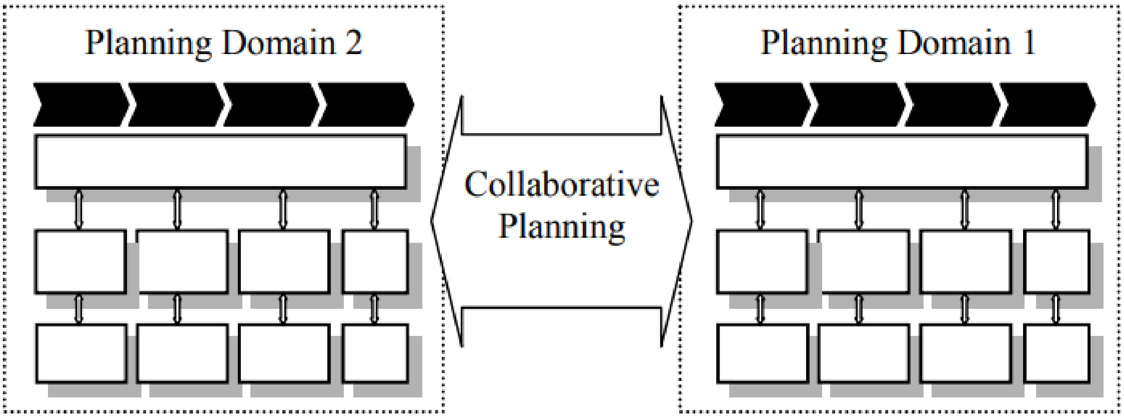

Figure 2.5: Collaborative planning, the figure shows that two planning environments collaborate to create a common planning setting (Kilger & Reuter, 2005).

A collaborative process can be shown as a cyclic process, as described in figure 2.6. The first step is the domain planning, and this part of the cycle is where the initial plans are performed, in the next step is the data exchange. The third step is crucial, and it is about adjusting plans in such a way that they are consistent and committed to. After these first three phases are done it is time to execute the plans and measure the performance (Dudek, 2009).

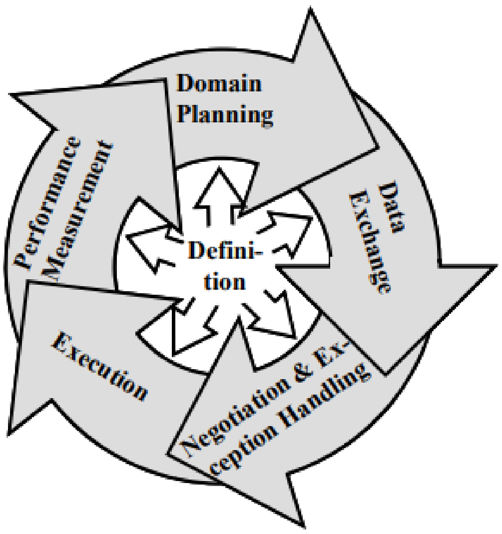

Figure 2.6: Collaborative cycle, figure show an generic collaboration planning environment (Kilger & Reuter, 2005).

2.7 Material and Information Flow

The information and material flow, from a supply chain perspective, at a production company, can be illustrated as in figure 2.7 (Meridion, 2021). The figure is a general model of a information and material flow. The thin red arrows in the figure illustrate the information flow, and the blue thick arrows display the flow of materials. The process starts when the company receives an EDI from a customer and 1) a planner handles the order. 2) The planner develops a production plan based on the EDI, and 3) an EDI is sent to a supplier to get raw material for the production. 4) The raw material is delivered to the company, 5) the raw material is transformed into a product. 6) When the product is finished it will be shipped from the warehouse to the customer. In this projects is the "order handling" process the part of the value chain that is evaluated, improved, and piloted.

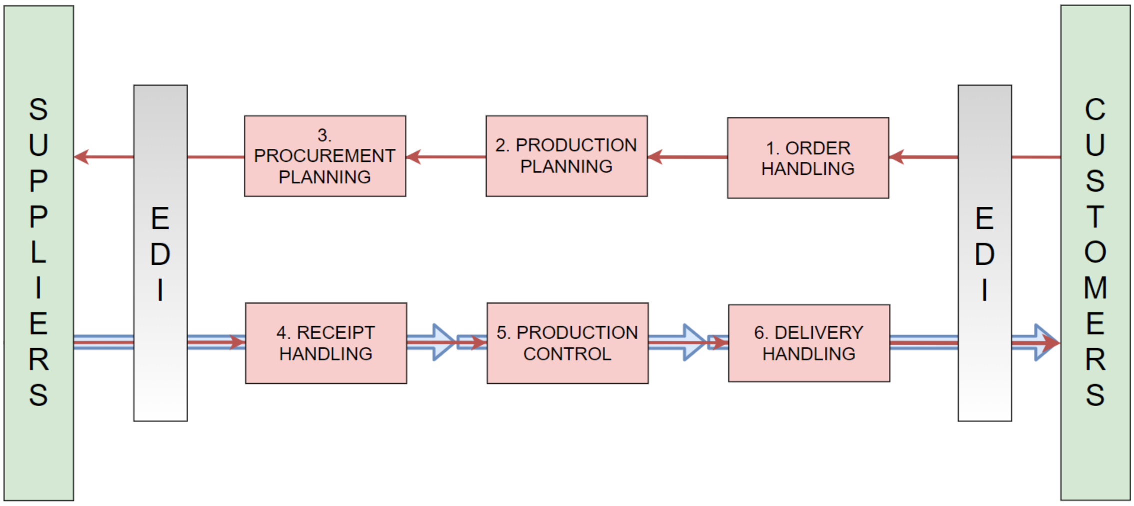

Figure 2.7: An example of a information and material flow at a production company, From customer order to delivery (Meridion, 2021).

2.8 Theoretical Frame Connected to the Project

The presented theoretical frame is connected to the research questions. Table 2.4 shows areas that are connected with the respective question. The first section 2.1 creates a background for every question and gives the reader an understanding of the supply chain and the planning environment in the automotive industry. 2.2 and 2.3 are about forecasting, planning, and measuring methods that currently are used in the industry. These measuring methods (MAPE, FAI, and WTS) are used in this case. Thereby are these parts mainly connected to research questions one and three. 2.4 connects with every question. It was important to understand how variations affect the planning environment and how it affects other parts of material and information flow. Visibility and collaborative planning are explained in 2.5 and 2.6. It is connected to the second and third research question both in regards to implementing a new process and to understand how other processes are affected. The final part, 2.6 is also mainly connected to research question two and three both by understanding the process and seeing how the flow can be affected by changes.

Table 2.4: Theoretical frame connected to research questions, The X shows connections.

Theoretical Frame	RQ 1	RQ 2	RQ 3
2.1 The Supply Chain Planning Process in theautomotive industry	X	X	X
2.2 Forecasting	X		X
2.3 Demand Planning and Control	X		X
2.4 Variations in delivery schedules	X	X	X
2.5 Visibility in Supply Chains		X	X
2.6 Collaborative Planning		X	X
2.7 Material and Information Flow		X	X

3
Method

In the following section is there a background of the case company, a description of the research approach, and how information and data were accumulated. This project is based on a project called "*Fordonstrategisk Forskning och Innovation*" (FFI). This project is shortly explained.

The method chapter includes a clarification of how both the quantitative and the qualitative data was collected, and it includes why, and when certain information collection activities were made. There is also a description regarding how the data was analyzed and how the gathered data helped towards the project aim and how it gave validity and credibility to the results.

3.1 Study Design

The research contained, as mentioned, a mix between a qualitative and a quantitative approach. The idea behind this was that the quantitative studies would give an understanding of the problem in form of numerical values and statistical analysis. While the qualitative data would give a subjective view of the problem from employees of the case company(Bryman & Bell, 2011). To achieve the first part of the aim there was a prerequisite to understand how big the actual fluctuations in the delivery schedules were. Thereby was a large amount of quantitative data required. The qualitative information was gathered in form of interviews, continuous meetings, and a workshop. The mixed approach was a condition in order to map the current planning process and to be able to create a new process of handling volatility and communicating to costumers.

3.1.1 Overview of the Project Method Flow

The Project was divided into four stages, stage one to stage four, according to figure 3.1. During the project was continuous meeting held from stage one to stage four. The green boxes in the figure display the method used and the red boxes are the results. The arrows indicate inputs, the dotted arrows are inputs from the methods and the filled arrows are inputs from achieved results. The project was started with a literature study which created an understanding and background regarding the subject. The study together with meetings and interviews paved the way for the creation of the mapping of the old order handling process. The quantitative data analysis gave a result that showed the current volatility in the delivery plans, the result was compared to benchmarks from the literature study. Stage two was about creating a new process. This was made possible by having meetings and creating new freeze times, the chosen freeze times was decided by the case company. The new process was an improvement of the old order handling process. Further literature studies were carried out in this stage to create an adequate understanding and background. In the third stage was the new process deployed, via a pilot which included four customers. The pilot was analyzed, and data regarding delivery plans were gathered. The pilot customer's variations in delivery plans after the pilot were compared with variations before the pilot was deployed. In stage four was the pilot evaluated and a suggestion of how the company can implement the new process put forward and discussed in a workshop. All activities and methods are explained more in detail below.

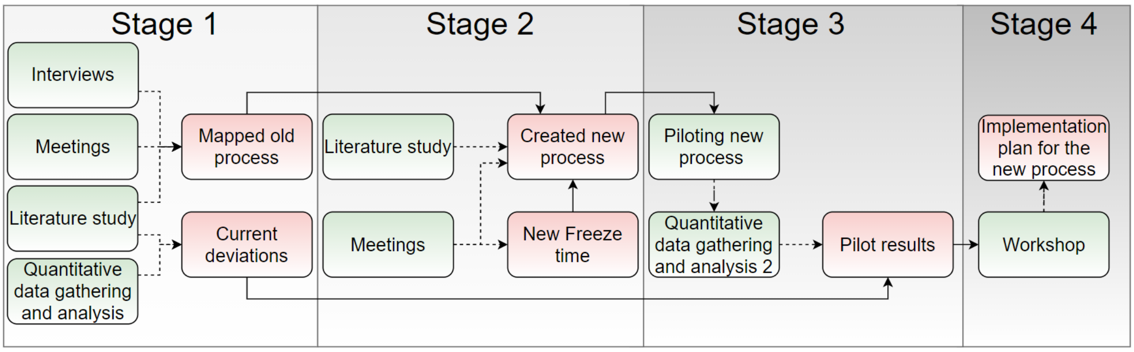

Figure 3.1: Project method flow, the figure shows how the project was performed.

3.1.2 Connecting Method Flow to Research Questions

How the stages are connected to the research questions are described in table 3.1. The first research question was answered in the first stage because the first question was about figuring out the current variations and making sense of how good/poor the variations are. This was enabled by analyzing data from the ERP system and the FAI tool. The results from the analysis were compared to VDA (2008)s classification table, which enabled the classification of the results.

The second question was about implementing and designing a new process that handles the variations in delivery plans. This question demanded inputs from all stages, to answer it. Outputs from the first stage were the mapping of the old process, stage two was about creating and designing the process, and the implementation of the new process was the main focus in stages three and four.

To understand how variations and reducing variation affect other processes was in this case hard, due to different circumstances. This question was mainly answered by evaluating the results of the pilot and by understanding how other processes are affected by volatility. Thereby was this question answered by concluding the interviews and literature study from stage 1, results in stage 3, and a final meeting in stage 4.

Table 3.1: How the research questions are connected to the different stages in the method flow. The X shows connections.

	RQ 1	**RQ 2**	**RQ 3**
Stage 1	X	X	X
Stage 2		X	
Stage 3		X	X
Stage 4		X	X

3.2 The FFI research project

There is an ongoing (since 2018) research project called "Future of sharing schedule information in automotive industry supply chains using advanced data analytics" that is carried out by Chalmers funded by FFI. The background to this project is that supply chains within the automotive industry are often negatively impacted by low accuracies of forecasts of delivery schedules. Several suppliers and OEMs are involved in the project, including the case company, to "generate a best practice description of how planning information is shared and used in the supply chains, and develop and field test new methods and models for measuring, visualizing and predicting delivery schedule variations in supply chains" (Chalmers, 2021).

