

**UNIVERSITY OF VAASA  
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INDUSTRIAL MANAGEMENT**

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**Developing material forecasting process in a case company**

Master's Thesis in  
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## ABBREVIATIONS

PTS – Purchase to Stock

PTO – Purchase to order

SCM – Supply Chain Management

MM – Materials Management

PLM - Product Lifecycle Management

CRM - Customer Relationship Management

MRP – Material Requirements Planning

MRP II – Manufacturing Requirements Planning

ERP – Enterprise Resource Planning

BOM – The Bill of materials

MSP - The master production schedule

SAP – The ERP system of the case company

MAD – The mean absolute deviation

MAPE – The mean absolute percent error

MSE – The mean square error

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**ABSTRACT**

One of the main tasks of the materials management is to guarantee a sufficiently good service level for production to meet customer demand. In practice, this means delivering the materials at the right time in the right place in the right quantities. However, this task is very challenging, especially if material volumes and consumption fluctuations are high. One way to ensure a good service level to production is to forecast the demand for materials. This aims to anticipate and ensure that suppliers of materials and components are able to respond to the material needs of production.

The purpose of this study is to develop the material forecasting process in the case company. The aim is to improve the process by developing and implementing a suitable forecasting method and tool for case company's business environment. The theoretical framework of the research is largely based on the scientific literature of forecasting. The theory part also introduces the field and concept of Materials Management. The study is made in a close collaboration with the case company. The research method is case study and research can be characterized as a development study. The research material consists of meetings organized during the study and the statistical data from the case company's ERP system.

The study found that the case company's forecasting process was not effective and the forecasts were too much based on history. However, a suitable method and tool were created to enhance the forecasting process as a result of the development project. The method and tool are compatible with the case company's ERP system. The developed method has been put into operation in the company which shows the successful of the development project. However, the study calls continuous monitoring of the reliability of the developed forecasting method.

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**KEYWORDS: Forecasting, Forecasting method, Forecasting tool, Materials Management**



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**TIIVISTELMÄ**

Materiaalin hallinnan yksi päätehtävistä on varmistaa riittävän hyvä palvelutaso tuotannolle. Käytännössä tämä tarkoittaa oikeiden materiaalien toimittamista oikeaan aikaan oikeaan paikkaan oikeina määrinä. Tehtävää voidaan pitää erittäin haastavana erityisesti kun materiaalien määrät ovat isoja ja niiden kysyntä vaihtelee jatkuvasti. Yksi tapa hyvänpalvelu tason varmistamiselle on materiaalien kysynnän ennustaminen.

Tämän tutkimuksen tarkoituksena on kehittää materiaalien ennustamisprosessia case yrityksessä. Tavoitteena on parantaa prosessia kehittämällä ja toteuttamalla materiaalien ennustamiseen sopiva menetelmä ja työkalu case yritykseen. Tutkimuksen teoreettinen viitekehys rakentuu pääosin ennustamiseen liittyvien teorioiden pohjalta. Teoriaosuudessa esitellään myös materiaalin hallinnan konsepti. Tutkimus tehdään tiiviissä yhteistyössä case yrityksen kanssa. Tutkimusmenetelmänä käytetään tapaustutkimusta. Tutkimusta voidaan luonnehtia myös kehitystutkimukseksi. Tutkimuksen aineisto koostuu tutkimuksen aikana järjestetyissä tapaamisissa syntyneistä havainnoista ja päätelmistä sekä tilastollisesta tiedosta, joka on kerätty yrityksen tuotannonohjaus järjestelmästä.

Tutkimuksessa selvitettiin, että case yrityksen ennustamisprosessi ei ollut tarpeeksi tehokas ja materiaaliennusteet pohjautuivat liikaa historiaan. Kehitystutkimuksen tuloksena saatiin kuitenkin luotoa menetelmä ja työkalu, joilla ennusteprosessia saatiin tehostettua case yrityksessä. Kehitetty menetelmä ja työkalu ovat yhteensopivia case yrityksen tuotannonohjausjärjestelmän kanssa. Ne on otettu käyttöön yrityksessä, mikä kertoo kehitysprojektin onnistumisesta. Tutkimus kuitenkin kehottaa kehitetyn menetelmän luotettavuuden jatkuvaa seuranta.

---

**AVAINSANAT:** Ennustaminen, Ennustemenetelmä, Ennustetyökalu,  
Materiaalinhallinta

# 1 Introduction

## 1.1 Background

*“ The efficiency of any organization depends on the availability of component parts and materials in the proper quantity, quality, price, range and time”* (Shridhara Bhat 2009). Thus, the lack of components or any material used in manufacture can cause significant problems in industrial company. Even the absence of a small component may stop the entire production line. Therefore, in the worst case, the lack of materials may lead to delays in deliveries which in turn can lead additional costs, customer dissatisfaction and negatively affect the company’s reputation. This is emphasized in a large company that manufactures bigger products from small components. In that case, the company’s material flow may include thousands of different components and parts. Therefore the management of materials can be considered as one of the most critical success factors in supply chain of organization.

The main task of Materials Management is to provide the best service level for manufacture while keeping a stock value at an agreed level. That requires constant cooperation and communication with suppliers. Because of the fluctuations in material demand and constantly changing product structures increases the risk of the shortage of materials. The long delivery and transportation times of complex materials add more challenges to the Materials Management.

However, the disadvantages caused by the lack of materials can be prevented by a successful forecasting process. By managing and forecasting material consumption the organization can help their component suppliers to respond to the future demand. Because of that forecasting can be considered one of the most important tasks in the department of Materials Management. However, forecasting is very challenging process which generally requires a lot of knowledge and skill to combine information about the predictable phenomenon.

## 1.2 Objectives and limitations

This research is done in cooperation with a large global case company. The study focuses on a company's unit in Finland. The main purpose of the research is to develop the supplier forecasting process in that unit. The work is directed at the unit's electrification factory. The high volume of components in electrification factory increases the importance of this study. Also the suppliers strong reliance on forecasts increases the development needs. Moreover, it has been found that the forecasting process needs development activities in electrical factory.

The aim of the study is to create new forecasting model that is suitable for the operating environment of the object. The purpose of the new model is to simplify the forecasting process and improve the efficiency of forecasting. By simplifying the process, the company will no longer need to spend so much resources on forecasting. In turn improving forecasting density would help suppliers better respond to demand fluctuations in the future.

The aim of the research is to find out the different models of forecasting and their suitability of the operating environment to be studied. Appropriate forecast models are searched on the basis of the theoretical framework. Company's internal forecasting models are also used to support research. The best result is achieved by examining the development needs of the forecasting process and by creating and implementing the development proposals.

The aim of the work is also to develop a tool for forecasting. The aim is that the tool will be able to make reliable material forecasts for all suppliers. The tool should be easy to use to reduce the resources available for forecasting. The tool should also include all predictable materials.

This study is confined to exploring only the operating environment of the object. The new forecast model is being applied precisely to this environment and may not be applicable elsewhere. The study is limited to examining only predictable materials, in this case it means materials to be stocked in other words purchase to stock (PTS) materials.

Customized product specific materials, purchase to order (PTO), will not take into account.

### 1.3 Research questions

To meet the objectives, the research tries to answer the next questions. The main question of the research is: *How the case company's forecasting process could be developed?* To find the best answer to this question the study must first answer the following sub questions:

- *What kind of forecasting methods have been presented in previous studies?*
- *What are the current forecasting methods in case company?*
- *What are the main development needs of the forecasting process in case company?*
- *What are the measures to respond to development needs?*

The answer to the first sub-question is obtained through the theoretical framework. The answer to the other sub-questions is gained through the case company's internal information and network. The answer to the main question of the study is obtained by combining the information acquired with sub-questions.

### 1.4 Structure of the research

The research is divided into five main sections. The first section contains an introduction of the study. This reflects the background, objectives and research problems of the aid. The introduction also reveals what the issues are in the study and what is left out of the research. The second part discusses the theory of the research topic. It seeks to create a theoretical starting point for the whole research.

The third section deals with the methodology of the research. It presents the data collection and analysis methods used in the study. The fourth chapter presents the results of the study. It presents the key features of the previous and developed forecasting methods, as well as their comparison and evaluation.

The fifth is the final words of the study. These reveal the findings and conclusions of the research. There will also be presented potential further research topics.

### 1.5 Research orientation

This research is a case study that is targeted at a previously mentioned real life company. According to the nature of the research topic, case study is best suited method to this research. In addition, the study is intended to investigate exclusively the process of the case company. The data sources of the study are the several employees of the company and the company's internal information system. The research is also partly based on observations, which has emerged previously while the researcher has been in employment with the company.

This research can be regarded as a development project that addresses the problem of the real working life in the case company's business environment. The purpose of the development project is to develop the case company's forecasting process. In addition to the researcher, a number of employees of the case company are involved in the development project.

The development project consists of several meetings and analysis of statistical data. Meetings and analytics are used to find a suitable forecasting method that is compatible with the case company's information system. It can be said that the research was done in a strong collaboration with the case company.

## 2 LITERATURE REVIEW

Following section describes the fundamental theories about material forecasting and related elements. This section creates a theoretical framework for empirical research. As priming for forecasting theories are dealt with the organization's material management and planning which are strongly related to material forecasts. Forecasting theories create a comprehensive theoretical starting point that will later be linked to practical work.

### 2.1 The field of Materials Management

Globalization has brought new opportunities for purchasing materials and components around the world. The consolidation of the Internet and e-commerce has also increased the potential of communication and global trading. At the same time, the challenges of managing material flows have increased. In organizations, these functions are managed through Supply Chain Management (SCM). SCM is also combined with all other activities that enable consumers to get the final product or service. (Sakki 2014.)

An increasing proportion of the turnover of industrial companies consists of purchased materials. Thus, the company's ability to manage purchases and materials is directly proportional to its result. The efficiency of an organization depends on the availability of components and materials. During the last few years it has been seen necessary that the company's material flow is managed by a unit or a team. This unit is generally referred to as Materials Management (MM). The unit is managed by the Materials Manager. All the functions of bringing materials to production are combined under the Materials Management. (Bhat 2009.)

There are many different definitions for material management in the literature. A few definitions are shown below:

- 1) Bailey et al (1994) defined that Materials Management is the “management of the flow of materials into an organization to the point where those materials are converted into the form's end product(s)”.

- 2) Chunawalla (2008) defined the material management as the one responsible for the entire material cycle, which consists of parts such as purchase, inventory management, reception and inspection, transportation, physical distribution and material handling. (Chunawalla 2008.)
- 3) One simple definition is that The “Materials Management is the process of management which coordinates, supervises and executes tasks associated with flow of materials to, through and out of an organization.” (Bhat 2009.)

SCM is generally seen as a bigger totality than MM. SCM includes, in addition to Materials Management, manufacturing, data transfer and financial transactions. (Viitala 2013). Thus, the Materials Management can be considered as one of the SCM’s tasks.

Material Management is usually associated with three main tasks: purchasing materials, stocking and material handling. Understanding the importance of MM has clarified and expanded its tasks. (Chunawalla 2008). Table 1 shows the most typical Materials Management responsibilities today.

Table 1. Tasks of material management. (Adapting Chunawalla 2008: 3).

Task	Purpose
Purchasing	Ordering materials, vendor selection and negotiations and value analysis.
Materials Planning	Planning and forecasting material requirements.
Resource Planning	Planning resources for purchasing
Materials Handling and Traffic	External and internal movement of materials.
Stocking	Storage, maintenance and inventory of materials.
Inventory Control	Configuring optimal order quantity, setting inventory levels and configuring safety stocks.
Disposal	Disposal of waste, surpluses and obsolete materials.
Physical Distribution	Distributing finished products to customers. In some cases traffic and physical distribution may be the same thing.



The main objective of Materials Management is to provide the required customer service level and maximize the use of company resources. With successful material management, the company can increase its profit significantly. (Arnold & Chapman 2001: 10). The main object of Materials Management can be considered making available services and materials of right quality in the right quantity from the right source at the right time at the right price. (Bhat 2009). In order to clarify the overall picture of MM, Figure 1 shows the concept of the Materials Management.