Further, the project is divided into six different steps. The steps consists of:

1. Survey studies to understand how information is used in the supply chain.
2. Analyzing delivery schedule data to find common patterns in terms of variation.
3. Finding causes and consequences of the patterns.
4. Study how machine learning models can be used to visualize and predict variations in delivery schedules.
5. Study and analyze how these findings can be implemented in the planning processes and this is what this project will focus on.
6. The sixth and final step is dissemination. Important findings from the previous steps will be presented in the theory chapter below.

3.3 Case background

In the spring of 2020, another thesis project was performed at the same company. During this project lots of relevant data were gathered and also some important findings were made which will be presented in this section.

3.3.1 The Planning Process at the Case Company

The case company plans over three main horizons which are 2-12 months, 8 weeks, and 2 weeks (Hansen & Sveide, 2020). The longest horizon, 2-12 months, is planned in a monthly long-term S&OP meeting. These meetings aim to understand the long-term demand and try and balance the capacity with this. The two shorter horizons are planned in a weekly short-term S&OP meeting. The aim of these meetings is the same but for a shorter time horizon. The production plan for the coming eight weeks is set by the production planner and software is doing the execution and control planning on a two-week horizon. This is summarized in table 3.2.

Table 3.2: Overview of planning process (Hansen and Sveide, 2020), which describes how the Planning area are connected to Aggregation level, frequency and horizon.

Area	**Aggregation Level**	**Frequency**	**Horizon**
S&OP	Business Area Level	Monthly	2-12 Months
Production Planner	Item Group Level	Weekly	8 Weeks
Planning Software	Article No. Level	Weekly	2 Weeks

The production plans that are set in these meetings are based on EDIs as well as on forecasts produced by S&OP (Hansen & Sveide, 2020). Generally the first three months of the production plans are based on EDI plans and everything after that is based on forecasts, which in turn are partly based on EDI plans. This is visualized in figure 3.2.

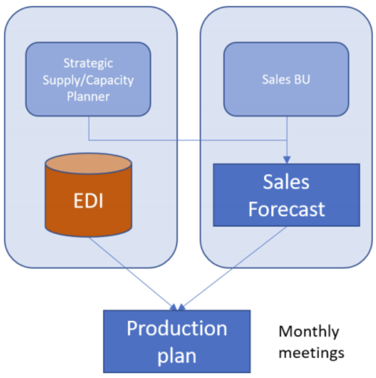

Figure 3.2: EDI and Forecasts as input to production planning (Hansen and Sveide, 2020).

3.3.2 Effects of Variations in Delivery Schedules

Hansen and Sveide (2020) concluded that the variations that the case company experienced caused a lot of problems, both socially and economically. For the production planners, variations and uncertainties in the delivery schedules contribute to a big part of the workload and also creates a lot of stress. I.e. the more variations, the more time the planners will have to spend on re-planning and monitoring the plans which also takes time from other tasks such as improvement work.

From an economic perspective, the variations cause a lot of costs. Premium freights both from suppliers and to customers, extra inventory, and overtime in production are all examples of what kind of measures can be used to handle the variations(Martinsson & Sjöqvist, 2019). Hansen and Sveide (2020) concluded that all of these measures are taken by the case company and if the variations could be lowered, these extra costs could also be lowered. Also, it is important to notice that the decreases in delivery plans, in the end, leads to lost revenue, which of course also is unwanted.

3.3.3 The Case Company Related to its Suppliers and Customers

The case company is as mentioned rather newly founded and are thereby small in comparison to both their customers and their suppliers. Figure 3.3. shows a comparison with on of the company's suppliers and one of its customers. According to interviews performed by Hansen and Sveide (2020) this difference in size makes it difficult to put requirements, both on suppliers and customers.

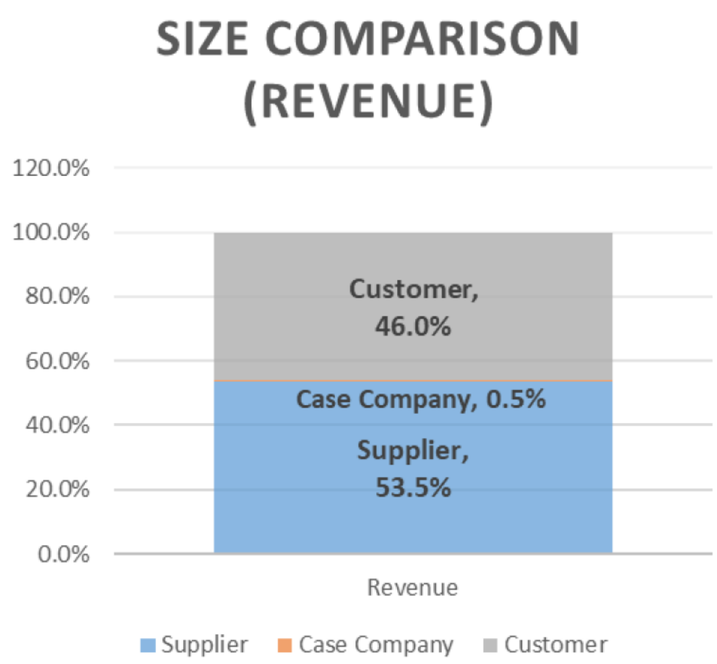

Figure 3.3: Size comparison between the case company, their customers and their suppliers (Hansen and Sveide, 2020).

3.3.4 Material Flow at Case Company

An example of a product's material flow at the case company is described in figure 3.4. There are two parallel lines with raw material which both go to component manufacturing. Then the product is tested, assembled, and finished.

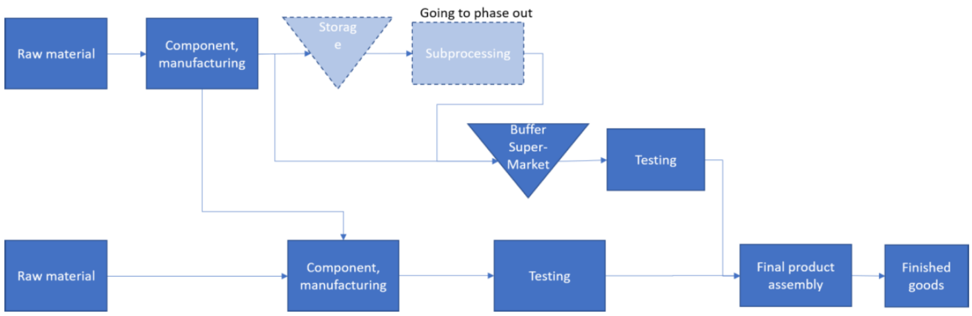

Figure 3.4: Case company material Flow (Hansen and Sveide, 2020).

3.4 Qualitative Data

In order to understand how the old order process worked and also to understand what the case company wanted of the new process, qualitative data was collected. This was mainly done by conducting interviews and by having continuous meetings several times a week.

3.4.1 Interviews

To understand the current order handling process at the case company, qualitative interviews with planners and the capacity manager were performed. Several interview questions were produced, and the questions were mainly regarding how the work process currently is structured, especially how they work in regards to changes in delivery plans. The questionnaires, and the answers are found in appendix A. The main reason for the interviews was, in short, to get answers which would make it possible to map the current planning work process, and to create an in depth understanding of the problems in the planning process, caused by volatility. All the interviews were conducted online via Microsoft Teams due to prevailing circumstances, which was the pandemic caused by Covid-19. Two planners and one capacity manager at the case company were interviewed. In table 3.3 the inputs of the interviews are shown and the table also shows in which stages the input was used. The answers from the interviews were homogeneous which enabled the mapping of the current process. The uniform answers from different planners made it possible to classify the results from the interviews as credible.

Table 3.3: Shows the inputs of the interviews and which stage in the method flow the inputs were used.

Interview	Input	Method flow stage
Planner 1 and 2	Input regarding old process and input regarding new process	1 and 2
Capacity manager	Input regarding new process and input regarding overall planning environment	1,2 and 3

After the interviews were dispatched the task of creating a planning process mapping was started. The answers from the interviews were the basis for the created model. To validate the created current process map another meeting with all the planners and managers was performed and they approved the new process.

3.4.2 Continuous Meetings

Throughout the entire project were continuous meetings held, the meetings were carried out twice or three times every week. Participants in these meetings were two representatives from the business unit, the logistics manager, the capacity manager, a group manager, and a production/customer planner. These meetings enabled the project to continue to move forward, stay on track and the meetings were also a great source of qualitative information. For example, feedback was given on the development of the new order handling process and on the mail templates that are included in this process. This was also a first verification of the process and that it was possible to pilot.

3.4.3 Creating and Piloting the New Process

Firstly, with help from the interviews an understanding of the old process and its flaws were created. This was then combined with the wanted outcome of the new process. I.e. implement the new freeze periods and lower the variations in the delivery schedules. This made it possible to map a new process with more steps and which also included the possibility to stop plans if they were outside the freeze time requirements. This draft was then shown in the continuous meetings and feedback was given by the participants. With this feedback, the proposal was improved, and then it was ready for pilot testing.

To test and further improve the process a pilot test was performed during five weeks. Four different customer plants originating from the same OEM were chosen as the pilot plants. They were chosen by the company supervisor. The reason for this choice was that these plants were experienced as worst when it came to forecasting accuracy. The customers are in this report labeled as A, B, C, and D where customer A and B are first-tier suppliers to the OEM and customer C and D were plants directly connected to the OEM.

An info mail, a mail template, and a deviance template for the pilot were created. This was necessary in order to pilot the new work process towards the pilot customers. As explained prior has the case company a desire to change the freeze times. One information mail was sent to every pilot customer and thereby the pilot was started. The new freeze times meant that the pilot customers were not allowed to freely change delivery plans. Every time a change outside the freeze period was made, the new process was used. The templates and the new process is presented in the result part, As well as the results and effects of the pilot.

3.4.4 Workshop

The final step in the project was to create an implementation plan for the new process and new freeze periods. After the final data from the pilot was gathered a proposal of how the new process can be implemented was put forward in the workshop. The workshop was divided into three parts, where different discussion points were debated. The three points were: part one - discussions regarding the new process, part two - discussions regarding results of the pilot, and part three - discussions regarding future implementation/implementation kit, see appendix B for the notes and discussion points. After the workshop was performed a final version of the implementation plan was created and delivered to the case company. The inputs from the workshop were mainly regarding which customers to include and when they should be included. The new work process and mail templates were not changed. Notes from the workshop are found in Appendix B.

3.5 Quantitative Data

The performed data gathering and analysis were divided into two stages, in stage 1 and stage 3 (see figure 3.1.) The first part was to gather and analyze data to discover how much variation the company currently have in their delivery plans. The second part consisted of gathering data from the pilot customers to map how they responded to the new process, and to analyze if variations after the pilot had changed. How this was carried out in detail is explained in this section.

3.5.1 Gathering and Analyzing Data - Current Variation

The ERP system and the FAI tool automatically archives historical delivery plan data. Historical data from the FAI tool could thereby be analyzed and translated into visual graphs and values which demonstrate variations. MAPE profiles, FAI values, and WTS-values were created and one MAPE profile and two FAI and two WTS values were formed for every one of the four pilot customers, this graph and these values were chosen because they reveal the variations in the delivery plans in a clear manner.

The profiles and values are built of data from the period 2020-05-01 to 2021-03-21 and from the four pilot customers. This specific time frame was chosen due to the Covid-19 pandemic. The dates between 2020-03-01 to 2020-05-01 have a clear noise, due to Covid-19, thereby including data from this period would have created fluctuations that would have displayed a skewed representation of the delivery plan variations. The data also had to be further cleaned by removing delivery plans from when a product is recently released or has gone obsolete since these plans naturally have a large variation.