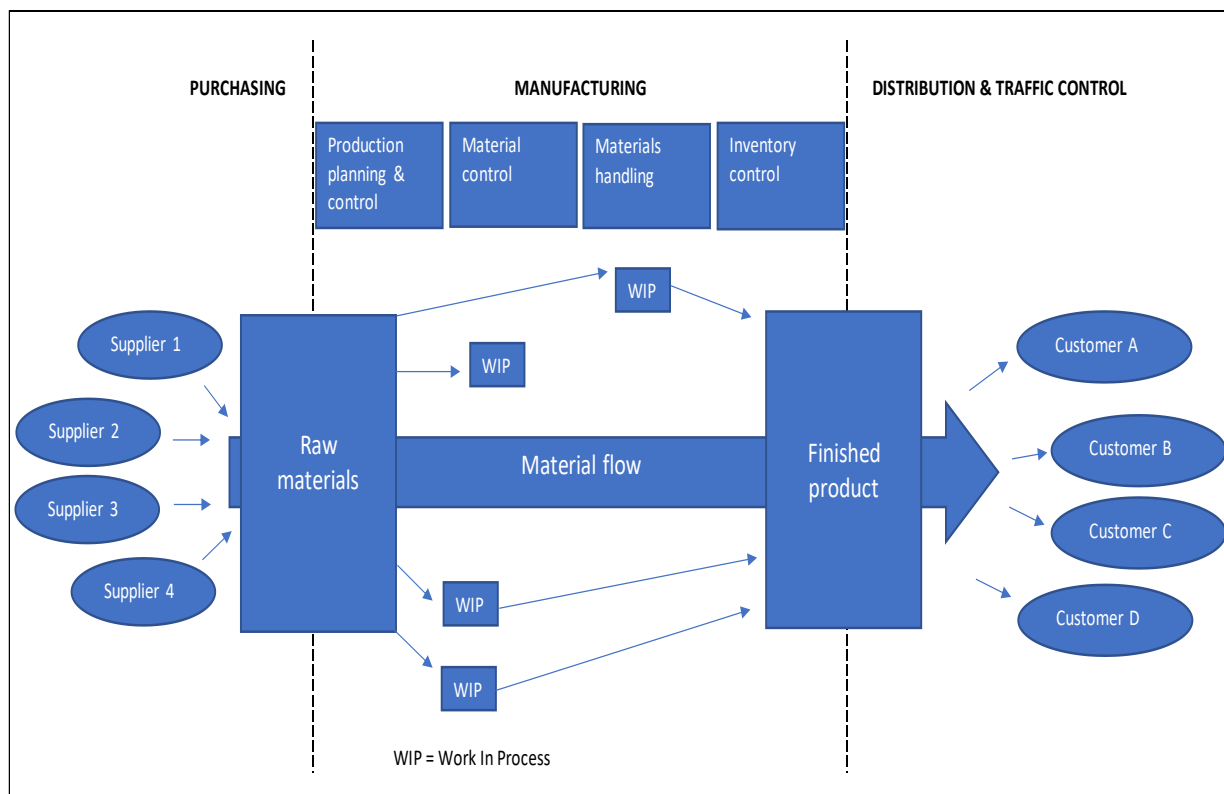


Figure 1. The concept of Materials Management (Adapting Bhat 2009: 7).

### 2.1.1 Material Requirements Planning

Planning material flow is an important part of the Material Management. The planning of the materials is intended to show in advance the material requirements in response to production requirements. Material plans follow the production plans which in turn are

based on demand forecast of finished products. (Chunawalla 2008). Materials planning is one part of the production planning. (Bhat 2009).

Materials planning is generally made on the basis of the material budget. Material budget is an estimate of the costs of materials purchases and thus helps to materials planning. The importance of materials planning cannot be overlooked. Failing in materials planning can lead to over-ordering, which arouses additional challenges and costs for storage. It also negatively affects the productive use of materials. In the worst case, it may lead to obsolescence and deterioration of materials. Poor materials planning can also result in under-ordering, which in turn can lead to a shortage of materials and, consequently, delays in deliveries. (Bhat 2009.)

A well-designed material planning system will provide a variety of benefits to the company. It enables to prepare for the future and not just to react to the situation. Therefore it helps the company to get things done effectively. Thus material design can avoid material shortages. An efficient system enables buyers to know about the future purchases in advance. Thereby they are able to make their own purchase plans. (Bhat 2009.)

As computers became more common, material management and, in particular, materials design began to be automated with computer-based programs. These programs known as Material Requirements Planning (MRP) systems. (Sheldon 2008). According to Mabert (2007) factories began to manage material flows with the help of MRP systems at the end of the 20th century. Chunawalla (2008) defined MRP as an Inventory Control and Production Planning System which is a computer-based and time-phased.

The idea behind the MRP was very simple. Bill of Materials (BOM) were defined for each product. BOM defined the materials and component requirements of the products. These material requirements were linked to Inventory records. Thus, the MRP system provided signals for purchase orders. (Sheldon 2008). According to Wilson (2015) MRP systems depend on identifying the right parts and the right amount of material in production planning. BOMs are therefore indispensable to the effectiveness of these systems. MRP systems make great efforts to ensure that BOMs are correct. Figure 2

demonstrates the structure of the MRP system. Chunawalla (2008) defined four main elements of MRP systems:

1. The master production schedule (MSP). This drives the MRP.
2. The bill of materials (BOM) or product structure file.
3. The inventory records file.
4. The MRP software package.

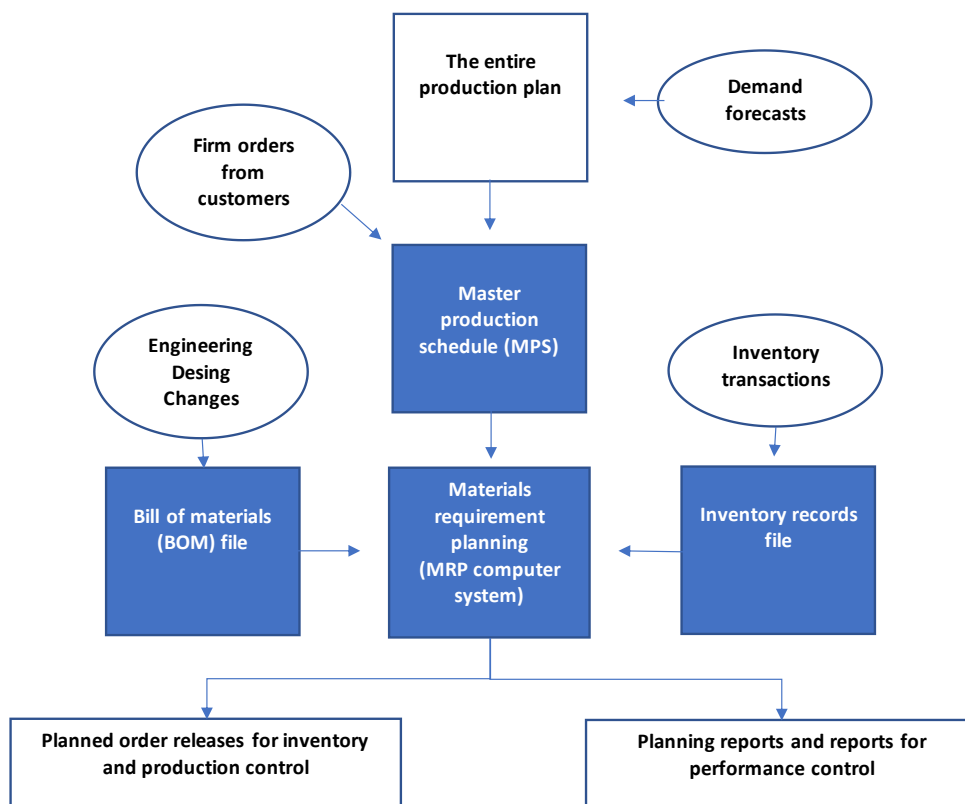


Figure 2. The Structure of MRP system. (Adapting Chunawalla 2008 & Yang 2016).

At the turn of the millennium, several companies implemented the new software system to integrate their processes. These package systems are widely categorized as Enterprise Resource Planning (ERP) systems. Over the years, ERP systems evolved from MRP systems after the various phases. (Mabert, Soni & Venkataramanan 2003). According to

Fulford (2013) today's ERP systems are an important part of the capital expenditure of many companies, but on the other hand, efficient management of ERP systems has a major impact on business performance.

### 2.1.2 Enterprise Resource Planning (ERP)

According to Costa, Ferreira, Bento and Aparicio (2016) ERP systems are the core of every organization. In their article, they introduced the definition that Enterprise Resource Planning (ERP) systems are comprehensive and packaged software solutions that try to integrate all company's business processes into a single entity that can be viewed from a single information system and IT architecture.

Enterprise Resource Planning (ERP) seeks to combine all departments and their functions in a single computer software that is able to serve the needs of all those departments. In other words, the software should be able to serve people in finance, people in human resources and people in the warehouse at the same time. With ERP, these different units can more easily share information and communicate with each other. (Parthasarthy 2007.)

The evolution of existing ERP systems has begun for several decades ago. Already in the 1960s several organizations developed and introduced an automated inventory management system. Next, in the 1970s, a Material Requirements Planning (MRP) system was developed which mainly dealt with the requirements of a product or parts in accordance with the master production schedule. Development continued and in the 1980s the first Manufacturing Resources Planning (MRP II) systems were introduced. In addition to materials planning it included areas such as shop floor, project management, distribution management, human resources, finance and engineering. (Abdullah 2017.)

The first comprehensive ERP systems took first steps in the early 1990s. They were developed based on MRP and MRP II systems. As a result, ERP systems integrate business processes including all aspects as manufacturing, distribution, accounting, finance, human resource management, project management, warehousing, maintenance and service and transportation. They provide visibility, accessibility and consistency throughout the company. (Abdullah 2017.)

After the first occurrence of a comprehensive ERP system, they will be further developed. These systems are called Extended ERP Systems. (Abdullah 2017) According to Samara (2015), new modules such as Supply Chain Management (SCM), Product Lifecycle Management (PLM) and Customer Relationship Management (CRM) are among the newest ERP systems. Figure 2 shows the main steps of the evolution of ERP

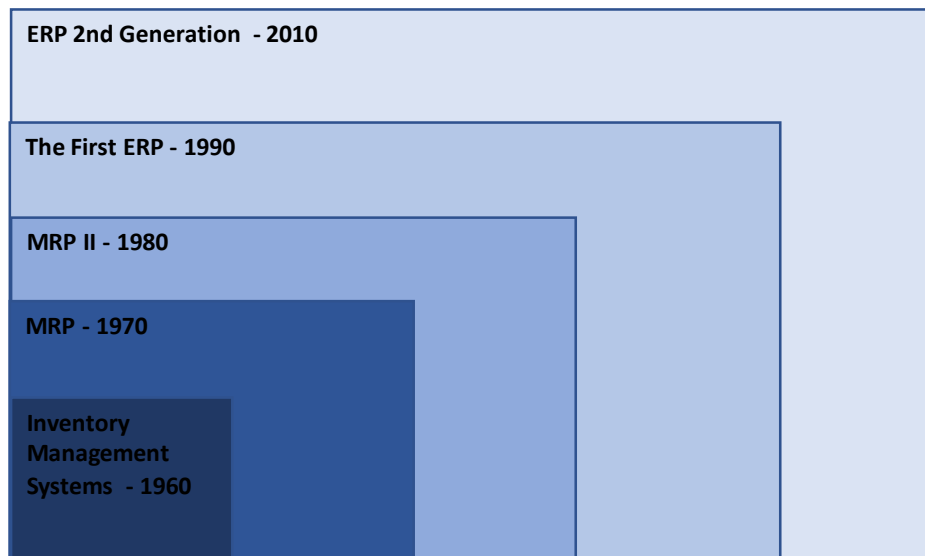


Figure 3. Evolution of Enterprise Resource Planning (ERP). (Adapting Abdullah 2017 & Samara 2015).

## 2.2 Forecasting and managing demand

Demand management is a process of supply chain management designed to balance customer needs with the supply chain capabilities. It includes demand forecasting and synchronization with procurement, distribution and production. (Croxtton, Lambert, Garcia-Dastugue & Rogers 2002). Arnold & Chapman (2001: 196) defined demand management as the function of managing and identifying all product-related demand. According to their book, demand management is a link between marketing and material management. Demand management takes place in the short, medium and long term. Forecasting is one of the main tasks of demand management.

According to the science dictionary, the forecast is an estimate of what will happen in the future. (Vocabulary 2018). Forecasting is important in many ways in different phases of life. As individuals, we try to predict success in, for example, occupation, investment, and marriage. Organizations use large amounts of money based on forecasts, for example, on acquiring a new factory or product. Forecasting and planning are often perceived as the same thing. However, the plans refer to what the future should be, while the forecasts are intended to tell what it will be like. (Armstrong 2001a.)

Forecasts are needed to support decision-making in many different situations. The decision to build a new plant within five years requires forecasts for future demand. Stocking inventories are based on forecast of storage requirements. (Hyndman & Athanasopoulos 2013). According to Acar, Everette & Gardner (2002) forecasting is one important factor affecting the operational performance of the supply chain. Therefore, poor forecasts may lead to destructive decisions. (Armstrong 2001a).

Forecasts can be divided into three different time horizons: short-term, medium-term and long-term. In other words, forecasts can be made from a few minutes to several years in advance. Time horizon depends on the nature of the predictable phenomenon. For example, short-term forecasts are needed for scheduling personnel and production, medium-term forecasts are needed for raw material volume planning and long-term forecasts are needed for strategic planning. (Hyndman & Athanasopoulos 2013). However, according to Armstrong (2001a) decision-makers need forecasts only when there is uncertainty in the future. However, uncertainty often occurs in companies decisions. In these cases, forecasts can be significant benefit in support of decision-making.

Forecasting demand is an important activity that affects companies world-wide regardless of their branch of industry. Prediction of demand is a critical function in increasing supply chain efficiency and it affects all aspects of the company. For example, the demand forecasts will determine the amount of raw materials, the volume of end-product stocks, the number of products to be transported, the number of people to be hired and the number of factories to be built. In the current world economy, the passage of the entire supply chain from raw material to the finished product and consumers may take a lot of time.

Therefore, demand forecasts are essential. Companies must be able to predict the need for the future to be able to respond immediately to their customers.. (Chase 2013.).Forecasts are essential for a successful business of organizations. (Kumar & Suresh 2009).

While studying demand forecasting, there are often two types of demand in literature, Independent demand and Dependent demand. These two have a significant difference. Independent demand is affected by market conditions outside the scope of operations. In other words, demand is independent of operations. While dependent demand is related to the demand of another item. When a product consists of parts and components, their demand depends on the demand for the finished product. For example the MRP is based on dependent demand. (Chunawalla 2008.) This study focuses on forecasting dependent demand.

### 2.2.1 Forecasting process

The forecasting process consists of several stages. At the beginning of the forecasting process, it should be determined that what is going to be predicted. For example, does an organization predict a single product or a whole product group? When a prediction object is known, it is necessary to define the time horizon. Do we need forecasts a month in advance or five years in advance? It is also necessary to determine how often forecasts should be made. (Hyndman & Athanasopoulos 2013.)

Knowing what kind of forecasts are needed, it is necessary to determine what kind of information the forecast is based on. This information should be collected, although it may already exist. It is therefore important to identify where and how information is stored. a Large part of the predictor's time can be used to locate and compare available data before developing suitable forecasts. (Hyndman & Athanasopoulos 2013.)

Hyndman & Athanasopoulos (2013) presented the five basic steps of the forecasting process. In turn Shridharabhat, K. & Aswathappa, K. (2009) shared the prediction process into seven steps. According to these two opus, the steps of the forecasting process can be broken down as follows:

### 1. Definition of forecasting targets.

This includes the definition of problem. It requires understanding of the predictable phenomenon. This also includes determining prediction needs such as the time horizon, forecasting frequency and forecasting target(s). In addition, this includes the definition of the details required by the forecast, such as the amount of resources and the goal of the forecast accuracy.

### 2. Data collection.

At this stage, it is necessary to determine the method of collecting the data. Whether to use statistical data or an expert's view. Both are often needed to produce a good forecast. The information needed for the forecast must be collected before the forecast is prepared.

### 3. Preliminary data analysis.

It is also important to analyze the collected data before selecting the forecast method. Information analysis can help to find out significant variables for the forecast. For example, whether there is any seasonal variation that can be observed, whether the data is related to a trend or whether expert help is needed to make a forecast.

### 4. Selecting a forecasting method.

Choosing a forecasting method depends on the availability of historical information, the interdependence between potential variables and the purpose of the forecasts. Each model has its own structure and is suitable for different types of forecasts. Usually two or three potential models are compared to choose a suitable method.

### 5. Using and monitoring forecasting method.

When the forecasting method is selected and the parameters affecting it are defined it can be used to make a forecast. It is also important to monitor and evaluate the selected



method to see if it performs in the desired way. It also enables for a continuous development of the method. Figure 4 shows demonstrates the forecasting process.

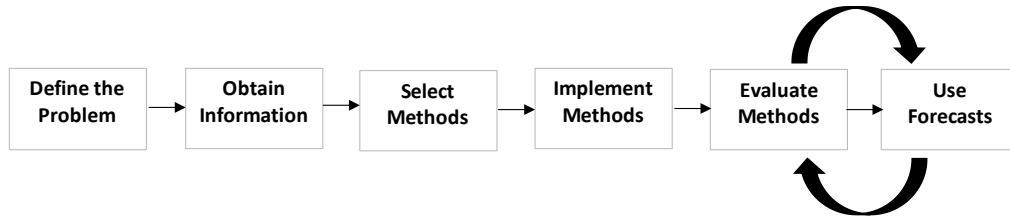


Figure 4. The process of forecasting. (Adapting Armstrong 2001a).

### 2.2.2 Forecasting methods

There is a very large number of forecasting methods for different decision-making situations. In general, demand forecasting approaches can be divided into two main categories. (Kumar & Suresh 2009).

1. Qualitative forecasting methods. The qualitative methods are mainly based on subjective inputs (Aswathappa & Bhat 2010). The qualitative forecasts are based on intuitions, judgment and informed decisions. (Arnold & Chapman 2001: 202). Qualitative forecasting methods can include experiences and personal views. For this reason, the results may differ between the different individuals. (Kumar & Suresh 2009). According to Hyndman & Athanasopoulos (2013) the cognition of the individual and its limitations is the most critical element in qualitative forecasting. Qualitative forecasts are usually made by an expert in their field (Rushton, Croucher & Baker 2014: 211). Table 2 shows the most common qualitative forecasting methods.

Table 2. Qualitative forecasting methods.

Method	Description
The Delphi Method	The method is based on the forecast prepared by the group of experts. A group of experts prepared a reasoned preliminary forecast of the agreed matter. Experts receive feedback on the forecast and they will review the forecast based on feedback received. The final forecast is obtained when the necessary consensus is reached. (Hyndman & Athanasopoulos 2013.)
Analogy Forecasting or Historical analogy	The method is based on a comparison of similar products. (Kumar & Suresh 2009). For example, when price-setting the house's market value, the appraiser compares the house to the corresponding houses sold in the area. (Hyndman & Athanasopoulos 2013).
Executive opinion	Leaders such as production, finance and marketing managers prepare forecasts together. (Kumar & Suresh 2009). Predictions usually arise at a group meeting where managers provide information from their own area. (Hyndman & Athanasopoulos 2013). This method is also often used with a qualitative method where managers change qualitative outcomes according to their views. (Putra 2009).
Sales Force composite	Method is based on expert opinion from the sales force members. (Amstrong 2001a). It is also based on the assumption that salespeople have the best view of customers and their future needs. (Putra 2009). According to Hyndman & Athanasopoulos (2013) salespeople intuitions of customers purchasing intents bring valuable expertise and experience to this forecasting method.
Market or customer surveys	The method is based on consumer interviews or surveys. (Kumar & Suresh 2009). They seek to clarify customers' purchasing intentions and behavior. (Hyndman & Athanasopoulos 2013). According to Putra (2009) a broad

	statistical analysis is usually used to analyze the results of the survey to test the assumptions of consumer behavior.
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2. According to Chase (2013), forecasts that are based on past sales history or relationships between earlier sales and another variables are quantitative methods. Quantitative methods can also be considered mathematical and objective. Quantitative forecasting methods combine two issues: sufficient numerical data about the past and the assumption that history repeats itself to some extent. (Hyndman & Athanasopoulos 2013). The quantitative methods are divided into two main groups: time series methods and causal or associative methods. Time series are based on the assumption that the past will be reflected in the future while associative methods take into account the factors and variables that can affect the predicted amount. (Shridharabhat, K. & Aswathappa, K. 2009).

There are a lot of different quantitative predictive methods. They are often developed for a specific purpose. Each method has its own features, purposes and precisions. (Hyndman & Athanasopoulos 2013). Table 3 shows the most common quantitative forecasting methods.

Table 3. Quantitative forecasting methods. The table is compiled from sources: (Amstrong 2001; Kumar & Suresh 2009; Shridharabhat, K. & Aswathappa, K. 2009; Hyndman & Athanasopoulos 2013; Montgomery, Jennings & Kulahci 2015).

Method	Description
Naive methods (Time series)	The forecast is equal to the last realized value or the latest value is changed to larger or smaller according to a percentage. For example, 100 pieces of a product were sold in January, then demand forecast of this product is 100 pieces in February.
Moving averages (Time series)	<p>The method is based on the actual values of the recent history. The forecast is obtained by summing up the actual demand during given periods and dividing it by the number of periods. The basic formula of moving averages is:</p> $\text{Moving average} = \frac{\sum \text{demand in previous periods}}{n}$ <p>(1)</p> <p>Where,  <math>n = \text{number of periods}</math></p> <p>The moving average can also be weighted. In that case, the weight of certain values is emphasized in percentage or in real numbers.</p>
Exponential smoothing (Time series)	The method is based on the weighted averages of previous observations, giving the latest observations a greater weight. Thus, the weights exponentially decrease when the observations get older. The forecast can be calculated using the following formula:

	$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$ <p>(2)</p> <p>Where,</p> <p><math>F_t</math> = Forecast for this period (<math>t</math>)</p> <p><math>F_{t-1}</math> = Forecast for the previous period (<math>t - 1</math>)</p> <p><math>A_{t-1}</math> = Actual demand for the previous period (<math>t - 1</math>)</p> <p><math>\alpha</math> = Smoothing constant (Value is between 0 and 1)</p> <p>Choosing a smoothing constant usually requires expertise or experiments. For example, trend-based methods are based on exponential smoothing. Then smoothing constant changes linearly, exponentially or in other projection according to the past or existing trend.</p>
ARIMA models (Time series)	<p>ARIMA models are advanced methods for analyzing time series. ARIMA is the abbreviation of Autoregressive integrated moving average. The ARIMA models consist of several different models. First, an autoregressive model (AR) and a moving average model (MA) are defined. By combining these two, an autoregressive moving average model (ARMA) is obtained. By integrating ARMA, the ARIMA model is obtained. The ARIMA models attempt to describe autocorrelations in data.</p>
Regression and correlation methods (Associative)	<p>Methods based on regression and correlation are based on a hypothesis where two variables have a linear relationship. It can use either one or a number of associative variables for forecasting. Two examples of these methods are shown below:</p> <p>The Simple linear model (Simple Regression)</p> $y = \beta_0 + \beta_1 x + \varepsilon$ <p>(3)</p> <p>Where,</p>

	<p><math>\beta_0</math> and <math>\beta_1</math> determine inclination and intersection of the line</p> <p><math>\beta_0 =</math> The forecasted value of <math>y</math> when <math>x = 0</math></p> <p><math>\beta_1 =</math> The forecasted increase in <math>Y</math> when <math>x</math> increases a one unit</p> <p><math>\varepsilon =</math> the random "error"</p> <p>4</p> <p><b>Multiple linear regression (Multiple Regression)</b></p> $y_i = \beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \dots + \beta_k x_{k,i} + e_i,$ <p>(4)</p> <p>Where,</p> <p><math>y_i =</math> Variable to be forecast</p> <p><math>x_{1,i}, \dots, x_{k,i} =</math> Predictor variables (must be numerical)</p> <p><math>\beta_1, \dots, \beta_k =</math> coefficients that measure the marginal effects of each prediction variables</p>
Econometric (Associative)	<p>Econometric forecasting methods use simultaneously a number of regression models associated with broad economic activity. Often in econometric methods, qualitative information is combined with quantitative data.</p>

### 2.2.3 Selecting a forecasting method

Selection of forecasting method is very important in order to achieve the best forecast results. (Permanasari, A. E. 2010). For example, in a modern supply chain, designing the right amount of inventory without proper forecasting is extremely challenging. (Dweiri Khan & Jain 2015).