A MAPE profile displays variations in delivery plans by adding changes in delivery plans as absolute amounts. The profile of the four customers was calculated by using equation 3.1. Δ_i is the difference between reference demand and forecasted demand. d_0 is the reference demand which is the same as the actual demand.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|\Delta_i|}{d_0} \tag{3.1}$$

The FAI value is an index that describes the mean accuracy of delivery plans within a certain period. When calculating the FAI value, two different sets of parameters were used (Chase, 2016). The first value was calculated, where the mean from weeks 2,3, and 4 used, this was called "Setting 1". Setting 1 was used to understand the forecast accuracy for four weeks closest to the demand date. For "Setting 2" weeks 2, 5, and 10 were used. This setting was used to get an overall understanding of the forecasts. The FAI value is calculated with equation 3.2. α_i is a value between 0 and 1 and can be chosen so that different weeks/lags have different importance for the FAI value. Different α_i values were used and dates closer to the delivery date were given a higher α_i.

$$FAI = \sum_{i=0}^{n}\alpha_i max\left\{0; 1 - \frac{|\Delta_i|}{d_0}\right\} \tag{3.2}$$

A WTS value is a value that displays an indication of the customer's tendency to over-or underestimate desired goods (Ekberg et al., 2019). The WTS was also calculated into two values which were called "Setting 1" and "setting 2" as well. Where the first value shows a mean of weeks 2, 3, and 4 and the second 2, 5, and 10. The same α_i values as FAI were applied on the WTS. The WTS is calculated with equation 3.3.

$$WTS = \frac{\sum_{i=1}^{n} a_i\Delta_i}{\sum_{i=-1}^{n} a_i\left|\Delta_i\right|} \tag{3.3}$$

In order to verify the data, a comparison between the data from the ERP-system and FAI were performed, the values and recorded data matched which enabled the verification of the data. The results of the FAI values, WTS values, and MAPE profile were validated by a manager from the case company.

3.5.2 Gathering and Analyzing Data - Pilot

To try out, confirm, and validate the developed order planning process a pilot test was performed. From this test, data were collected regarding the deviating delivery plans. Information was put into a log each time an EDI plan was received containing a deviation compared to the old plan. The information consisted of how the new was applied, how big changes there were in the plans, which date they were received for which freeze period it got stopped etc.

This data was then analyzed to understand what effects the new process could have on the supply chain. For example, if it could lower the fluctuations in the EDI plans, if the customers accepted the new freeze time requirements, if the flow as a whole would be more stable, and so on.

Furthermore, data on the delivery plans from the pilot weeks was retrieved from the ERP system in order to make a similar analysis to the one described in subsection 3.5.1. The aim of this was to be able to compare the data from the pilot weeks with the analysis that was made on the current deviation to see if there were any differences and if any conclusions could be drawn from this.

3.6 Validity and reliability

The validity and reliability of both the qualitative and quantitative methods are explained below. Bryman and Bell (2011) defines validity as if it is possible to use the same methods and still get the same results in a repeated study.

3.6.1 Qualitative method

The interviews that were performed could have been with more planners and managers to create a higher level of credibility to the results, and some questions could have been changed or rephrased. The interviews conducted were, however, with knowledgeable people at the company. The people that were interviewed are all working in some way with delivery plans. Due to the knowledge of the interviewed staff and due to the uniform answers, the results were classed as credible. The results of the mapped process were further approved by the planners and managers which made it possible to conclude the results as validated.

The continuous meeting which was held throughout the project and the workshop was the greatest source of qualitative information. During the meetings short notes were taken. The notes were not extensive which could mean that some information was lost. However, the frequency of meetings where important information was discussed ensured that the information was gathered and remembered. The continuous meetings were a great source of reliable information, due to the experienced staff.

The short amount of time disabled the data collection regarding the third research question, there was no time to analyze other processes. The answer to this question is mainly anchored in prior projects and theory. But as a last attempt to validate that decreased volatility also will improve other processes at the case company, was a seminar/meeting arranged. In this meeting were industry experts present. This enabled a possibility to discuss and get validation regarding the effects of reducing the volatility. The project and mainly the results from the pilot were presented and discussed. During the discussions about reducing volatility, was it agreed from both people from the case company and industry experts that, the case company will improve other processes as they decrease variations in delivery plans. Thereby was the final question validated both in theory, by industry experts and by employees from the cases company.

3.6.2 Quantitative method

If critically assessing the choice of the quantitative method some problems can be found. First of all, there were some flaws in the data that was collected and analyzed to produce the MAPE profiles. Some obsolete products were still in the system which generated 0% error profiles incorrectly. These were cleaned out from the data set. By having to clean the data there is a risk that correct data was removed as well which would have affected the profiles. Furthermore, it is important to understand that only working with percentages on an item-number level in some cases can be misleading. For example, if a plan changes from 10 to 20 units, that is an error of 100%, and also if a plan changes from 10 000 to 20 000 units that are still just an error of 100%. This means that changes that have a significantly different impact on the supply chain, weigh just as much when drawing the MAPE profiles. It is also important to understand that the percentage error when the forecast has been too low can not exceed 100% while for forecasts that have been too high the percentage error can be infinitely high (Tofallis, 2015). This could also have affected the results. However, with the available time and the data cleaning that was made, sufficient conclusions of the analysis could be drawn.

It is also possible to argue that the pilot should have been conducted for a longer time to get better and more accurate data. If the pilot would have continued for a longer time more data could have been extracted and thereby shown more reliable results. Looking at the graphs and doing an analysis of it however showed that the pilot customers may have adjusted to the new freeze times. Even though the time spawn was short, it was possible to distinguish a change in the data, and see differences between delivery plans before and during the pilot was performed. Due to the change in data, it was possible to classify the results as credible.

The data that was collected during the pilot was also affected by production shutdowns which lead to major decreases in the delivery plans. This of course made the data "worse" and gave less validity to the pilot method. If you repeat the pilot with the same prerequisites but not in the same weeks you will get a different result. Despite this, it was possible to draw some conclusions from the data collected.

4
Result

In this part of the report are the results of the interpreted data shown, the created new and old planning process displayed, and the outcomes of the pilot presented.

4.1 Current variation in delivery plans

There are several ways to show variations in delivery plans. For this case has the variations be chosen to be displayed via MAPE profiles, FAI values, and WTS values. The results of the MAPE, FAI, and WTS, concerning the pilot customers, is presented below.

4.1.1 MAPE Profiles

The four pilot-costumers MAPE profiles are displayed in figure 4.1. The Figure shows how accurate the plans are compared to the delivery date, i.e the 4 on the

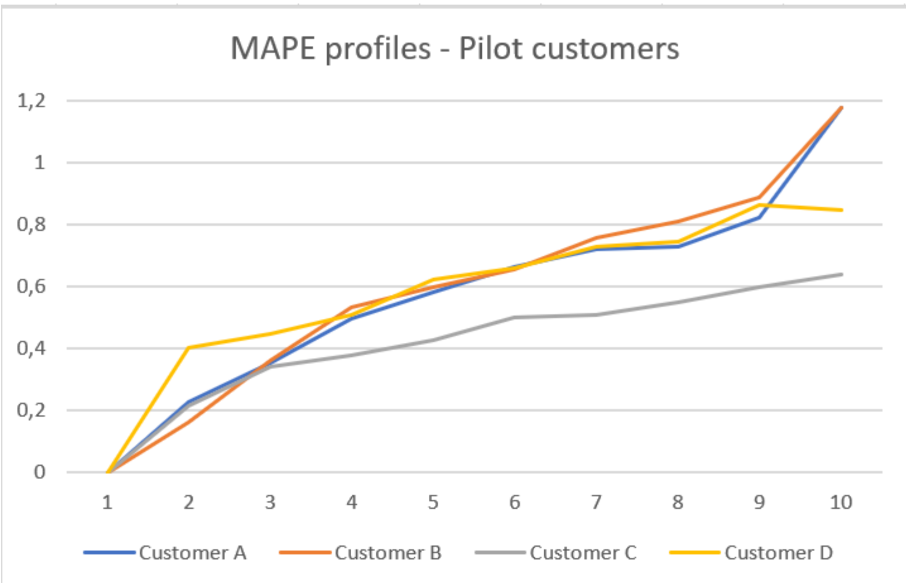

Figure 4.1: MAPE profile for all pilot customers, the X-axis represents the weeks plus the planning buckets and the y-axis is the percentual deviance.

x-axis is referring to the planned demand four weeks before the real demand date. The y-axis represents the perceptual deviance from the plans to the delivery day, where 0,1 means 10 percent. The MAPE profile is based on item aggregation level (Jonsson & Mattsson, 2009). Customer C and D are always ordering with set multiples which differs with each item number while customer A and B are ordering different quantities almost every time.

As shown in figure 4.1 there is a clear uncertainty regarding quantities for all the customers included in the pilot. It is obvious that the planning process is hard to handle due to these deviations and changes - volatility cause problems (Syntetos et al., 2016) (Abolghasemi et al., 2019). According to the plotted profiles, customer C has the most accurate plans while customer D has the least accurate plans in the weeks closest to the demand date and customer A and B have the least accurate plans in the weeks furthest from the demand date.

4.1.2 FAI and WTS

The results of the FAI and WTS values are presented in table 4.1. It is distinguishable that the accuracy in the FAI values is getting worse further from the delivery date. The FAI values also show that there is a rather low accuracy in the delivery plans, especially compared to VDA (2008) FAI classification table (table 2.3). The WTS values show that the pilot customers tend to overestimate coveted quantities.

Table 4.1: FAI and WTS score for the pilot customers.

FAI and WTS score - Pilot customers				
Customer	FAI setting 1	FAI setting 2	WTS setting 1	WTS setting 2
A	75,1%	70,5%	-0,02	0,13
B	70,8%	67,0%	0,01	0,14
C	70,2%	67,5%	0,06	0,11
D	56,0%	53,5%	0,14	0,22

If looking at the table a bit more in detail it is possible to see that customer A has the best FAI score, both with setting 1 and setting 2. This is interesting to compare with the MAPE profiles where customer C seems to have the lowest mean average percentage error. Also interesting to notice is that customer D has the lowest score by some margin. This is easier to understand since they have by far the worst MAPE value in week 2 which is considered in both FAI setting 1 and FAI setting 2. However, The FAI results from all the pilot customers, compared to the VDA (2008) table are all considered poor.

4.2 The Order Handling Process at the Case Company

In this case study the focus is to improve and analyze the order handling process which is the first step in the information and material flow (figure 3.4). By improving the first step the entire information and material flow will get more smooth.

The conducted interviews, which can be found in Appendix A, made it possible to understand and map the current process for handling delivery schedules. Delivery schedules from customers are received in form of EDIs. How often they are received varies from once a day to once a week depending on the customer. The planner goes through new EDIs every day and releases plans that have been stopped for different reasons into the ERP system. Many changes in delivery plans occur, as shown by the MAPE profile and FAI values. However, the planners have no chance to affect this and customers rarely change the demand according to the case company's wishes. As a case in point, demand could be changed from 5000 products to 7000 products, within two to four weeks before shipping. Such a huge increase would mean that the production needs to be re-planned, and in many cases, it can lead to a backlog which in turn can lead to a lower service level. Besides risking late shipments, the backlogs affect other customers and the overall production performance. Another case is when demand is lowered e.g., from 5000 to 3000 pieces. This would also require a re-planning process, and this can lead to a production that is not fully utilized. The latter is however not as problematic for the current situation of the company. The planning process as it currently is leads to many problems for both the planners and the production. The current process mapping is illustrated in figure 4.2.

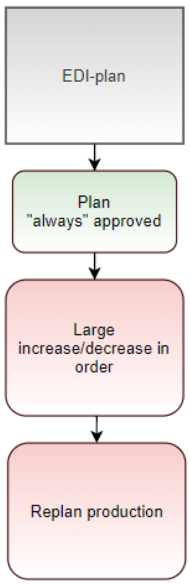

Figure 4.2: Old order handling process.

In this stage of the project, the case company had no agreements with its customer regarding freeze times in the delivery schedules. This means in theory that the customers are allowed to make changes in quantities and date the day before shipping day. However, the supplier was working on an agreement with its customers that would regulate this. The suggestion from the case company's side was to not allow any changes at all within the first four weeks, 10 percent change within week five to twelve, and 20 percent change within week 13 to 52. This can be seen in table 4.2.

Also, within the first four weeks, no change between days would be allowed. The chosen freeze times are compared to the current accuracy very narrow.

Table 4.2: The new freeze time requirements.

Time period	Allowed Change
0-4 weeks	0%
5-12 weeks	+/- 10%
13-52 weeks	+/- 20%

The suggested regulation of delivery plans is illustrated by a deviation model in figure 4.3, changes in delivery plans are allowed only within the red lines. The y-axis represents decreases and increases in the delivery plan and the x-axis represents the weeks before delivery. These time fences was used during the development and pilot tests of the new process.

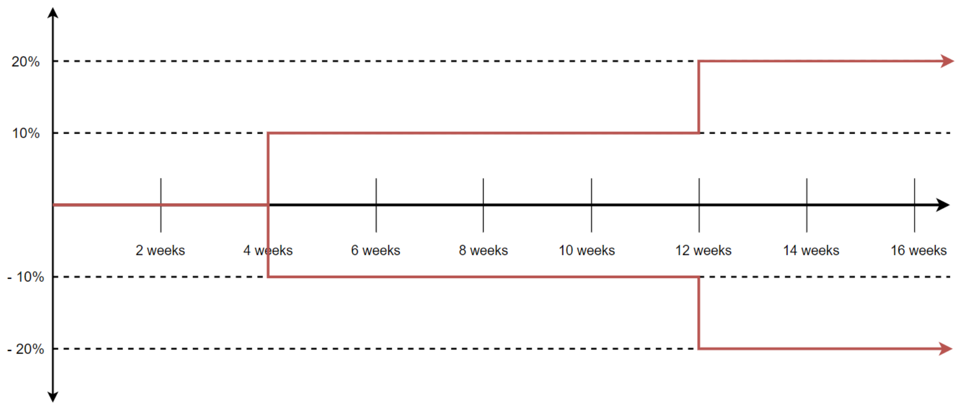

Figure 4.3: Deviation model which shows the allowed changes in delivery plans. The X-axis represents the weeks and the y-axis is the allowed changes in delivery plans in percentage.

4.3 The New Order Handling Process

To tackle the problem of high volatility and always changing orders, which in turn cause backlogs and unnecessary costs, a new order handling process around the new freeze times have been suggested and piloted. The pilot was run towards four customers, and several steps were added to the current/old order handling process.

The new suggested process was developed after analyzing the interviews and by getting input and feedback from the continuous meetings. The suggestion of the new process is: When an EDI is received there will be an automatic control by the ERP system. If the ERP system notices a change, the EDI will get stuck in the system, thereby will the delivery plan not be sent directly to the production. It is called "Status 25" when an EDI gets stuck and "Status 40" when a EDI is accepted.

When an EDI gets stuck, a planner will get notified and check the delivery plan. If the change is manageable the planner will be able to approve the change, if the change is not manageable, the planner will follow the new process of handling the deviance. Which is to send an email to the customer and advise them to restore the plan to previous quantities and dates. This mail has been standardized and is presented in the next section. The new order handling process map is shown in figure 4.4

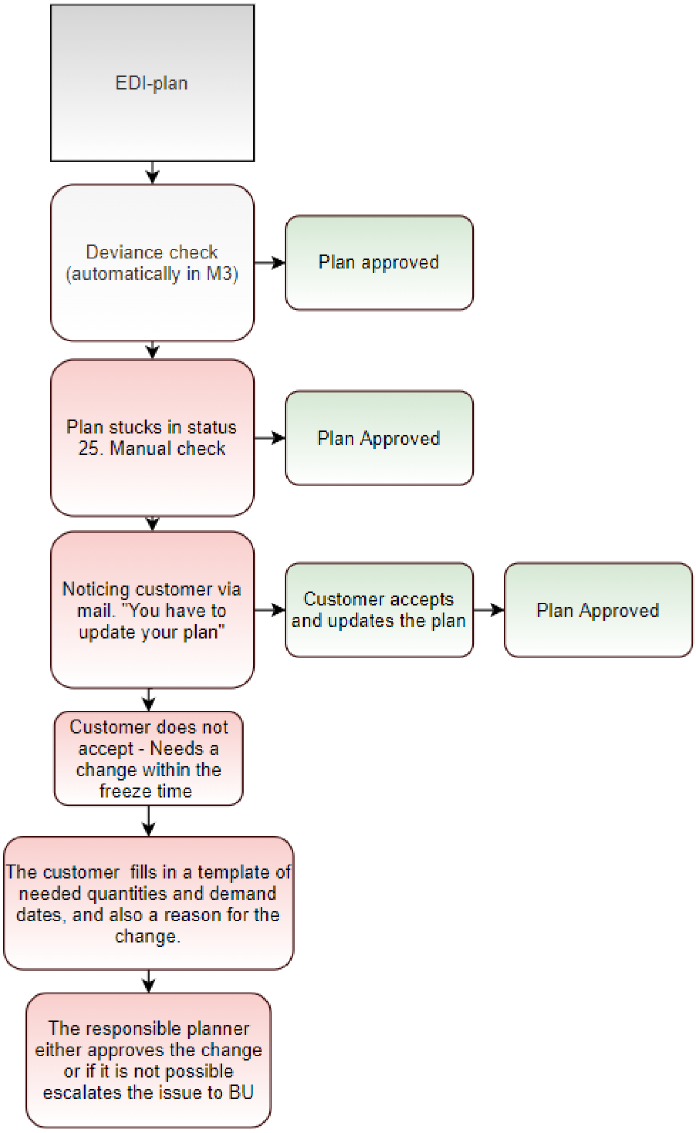

Figure 4.4: Process map for the suggested order handling process.

Delivery schedules are often automatically generated, which means that the customer is not always aware of the change. The case study showed that a standardized email is, in some cases, good enough for making the customer realize that they must restore the originally planned delivery schedule. If however, a customer needs to make an urgent change within the freeze time, they will need to send in a request A template has been arranged for this scenario.

4.4 Standardized Mails

Three suggestions of mails were put forward in order to support planners and to standardize how they approach the pilot customers. The proposed mails are displayed and described below.

4.4.1 Information Mail

To notify the four pilot customers of the new freeze time approach an information mail was created. The idea of this mail was to notify and inform the pilot customers regarding how the new process would affect them, and why this change is important for the case company. The information mail is presented in figure 4.5

Dear Customer,

Because of the current situation with increasing lead time from our suppliers we will, from CW12 and forward, start to reject EDI-plans that do not correspond with our own lead time requirements. These can be seen in the table below.

Time frame	Allowed change
0-4 weeks	0%
5-12 weeks	10%
13-52 weeks	20%

This means that every time a change in your delivery schedules is noticed, you will receive an email where we will ask you to restore your plan and move any needed changes to a later week that fits with the lead time requirements.

However, if there will be a need for urgent changes within the lead times that exceed the allowed amount, please fill in the attached deviation request template and send it back to your Veoneer planner.

To start with this will only concern the following part numbers:.......

Our aspiration is to get a better flow throughout the supply chain and production, which will lead to a more controlled planning environment.

Regards.

Figure 4.5: Information Mail to four pilot-costumers, regarding the new freeze time requirements. freeze time in the template refers to freeze periods.

4.4.2 Mail Template

To enable standardized communication towards the pilot customers a standard deviation mail template was created. The mail contains information regarding the EDI reference, the plant, the article number, when the change was received, which demand date the change is regarding, a figure showing the change, the amount changed in quantity, information regarding how they should restore the former plan, information about freeze time requirements, and what the customer should do if the change is urgent. An example of the template is displayed in figure 4.6.

Dear customer,

A change has been noticed in your latest delivery plan that doesn't meet our lead time requirements. This plan will be rejected. The change concerns:

EDI reference:	Reference
Plant/Unloading point:	Plant
Article number (our article number):	00000000000 (000000000A)
Change received:	2021-01-05
Demand date(s):	2021-01-11 & 2021-01-14

Plan received date / Demand date	2021-01-11	2021-01-14
2020-11-26	-	4824,000000
2020-12-01	-	4896,000000
2020-12-02	-	4896,000000
2020-12-03	-	4896,000000
2020-12-08	-	4896,000000
2020-12-09	-	4896,000000
2020-12-10	-	4968,000000
2020-12-15	-	4680,000000
2020-12-16	-	4752,000000
2020-12-17	-	4752,000000
2020-12-22	-	3744,000000
2020-12-23	-	3744,000000
2020-12-24	-	3744,000000
2021-01-05	2664,000000	3240,000000

Please restore the plan to previous quantities and date(s). If changes are needed, please make sure to match them with our lead time requirements.

Time frame	Allowed change
0-4 weeks	0%
5-12 weeks	10%
13-52 weeks	20%

However, if the change in the plan is urgent, please fill in the attached deviation request template and send it back to your planner.

Figure 4.6: Deviation mail template, which was sent to pilot-costumer who made changes within the freeze time requirement.

To create further understanding for customers snapshots from Qlik (a visualizing software) are used in the deviation mail template. The clip from Qlik shows when and how the change was made. Figure 4.6 displays a clip that shows how the customer changed the delivery plan. In this case, the customer added extra products six days before shipment. By sending this snap the customers will visually see the change, and in this case, see that this change in delivery plan is impossible to realize. The idea is to send a clear picture of the situation. This is one way of using the technical tool in the communication with the customer.

4.4.3 Deviation Request

If the customer needs to make an urgent change that is outside the freeze time requirements, they will have an opportunity to request a change in the delivery plan.

The customer must, however, fill in the "Deviation request template", where they are obligated to specify the part number, requested quantity, requested demand date, and an explanation regarding the reason for the change. The template is presented in figure 4.7. When the customer's request is received, it is assessed by a planner and there are three possible outcomes. It is either approved, declined, or approved with certain reservations, which are that the customer has to bear the extra expenses that the change would cause e.g costs of express deliveries.

Deviation request template	
Part number:	
Requested quantity:	
Requested demand date:	
Reason for change:	

Figure 4.7: Deviation request template, customers have to fill this template in order to make a change outside the freeze time requirements.

4.5 Results from the Pilot

At the time of writing the thesis and performing the pilot, there was a global semiconductor crisis that affected the whole automotive industry. Because of this crisis, the case company had lots of problems with material supply, and therefore decreases in demand were accepted during the pilot test, i.e. no actions were taken when decreased plans were received. However in the future, in a normal state, both increases and decreases will be rejected according to the new freeze time requirements. This had an impact on the results. Since the customer made larger decreases than normal the MAPE-profiles and FAI scores were negatively impacted by this and since the case company had their problems with material supply, the new process could not be fully used in these cases.

The pilot aimed to try out and improve the new order handling process. That means that every time a delivery plan from the pilot customer was stopped in status 25 the new process was applied and tried out. In total 25 delivery plans were deviating outside the freeze times during the five pilot weeks. This means that the new process was applied 25 times. It led to mixed results and varying outcomes. Often deviating plans were accepted manually due to decreases in demand which were preferable for the case company. Seven times the mail template was used to notify customers that they had increased their demand outside the requirements. Out of these seven times, five times the customer restored their plan and it could be approved. In two cases the customer said that they could not update the plan and neither did they send a deviation request. This meant the two last boxes in figure 4.4 was never reached. Because of problems with the deviation model that are described below, this plans got released into the system and the case company had to deliver according to these plans.

Figure 4.8 and 4.9 shows the spread between customers and in for which freeze time period the plan was stopped.