When selecting a suitable forecasting method, it is important to understand the nature of the demand. For example, when demand is seasonal, a method must be selected that includes seasonal variation. For example, if the nature of demand changes or the number of errors increases, it is usually necessary to make changes to the current method. (Croxtton at al. 2002.)

In addition to the nature of demand, it is important to understand the flow of information related to the forecasts. This means determining the sources of information, how input data is used and transferred to the method, and how and what of the output data is communicated to whom. For example, the company's ERP system can provide the necessary information for forecasting and can be used throughout the enterprise. (Croxton et al. 2002.)

According to Croxton et al. (2002) there are a large number of different forecasting software packages available on the market. They can be considered as one option in the situation of method selection. Then it must be taken into account that the features of the software are adapted to the needs of the company.

Armstrong (2001b) offered general guidelines to select a suitable forecasting method:

- If enough information is available, use the quantitative forecasting methods. If the data is enough and the data is good enough the quantitative methods are assumed to be more accurate than the qualitative methods. In order to assess the adequacy and quality of the data, it is important to take into account the amount, source, reliability and validity of the data.
- Favor structured forecasting methods. Especially when qualitative forecasting is needed, it is recommended to use it structurally. Structured forecasting methods are usually more accurate, easier to communicate and easier to improve over time.
- Favor simple methods. Simple forecasting methods are easier to understand, simpler to implement and they are cheaper. In addition, they are generally as accurate as the complex ones. More complex methods can be considered when it is possible to prove that complexity is beneficial. However, this usually requires a very good knowledge of the situation.
- Prefer causal methods instead of naive methods. Causal methods are usually more accurate, especially in long-term forecasting where changes are expected. Naive methods may be sufficient for short-term forecasts that have long history of stable demand.

- Identify the predictable phenomenon and consider what kind of forecasting method would be best suited to that situation.

#### 2.2.4 Monitoring and controlling forecasting methods

According to Armstrong (2001c) forecasting methods should be evaluated in the situations in which they are used. The estimation of forecasting methods is often based on determining different criteria or monitoring forecasting errors. This can be done, for example, by setting the upper and lower limits for how much forecasts may deviate from actual demand before changing the method parameters. (Shridharabhat & Aswathappa 2009).

Several different accuracy measures have been developed to measure the performance of the forecasting methods. The purpose of the meters is to provide information to support the development of methodology and the improvement of forecasting accuracy. (Mehdiyev, N. Enke, D. Fettke, D. & Loos, P 2016.)

In the simplest way, the forecasting accuracy can be measured by comparing actual demand with forecasted demand. Then the deviations between them can be identified, which can be called a forecasting errors. The forecast error can be calculated as follows:

$$\text{Forecast error} = \text{Actual demand} - \text{Forecast demand} \quad (5)$$

(Kumar & Suresh 2009.)

One common way to measure errors is the mean absolute deviation (MAD). Its purpose is to calculate the average of the total errors. (Arnold & Chapman 2001.)

$$MAD = \frac{\sum(\text{Actual demand} - \text{Forecast demand})}{n} \quad (6)$$

$n = \text{number of samples}$

One way to ensure good performance of forecasts is to use a tracking signal. It measures how well the forecast can predict actual values. (Shridharabhat & Aswathappa 2009). According to Kumar & Suresh (2009) the tracking signal's action limit is usually set



between 3 and 8. For example, if the action limit is 4, the tracking signal must be between -4 and 4, otherwise the forecast must be re-examined.

$$\text{Tracking signal} = \frac{\Sigma(\text{Actual demand} - \text{Forecast demand})}{MAD} \quad (7)$$

According to Shcherbakov, Brebels, Shcherbakova, Tyukov, Janovsky & Kamaev (2013) different criteria are used to assess the quality of forecasts such as calculation speed, ease of interpretation and error rates. In general, the methods used to measure forecasting accuracy and errors are used to solve practical problems. For example, mean square error (MSE) and mean Absolute percent error (MAPE) are very commonly used methods.

$$MSE = \frac{\Sigma(\text{Actual demand} - \text{Forecast demand})^2}{n-1} \quad (8)$$

$$MAPE = \left( \frac{\Sigma \frac{|\text{Actual demand} - \text{Forecast demand}|}{\text{Actual demand}}}{n} \right) * 100 \quad (9)$$

### 2.2.5 Combining forecasts

Combining forecasts is a comparison between different forecast methods or different data sources. Combining forecasts aims at better forecast accuracy and minimization of forecasting errors. Comparison of different data sources or different forecasting methods can achieve significant benefits especially in situations where a lot of uncertainty is present. By combining forecasts can reduce errors and improve forecasting accuracy. (Armstrong 2001d.)

One common way to combine forecasts is to modify quantitative forecasts by qualitative methods. Both quantitative and qualitative have their own strengths and weaknesses and can provide different information to the forecasting process. However, modifying the forecasts with qualitative methods can weaken forecasting accuracy. (Sanders & Ritzman 2001.)

Sanders & Ritzman (2001) listed six principles for combining quantitative and qualitative methods. They recommended that the forecaster should consider these principles when

deciding when and how qualitative methods could be used to improve the statistical forecast:

1. Modify the statistical forecast if important knowledge of the subject is known.
2. Modify the statistical forecast if there is a lot of uncertainty.
3. Modify the statistical forecast if it is known that there are changes in the environment.
4. Structure the qualitative modification process.
5. Document all the modifications made by qualitative methods.
6. Consider mechanically the combination of quantitative and qualitative methods over adjusting.

### 3. Research Methodology

The third main chapter describes the research methods used in the study. This chapter describes the main methodology of the research, the data collection methods and methods for processing data. The purpose of this chapter is to clarify to the reader how the research has been implemented in practice.

#### 3.1 Methodology

Quantitative research methods focuses mainly on the analysis of statistical data while qualitative research methods does not usually use statistical methods but tries to understand the nature of the research problem through the observations. (Baškarada 2014). In this study, both theories are used quantitative and qualitative. Qualitative methods are used to collect information to understand the research problem and its nature. Qualitative methods are also utilized in the development of the forecasting process. In turn quantitative methods are used in the tool evaluation.

This study can also be considered as a case study. According to Yin (1994) case study generally tries to answer "how" and "why" questions. The nature of the case study also involves studying the phenomenon of a real life. The main question of this study is "how" question and the research is trying to solve the problem in real life. One way to do a case study is to use one case. This is called a single case study. (Yin 1994). This study uses one case where the study can be considered a single case study.

In addition to the fact that the study is a single case study it can also be considered a descriptive case study. According to Baškarada (2014) descriptive case studies tend to describe the subject of the study fully in its context, which can also be used to create a new theory. The purpose of this study is to describe the present situation of the case company's forecasting process and its problems completely and then seek to find solutions by creating a new approach.

This study mimics a six-part case study process. Figure 5 demonstrates the case study process. It consists of the following stages:

1. Planning stage, which includes the definition of the research question and the research method.
2. Design stage focusing on unit analysis and development of a case study plan.
3. Prepare stage focuses on the development of researcher skills in case-related matters.
4. Collect stage involves collecting data and evidence using multiple data sources.
5. Analyze stage that includes theoretical suggestions.
6. A Share Stage, which involves audience definition, assigning evidence to the reader, reviewing and rewriting.

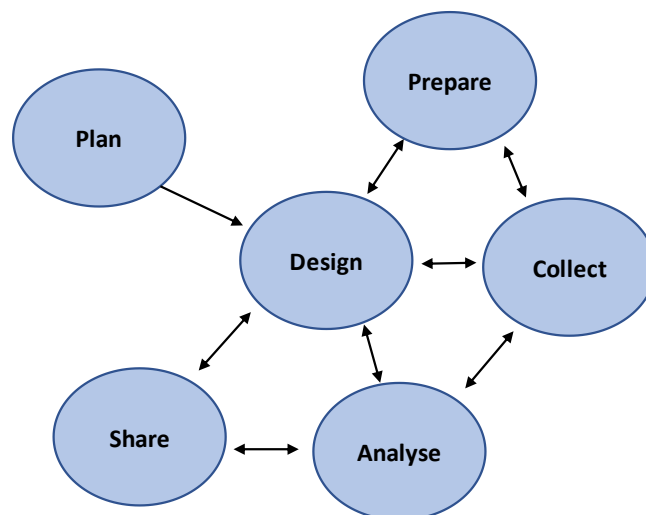


Figure 5. The case study process (Adapting Baškarada 2014).

### 3.2 Data Collection

The gathering of research data was largely based on a variety of undocumented interviews, conversations and meetings. The development of forecast process is based on the solutions and observations received at meetings. The forecasts themselves are based on quantitative data obtained from a case company's ERP system.

Table 4 summarizes the meetings and discussions organized during the study. Meetings have been organized and encoded using the forecasting process presented by Armstrong (2001a, figure 4). The forecasting process has been applied according to the nature of the study and consists of five different phases: problem definition, gathering information, creating a forecasting tool, tool evaluation and testing and tool development and use.

The following table 4 shows the meetings and participants during the study. Meetings have been assigned codes according to the steps of the process, because the meeting will later be used as sources of text. In turn table 5 shows the topic of the meetings. Table 5 is divided according to process steps.

Table 4. Meetings of the research.

<b>Date</b>	<b>Code</b>	<b>Type of data collection</b>	<b>Participants</b>
1. Problem definition			
13.11.2017	PD1	Face to face meeting.	Material Management Manager.
15.11.2017	PD2	Email interview and open conversation.	Material Management Monitoring.
15.11.2017	PD3	Email interview and open conversation.	Material Management coordinator.
15.11.2017	PD4	Email interview and open conversation.	Material Management coordinator.
15.11.2017	PD5	Email interview and open conversation.	Material Management coordinator.
27.11.2017	PD6	Face to face meeting.	Material Management Manager.
28.11.2017	PD7	Face to face meeting.	Material Management Monitoring.
2. Gathering information			
11.12.2017	GI1	Face to face meeting.	Senior Sourcing Specialist and Supplier Quality Engineer.

14.12.2017	GI2	Face to face meeting.	Material Management Manager.
15.12.2017	GI3	Skype meeting.	Supply Planner.
28.12.2017	GI4	Skype meeting.	Material Management Manager.
17.01.2018	GI5	Face to face meeting.	Material Management Manager.
18.01.2018	GI6	Face to face meeting.	MM Monitoring and Material Management worker.
19.01.2018	GI7	Face to face meeting.	Inventory Management Manager.
24.01.2018	GI8	Face to face meeting.	Material Management Manager.
29.01.2018	GI9	Face to face meeting.	Supply planning manager and Supply planner.
3. Creating a forecasting tool (Method selection)			
9.02.2018	MS1	Face to face meeting.	SL Delivery Application Specialist.
26.02.2018	MS2	Face to face meeting.	Material Management Manager.
27.02.2018	MS3	Face to face meeting.	Program Manager.
5.03.2018	MS4	Face to face meeting.	Material Management Manager.
6.03.2018	MS5	Face to face meeting.	Material Management coordinator.
12.03.2018	MS6	Face to face meeting.	Material Management Manager and Program Manager.
22.03.2018	MS7	Face to face meeting.	SL Delivery Application Specialist and MM manager.
4. Tool evaluation and testing (Method Evaluation)			
23.03.2018	ME1	Face to face meeting.	Material Management coordinator.
26.03.2018	ME2	Face to face meeting.	Material Management coordinator.
5. Tool development and use			
16.04.2018	TD1	Face to face meeting.	Lead Application Specialist.
16.04.2018	TD2	Face to face meeting.	Material Management Manager.

Table 5. The purposes of the meetings.

<b>The stage of the process</b>	<b>Codes</b>	<b>Purpose</b>
Problem definition	PD1-PD7	A total of seven meetings that identified the company's forecasting process problems and potential development needs. However, before the investigation of the current situation, the company's expectations and objectives for this research were reviewed.
Gathering information	GI1-GI9	During the second phase of the process, the focus was on gathering information on the development of a potential forecasting tool.
Creating a forecasting tool	MS1-MS7	The purpose of these seven meetings concerned the creation of a tool by means of previously collected information.
Tool evaluation and testing	ME1-ME2	In these meetings, the functionality of the tool was tested in practice and potential development needs were sought.
Tool development and use	TD1-TD2	At this point, the focus was on developing and implementing the final tool.

### 3.3 Dataset

The dataset of the research consists of written and statistical data. Written information consists of notes of the meetings and email discussions that have accumulated during the study. The content of the written data depended on the topics of meeting or e-mail. Mostly their content consisted of contacts, instructions or answers.

In turn the statistical data consisted of case company's components and materials. The case company's ERP system contained all the information about the materials. The research dataset was designed by filtering only the necessary and relevant information for the study. The statistical dataset includes the case company's PTS materials, their suppliers, historical demand of the materials, sales forecasts of the products, material forecasts of the previous methods and material forecasts of the developed method.

### 3.4 Data processing

The information obtained from the meetings was mainly qualitative. Its analysis was based on the conclusions reached at joint meetings. In turn, the forecasting tool is based on quantitative data obtained from a case company's ERP system. The tool developed during the study as a sum of qualitative and quantitative data. Figure 7 shows the process flow and how qualitative and quantitative information is used.



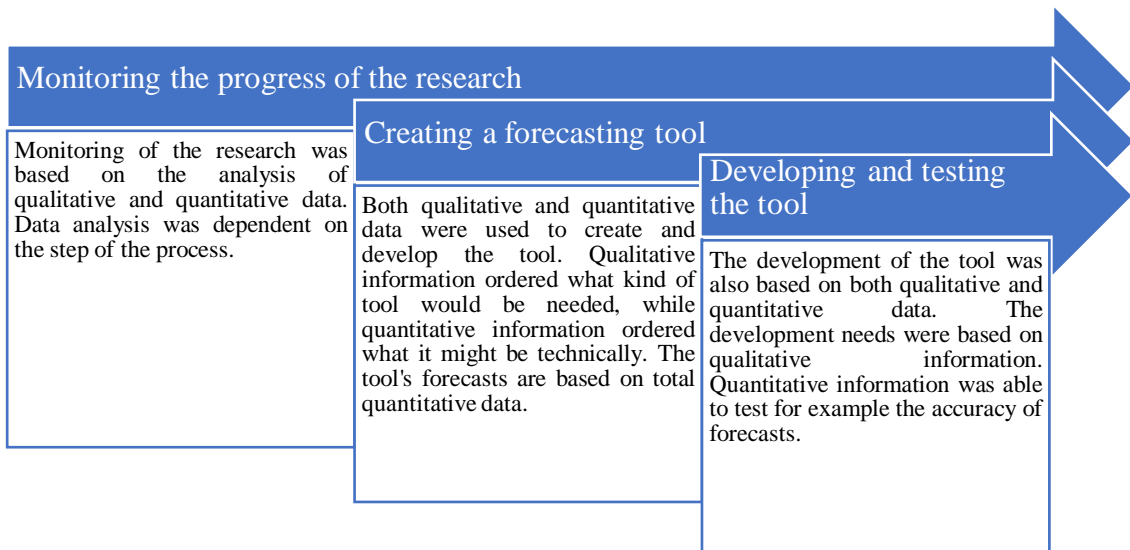


Figure 6. The process flow.

The current situation of the case company's forecasting process is analyzed by using SWOT analysis. Its purpose is to find possible development needs of the process. It is also used to evaluate the new forecasting model. SWOT analyzes of the new and old forecasting model are also used to compare each other. Thus, we see the changes made and possible further development needs.

SWOT analysis has been developed in the 1960's in the United States and has been a highly popular management tool. It consists of the words strengths, weaknesses, opportunities and threats. Its purpose is to measure the company's strategic position by comparing the company's strengths and weaknesses with threats and opportunities. In addition to leadership, it has been applied in other disciplines as well. (Vuorinen 2013)

The objective of the SWOT analysis is to produce analysis first, followed by choices and action plans. However, it requires an in-depth knowledge of the subject being analyzed. SWOT's sub-areas S (Strengths) and W (Weaknesses) are internal issues within the company while O (opportunities) and T (threats) are external issues related to the operating environment. (Vuorinen 2013). Figure 6 shows the structure of the SWOT analysis.

<b>Internal environment</b>	<b>Strengths</b>	<b>Weaknesses</b>
<b>External environment</b>	<b>Opportunities</b>	<b>Threats</b>

Figure 7. The structure of the SWOT analysis (adapting Vuorinen 2013).

The previous and developed forecasting method was also evaluated using MAD and Tracking signal. (See chapter 2.2.4). The values obtained from the calculations are compared and they provide conclusions.

## 4. The results of the research

### 4.1 Case company and current situation

#### 4.1.1 Company introduction

The target company of the research is founded in Finland and is a global provider of industrial products and services. It is a major employer in the world today employing tens of thousands of workers around the world. The research is directed at the group's subsidiary, which is based in Finland. More specifically, it is directed at the part of the factory that manufactures electrical equipment. (Intranet of the case company.)

Materials management of the electrical factory is responsible of the material forecasting. The main task of materials management is to ensure that the materials are sufficient to enable production to respond to customers' demand. The forecasting is one of the most critical parts of that process. Forecasting is aimed at ensuring that suppliers are able to meet the material needs of an electrical factory. These forecasts are called supplier forecasts. (PD1.)

Large material quantities increases the importance of supplier forecasts at that electrical plant. There are thousands of components and parts to be purchased. In addition, material needs vary continuously. In other words, it is impossible for suppliers to respond to the material demand of an electrical plant without suitable forecasts. (PD1.)

The materials management team consists of ten people, seven of whom are responsible for the actual purchasing of materials. The remainder are responsible for the maintenance of materials. The actual purchase of materials is divided into PTO and PTS purchases where employees have their own area of responsibilities. Creating of supplier forecasts is the responsibility of PTS buyers, because the forecasts only contain PTS materials. Figure 8 demonstrates materials management of case company. (PD1.)

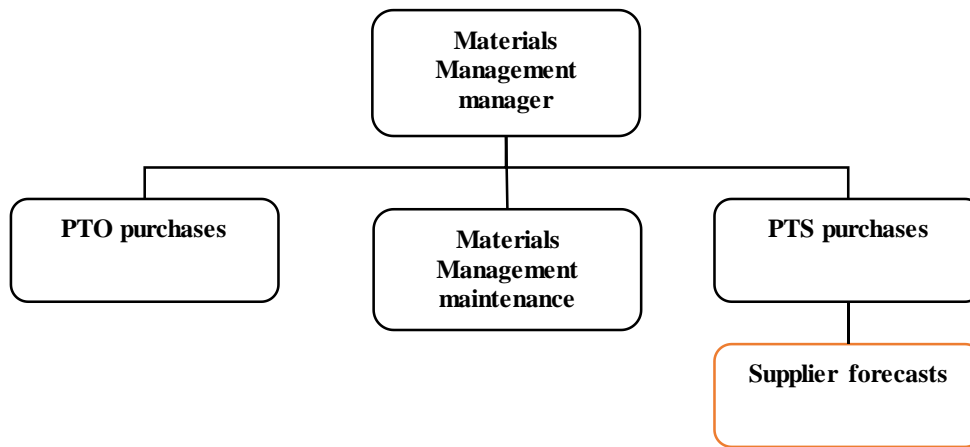


Figure 8. Materials Management of the case company.

#### 4.1.2 Current situation of the forecasting process

Supplier forecasts have been made in this company since its inception. In connection with the supplier agreement it is also agreed to make material forecasts and the frequency of updating them. Forecasts are sent to suppliers monthly, semiannually or annually depending on the request of the supplier. The forecast includes an estimate of the consumption of that period on all supplier's PTS materials. (PD 1-7.)

Forecasts are currently being made in many different ways in this company. Forecasts are made on the basis of each individual's own experience and skills. All forecast are done manually and commonly they are made from one material at a time. Forecasted future demand is strongly based on the forecaster's experience and know-how to use available information. (PD 1-7.)

According to interviews and observations the most important source of information for forecasting is the company's ERP system SAP. It provides a lot of essential information for forecasting. SAP enables access to historical data of materials. By using its various transactions the actual consumption of the materials, the actual amount of purchases and the actual quantities received can be examined. Form here you can also see the current

balance of materials and order lot sizes. SAP can also see a bit of future demand in the short term. (PD 1-7.)

However, most of the forecasts are largely based on historical data, particularly to past consumptions. Based on the interviews, it can be stated that the earlier consumption of materials is the starting point for the forecasts. All current forecasts are based on some level of previous consumption. Another connecting factor in the different worker's forecasting style is the examination of the material requirements of the following month. The forecasted amount will be changed if there is a big difference between the material requirements of the following month and the previous consumption of materials. Some forecasts have used other historical data in addition to previous consumption. For example, average purchase volumes have been used to improve forecast accuracy. (PD 1-7.)

The case company did not have a common line of how to make predictions and there were no agreed forecasting methods. Based on the observations made in the research, current forecasting methods can be considered as adaptation of the moving average (table 3). However, the moving average is not usually used solely, but the figures are changed according to the predictor's estimate. (PD1-7.)

Moving average has been used in forecasts that contain hundreds of materials. Averages have been obtained directly from SAP and did not need to be calculated. SAP will give the moving averages of the desired materials for the previous three, six or twelve months. Figure 9 is an example of material consumption averages from SAP. (PD1-7.)

$$\text{moving average} = \frac{\sum \text{demand in previous periods}}{n} \quad (1)$$

$n = \text{number of periods}$

Material No.	Avg.Mon.Cons.Last 3Mon.	Avg.Mon.Cons.Last 12Mon.	Avg.Mon.Cons.Last 6Mon.
Material 1	53,000	24,583	40,167
Material 2	16,000	34,750	43,667
Material 3	173,000	148,500	138,167
Material 4	8,000	15,250	11,333
Material 5	19,333	39,417	36,000
Material 6	1,667	2,083	2,833
Material 7	11,000	22,750	17,333
Material 8	0,667	0,833	0,667
Material 9	0,667	0,917	0,667
Material 10	74,000	41,583	57,000

Figure 9. An example of Moving averages.

Usage of moving average depends on the time period of the forecast. For example, when the forecast is made for the next three months the previous three months moving average is used. Thus the moving average is multiplied by the number of forecast months. Figure 10 shows an example of usage of the moving average in the forecast. (PD1-7.)

Material No.	Forecast next 3 months	Forecast next 6 months	Forecast next 12 months
Material 1	(53x3 =) 159	(24,583x6=) 241	(40,167x12=) 295
Material 2	48	262	417
Material 3	519	829	1782
Material 4	24	68	183
Material 5	58	216	473

Figure 10. Forecasting by using moving average.