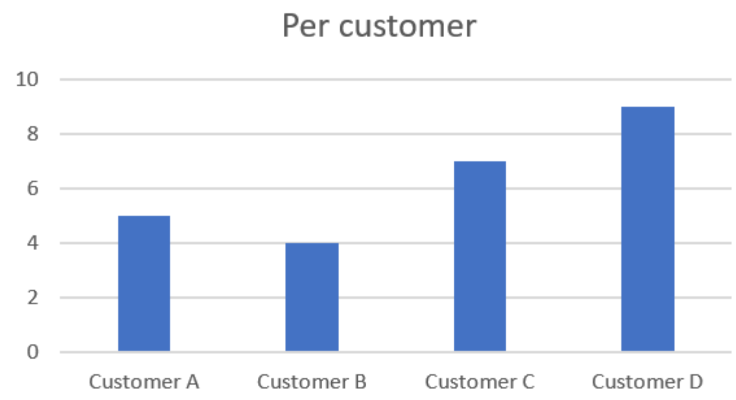

Figure 4.8: Plans stopped in status 25 for respective customer.

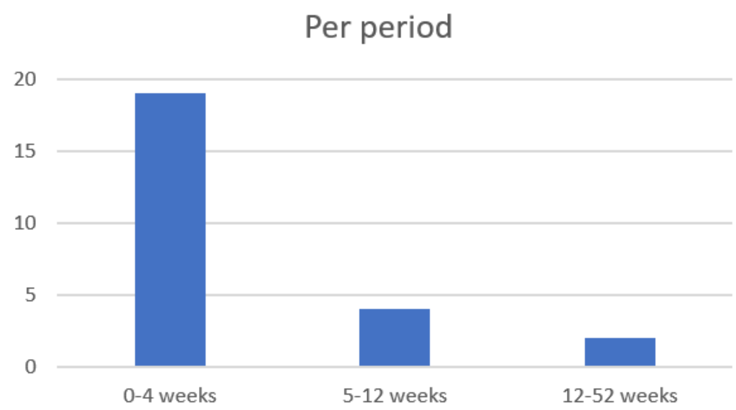

Figure 4.9: Plans stopped in status 25 per freeze time period.

From this, one can see that customer D had the most deviating plans and that the most common deviation was found in the first freeze time period, 0-4 weeks before delivery. It is also interesting to note that in the first two weeks of the pilot customer A and B had the most changes and many deviations mails were sent to them, according to the process. However, this changed during the latter part of the pilot and they had no deviating plans the last two weeks. Customer D on the other hand had an even spread of their nine deviating plans. Through email conversations with their material planner, it was found out that their delivery plans are solely based on their production plan which in turn only is frozen for the ten coming days. Everything after this is based on a forecast which in other words meant they could not change their plans according to the new freeze time requirements.

4.5.1 FAI, WTS and MAPE-profiles from the pilot weeks

Figure 4.10 shows the MAPE-profiles for the four different customers during the pilot weeks. The MAPE value for each week(2-10) is calculated and then an average of this is taken to map the profiles. So, for these profiles the values are just an average of five weeks, hence the noisy profiles. Because of this, it is hard to make fair comparisons with the MAPE profiles shown in figure 4.1.

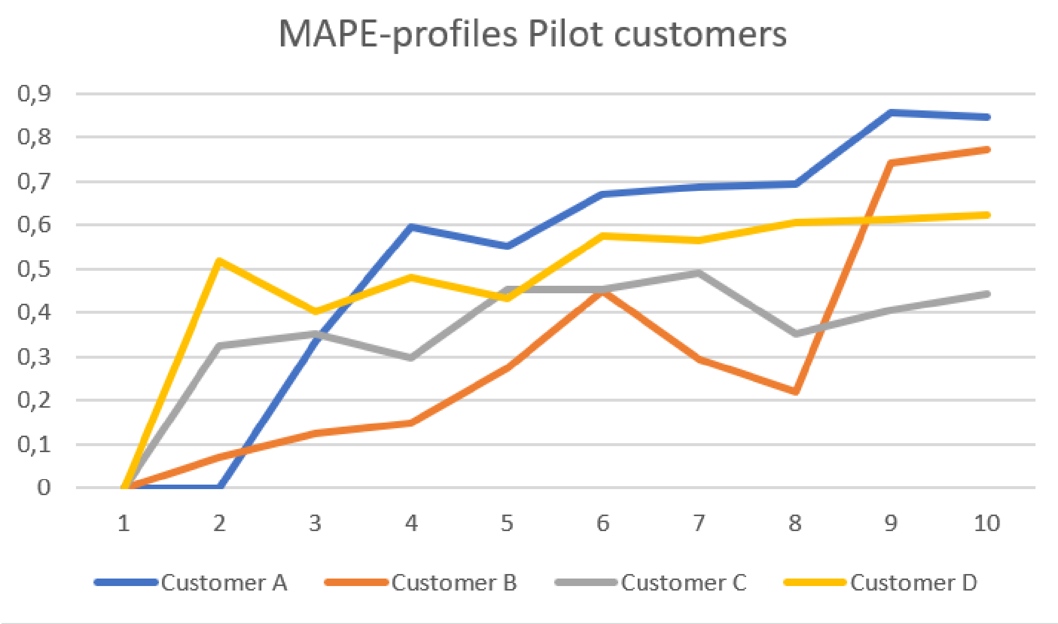

Figure 4.10: MAPE profiles for pilot customers during the pilot weeks, the X-axis represents the weeks and the y-axis is the percentual deviance.

In table 4.3 the FAI and WTS score for the pilot weeks are shown using setting 1 and 2 as earlier described. The scores are an average of five weeks. The scores are similar to the ones shown in table 4.1 and some cases even worse. Important to mention is that customer A shut down their production during weeks 1 and 2 of the pilot test and customer C and D shut down their productions during week 5 of the pilot. This harmed the FAI average and is visualized in figure 4.11.

Table 4.3: FAI and WTS score for the pilot customers during the pilot weeks.

Customer	FAI setting 1	FAI setting 2	WTS setting 1	WTS setting 2
A	66,4%	70,8%	0,23	0,45
B	87,0%	72,0%	-0,38	-0,04
C	61,2%	60,2%	0,1	-0,07
D	48,4%	46,8%	0,62	0,33

In figure 4.11 the FAI score with setting 1 for each week of the pilot can be seen. If ignoring the shutdowns in week 5 of the pilot one can identify positive trends for customer A, B, and C where both customers A and B had a score 100% the last week of the pilot. For customer D no sign of improvement can be seen.

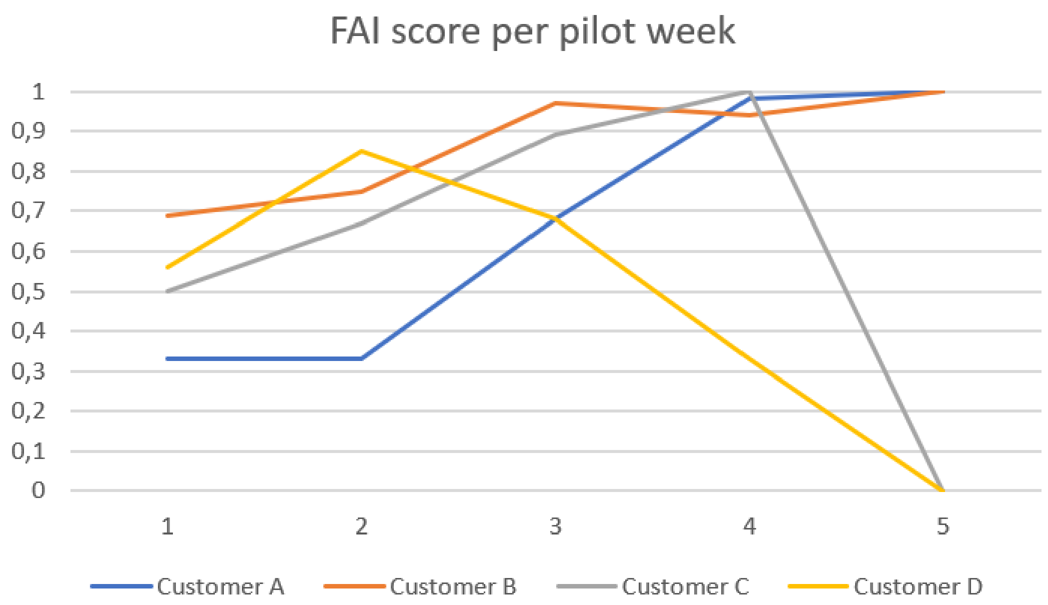

Figure 4.11: FAI score for each pilot week using setting 1, the X-axis represents the weeks and the y-axis is the percentual deviance.

4.5.2 Customer agreed to four week freeze time

A result of the pilot was that the pilot OEM with its four plants/customers partly agreed on the new freeze time requirements. This was enabled three weeks into the pilot after a meeting was arranged between the case company and the customer. The meeting included both planners, managers, and people from the legal departments. The meeting enabled an understanding from the customer. During the meeting, the case company had a chance to explain and show the customer how much deviance there currently are in the delivery plans and also that in urgent cases deviations can be accepted if they are manageable for the case company. With this mutual understanding, the customer agreed to 0% change in the delivery plans within the first four weeks. The two later periods were left for further discussions.

4.5.3 Problems with the ERP deviation model

During the pilot, several problems regarding the ERP system and its deviation model were detected. One of the problems was considering stopping deviating plans. When an EDI contains a change that is not allowed it should get stuck in "status 25". However, when an EDI is stuck in "status 25" and the customer sends a new EDI, with the same not accepted demands, the system will automatically release the EDI to the system and put it in "status 40", even though the change is not acceptable. Practically this meant that it was not possible to reject the EDI plans, the only way of keeping the old plans was if the customer willingly changed back to the old, not deviating, demands.

Another problem that was found with the model was that it did not stop plans that contained changes within the different lead periods. I.e. the model only stopped a plan to status 25 if the total quantity in one of the three different periods deviated. This meant that the pilot customers could move demand within the periods without it being noticed. This created a problem when customers, for example, moved a demand from week four to week two and this is also against the freeze time requirements.

Finally, if the case company had a backlog or a delivery was late, the deviation model calculated this demand as an increase, and the plan was automatically put in status 25. All of these mentioned problems were however solved with the help of technical consultants, but most likely these defects had an impact on the pilot results.

4.6 Workshop Summary

Notes from the workshop are found in Appendix B. The workshop was held in Swedish, notes were taken in Swedish and then translated into English. The idea behind this workshop was to start discussions about how the new order handling process can be improved and how it should be implemented for all customers.

The participants were pleased with the results from the pilot and the process as it was performed. The case company will continue to use the FAI application to compare and analyze variations. There was a discussion regarding how the process should be implemented further, and how many and which customers to include at a time. It was agreed that around 4 customers should be included at a time. It was concluded that meetings are necessary to anchor the change at the customers, instead of just sending an information mail. The case company may have to utilize different freeze times towards different customers depending on the customers' internal lead times.

4.7 Implementation Kit

After evaluating results from the pilot and what was learned from the workshop (Appendix B - Workshop notes) it was distinguished that the information mail was in some cases, not a sufficient method of making the customer understand what was being tested. Thereby it was shown that meetings with the customers will be needed to anchor the change. To continue to implement the new freeze time requirements and the new order handling process with new customers, a start-up meeting and an information mail will be required, in the initial part.

The case company planners must learn how to use the FAI tool. Both to make a snip from the delivery plan change, and they should know how to use the FAI tool to evaluate how the customers are meeting the freeze requirements, To see if there have been any improvements.

The pilot showed that extra work will occur for planners when implementing the new process. Both to make the customers understand and also to handle deviations. This makes it clear that the case company has to introduce some customers at a time. Trying to implement the new process throughout all customers and products would create too much work for planners.

After the workshop was performed were certain steps suggested to implement the new process and freeze times. The list below is a proposition of how the new freeze time can be implemented step by step.

1. Decide how many customers/products that should be included in the new freeze time requirements.
2. Decide which customers/products that should be included in the new freeze time requirements.
3. Arrange meetings to ensure that the customers understands what this means for them.
4. Send an email to customers planners in order to ensure that they are informed regarding the change.
5. Utilize the new order handling process that was used in the pilot.
6. Use the FAI-tool to ensure that the customers has improved accuracy in plans.
7. When the customers has achieved an acceptable accuracy in delivery plans, repeat implementation steps with new customers.

4.8 Possible Future Process

After the pilot and discussion with the case company, it was clear that there is room for even more improvements in the order handling process. To make further improvements is, however, a higher level of automation in the ERP system required. In the new process, the ERP system notices changes and puts them to "status 25" if the change is outside the freeze period. Nevertheless, the system itself does not act on these changes. A possible future scenario could be that the system sends a deviation mail automatically with the respective information, to the respective customer. Thereby would the process of handling volatility become more automatized. Figure 4.12 illustrates the possible future scenario.

To improve the process even more the customers must change the parameters in their MRP system to not make any changes outside the requirements in the frozen time zones. If they could do that it would automatically mean that no plans would get stuck in status 25 and the problem of MRP-nervousness would disappear for the case company. Since the pilot OEM now has agreed to a frozen zone with no changes in the first four weeks, this improvement should not be impossible. However, a potential drawback with this improvement is that the customers might need bigger buffers to be able to handle variations in their production. But as long as they have agreed to the freeze time requirements this should not affect the supplier.

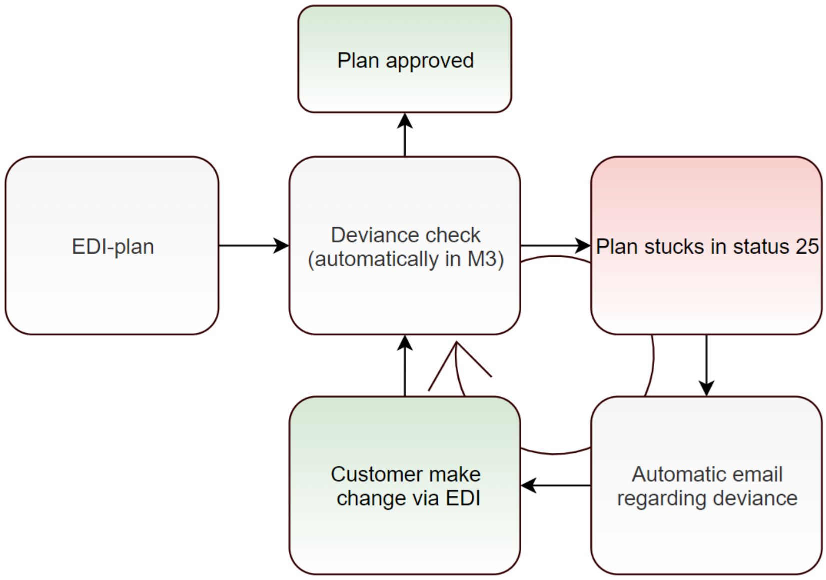

Figure 4.12: Possible future scenario. The figure shows an almost ideal process, which is automatized.

5
Discussion

In this part of the report are the results discussed and how they connect to the research questions. The results are connected to interviews, workshop and the presented theoretical frame. Why certain results were achieved is discussed critically. The contribution and future recommendations based on the results are also presented in this part of the report.

5.1 Research Question 1

"how much volatility is there currently in the delivery plans?"

To answer the first research question a quantitative analysis was made on the old delivery plans from the four pilot customers. MAPE-profiles were plotted and the FAI and WTS score was calculated using two different settings. The results from this are presented in the results chapter. When comparing the results from 4.1 and the classification presented by VDA (2008) it is obvious that the plans are very volatile and all of the customers scored "poor", both when using setting 1 and setting 2. Since the four customers come from the same OEM, other OEMs were shortly investigated and it was found that they averaged an FAI score of 75% which is poor but slightly better than the OEM that the pilot was run against.

Furthermore, the MAPE-profiles in 4.1 showed that the plans are volatile, already from two weeks before the delivery date and that they generally get less and less accurate the further away from the delivery date they are received. Finally, if looking at the WTS scores in table 4.1 it is clearly shown that the four pilot customers tend to overestimate their demand in the delivery plans.

This analysis validated the assumptions made by the case company. I.e. that delivery plans are very volatile and especially the chosen OEM. This gave a clear sign that improvements had to be made and that the chosen customers were suitable to try the suggested process on.

5.2 Research Question 2

"How should the new planning- and communication process be designed? And how can it be implemented?"

The suggested new process in figure 4.4 showed to work quite well during the pilot test. Still, some problems were found, mainly with the implementation of the process and the deviation model that the ERP system uses to detect deviating plans. This along with other interesting notes is discussed in the following section.

5.2.1 New Process and Implementation

One aim with the pilot was to validate the new suggested process that is visualized in figure 4.4. As presented in the results during the five pilot weeks, were 25 EDI-plans outside the freeze periods received and put in status 25. The manual check of the status 25-plans was found to be necessary since the case company wanted to accept decreases in demand. When increases were received a mail was sent to the customer according to figure 4.6. This was done seven times and five of the times did the customer restore their plans to the old demands. This shows that the customer understood the mail template and that 71% of the time it reached its target. In the other cases, when the customer did not change back their plans the customer was meant to send a deviation request, according to the new process. However, this was not the case and maybe this step in the process needs to be revised. On the other hand, both problems with the ERP deviation model and no mutual agreement were reached at this time. Now, these problems have been fixed, and it is now possible for the case company to actually reject plans. If they start to reject plans going forward, the customer will need to fill in the deviation request, in order to get their needed quantities on time.

With this said, it is also important to understand that not all the planners at the case company works in the same way, and thus the suggested process may not be optimal for everyone. Planners will find their own way of handling variations and communicating with the customers, but the pilot showed that the new process has the potential to be successful.

5.2.2 Decreases and Increases in Delivery Plans

An important thing that was noticed during the pilot test of the new process with the new requirements is that not all changes in delivery plans are the same, or at least does not give the same consequences. It is important to make a difference of decreases and increases and what is worse is dependent on the situation at the supplier and the market as a whole.

As earlier mentioned, there was a global semiconductor crisis that affected the whole automotive industry during the pilot test. This meant that both the case company and its customers had problems with material supply. This meant, in this cases that short-term decreases were often a positive thing since it bought them time to catch up with both production and material supply. However, at the same time last year at the beginning of the covid-19 outbreak, there was a very sudden drop in demand from all customers. This meant that all of a sudden they had a large overcapacity in the production and they had to send personnel home (Hansen & Sveide, 2020).

In situations like this, short-term increases in demand are welcome.

What can be learned from this is that when working with freeze time requirements like in this case, it is important to distinguish the effects from increases and decreases, and that is why it is important to have a manual check of each EDI plan that is stopped by the ERP system, just as suggested in the new process. When doing the manual check, the planner should have enough knowledge to understand if the plan can be accepted or not. In an ideal situation, with normal capacity, no backlog, and no material shortages you want no variations in the delivery plans. But in situations like the two examples above, you want to be able to accept short-term increases or decreases depending on the situation to improve the flow of the supply chain.

5.2.3 Communication with customers

It was noticed early on in the project that clear communication with customers is important when trying to make changes and implement new processes. At the start of the pilot, all pilot customers were informed about the new freeze time requirements via an information mail, however, this seemed not to be the best way of informing the customers. The information mail aimed to make the customers understand the freeze times and that they immediately would start to send their plans according to the new freeze times. This was not the outcome. There was close to no response from the customers on the information mail and they kept sending deviating delivery plans outside the requirements. It was obvious that the new process and freeze times were not anchored with the customers.

As described in the results was a meeting arranged to further anchor the new freeze times and to create an understanding between supplier and customer. It is important to build trust and a good culture between the involved parts to increase the performance in the supply chain (Barratt & Oke, 2007) and this was shown in this case. The case company had the chance to explain their internal process and why they wanted to implement the new freeze times and the customer had the chance to raise their concerns on how potential problems to the new freeze time requirements and how these would be solved. The meeting resulted in an agreement that can be used to further decrease the variations in the delivery schedules and this will, in turn, reduce the time that planners need to spend on EDI planning.

5.2.4 Collaborative Planning With the New Process

If comparing the theory on collaborative planning with the new order handling process one can see that there are many similarities. With the old process, shown in figure 4.2, the negotiation and exception handling step from the cycle (Kilger & Reuter, 2005) was not included in the operative order planning process. With the new process, the case company has started to reject plans outside the frozen time zones, but they still give the customer a chance for negotiation, and exceptions can be made if customers use the deviation request template. With the old process, the customers just told the case company how many parts they needed and the case company had to deliver accordingly. Now both sides have a chance to commit to the plans and hopefully, both sides of the supply chain can increase performance, competitiveness and reduce costs (Dudek, 2009).

5.2.5 ERP deviation model

As shown in the results, quite a few problems were found with the deviation model in the ERP system that automatically checks if new delivery plans differ from the last received plan. These problems were however solved during the pilot and the model has successively gotten better at recognizing deviating plans. However, there are still some problems with the model. For example, the model only compares new plans to old plans on a percentage basis and not on quantities. This means that if a customer changes a demand from five units to ten units the plan will be stopped, even though it is often not a dangerous change for the case company. This creates extra, unnecessary, work for the planners. But still, the freeze time requirements that are communicated to the customers are in percentages which means that the deviation model should be based on the same thing. So maybe the requirements should not be in percentage but quantity instead.

Also, the model has problems with catching nervous plans, as it only catches changes between weeks within the first four weeks. I.e. it can not see changes between days if it is in the same week and after four weeks the model can only see changes if quantities changes. This means that even if the model is used to its full potential, FAI scores can still be bad.

5.3 Research Question 3

"How can the new process and freeze times affect other processes within production and supply chain?"

It is clear that the new suggested order handling process and the new frozen time zones will affect other processes, both at the case company and their customers and suppliers. In this section will potential scenarios and how the new process can affect other processes be discussed. Also, the results from the pilot will work as input for this discussion.

5.3.1 Effects of Pilot Results

The results from the pilot test of the new process and frozen time zones gave mixed results and it is important to note that the pilot only ran for five weeks and it is hard to draw any proven conclusions. However, what could be seen, as explained in the results chapter, is that three out of the four customers had a rising trend in their forecast accuracy when looking two to four weeks before the demand.

5.3.1.1 MAPE, FAI and WTS

If comparing the quantitative data that was gathered before and after the pilot it can be seen that it points in different directions. From the MAPE-profiles in figure 4.1 and figure 4.10 it is hard to draw any conclusions or comparisons. The reason for this is that the data that was used to draw the MAPE profiles before the pilot consisted of delivery plans from approximately 40 weeks while the data for the pilot-MAPE-profiles only consisted of delivery plans from five weeks. The profiles show average values from two to ten weeks before the demand date and since the pilot only was for five weeks the data points from six to ten weeks before the demand date was not affected by the new way of working.

However, if trying to do some kind of comparison it can be seen that customer B had more accurate plans overall after the pilot, especially in the first two weeks. Customer D on the other hand had less accurate plans after the pilot. The reason for this is that first of all they did not respond very well to the new freeze time requirements and they also had to shut down their production during the last week of the pilot which meant that all the demand for this week was removed which in turn resulted in 0% forecast accuracy.

If instead of looking at the FAI scores in table 4.1 and table 4.3 similar results can be seen. If looking at the tables, that show the average FAI score during the two different periods(before and after the pilot), it is hard to see any signs of improvement. This is also closely related to the shutdowns and because of this, it was interesting to look at the FAI score for each week(in figure 4.11) to see how it developed during the pilot weeks. From this figure, it is possible to see that the FAI scores tended to be better and better during the pilot. This may be just a coincidence but after studying similar graphs in a longer time perspective no similar trends were found. However, it will be important for the case company to keep monitoring the FAI scores for each to see if the improvement continues. If not more actions are needed.