In addition to moving average, the forecasts are adjusted according to the informed decisions of predictor. In other words, the moving average is combined with the predictor's estimate. In practice, this means changing manually the forecasted values obtained by the moving average method. For example the predictor's knowledge of the future consumption of a particular material may affect the final forecasting value. (PD1-7.)

However, in this case, the predictor's opinion was most affected by the existing material requirements. Material requirements are visible in SAP and can be viewed by one material at a time. In general, material requirements are displayed from two months to four months in advance, but the longer the future is considered at the more requirements will change.

Even up to the next month's requirements may change significantly after forecasting. (PD1-7.)

However comparing the existing material requirements with the moving average can show significant differences, whereupon the forecast value must be changed. Some of the forecasts have been made solely by this method. Figure 11 is an example of the requirements view of SAP while Figure 12 illustrates the combination of moving average and predictor's estimate methods. (PD1-7.)

A..	Period/segm...	Plnd ind.req...	Requirements
	Stock		
	M 05/2018	0	5-
	M 06/2018	0	4-
	M 07/2018	0	2-

Figure 11. Material requirements in the SAP. (SAP of the case company)

Requirements	month 1	month 2
Material 1	5	4
Material 2	83	9
Material 3	84	54
Material No.	Forecast next 3 months by moving average	Forecast next 3 months by executive opinion
Material 1	159	> 60
Material 2	48	< 150
Material 3	519	= 520

Figure 12. The combination of moving average and predictor's estimate.

As shown in figure 12, material 1 has much less requirements than the forecast implies. In this case, forecast of material 1 must be reduced. The reduced value is based on moving average, requirements and the predictor's opinion. In this case, the predictor assumes that the requirements will be even more, but believes the forecast with moving averages is too high. (PD1-7.)

In turn, the requirements of material 2 exceed the forecasted amount already in the first month. In this case, the forecast by the moving average is way too low. The predictor does not believe that the consumption of this material will continue to be high, so he/she estimates that the consumption for the next three months is 150. With regard to the third material, the predictor estimates that the forecast with moving averaging is very close to the truth, so that he/she does not change the forecast. He/she only rounds the number according to the lot size, as he did for the rest of the materials. (PD1-7.)

#### 4.1.3 SWOT analysis of the previous forecasting methods

The SWOT analysis was made on the basis of the meetings PD2-PD5. The meetings examined and observed the strengths, weaknesses, opportunities and threats of the forecasting process. In this case, weaknesses can also be considered as clear developmental needs. Table 6 shows the results of the SWOT analysis in a nutshell.



Table 6. SWOT analysis of the previous forecasting models.

<b>Internal environment</b>	<b>Strengths:</b> <ul style="list-style-type: none"> <li>- The forecasting accuracy is good enough.</li> </ul>	<b>Weaknesses:</b> <ul style="list-style-type: none"> <li>- Making forecasts is too complicated and time-consuming: there is no common way to make forecasts.</li> <li>- Forecasting is based too much on history: Suppliers cannot prepare fluctuations of future demand: Deliveries will be delayed.</li> <li>- Poor use of sales forecasts: Not seeing enough for the future.</li> </ul>
<b>External environment</b>	<b>Opportunities:</b> <ul style="list-style-type: none"> <li>- Simplification of the process: Making forecasts become easier: making forecasts requires less resources.</li> <li>- Process automatization: Making forecasts becomes faster: forecasts can be made more densely.</li> <li>- Use of the sales forecast: The fluctuations of future demand appear in forecasts.</li> </ul>	<b>Threats:</b> <ul style="list-style-type: none"> <li>- Large quantity of materials.</li> <li>- Changes in product structures.</li> <li>- Reliability of sales forecasts.</li> <li>- Product structure changes: structural changes do not appear in history.</li> </ul>

The strengths of the SWOT analysis are those that were also to be maintained in the new forecasting method. In turn, weaknesses are the development needs of the forecasting process. Opportunities are ways of improving these weaknesses, whereas threats are things that can increase the challenges of these opportunities. In other words, the SWOT

analysis was used to find out the guidelines of the development project. By following these guidelines, a new forecasting method was developed for the case company.

On the basis of meetings and interviews, the strengths of the previous forecast methods were difficult to find. The only strength was the accuracy of the forecasts. Accuracy was not the best possible but in the case company's business environment it can be considered good enough. (See Table 9). Instead, there were a lot of weaknesses, opportunities and threats. They also relate into each other, creating a belief in the success of a development project.

## 4.2 The developed forecasting method

### 4.2.1 The new forecasting method

Three main factors emerged in the development of the forecasting process: simplification of the process, utilization of sales forecasts and automatization of the process. In addition to taking these factors into account, the new forecasting method had to be compatible with case company's information system. In other words, it had to be compatible with SAP. (PD6-7 & GI1-2.)

The forecasting process was simplified by creating a method that is able to predict all electrical plant PTS materials simultaneously. In practice, this meant that every supplier forecasts of electrical factory could be done at one time. Previously, for each supplier, the forecast was made one at a time.

In addition to simplifying the process, utilization of sales forecasts was one of the goals. The case company made short-term and mid-term sales forecasts by supply planning team. Sales forecasts were made by product group for each factory separately. The best way to use the sales forecasts to support the forecasting of materials was the mid-term plan which included the product groups of each plant and an estimate of their sales over the next period of one year. This forecast called demand budget is updated quarterly four times a year. (GI3 & GI9.)

Automatization of the process meant co-operation with the subcontractors encoder that encoded the excel-based entity from the developed forecasting model. Automatization aimed at increasing the efficiency of the forecast process and the usability of the new forecast model. In practice, it aimed at making every employee of the materials management able to use a new forecast model. (TD1.)

The new forecast model is also partly based on averages of material consumption. In the new forecast model, averages are calculated by product group so that materials can be combined with the sales forecast. In other words, for each material, average consumption is calculated per product order over a given period of time. Agreed period of time is three months back and two months ahead. (MS1-MS7.)

The new forecast model consists of four phases: updating sales forecast, updating moving average of materials, combining the sales forecast with the moving average and combining forecasts of product groups.

1. Updating sales forecast

In case company, sales forecasts are made according to the needs of different units in the short- and mid-term. Making sales forecasts is the responsibility of the supply planning team. Short-term forecasts are made and shared internal weekly while the mid-term forecast is updated and distributed quarterly four times a year. These forecasts are available to all employees on case company's intranet and can be viewed at any time. (G1-GI9.)

Due to appropriate update interval and clarity, the mid-term forecast was best suited for exploitation of material forecasts. This mid-term forecast is also called a demand budget. The demand budget includes all the product groups in the electrical factory and an estimate of their sales in the following year. One product group generally contains several products. These products generally have a different product structure, i.e. BOM. Due to the large product volumes, the sales forecast is made by product group. (GI1-GI9.)

In practice, updating sales figures is very simple with respect to the new forecast model. This must be done four times a year when the demand budget is updated to keep the sales figures up-to-date in the forecasting model. In practice it means copying them to a specific location. Figure 13 is an example of the demand budget of the electrical factory.

Product	2018												TOTAL	2017	2018
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Product group 1	175	113	114	114	115	115	116	115	113	114	112	111	1391	1426	
Product group 2	143	82	83	86	99	109	112	113	92	102	83	78	1008	1182	
Product group 3	25	24	26	24	25	26	26	25	24	26	24	23	340	299	
Product group 4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
Product group 5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
Product group 6	16	11	26	22	28	41	42	29	35	29	38	34	313	352	
Product group 7	48	34	68	44	88	97	95	68	83	66	87	81	890	858	
Product group 8	0	4	0	8	11	4	11	3	14	6	6	2	21	69	
Product group 9	14	22	26	8	43	24	27	20	24	21	25	23	153	278	
Product group 10	128	91	220	260	260	237	248	225	214	217	153	132	1978	2383	
Product group 11	68	36	65	49	82	89	96	95	64	87	43	42	680	817	
Product group 12	0	1	2	1	2	2	2	2	1	2	1	1	11	16	
Product group 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Product group 14	50	26	33	25	46	27	48	48	26	27	26	28	480	410	
Product group 15	0	0	0	0	0	0	0	0	0	0	0	0	6	0	
Product group 16	205	223	249	223	173	160	161	178	169	164	150	111	2513	2165	
Product group 17	24	23	24	26	27	28	34	35	37	44	43	30	298	375	
<b>Total</b>	<b>896</b>	<b>690</b>	<b>935</b>	<b>891</b>	<b>998</b>	<b>959</b>	<b>1019</b>	<b>956</b>	<b>896</b>	<b>904</b>	<b>789</b>	<b>697</b>	<b>10084</b>	<b>10630</b>	

Figure 13. Demand budget. (Intranet of the case company).

## 2. Updating moving average of materials

The new forecast model also applies to the moving average. In this model, the moving average is used to determine average consumption of materials against one production order. Figure 14 demonstrates the calculation of average consumption per one production order in practice. The average consumption of a given material per one production order is calculated by formula:

$$\text{Average consumption/order} = \frac{\sum(\text{Material Demand given period of time})}{\sum(\text{Order given period of time})} \quad (10)$$

An appropriate period of time was considered to be three months back and two months ahead from a date of calculation. The decision took into account case company's business environment and capabilities of SAP. Average consumption is calculated separately for each product group in order that materials can be allocated to the demand budget. In other words this means calculating the average BOM for each product group. (MS1-MS7.)

<b>Material</b>	<b>Sum of demand</b>	<b>Orders ( Product Group 1)</b>	<b>Average cons./Order</b>
Material 1	10	100	0,10
Material 2	27	100	0,27
Material 3	14	100	0,14
Material 4	1	100	0,01
Material 5	104	100	1,04
<b>Material</b>	<b>Sum of demand</b>	<b>Orders ( Product Group 2)</b>	<b>Average cons./Order</b>
Material 1	5	45	0,11
Material 2	51	45	1,13
Material 3	13	45	0,29
Material 4	45	45	1,00
Material 5	162	45	3,60

Figure 14. The calculation of average consumption per order.

### 3. Combining the sales forecast with the moving average

The material forecast for one product group is obtained by combining the calculated averages with the demand budget. Figure 15 shows examples of combining the sales forecast with moving averages. They can be combined by multiplying the average consumptions per order to sales forecast. (MS1-MS7.) Consequently It can be calculated using the following formula:

$$\text{Forecast per product group} = \text{Average consumption/order} * \text{Sales forecast} \quad (11)$$

<b>Product group 1</b>		<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>	<b>Jun</b>
<b>Material</b>	<b>Average cons./Order</b>	<b>175</b>	<b>113</b>	<b>114</b>	<b>114</b>	<b>115</b>	<b>115</b>
Material 1	0,10	17,50	11,30	11,40	11,40	11,50	11,50
Material 2	0,27	47,25	30,51	30,78	30,78	31,05	31,05
Material 3	0,14	24,50	15,82	15,96	15,96	16,10	16,10
Material 4	0,01	1,75	1,13	1,14	1,14	1,15	1,15
Material 5	1,04	182,00	117,52	118,56	118,56	119,60	119,60
<b>Product group 2</b>		<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>	<b>Jun</b>
<b>Material</b>	<b>Average cons./Order</b>	<b>143</b>	<b>82</b>	<b>83</b>	<b>86</b>	<b>99</b>	<b>109</b>
Material 1	0,11	15,89	9,11	9,22	9,56	11,00	12,11
Material 2	1,13	162,07	92,93	94,07	97,47	112,20	123,53
Material 3	0,29	41,31	23,69	23,98	24,84	28,60	31,49
Material 4	1,00	143,00	82,00	83,00	86,00	99,00	109,00
Material 5	3,60	514,80	295,20	298,80	309,60	356,40	392,40

Figure 15. Combining the sales forecast with moving averages.

For example, material 1 was received number 17,5 in January for product group 1, see figure 15. Thus, the method predicts that in January the consumption of material 1 in product group 1 will be 17,5 pieces. In turn, for the product group 2, the consumption of the same material in January is slightly under 16 pieces.

#### 4. Combining forecasts of product groups

The final material forecast is obtained by combining the forecasts of all product groups. Many products and product groups of the electrical factory need the same materials. There are also components that are consumed only for a particular product. However, total consumption of materials can be calculated for the entire factory by combining product forecasts. (MS1-MS7.) For example, material one requires a total of 33 to cover the needs of product groups 1 and 2. Figure 16 shows a final forecast of the materials of figures 14 and 15.

Material	Sum of Jan	Sum of Feb	Sum of Mar	Sum of Apr	Sum of May	Sum of Jun
Material 1	33	20	21	21	23	24
Material 2	209	123	125	128	143	155
Material 3	66	40	40	41	45	48
Material 4	145	83	84	87	100	110
Material 5	697	413	417	428	476	512

Figure 16. The final forecast.

Subsequently, the materials are targeted to the right suppliers. All suppliers can be obtained from the SAP of the case company. After targeting the case company supplier forecast is complete. The final data includes all the requirements causing PTS materials of all suppliers and their forecast for the following year on a monthly, quarterly, semi-annually and yearly basis. The final forecast data has been left as simple as possible in order to be modified if necessary. (MS1-MS7.)

Automatization of the process refers to the automatization of steps 2-4. Only updating sales forecasts must be done manually. The tool is excel based, which in practice retrieves the required information from SAP, calculates averages, combines them with the updated sales forecast, combines forecasts of each product group and finally target the materials to their suppliers. The final output of the tool is shown in the appendixes one and two. (MS1-MS7.)

#### 4.2.2 SWOT analysis of the developed method

This SWOT analysis is done on the same principle as in section 4.1.3 so that they are comparable to each other. Thus, the purpose of this SWOT analysis is to evaluate the strengths, weaknesses, opportunities and threats of a new tool. At the same time, it also partly explains the success of this development project. Table 7 is a SWOT analysis of the developed forecasting model.

Table 7. SWOT analysis of the developed forecasting model.

<b>Internal environment</b>	<b>Strengths:</b> <ul style="list-style-type: none"> <li>- Efficiency.</li> <li>- Ease of use.</li> <li>- Looking at the future.</li> <li>- Adaptation to changes in product structure.</li> </ul>	<b>Weaknesses:</b> <ul style="list-style-type: none"> <li>- Complex implementation.</li> <li>- Poor formability of the tool.</li> </ul>
<b>External environment</b>	<b>Opportunities:</b> <ul style="list-style-type: none"> <li>- The forecasts can be upgraded at any time without causing much resource usage.</li> <li>- Utilizing the tool for inventory planning.</li> <li>- Could the forecast model be used for forecasting other materials in addition to PTS materials?</li> </ul>	<b>Threats:</b> <ul style="list-style-type: none"> <li>- Reliability of sales forecasts.</li> <li>- Break down of the tool.</li> <li>- Changes in the structure of sales the forecasts.</li> </ul>

As the table shows, the four most important strengths of the new model are: efficiency, ease of use, anticipation of the future and change adaptation. Efficiency means that forecasting is fast and does not spend time or resources so still forecast accuracy remains good enough. Ease of use refers to automatization. It enables all employees to use the

tool. In practice, the automatic tool works by pressing one button. In addition to these, the developed forecasting model utilizes sales forecasts. Consequently, it takes into account future fluctuations in demand. The new model also takes into account changes in product structures when the forecasting figures are updated. (ME1-ME2.)

Although the developed model contained many strengths, the weaknesses were not avoided. One weakness in the model is its complicated implementation. The idea of the model is simple, but for technical reasons it requires a lot of SAP and excel expertise. This vulnerability occurs when the automated tool stops working for some reason. In that case, the model would have to be used manually when all employees would not be able to use it. Another weakness is also strongly associated with the tool. It is very difficult to edit the tool. This means that if a tool needs some level to modify it, it can only be done by a tool-making person or a highly experienced coder. (ME1-ME2.)

The developed forecasting model and tool allow for dense updates of forecasting figures. The numbers can be updated frequently because it does not require much resource use. On the other hand, sales forecasts are updated only four times a year, but continuous change in product structures requires a more frequent update of forecasts. In addition, the model and tool provides new opportunities for the case company. For example, utilizing the tool in inventory planning or predicting other than PTS materials are potential further opportunities. However, these require a lot of further research. Hence, these can be considered as possible further research topics. (ME1-ME2.)

Creating a new model also created new threats and risk factors that should be taken into account. The forecast model relies heavily on sales forecasts. If the sales forecasts are defective or untrustworthy, forecasts made by the developed model are also unreliable. As in the case of weaknesses already mentioned tool repair and manual use of the model is challenging. Thirdly, changes in the structure of sales forecasts can be seen as a threat. Then the tool would have to modify what is very challenging and there are not many people skilled enough. (ME1-ME2.)



#### 4.2.3 Comparison and evaluation of the developed and the previous forecasting methods

The forecasting accuracy and performance are measured by the mean absolute deviation (MAD) and tracking signal. MAD measures the mean forecasting errors over a given time period and the tracking signal measures how well the method predicts actual values. (See chapter 2.2.4). Ten random materials have been taken for measurement. Both methods have used the same materials. Next is an example of how the calculations are made. Table 8 contains the necessary data for calculation. Below the table is an example of calculations of one material. Table 9 contains the results of all calculations. (ME1-ME2.)

Table 8. The information needed for the calculations of MAD and tracking signal.

<b>MATERIAL 1</b>				
<b>Month</b>	<b>Actual Demand</b>	<b>Forecast</b>	<b>Error</b>	<b>Absolute error</b>
1	185	133	52	52
2	123	133	-10	10
3	157	133	24	24
4	153	133	20	20
5	117	133	-16	16
6	121	133	-12	12
		<b>Total</b>	<b>58</b>	<b>134</b>

$$MAD = \frac{134}{6} = 22,33 \quad (6)$$

$$Tracking\ signal = \frac{58}{22,33} = 2,6 \quad (7)$$

Tracking signal action limit were set to 6. Hence, if the tracking signal value is below -6 or exceeds 6 the forecast is not good enough in this evaluation. Limits are set according to the case company's business environment, where high consumption of materials permits more forecasting errors.

Table 9. The results of calculation of MAD and tracking signal.

Previous method	MAD	Tracking signal	The developed method	MAD	Tracking signal
Material 1	22,3	2,6	Material 1	21,2	4,9
Material 2	8,7	-2,5	Material 2	6,3	-0,6
Material 3	20,0	6,0	Material 3	4,8	-6,0
Material 4	6,0	4,3	Material 4	2,2	-2,3
Material 5	1,5	-6,0	Material 5	0,3	6,0
Material 6	1,3	-6,0	Material 6	0,3	6,0
Material 7	14,8	-2,5	Material 7	15,8	5,2
Material 8	1,7	1,2	Material 8	2,7	1,5
Material 9	3,8	4,9	Material 9	1,7	-2,4
Material 10	4,2	-2,1	Material 10	3,3	-3
<b>Total</b>	<b>84,3</b>			<b>58,6</b>	

As the results shows, there are not a big difference in previous and new forecasting methods. Although both had three materials in the limit, both methods survived this inspection without any action. However, this proves that the new model did not weaken forecasting accuracy even if it did not use predictor's estimate. In fact, the new model had much less forecasting errors, so it can be said that the forecasting accuracy of the new model is even better. In addition, the distribution of forecasting errors is more evenly distributed in the developed method, indicating that a better reactivity to demand fluctuations.

Another comparative object is the efficiency of the forecasting methods. In the previous method, one supplier forecast required one to three working days, depending on the size of the forecast. In any case, supplier forecasts have been made on a monthly, quarterly, semi-annual or yearly basis. This means that they have used a workload of weeks for forecasting in material management at an annualized rate.

With the current forecasting method, forecasting is much more efficient. Efficiency is based on technique that provides forecasts for all suppliers at the same time. By using the new method manually, forecasting took about 4-6 hours. In turn, the automated tool does not take any work hours in practice. This approves that the new method is a much faster way of forecasting. The new method can save you several days or even weeks of working

hours during the year. This can be considered a very significant advance in the materials management.

The developed and old method was also compared on the basis of SWOT analysis. The benchmarks were the strengths, weaknesses, opportunities and threats known from the SWOT analysis. The purpose of the comparison is to observe what has been improved in the developed method compared to the previous methods. Table 10 contains the summaries of both SWOT analyzes. Below the table is more detailed results and observations of the comparison.

Table 10. Comparison of SWOT analyzes.

<b>The previous methods</b>	<b>The developed method</b>
<p><b>Strengths:</b></p> <ul style="list-style-type: none"> <li>- Forecasting accuracy.</li> </ul>	<p><b>Strengths:</b></p> <ul style="list-style-type: none"> <li>- Efficiency.</li> <li>- Ease of use.</li> <li>- Use of sales forecasts.</li> <li>- Adaptation to changes.</li> </ul>
<p><b>Weaknesses:</b></p> <ul style="list-style-type: none"> <li>- Complicated.</li> <li>- Time-consuming.</li> <li>- Based too much on history.</li> <li>- Poor use of sales forecasts.</li> </ul>	<p><b>Weaknesses:</b></p> <ul style="list-style-type: none"> <li>- Complex implementation.</li> <li>- Poor formability of the tool.</li> </ul>
<p><b>Opportunities:</b></p> <ul style="list-style-type: none"> <li>- Simplification.</li> <li>- Automatization.</li> <li>- Use of the sales forecasts.</li> </ul>	<p><b>Opportunities:</b></p> <ul style="list-style-type: none"> <li>- Inventory planning.</li> <li>- Utilizing the model for PTO materials.</li> </ul>
<p><b>Threats:</b></p> <ul style="list-style-type: none"> <li>- Large quantity of materials.</li> <li>- Product structure changes.</li> <li>- Reliability of sales forecasts.</li> </ul>	<p><b>Threats:</b></p> <ul style="list-style-type: none"> <li>- Reliability of sales forecasts.</li> <li>- Break down of the tool.</li> <li>- Changes in the structure of sales forecasts.</li> </ul>

As shown in the table, the developed method has been able to overcome the weaknesses of the previous methods. The developed method has been able to reverse the weaknesses

of the previous methods into the strengths by simplification of the process, automatization and utilization of sales forecasts. At the same time, the new method has been able to maintain or even improve the strength of the old methods. (See table 9).

In addition, the developed method has been able to overcome two possible threat factors, large quantity of materials and product structure changes. The reliability of the sales forecasts remains in the threats also in the developed method, because it cannot be influenced by materials management.

Although the developed method has eliminated many of the problems of the old methods, it has its own weaknesses and threats which should be taken into account when using the method. On the other hand, it has also given the case company new opportunities that could be utilized in the future.

## 5. Conclusions and discussion

The aim of the research was to develop a supplier forecasting process in the case company. The purpose of the practical work was to create a suitable forecasting method and tool for forecasting in the business environment of the case company. The objective was to improve the efficiency of forecasting, thus reducing the number of resources to be used for forecasting. However, reaching the goals required extensive research and practical contribution.

The study found that case company's existing forecasting methods were not defined. On the contrary, the employees who responded of forecasting had developed their own ways of predicting. The habits differed a little bit from each other. Based on the observations made in the research, the greatest similarities in the company's earlier forecasting methods were the interpretation of the material consumption in history and elaboration of the forecasts manually according to the employer's ability to judge. In theory, these predictive styles mostly adapting the moving average. Most of the forecasts included nuances of moving averages and expert estimates.

The research found that the biggest challenges of the case company's forecasting process and methods were that forecasting took too much time and did not take advantage of case company's sales forecasts. Hence, forecasts were made at last moment and they were based too much on history. These challenges could also be interpreted as the most important development needs of the case company's forecasting process.