If looking at the WTS score in the same tables it could be seen that in general, the customers tend to overestimate their demand, since most of the scores are positive. Also, the over/underestimations tend to be larger when using setting 2 which is reasonable since the plans tend to be more accurate closer to the delivery date. If looking at the scores after the pilot more in detail, no reasonable conclusions can be made. For example, for customer B the WTS score with setting 1 was -0,38 and with setting 2 -0,04. The setting 1 score shows that they mainly underestimated and setting 2 shows that the plans contained an almost equal amount of under- and overestimations. Customer D had bigger estimations, 0,62, when using setting 1 than when using setting 2, 0,33. This indicates that also here the data is noisy and to get better results the pilot should have been conducted for a longer time. All in all, it is hard to draw any clear conclusions from the pilot because of shutdowns and a small data set. However, signs of improvement could be seen when analyzing different weeks with each other.

5.3.2 How the New Process Affect Other Processes

The implementation of the new process and freeze time requirements has and will affect other processes, both internally at the case company, and externally at their suppliers and customers. If speculating, it is possible to think about the outcome of the new way of working as two different scenarios. *Scenario 1:* Customers adapt to the new freeze times and start to send delivery plans that are within the requirements which means less administrative work for the planners than before, a better planning environment, and cost savings. *Scenario 2:* Customers do not adapt to the new requirements and keep on sending volatile delivery plans which would mean more administrative work for the planners than before, to make sure that deviating plans do not get accepted and that deliveries are made correctly. However, they would probably still save costs in form of fewer premium freights and a smoother production flow.

5.3.3 Planning

Both according to the interviews made in this project and the interviews made last year at the case company reveal that a lot of time is spent on handling variations in delivery plans (Hansen & Sveide, 2020). Since the EDIs, i.e. the delivery plans work as input for planning at both short and mid-term as well as producing the internal forecast (i.e. S&OP, MPS and execution and control), variations cause a lot of problems in the planning process at the case company. Both for the operative and strategic planners. When the delivery plans change, both the production plan, the material plan, and forecast need to change accordingly and this means that a lot of time needs to be spent on re-planning. The time for handling EDIs could be reduced if scenario 1 is reached. With less volatile plans, within the requirements, time could be spared and used for other tasks such as improvement work (Case Company Planner 1, 2021; Case Company Planner 2, 2021; Capacity Manager, 2021).

If on the other hand scenario 2 would occur, there is a risk that the time for handling EDIs would be larger since the new suggested process contains more steps than the old way of working. If this would be the case it is important to as soon as possible reach the possible future process that is suggested in the results, which is a more automated process. However, this requires lots of technical work with ERP-system and thus also big investments. But you could also argue that since the capacity management of the OEM that the pilot test was run against now has agreed to the new freeze times and that they are anchored in the agreement, the plans should not be able to deviate. This also means that it is important to reach this agreement with the other OEMs as well, otherwise, scenario 2 is likely to be reached.

Furthermore, with lower or no variations in the customer demand on a shorter horizon; fewer buffers and inventories would be needed since there would be no risk of sudden demand increases or decreases, which in turn would save costs (Capacity Manager, 2021). When sudden increases happen companies need to have inventories both for raw material but also for finished goods, to be able to deliver according to the increase and at the same time keep the level of finished goods that is desired.

Also, costs would be saved for transports. When sudden increases are received, premium freights often need to be used to get raw material in time, and premium freights needs to be used for the finished goods towards the customer if the regular shipment is missed (Case Company Planner 1, 2021; Case Company Planner 2, 2021). Lower or close to no variations would mean that the need for premium freights would be significantly reduced.

5.3.4 Production

The production processes at the case company are also affected by the variations in the delivery schedules. From interviews conducted both this year and last year(Hansen & Sveide, 2020), it was found that one of the major problems that are caused by volatile demand is the planning of what shifts to run. As Hansen and Sveide (2020) discusses there are three different shift levels with different output capacities at the case company. When the wanted production output is balancing between shifts, it is very sensitive to variations. Sudden increases then mean that extra man-hours are needed and adding extra personnel with short notice is a big cost. Decreases can also create problems in form of that planned personnel is not needed and needs to be sent home. This also creates unnecessary costs (Capacity Manager, 2021). Both of these problems could be mitigated if sudden variations would disappear.

Moreover, production performance is also affected by large variations in demand. Figure 3.4 shows an overall image of the production flow at the case company. It can be seen that it is a quite complex flow that also contains an extra buffer between component manufacturing and final assembly. If customer demand is volatile and uncertain it leads to an uncertain production plan. An uncertain production plan leads to smaller batches and more setups in the production, which in the end will decrease the up-time of the production lines and lower the yield. The hope is that the new process and freeze times will make the customer demand more stable and in that way, the production plans can be more stable which in the end will lower the effects of the above-described issues.

5.3.5 Customers and Suppliers

One of the reasons why the case company wanted to implement the new freeze time requirements was that they have quite tough requirements from their suppliers (Capacity Manager, 2021). As already explained this problem has been solved by using premium freights for the raw material when they received increases from their customers. With the new requirements on the customers, will the case company's EDI plans that they send to their suppliers be more accurate. However, since the suppliers already had tough requirements on the case company, will their processes not be largely affected.

If instead of looking at the customers, it is more obvious that they will be affected by the new freeze times. After the first information mail was sent and the pilot was started, the plans kept on deviating which means that the customers could not adapt overnight to the new freeze times. However, as earlier mentioned three out of the four customers showed a rising trend during the pilot and it seems like they started to follow the new freeze times. The fourth customer clearly stated that their delivery plans are based on their production plan which is only frozen for ten days. Everything after these ten days is forecast. Their plans kept varying during the pilot and it seems like they could not adapt to the freeze times.

Since the OEM during the pilot accepted the new requirements, the customer that said that they could not follow the freeze times has to make changes in their planning processes. What is likely to be needed is a bigger stock of the products that the case company supplies. If speculating, one of the reasons for their constantly changing delivery plans is that their production plan change just as much, and if they cannot change their delivery plans they need to increase their safety stock (Blackburn et al., 1985). However, this comes with a cost and that is likely the reason why it is a struggle to implement freeze times like in this case. It is also important to mention that with more accurate plans the case company will be able to more securely deliver to their customer and risks for stops will be smaller. I.e. in one way, the new frozen zones will also benefit the customers. Also, with the new process the customer has a chance to make necessary changes but outside the requirements by filling out the deviation request template. This can be seen as the negotiation and exception handling step in a collaborative planning cycle which in total can increase competitiveness, performance and reduce costs (Dudek, 2009).

5.3.6 Lot Sizing

Blackburn et al. (1985) are saying that one of the causes for MRP-nervousness, i.e. volatile delivery schedules, is lot-sizing decisions. One thing that was noticed during the pilot test was that the customers with set lot sizes tended to make more changes in their delivery plans outside the new requirements than the other customers, who do not have set lots. One potential reason for this is that whenever the customers with set lot sizes had to make changes for whatever reason these changes are often at least 50% of the original quantity, depending on the customer and the size of the multiple. For example, if a customer with a set multiple of 500 units from the beginning shows a demand of exactly 500 units for a given date and then they need to increase the demand with 50 units, then the increase will be 500 units, leading to a forecast error of 100%, i.e. an FAI score of 0%. If comparing this with a customer that does not use set multiples, their forecast error would be only 10% in the example above since they would only need to increase the demand with exactly 50 units.

There are both pros and cons with using lot sizing. In a perfect world with no fluctuating demand, it would only be beneficial to use multiples since they are calculated to save as much cost as possible by using the sweet spot between ordering cost and inventory cost (Jonsson & Mattsson, 2009). However, if it could be proven that set lot sizes caused bigger forecast errors and thus creating more volatile delivery schedules which in turn creates costs for the supplier (Dai et al., 2017) then maybe that would be a parameter to consider when setting the lot sizes. But it is also important to consider that the cost for fluctuating demand is mostly affecting the supplier and not the customer.

5.4 Recommendations for the Case Company

As explained the pilot test of the new process gave promising results with rising trends in forecast accuracy and with further work with the process it can give even better results. Planners at the case company will likely find their way of working with the new frozen time zones but still, the suggestion can work as a frame for the planners and can also visualize the workflow for new employees.

It is of high importance to automatize the process as soon as possible. As discussed, with ever deviating delivery plans the workload for the planners will be very high and if the process, or at least parts of it, could be automatized it will give the same results but at a lower cost. Of course, investments are needed for this and no calculations have been made on this part, but in the long run, it will be beneficial.

Regarding the implementation of the new process and frozen time zones, it was found that the information email was not sufficient for anchoring the process. The recommendation is to instead have a meeting with the customer that is concerned about the implementation. In this way, the new way of working will be anchored in a better way and potential problems can be discussed and solved.

Also, it is important for the case company to continuously do FAI measurements of the customers to see signs of improvement or if further actions are needed. Setting 1 that was used to monitor the accuracy of two to four weeks before delivery shows how good the customer in the first period of the frozen zones. This FAI value should be 100% if the customer is following the requirements and if this is monitored weekly it is easy to see how well the customers meet the first period of but for week 5-12 the score be at least 90% and for week 13-52 the score should be at least 80%.

6
Conclusion

After analyzing old delivery plans it is possible to conclude that there is currently high volatility and that many delivery plans are changed freely. The high variation is shown in the MAPE profile and the FAI values, (figure 4.1 and table 4.1) and they show that the further away from the delivery the bigger are the changes and higher are the imbalance. All plans would be considered poor compared to VDA (2008) FAI performance classification.

The condition with ever-changing delivery plans creates a hard-to-handle situation for the planners at the company, high vitality has proven in other cases to create a tough planning and forecasting environment (Syntetos et al., 2016) (Abolghasemi et al., 2019). To get control of the planning work the variations in the delivery plan have to be reduced. A hard-to-handle planning environment creates further disturbances in the internal information and material flow. Which further leads to unnecessary expenses. In order to lower these variations and get more control of the planning environment the suggestion from the case company was to implement freeze times towards their customers and with this create and implement a new internal order handling process.

To conclude how to design and how to implement processes, it was shown that easily interpreted processes and small changes make it easy to implement new processes. To improve the process even more it could be more automated to save time for the planners, but it is also important to manually check all deviations to see if they are acceptable or not. In special situations, increases or decreases can be beneficial for the supplier. It was however noticed that when making changes in freeze times and demanding customers to rethink deviations, it is important to arrange meetings and agreements with customers. Contracts regarding frozen time zones are necessary to implement the new process for all customers.

It is hard to determine and evaluate the result of the pilot and compare how it affected other processes, both due to the short time, and due to the new process was tested on only four customers. The time limitation prevented that more measurements could be taken and the sample size was probably too small to create a big enough difference. Results from the pilot, however, showed a tendency that the costumers included in the pilot did reduce the number of changes, and most importantly agreed on the first period of the new frozen time zones (0 percent changes 1-4 week).

If more costumers will agree on the change, it will affect other processes as well.

Because it should reduce the deviance in delivery plans. High volatility makes decision making and planning hard (Abolghasemi et al., 2019) and as stated by Dai et al. (2017) and Wang et al. (2014), high volatility can be connected to, for example, bad precision in performance, extra expenses, imbalance in inventory, and quality issues. Thereby it is possible to conclude that, if more customers will be included and agree on the freeze times, less volatility will occur, and thereby other processes will improve. This was further validated by people from the case company.

However, after evaluating the pilot, no real connections can be made between other processes being improved by the new freeze time, due to the time limitations of the project. If the case company continues to implement the new process towards more customers, they will be able to get measurable results. However, if assuming less volatility in delivery plans, conclusions can be drawn with help of literature that indicates that both planning and production processes will benefit from the new process.

6.1 Generalization and Sustainability

The problem with high volatility in delivery plans is a general within the automotive industry, and the accomplished result in this project can be generalized and used in other companies. The implemented process and freeze periods can be applied in other supply companies like the case company, and other suppliers both up and downstream in the supply chain. The process and freeze times may have to be adapted to match different requirements. Freeze times that were used in this project may not be perfect in every company's situation. But implementing freeze times would lower variations in other companies as well, and Thereby getting more control of the planning environment and reducing costs. It was clear in the project that communication and collaboration in the supply chain are important. It is recommended to utilize a collaborative approach when doing a freeze time implementation.

It is possible to conclude that if the case company reduces volatility in their delivery plans they will improve their overall sustainability. One big part of economical sustainability is not wasting money. As explained prior, is money saved when reducing volatility in delivery schedules. More ecological sustainability would be achieved by reducing co2 emissions which will happen when e.g the amount of premium freights are lowered. More control of the planning environment would mean that it would be easier to plan work hours for staff. This would enable the workers to plan their lives and ensure that they have work, and thereby increasing the social aspect of sustainability. The results regarding sustainability are generalisable towards other companies within the automotive industry.

6.2 Limitations

The project has overall been running smoothly, but there have however been some limitations that may have affected the outcome of the results negatively. The first limitation was the time aspect. If more time had been given, more time could have been used to run the pilot test. This could have given more reliable data and a more precise result. The pandemic disabled the opportunity to meet staff from the case company face to face this also could have affected the project's result negatively. The third and final big limitation was the semiconductor crisis which created disturbances in the data.

6.3 Further Research Suggestions

During this project, several areas have been found that need further investigation. Much connected to the new frozen time zones, but also on what is the best way to monitor variations in delivery plans and how to communicate between customers and suppliers when implementing new ways of working.

It has been clear that the new frozen time zones will benefit the case company in several different areas. However, it is more unclear how the implementation affects other parts of the supply chain. Studies could be made on the OEM and see how their material supply and production will react to the new freeze times and it would be interesting to see how the total cost for the whole supply chain is affected by the implementation. I.e. how inventories changes, how different production units are affected, how often premium freights needs to be used etc.

It would also be interesting to run a similar pilot but for a longer period. That would give more data and more accurate analysis could be made to be able to see how the accuracy of the delivery plans changes. In this project, a rising trend was found, but if doing something similar for example a year the conclusions would be more accurate and further improvements to the new process could be found.

Finally, it seems to be a need for a common way of keeping track of delivery plans and their variations. In this project FAI and WTS has been used but as discussed the FAI and WTS indexes have many drawbacks and it would be interesting to investigate what is the best way to monitor delivery plans. Whatever values are used, they have to be easy to understand for both customers and suppliers and a common platform for both parts to use would be beneficial for the cooperation.

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A

Appendix A - Questionnaires and Answers

The interviews were performed in Swedish, transcribed in Swedish then translated to English. The interviews where all approximately 20 minuets.

A.1 Planners

Questions for planners:

1. Can you describe your work process, and how you work with EDI:s?
2. How often are you in contact with your customers?
3. Have you ever declined a customer order/delivery plan?
4. How do you handle big variations and changes in delivery plans?
5. How much of you time in you daily work consists of handling EDIs and changes in EDIs?
6. How do you think the case company is impacted by big changes and variations in delivery plans?

A.1.1 Interview Answers - Planner 1

1. First the EDI comes in then you approve the plan. We do the actual production planning part in Compass (A program). We include the EDI needs in our short-term planning file, where we enter all EDIs for each product group. Then we enter the available time and OEE for each line. Then we plan the number per product, against how many we want, this is done in the short term planning file. Then we put the total need into Compass which helps us and plans automatically. From Compass, production orders are then transferred to the ERP system.

2. It can vary of course, as for example customer X is a fairly stable customer, then I do not come in contact with as often. Except when something big changes. Then I hear from me. This is what we have always done to that customer. But towards other customers where more changes take place, more contact is required. The majority of communication takes place via email.

3. It varies from customer to customer, but not very often. It is more common for me to refuse low-volume products, because we do not have material in stock

and cannot produce the wanted product in the near future. For products with a larger volume, you can often accept changes in the near future, but this can affect the possibility of delivering to other customers.

4. We have not denied large customers, for example when customer Y makes an increase we will email them and say that we have problems fulfilling the specific order, but then they often answer by saying that EDI is what it is and it is up to us to for fill it even though it may take time, and resulting in backlogs.

5. It is difficult to answer, the handling of EDI depends on how many customers you have, I have many small customers. Small customers means little time per EDI as it usually goes straight to approved. I would say that I spend about 1-2 hours a day on handling EDIs. What takes the most time is to understand variations in EDI. There is different handling that needs to be done some days and it can take more time while I only spend about 0.5h on EDIs other days. Some customers send EDI every day and some customers sends EDIs once a week, so it varies a lot. But on average 1-2 hours a day.

6. When a big change in an EDI is made, there is a lot of time needed for re-planning, especially when we plan between products. You always try to coordinate the production between different products. Major changes also affect pre-assembly (SMT) and the amount of material needed. There are many extra processes that start when there is a change, especially changes where there is a delivery in the near future. Increases negatively affect the entire flow and can lead to backlogs. Other products that would otherwise have been on time can also risk being backlogged. Sometimes we need to send express deliveries so that we can handle deadlines and sometimes we have to order express delivery from our suppliers so that we receive material on time. It affects material both in and out of the production, it lead to vicious circles.

A.1.2 Interview Answers - Planner 2

1. Well, since most of the customers are sending EDIs pretty much everyday I daily go through all customers and their new EDIs to see if there has been any changes in demand or if there are any other problems with the EDIs. Then the EDIs work as an input for both the daily production plan but also for the short term production plan that are made every other week.

2. It depends on the general delivery situation, if we have a big finished goods stock or a backlog for example. In backlog situations there are more communications with customers and sometimes you can almost spend all day emailing back and forth with customers. But when the situation is better and everything goes with regular transports almost a whole week can go by without any communication with the customers.

3. I don't know if you can say declined but sometimes when a customer has made

a big short term increase I've told them that we can't deliver according to that plan. But they never changes the demand, they just tell us to deliver as fast as possible and that we can't stop their production.

4. There is a number of things you have to do when big changes are received. First of all you have to understand how big of a changes it actually is and then you have to investigate how it affects your current production plan. Often it has to be revised to be able to deliver the correct amount. Also you have to check with the material planner to make sure that we have enough material to produce the wanted quantities. Big variations are very time consuming.

5. It is very hard to give a specific number since it varies from day to day. But I would say at least one hour per day, often more. But never more then 3-4 hours. Changes and variations are the reason that I sometimes have to spend more time.

6. Well, for me, as a production and customer planner I would say that most obvious cost is premium freights which you have to pay when you miss the regular transport. Other than that it leads to a lot of re-planning which is very time consuming. So I guess that is also a cost. It also creates a lot of extra work for the material planners to be able to supply the production with material when the plans are always changing.

A.2 Capacity Manager

Questions for capacity manager:

1. Can you describe your work process, and how do you work with EDI:s? How do you work with this short, mid and long term?
2. How do you handle big variations and changes in delivery plans?
3. How much of you time in you daily work consists of handling EDIs and changes in EDIs?
4. How do you think the case company is impacted by big changes and variations in delivery plans?
5. What would the case company have to earn by getting less variation in delivery plans?
6. Do you feel that you have enough control over how the plans varies?
7. Do you think that using FAI-values could be helpfully in communication towards costumers?

A.2.1 Interview Answers - Capacity manager

1. I do not work daily with EDIs, I use the EDIs for discussion with the business unit (BU) and also in discussion with the customer, I haven have monthly meetings with the BU. The EDIs used for discussion is mainly to follow changes in delivery plans. I also use the EDIs as basis when we look at the forecast and following up on customer plans. VMIS, is our internal forecast, which is based

on customer forecasts and IHS institutes for car sales, VMIS and IHS are used in a forecast. Customers also send long-term plans some customers are good at using long term EDIs, some customer are bad. When a customer is bad at forecasting is causes problems in our planning enviroment. The use of BKM, the customer portal, has been improved by one customer which now shows forecasts for up to 18 months, but this forecast rarely match to the EDIs. Not even the first two months, this causes confusion.

2. I have a discussion with the planner, and tell them that they need to go to the source of the problem and check the reason for the change, then we have a discussion with BU to investigate what can be done about it.

3. It's hard to know, I work with EDIs every week. We have weekly meetings and go through changes. It is hard to put an exact amount of hours, but i would say that i work with EDIs for about 10 - 15 hours per week, I often look at volumes and check for changes.

4. We are affected negatively by changes and variations. If we look at the situation today, it becomes very difficult to complete deliveries when we receive changes in the short term, this causes material and planning problems. Sometimes we need to increase shifts too. We have to re-plan and, increase or reduce staff. This creates costs. Also premium shipping to import materials and to send away products are needed. There are many extra costs because of the variation such as direct payroll, premium shipping out, etc.

5. We have a lot to earn by getting less variation. The whole chain would become calmer, we would be able to have secure delivery's both in and out, our plans in production would become more stable as well. Everything would get better really. All the problems that variations create would become smaller.

6. No, we need more control, we have high hopes of this project now (This Master thesis work) . But it is complex. It is difficult to look at certain increases, we must work on this and have good tools for this. Tools like FAI are great, I believe that they can be used in a great way for us.

7. I think that FAI could be good for a basis for discussion points, it is great to be able to show what the plan looks like, and how a certain change is. We could use "good" customers and use them a benchmarks in discussions with customers who are worse. it is a great way to compare statistics and show how it differs. The FAI value could be used as a KPI.

B

Appendix B - Workshop notes

The workshop was held in Swedish, notes were taken in Swedish and then translated into English. The workshop was about one hour with 6 people who are planners, and managers. The idea of this workshop was to start discussions about how the new "order handling process" and "new freeze time requirement" can be improved and how we should implement these for all customers. This was performed to give the project inputs for the implementation kit.

B.1 Part 1 discussions regarding the new process

Discussion points

1. New process
2. freeze time limits for all costumers
3. Adapting freeze time towards specific customers
4. Possible reasons for individual freeze time

B.1.1 Discussion summary part 1:

During the discussion it was concluded that the newly developed process as it is designed is approved and no changes in the process will be need. This specific discussion landed on how the freeze time should be adapted to specific customers. freeze times for customers will need to be valued individually. However, the guideline is to stick with the agreed freeze time which is 0 percent week 1-4, 10 percent week 5–12 and 20 percent week 13-52 for all customers. Exceptions may occur for customer that have internal freeze times and/or no contract can strengthen a change in the freeze time requirements.

B.2 Part two discussions regarding results of the pilot

Discussion points

1. Results Pilot
2. Problems in ERP systems
3. FAI-application

B.2.1 Discussion summary part 2:

Results from the pilot was shown and discussed. During the pilot was problems in the ERP system noticed, this was discussed and will probably be resolved shortly. Participants in the meeting were pleased with the results and did not comment this, except appreciation. A review of the FAI app was done where participants of the meeting were impressed and felt that it was a good way for them to understand how big the variations are and a good way to show customers what the situation looks like. This is something they will continue to include in the process.

B.3 Part three discussions regarding future implementation/implementation kit

Discussion points

1. Implementation kit
2. Our recommendations
3. Start up
4. Creating different emails for different customers
5. How planners should be notified
6. Suggestions on how to include new costumers
7. Time plan

B.3.1 Discussion summary part 3:

This discussion landed on how the new process should be implemented further. How many customers should bee included at a time, when should this project start and how should it be performed was discussed. It was concluded that the amount of customers that should be included per turn depends on the customers, but 3-4 customers at a time seemed like a reasonable amount. It was discussed how they should start with the implementation. New costumers can be selected by checking the variation in their delivery plans, the customers with the most variation should be included first, and from there on simply work from the bottom up. Something that was further discussed was that in the beginning when a new customer is introduced, the company should have a start-up meeting with the customer instead of just sending an email.

How the planners should work was also discussed, each one of the planners is allowed to control how they will work. There are however, proposals for notifications and emails when a change occurs. There was also a discussion about the design of the standardized emails, these can be reshaped, the standardized mails should be seen as a support for the planners. But they are however, not important for the process get itself. Different freeze times were also discussed and it was concluded that if there are cases where a customer has been given other freeze time, the email should be adapted for that customer.

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT
CHALMERS UNIVERSITY OF TECHNOLOGY
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