The identified development needs were addressed by simplifying the forecasting process, utilizing sales forecasts and automatize the process. Simplification of the process and the utilization of the sales forecasts required the development and implementation of a suitable forecasting method. In turn, the tool sought to automate the newly developed method. However, the method could not be developed directly on the basis of theory, rather it required a deep knowledge of the business environment of the case company. As an additional challenge, the method had to be compatible with the case company's ERP system in order to make the tool work correctly.

As a result of the development project, a new method was developed. With reference to theory, the method applied to moving average. Forecasts were based on a combination of moving averages of materials and sales forecasts of the case company. Comparison of previous and new forecasting methods proved that utilization of sales forecasts improved the responsiveness of forecasts to fluctuations in demand. This resulted in more accurate forecasts. The development project also succeeded in creating a tool that uses the developed method. The technical creation of the tool and the coordination of the case with the company's ERP system included many challenges. However, the result was a tool that accelerated forecasting significantly.

The previous and developed forecasting method was tested using the MAD and Tracking signal, known from theory. The results of the tests showed that, according to the tracking signal, both predictive elements can be considered sufficiently accurate when all values remained inside the action limits. The test showed that in the previous forecasting method, the total MAD of samples was 84.3, while the total MAD of the new method was 58.6. This showed that the new method was much more accurate in this test, due to better responsiveness to demand fluctuations.

In addition to the accuracy tests, the previous and new methods were compared by efficiency. Using the previous methods, a single supplier forecast required about 1-3 working days. Thus, on a yearly basis, it took weeks to make all the forecasts.

Thus, when the sales forecasts were combined and the tool created, the resulting benefits prove the success of the development project. The developed method even manually used took about a half of working day to obtain all supplier forecasts. The automatic forecasting tool virtually lost no working time. So the comparison showed that the developed method could save several weeks of working time per year. This was the most significant development step in the case company's forecasting process.

As a direct response to the main research question, it can be stated that in this context, the forecast process could be developed by simplifying process, utilizing sales forecasts and process automatization. However, responding to the research question required a large research and development project.

As a result of the investigation and development project, forecasting in the case company will change. This will require the employees of the materials management to learn about the new method and tool usage. However, this is not a big deal since the new method will bring new opportunities to further develop the management of the material. In the best case, the developed method and the tool applied to it reduce the lack of materials, which in turn improves production capability to meet customers' needs. Forecasts produced by the developed tool have already been used by several supplier forecasts. The first impressions of them have been promising. Anyhow, the performance of the developed method and tool should be under monitoring continuously, so that they can be modified if necessary.

Investigating forecasts, especially the development of the forecasting process, is always case-specific. There are a number of forecasting methods, formulas, and instructions presented in theory. It may be very challenging to find a just-right method for the predictable object. The most important thing is to know the operating environment of the object. With regard to this project, theoretical guidelines for the forecasting process were more helpful than the methods and formulas. However, in companies like this case, forecasts are so important that it is recommendable to spend time and money to developing them. In the best case they can achieve significant benefits.

During the research, new issues emerged that could be explored in the case company. Utilizing a developed tool for forecasting of PTO materials is one of the potential subject for further research. Another potential utilization of the tool could be inventory planning, which also requires further research. The use of the developed method for the other factories of the company would be recommended as a further research topic as well.

Overall, forecasting could be explored indefinitely. It is almost invariably very challenging and ultimately the forecasted figures can only be considered as educated guesses, as they rarely find it perfectly accurate. However, usually they provide guidelines for the future, which in many cases are necessary to maintain and improve business.

## REFERENCES

- Abdullah, A. M. A. (2017). Evolution of Enterprise Resource Planning. *Excel Journal of Engineering Technology and Management Science*. 1:11, 1-6.
- Acar, Y. Everette, S. & Gardner, Jr. (2012). Forecasting method selection in a global supply chain. *International Journal of Forecasting* 28:4, 842-848.
- Armstrong, J. S. (2001a). *Principles of forecasting: A Handbook for Researchers and Practitioners*. (E-Book). Boston, Kluwer Academic Publishers.
- Armstrong, J. S. (2001b). *Selecting Forecasting Methods*. In: Armstrong, J. S. 2001. *Principles of Forecasting*. Boston, Kluwer Academic Publishers. p. 365-386.
- Armstrong, J. S. (2001c). *Evaluating Forecasting Methods*. In: Armstrong, J. S. 2001. *Principles of Forecasting*. Boston, Kluwer Academic Publishers p. 443-465
- Arnold, J. R. T. & Chapman, S. N. (2001). *Introduction to materials management*. 4th ed. Upper Saddle River (N.J.), Prentice Hall.
- Aswathappa, K. & Bhat, K. S. (2010). *Production and Operations Management*. (E-book). Global Media.
- Baily, P. J. H., Farmer, D., Jessop, D. & Jones, D. (1994). *Purchasing principles and management*. 7th ed. (E-book). London, Pitman.
- Başkarada, S. (2014). Qualitative Case Study Guidelines. *The Qualitative Report* 19:40, 1-25.
- Bhat, K. S. (2009). *Materials management*. (E-book). New Delhi, Himalaya Publishing House.



- Chase, C. (2013). *Demand-Driven Forecasting: A Structured Approach to Forecasting*. (E-book) John Wiley & Sons.
- Chunawalla, S. A. (2008). *Materials and purchasing management*. (E-book). New Delhi, Himalaya Publishing House.
- Costa, C. J. Ferreira, E. Bento, F. & Aparicio, M. (2016). Enterprise resource planning adoption and satisfaction determinants. *Computers in Human Behavior* 63, 659-671.
- Croxton, K. L. Lambert, D. M., Garcia-Dastugue, S., & Rogers, D. S. (2002). The demand management process. *International Journal of Logistics Management* 13:2, 51-66.
- Dweiri, F. Khan, S. A & Jain, V. (2015). Production planning forecasting method selection in a supply chain: A case study. *International Journal of Applied Management Science* 7:1, 38.
- Fulford, R. (2013). A case study of strategic enterprise resource planning management in a global corporation: Standardisation is the basis of competitive advantage. *Journal of Systems and Information Technology* 15:1, 117-132.
- Hyndman, R.J. and Athanasopoulos, G. (2013) *Forecasting: principles and practice*. OTexts: Melbourne, Australia. [online]. [13.03.2018-13.04.2018]. Available: <http://otexts.org/fpp/>.
- Intranet of the case company. [online]. [16.04.2018]. Available for employees of the company.
- Kumar, S. A. & Suresh, N. (2009). *Operations Management*. (E-book). New age international
- Mabert, V. A. (2007). The early road to material requirements planning. *Journal of Operations Management* 25:2, 346-356.

- Mabert, V. A. Soni, A. Venkataramanan, M. A. (2003). The impact of organization size on enterprise resource planning (ERP) implementations in the US manufacturing sector. *Omega* 31:3, 235-246.
- Mehdiyev, N. Enke, D. Fettke, D. & Loos, P. (2016). Evaluating Forecasting Methods by Considering Different Accuracy Measures. *Procedia Computer Science* 95, 264-271.
- Montgomery, D. C., Jennings, C. L. & Kulahci, M. (2015). *Introduction to Time Series Analysis and Forecasting*. 2<sup>nd</sup> ed. (E-book). Hoboken, Wiley.
- Parthasarthy, S. (2007). *Enterprise Resource Planning: A Managerial & Technical Perspective*. (E-book). New Age International.
- Permanasari, A. E. (2010). Forecasting method selection using ANOVA and Duncan multiple range tests on time series dataset. *Information Technology (ITSim), International Symposium in 2*, 941-945.
- Putra, L. D. (2009) *Qualitative Forecasting Methods and Techniques*. [online]. [13.04.2018]. Available: <http://accounting-financial-tax.com/2009/04/qualitative-forecasting-methods-and-techniques/>.
- Rushton, A. Croucher, P. & Baker, P. (2014). *The handbook of logistics & distribution management*. Revised 5th ed. (E-book). London, Kogan Page.
- Sakki, J. (2014). *Tilaus-toimitusketjun hallinta: Digitalisoitumisen haasteet*. 8th ed. (E-book) Vantaa, Jouni Sakki Oy.
- Sanders, N. R. & Ritzman, L. P. (2001) *Judgmental Adjustment of Statistical Forecasts*. In: Armstrong, J. S. 2001. *Principles of Forecasting*. Boston, Kluwer Academic Publishers. p. 405-416.
- Samara, T. (2015). *ERP and Information Systems*. (E-book). John Wiley & Sons, Incorporated

SAP. The ERP system of the case company. [online]. [19.04.2018]. Available for employees of the company.

Science dictionary. [online]. [10.04.2018]. Available: <https://www.vocabulary.com/dictionary/science>

Shcherbakov, M. V. Brebels, A. Shcherbakova, N. L. Tyukov, A. P. Janovsky, T. A. & Kamaev, A. (2013). A Survey of Forecast Error Measures. *World Applied Sciences Journal* 24, 171-176.

Sheldon, D. H. (2008). *Lean Materials Planning and Execution*. (E-book) J. Ross Pub.

Shridharabhat, K. & Aswathappa, K. (2009). *Production and Operations Management*. (E-book). Global Media.

Viitala, R. (2013). *Liiketoimintaosaaminen: Menestyvän yritystoiminnan perusta*. 6th ed. (E-book). Helsinki, Edita.

Vuorinen, T. (2013). *Strategiakirja: 20 työkalua*. (E-book) Helsinki, Talentum.

Wilson, J. M. (2015). The origin of material requirements planning in Frederick W. Taylor's planning office. *International Journal of Production Research* 54:5, 1-19.

Yang, M. (2016). *Lecture 9-1 The Overview of MRP system*. [online]. [09.04.2018]. Available: <https://www.youtube.com/watch?v=xNwIh28YgbE>

Yin, R. K. (1994). Case Study Research Design and Methods. *Applied Social Research Methods Series* 5, 1-53.



## Appendix 2

Row Labels	Material Description	Supplier	Count of Quarterly Forecast	Sum of Q1	Sum of Q2	Sum of Q3	Sum of Q4	Count of Semiannually Forecast	Sum of 1st Half	Sum of 2nd Half	Count of Yearly Forecast	Sum of 2018
Material 1	Description 1	Supplier 3		74	81	203	111		155	214		369
Material 2	Description 2	Supplier 1		4	5	5	4		9	10		18
Material 3	Description 3	Supplier 1		6	6	7	6		12	12		25
Material 4	Description 4	Supplier 1		2	3	3	3		5	6		11
Material 5	Description 5	Supplier 1		49	63	71	51		112	121		233
Material 6	Description 6	Supplier 1		7	8	8	8		15	15		30
Material 7	Description 7	Supplier 1		16	15	14	13		31	27		58
Material 8	Description 8	Supplier 1		10	10	10	7		20	17		37
Material 9	Description 9	Supplier 1		15	14	13	12		29	25		54
Material 10	Description 10	Supplier 1		86	70	64	54		156	118		274
Material 11	Description 11	Supplier 1		11	13	15	11		24	25		50
Material 12	Description 12	Supplier 1		8	10	12	10		19	22		41
Material 13	Description 13	Supplier 3		13	10	9	8		23	17		40
Material 14	Description 14	Supplier 4		6	7	7	5		13	13		26
Material 15	Description 15	Supplier 2		327	294	366	243		621	609		1230
Material 16	Description 16	Supplier 4		80	78	78	76		159	155		314
Material 17	Description 17	Supplier 1		13	15	19	21		27	40		68
Material 18	Description 18	Supplier 2		118	98	90	76		215	166		381
Material 19	Description 19	Supplier 5		12	14	16	11		26	27		53
Material 20	Description 20	Supplier 6		2	3	3	2		5	6		11
Material 21	Description 21	Supplier 2		142	143	153	124		285	277		562
Material 22	Description 22	Supplier 3		10	12	14	10		22	24		46
Material 23	Description 23	Supplier 2		344	594	555	422		938	977		1915
Material 24	Description 24	Supplier 2		34	58	54	41		92	96		188
Material 25	Description 25	Supplier 7		1	1	1	1		1	1		3

